Review

Socioeconomic status and changing inequalities in colorectal cancer? A review of the associations with risk, treatment and outcome

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ABSTRACT

Background: Upcoming mass screening for colorectal cancer (CRC) makes a review of recent literature on the association with socioeconomic status (SES) relevant, because of marked and contradictory associations with risk, treatment and outcome.

Methods: The Pubmed database using the MeSH terms 'Neoplasms' or 'Colorectal Neoplasms' and 'Socioeconomic Factors' for articles added between 1995 and 1st October 2009 led to 62 articles.

Results: Low SES groups exhibited a higher incidence compared with high SES groups in the US and Canada (range risk ratio (RR) 1.0–1.5), but mostly lower in Europe (RR 0.3–0.9). Treatment, survival and mortality all showed less favourable results for people with a lower socioeconomic status: Patients with a low SES received less often (neo)adjuvant therapy (RR ranging from 0.4 to 0.99), had worse survival rates (hazard ratio (HR) 1.3–1.8) and exhibited generally the highest mortality rates up to 1.6 for colon cancer in Europe and up to 3.1 for rectal cancer.

Conclusions: A quite consistent trend was observed favouring individuals with a high SES compared to those with a low SES that still remains in terms of treatment, survival and thus also mortality. We did not find evidence that the low/high SES gradients for treatment chosen and outcome are decreasing. To meet increasing inequalities in mortality from CRC in Europe for people with a low SES and to make mass screening successful, a high participation rate needs to be realised of low SES people in the soon starting screening program.

1. Background

Socioeconomic inequalities in incidence and outcome have been reported for a variety of cancer types.[1–6] In general, cancer mortality is about 20–80% higher among individuals with a lower socioeconomic status (SES).[7] This disadvantage may be the result of a higher cancer incidence in some countries and/or lower cancer survival rates in most of them. A comprehensive review of studies published up to 1995 revealed an opposite trend for colorectal cancer (CRC)[7] – worldwide the

third most common type of cancer. For colon cancer low risks for individuals with a low SES were reported, both for mortality and incidence – in contrast to rectal cancer for which no consistent associations were observed.[7] However, CRC mortality appeared to be highest among people with a poor education across Europe during the 1990s.[8] On the eve of mass screening for colorectal cancer in the Netherlands a precise insight into the relationship with SES is even more relevant, since participation of high risk groups is crucial to obtain optimal screening results. We therefore conducted a systematic review of the relationship between SES and colorectal cancer incidence, treatment, survival and mortality.

2. Materials and methods

The electronic database of Pubmed was searched using the following strategy: ('Neoplasms'[Majr:NoExp] or 'Colorectal Neoplasms'[Mesh]) and ('Socioeconomic Factors'[Mesh]). Only articles in English added to Pubmed between 1st January 1995 and 1st October 2009 were included. All types of studies focusing on incidence, (determinants of) treatment and outcome (i.e. survival and mortality) were included, except reviews. All patients with colon or rectal cancer were included, independent of their characteristics (such as age, race, and place of residence). For treatment and mortality, we also included studies that did not distinguish between colon and rectal (i.e. colorectal cancer in general). If several ethnic groups were studied, only the results for Caucasians are presented here. Studies that used education, occupation, income, poverty or combinations of any of these as indicators of SES were included.

Articles were first screened by title for their contents, then by abstract. Full text was obtained for articles that met the above-mentioned inclusion criteria. After reading, these articles were judged and either included or excluded. Articles were excluded because of several reasons, i.e. since no abstract was available we should read the complete article; young age; focus only on spatial, rurality or race but not on education, occupation, income or poverty; or without distinction between colon and rectum. Furthermore, the reference lists of all included articles were screened for useful articles. Selection and abstraction were performed by one reviewer (MA). We extracted data on author, journal, year of publication, type of study, population at-risk, period of diagnosis, cancer (sub)site, SES indicators, results, suggested causes of inequalities and possible useful references from the included articles. The data is summarised in separate tables for incidence, treatment, survival and mortality. Data is presented as the odds of low versus high SES, calculated from the data in the articles.

3. Results

The Pubmed search yielded 1808 articles, which were scanned by title (resulting in 232 abstracts) and then by abstract (resulting in 120 full-text articles). Of these, 55 were included in this review. After scanning the reference lists, seven additional articles were included. Nineteen articles on incidence, 14 on survival, 20 on mortality and 14 on treatment were included; five studies concentrated on combinations of two of these, i.e. one on incidence and survival; one on incidence and mortality; and three on treatment and survival. Results are presented in Tables 1–4; comprehensive tables can be found in Supplementary material.

3.1. Incidence

In the United States (US) and Canada (Table 1A) a lower social class was generally associated with higher risk of colon and rectal cancer, whereas European studies predominantly found lower risks (Table 1B).

Risk estimates among low SES groups in the US and Canada ranged from 1.0 to 1.6 if diagnosed before the mid-1990s (Table 1A),[9–15] whereas a study of patients diagnosed thereafter in the state of Alabama showed a lower risk (range 0.9–1.0).[16]

European relative risk estimates (Table 1B) ranged from 0.3 to 0.9 for low compared to a high SES in Italy,[17,18] Finland,[1] Sweden,[19] Norway,[20] while no association[21] or increased risk was found in another Italian study,[21] and in France,[22] Denmark[23] and the Netherlands,[2] depending on the indicator used for measuring SES. In agreement with the majority of the results of European origin, Australian and South Korean studies reported a lower incidence among individuals with a low SES.[24–26]

3.2. Treatment

A lower chance of receiving curative treatment among colon cancer patients with a low SES was demonstrated consistently: odds ratios for surgery, (adjuvant) radiotherapy or (adjuvant) chemotherapy ranged from 0.4 to 0.99 for those with a low compared to a high SES (Table 2).[27–35]

Rectal cancer patients from low SES groups were less likely to receive radiotherapy and chemotherapy,[28,35,36] but this was not uniform. Furthermore, the risk of having a permanent stoma after surgery was higher among low SES patients (risk ratio (RR) 1.4)[31] as well as the chance of undergoing abdomino-perineal excision of the rectum (APER).[31,37,38]

3.3. Survival

Both colon and rectal cancer patients from low SES groups consistently had worse survival rates compared to high SES patients (Tables 3A and 3B); reported 5-year relative survival rates for low SES patients compared to high SES patients ranged from 0.5 to 0.9.[23,31,39] Furthermore, the risk of dying in the first 5 years after diagnosis was consistently elevated for patients with a low compared to a high SES (hazard ratio (HR) ranging from 1.1 to 1.8) (Table 3B).[30,40–53] From 1986 to 1999, the survival disparities increased in England and Wales in both colon and rectal cancer patients.[54,55]

3.4. Mortality

Mortality from colorectal cancer was generally highest among individuals with a low SES (Table 4A and 4B), also for the subsites colon and rectum separately. One US study showed a transition from lower towards higher colorectal cancer

Table 1A – Associations between incidence of colon and rectal cancer and socioeconomic status in US and Canada.

Author, year	Study base	Indicators	Type of measurement		Risk of low versus high SES	
					Males	Females
Colon						
Gorey and Vena, 1995[12]	US, 1979–1986	Poverty	RR[a] (95% CI)[b]		**1.39 (1.24–1.55)**[c]	**1.48 (1.33–1.65)**
Gorey et al., 1998[11]	Canada, 1986–1993	Poverty	Standardised incidence rate ratio		**1.11 (1.02–1.20)**	0.99 (0.97–1.01)
Krieger et al., 1999[10]	US, 1988–1992	% Working, professional, poverty, education	Incidence rate ratio		**1.3 (1.1–1.6)**	**1.3 (1.1–1.6)**
Mackillop et al., 2000[9]	US, 1988–1992	Income	RR	US	**1.08 (1.01–1.14)**	**1.10 (1.03–1.16)**
	Canada, 1989–1993			Canada	**1.20 (1.10–1.33)**	**1.15 (1.05–1.28)**
Shipp et al., 2005[16]	US, 1996–1999	Education	RR		**0.91 (0.85–0.97)** *Both sexes*	
		Income			0.99 (0.98–1.01) *Both sexes*	
		Poverty			1.02 (0.93–1.09) *Both sexes*	
Mouw et al., 2008[15]	US, 1995–1996	Education	RR		1.10 (0.94–1.29)	**1.37 (1.06–1.77)**
Rectal						
Gorey and Vena, 1995[12]	US, 1979–1986	Poverty	RR		**1.36 (1.16–1.60)**	**1.64 (1.39–1.94)**
Gorey et al., 1998[11]	Canada, 1986–1993	Poverty	Standardised incidence rate ratio		**1.25 (1.08–1.44)**	**1.04 (1.01–1.07)**
Mackillop et al., 2000[9]	US, 1988–1992	Income	RR	US	**1.19 (1.10–1.32)**	1.02 (0.98–1.05)
	Canada, 1989–1993			Canada	**1.23 (1.09–1.43)**	1.00 (0.94–1.08)
Mouw et al., 2008[15]	US, 1995–1996	Education	RR		**1.50 (1.17–1.92)**	1.05 (0.68–1.62)

[a] RR: relative risk or risk ratio.
[b] 95% CI: 95% confidence interval.
[c] Values in bold are statistically significant.

Table 1B – Associations between incidence of colon and rectal cancer and socioeconomic status in Europe, Australia and South Korea.

Author, year	Study base	Indicators	Type of measurement	Risk of low versus high SES		
					Males	Females
Colon						
Van Loon et al., 1995[2]	The Netherlands, 1986–1989	Education	RR[a] (95% CI)[b]		1.00 (0.54–1.85)	1.14 (0.50–2.56)
		Occupation			1.41 (0.77–2.56)	1.39 (0.67–2.94)
		Social standing[d]			**0.38 (0.19–0.76)**[c]	1.22 (0.26–5.88)
Marshall et al., 1999[22]	France, 1988–1992	Socioprofessional hierarchy	Odds ratio		2.4 (0.8–7.2)	
		Employee category			1.2 (0.4–3.4)	
Tavani et al., 1999[17]	Italy, 1985–1996	Education	Odds ratio		**0.41 (0.31–0.53)**	0.78 (0.53–1.14)
		Social class (occupation)			**0.43 (0.34–0.55)**	**0.75 (0.58–0.97)**
Pisa et al., 2000[18]	Italy, 1992–1996	Education	Odds ratio		**0.26 (0.15–0.43)**	**0.33 (0.18–0.63)**
		Occupation			**0.42 (0.26–0.67)**	0.77 (0.43–1.43)
Bouchardy et al., 2002[87]	Switzerland, 1980–1993	Occupation			↑SES ↑risk	
Hemminki and Li, 2003[19]	Sweden, 1961–1998	Education	Standardised incidence ratio		**1.11 (1.04–1.18)**	**0.90 (0.81–0.99)**
Braaten et al., 2005[20]	Norway, 1991–2001	Education	RR			1.23 (0.70–2.20)
Weiderpass and Pukkala, 2006[1]	Finland, 1971–1995	Education, occupation, industrial status, industry groupings	Standardised incidence ratio		**0.78 versus 1.37 [RR = 0.6]**[a]	0.92 versus 1.13 [RR = 0.8]
Egeberg et al., 2008[23]	Denmark, 1994–2003	Education	Incidence rate ratio		0.93 (0.85–1.01)	1.02 (0.93–1.12)
		Disposable income			1.01 (0.94–1.08)	0.94 (0.88–1.01)
		Social class (occupation)			**0.70 (0.61–0.81)**	0.87 (0.67–1.14)
		Housing tenure			**1.19 (1.12–1.26)**	0.98 (0.93–1.05)
		Size of dwelling			**1.30 (1.10–1.52)**	0.86 (0.67–1.11)
Spadea et al., 2009[21]	Italy, 1985–1999	Education	Relative risk	1985–1999	0.93 (0.83–1.04)	0.93 (0.80–1.07)
				1985–1989	**0.73 (0.60–0.90)**	0.79 (0.61–1.03)
				1990–1994	1.12 (0.90–1.38)	1.00 (0.77–1.30)
				1995–1999	1.00 (0.82–1.21)	1.04 (0.82–1.30)
Burnley, 1997[25]	Australia, 1985–1991	Income	Pearson correlation		**0.27**	
		Jarman index[d]			−0.21	
Pearce and Bethwaite, 1997[26]	New Zealand, 1984–1987	Elley–Irving scale[d]	Incidence/100,000 person years		8.9 versus 12.9 [RR = 0.7]	
Kim et al., 2008[24]	South Korea, 2001	Income	Relative index of inequalities per 100,000 population		0.98 (0.61–1.57)	**0.69 (0.59–0.80)**

Rectal

Tavani et al., 1999[17]	Italy, 1985–1996	Education	Odds ratio		**0.41 (0.31–0.53)**	0.99 (0.60–1.64)
		Social class (occupation)			0.85 (0.63–1.16)	0.85 (0.61–1.19)
Pisa et al., 2000[18]	Italy, 1992– 1996	Education	Odds ratio		0.77 (0.42–1.43)	**0.31 (0.14–0.67)**
		Occupation			1.11 (0.67–2.00)	0.83 (0.38–2.0)
Bouchardy et al., 2002[87]	Switzerland, 1980–1993	Occupation			No association	
Hemminki and Li, 2003[19]	Sweden, 1961–1998	Education	Standardised incidence ratio		**0.83 (0.76–0.91)**	0.92 (0.80–1.06)
Braaten et al., 2005[20]	Norway, 1991–2001	Education	RR			0.63 (0.33–1.20)
Weiderpass and Pukkala, 2006[1]	Finland, 1971–1995	Education, occupation, industrial status, industry groupings	Standardised incidence ratio		0.92 versus 0.98 [RR = 0.9]	0.92 versus 1.10 [RR = 0.8]
Egeberg et al., 2008[23]	Denmark, 1994–2003	Education	Incidence rate ratio		1.02 (0.93–1.12)	1.12 (1.00–1.27)
		Disposable income			**1.09 (1.01–1.18)**	0.99 (0.90–1.07)
		Social class (occupation)			**0.83 (0.73–0.97)**	0.92 (0.60–1.07)
		Housing tenure			**1.17 (1.10–1.25)**	1.04 (0.96–1.13)
		Size of dwelling			1.16 (0.97–1.39)	1.07 (0.78–1.45)
Spadea et al., 2009[21]	Italy, 1985–1999	Education	Relative risk	1985–1999	**1.27 (1.07–1.50)**	1.16 (0.94–1.43)
				1985–1989	0.94 (0.71–1.25)	1.09 (0.73–1.63)
				1990–1994	**1.57 (1.15–2.14)**	1.27 (0.88–1.84)
				1995–1999	**1.44 (1.09–1.91)**	1.08 (0.76–1.55)
Pearce and Bethwaite, 1997[26]	New Zealand, 1984–1987	Elley–Irving scale[d]	Incidence/100,000 person years		9.3 versus 7.9 [RR = 1.2]	
Kim et al., 2008[24]	South Korea, 2001	Income	Relative index of inequalities per 100,000 population		0.97 (0.66–1.43)	1.29 (0.84–1.98)

[a] RR: relative risk or risk ratio [brackets represent relative risks calculated from the data].
[b] 95% CI: 95% confidence interval.
[c] Values in bold are statistically significant.
[d] Jarman index: elderly living alone, one parent families, unskilled, unemployment, overcrowding; Elley–Irving scale: occupation, income and education; social standing: based on an ordering of occupational titles according to social standing.

Table 2 – Associations between treatment of colon, rectal and colorectal cancer and socioeconomic status.

Author, year	Study base	Indicators	Type of measurement	Stage	Therapy	Colon	Rectal	Colorectal
						Odds for receiving treatment for low versus high SES patients		
Roetzheim et al., 2000[27]	US, 1994	Education (E) Income (I)	OR[a] (95% CI)[b] (I): Change in odds of receiving therapy per increase in income category	I-IV	Surgery			E **0.68 (0.47-0.99)**[c] I 0.93 (0.85-1.02)
					Radiotherapy	E 0.78 (0.55-1.10) I **0.90 (0.83-0.98)**	1.02 (0.49-2.15) **0.79 (0.67-0.93)**	
					Chemotherapy			E 0.84 (0.59-1.19) I 0.98 (0.90-1.06)
Schrag et al., 2001[35]	US, 1992-1996	Income	OR	II-III	Any adjuvant radiotherapy Adjuvant radiotherapy + chemotherapy		0.92 (0.63-1.33) 0.73 (0.51-1.06)	
Campbell et al., 2002[29]	UK, 1995-1996	Carstairs index[d]	OR	I-IV	Surgery Radiotherapy Chemotherapy			0.52 (0.14-1.87) 0.85 (0.38-1.91) 0.49 (0.22-1.10)
VanEenwyk et al., 2002[34]	US, 1996-1997	Income	OR	II colon II-III rectum	Chance of NOT receiving adjuvant therapy	**2.0 (1.2-3.1)**	0.7 (0.4-1.3)	
Ayanian et al., 2003[36]	US, 1996-1997	Income	OR	III colon II-III rectum	Adjuvant chemotherapy Adjuvant radiotherapy	0.8 (0.6-1.1)	0.7 (0.4-1.4)	
Hall et al., 2005[88]	Australia, 1991-2001	Occupation, income, education, housing	OR	?	Likelihood of surgery			1.13 (0.88-1.45)
Lemmens et al., 2005[33]	The Netherlands, 1995-2001	Housing and income	OR	III	Adjuvant chemotherapy	**0.5**		
McCory et al., 2006[28]	US, 1994-2001	Poverty	OR	II III II III	Chemotherapy Radiotherapy	**0.991 (0.988-0.995)**	**0.992 (0.986-0.998)** **0.992 (0.986-0.997)** **0.993 (0.987-0.999)** **0.991 (0.986-0.996)**	
Vulto et al., 2007[89]	The Netherlands, 1996-2005	Housing and income	OR	I-IV	Radiotherapy > 6 months after diagnosis		1.1 (0.8-1.7)	
Byers et al., 2008[30]	US, 1997	Combination of education and income	% Treatment	Regional stage	Chemotherapy			**50% versus 56% [RR = 0.9]**[a]
Meulenbeld et al., 2008[32]	The Netherlands, 1990-2004	Housing and income	% Treatment	IV	Chemotherapy 1990-1994 1995-1999 2000-2002 2003-2004	11% versus 22% [RR = 0.5] 15% versus 37% [RR = 0.4] 30% versus 53% [RR = 0.6] 47% versus 50% [RR = 0.9]		
Tilney et al., 2008[37]	England, 1996-2004	Index of multiple deprivation	OR	?	APER (abdominoperineal excision of rectum)		1.589 (1.449-1.744)	
Harris et al., 2009[31]	UK, 2000-2007	Index of multiple deprivation[d]	% Treatment	I-IV	Surgery Surgery, of which permanent stoma		79.2% versus 93% **[RR = 0.9]**[a] 40.8% versus 30% [RR = 1.4]	
Tilney et al., 2009[38]	Great Britain and Ireland, 2000-2005	Index of multiple deprivation	OR	I-III	APER (abdominoperineal excision of rectum)		1.638 (1.362-1.969)	

a OR: odds ratio [brackets represent relative risks calculated from the data].

b 95% CI: 95% confidence interval.

c Values in bold are statistically significant.

d Carstairs index: overcrowding, employment, social class, car ownership and index of multiple deprivation: income, employment, health and disability, education, skills and training, houses and services, living environment, crime.

Table 3A – Associations between survival (relative survival) from colon and rectal cancer and socioeconomic status.

Author, year	Study base	Indicators	Type of measurement		Survival of patients with low versus high SES	
					Male	Female
Colon						
Gorey et al., 1997[39]	US and Canada, 1986–1992	Income	Survival rate ratio (95% CI)[b]	US 1 year	**0.90 (0.86–0.94)[c]**	**0.94 (0.89–0.99)**
				US 5 year	**0.78 (0.65–0.94)**	**0.82 (0.69–0.98)**
				Canada 1 year	0.97 (0.92–1.02)	**1.06 (1.01–1.12)**
				Canada 5 year	0.97 (0.84–1.11)	**1.33 (1.14–1.55)**
Shack et al., 2007[90]	UK, 1996–2000	Scottish indices of multiple deprivation[d]	Absolute difference in 5-year relative survival		−5.7	−6.1
Egeberg et al., 2008[23]	Denmark, 1994–2003	Education	5-year relative survival (%)		42% versus 46% [RR = 0.9][a]	46% versus 49% [RR = 0.9]
		Disposable income			40% versus 46% [RR = 0.9]	**45% versus 55% [RR = 0.8]**
		Social class (occupation)			49% versus 48% [RR = 1.0]	42% versus 45% [RR = 0.9]
		Housing Tenure			**39% versus 46% [RR = 0.8]**	47% versus 49% [RR = 1.0]
		Size of dwelling			36 versus 49% [RR = 0.7]	37 versus 51% [RR = 0.7]
Mitry et al., 2009[55]	England and Wales, 1986–1999	1986–1995 Carstairs deprivation index[d]	Average change every 5 years in *absolute* deprivation gap (low–high SES):			
		1996–1999 Index of multiple deprivation[d]	1-year relative survival		−2.2 (−3.5, −1.0)	−1.4 (−2.5, −0.2)
			5-year relative survival		−1.9 (−3.4, −0.3)	−2.2 (−3.6, −0.8)
Rectal						
Gorey et al., 1997[39]	US and Canada, 1986–1992	Income	Survival rate ratio	US 1 year	**0.88 (0.83–0.93)**	**0.89 (0.80–0.99)**
				US 5 year	0.87 (0.69–1.09)	0.80 (0.61–1.05)
				Canada 1 year	0.96 (0.89–1.03)	1.02 (0.89–1.17)
				Canada 5 year	0.90 (0.72–1.12)	1.05 (0.81–1.37)
Shack et al., 2007[90]	UK, 1996–2000	Scottish indices of multiple deprivation	Absolute difference in 5-year relative survival		−5.3	−8.0
Egeberg et al., 2008[23]	Denmark, 1994–2003	Education	5-year relative survival (%)		44% versus 50% [RR = 0.9]	51% versus 57% [RR = 0.9]
		Disposable income			**41% versus 51% [RR = 0.8]**	49% versus 58% [RR = 0.8]
		Social class (occupation)			46% versus 56% [RR = 0.8]	68% versus 72% [RR = 0.9]
		Housing tenure			43% versus 48% [RR = 0.9]	50% versus 55% [RR = 0.9]
		Size of dwelling			41% versus 48% [RR = 0.9]	**29% versus 59% [RR = 0.5]**
Harris et al., 2009[31]	UK, 2000–2007	Index of multiple deprivation	5-year survival (%): all patients		**33% versus 64% [RR = 0.5]** *Both sexes*	
			:patients with resectional surgery		**50% versus 72% [RR = 0.7]** *Both sexes*	
Mitry et al., 2009[54]	England and Wales, 1986–1999	1986–1995 Carstairs deprivation index 1996–1999 Index of multiple deprivation	Average change every 5 years in *absolute* deprivation gap (low–high SES):			
			1-year relative survival		−1.4 (−2.7, −0.1)	−1.2 (−2.8, 0.3)
			5-year relative survival		−2.4 (−4.1, −0.6)	−2.5 (−4.5, −0.5)

[a] RR: relative risk or risk ratio [brackets represent relative risks calculated from the data].
[b] 95% CI: 95% confidence interval.
[c] Values in bold are statistically significant.
[d] Scottish index of multiple deprivation: income, employment, health, education, skills and training, housing, geographic access and crime; Carstairs index: overcrowding, employment, social class, car ownership and index of multiple deprivation: income, employment, health and disability, education, skills and training, houses and services, living environment, crime.

Table 3B – Associations between survival (risk of death) from colon, rectal and colorectal cancer and socioeconomic status.

Author, year	Study base	Indicators	Type of measurement		Risk of death of patients with low versus high SES	
					Male	Female
Colon						
Auvinen et al., 1995[41]	Finland 1971–1985	Occupation	RR[a] (95% CI)[b]		1.04 (0.82–1.33)	1.22 (0.98–1.49)
Lemmens et al., 2005[33]	The Netherlands, 1995–2001	Housing and income	Hazard ratio		1.0 *Both sexes*	
Zhang-Salomons et al., 2006[40]	US, 1988–1992, Canada, 1989–1993	Income (I)	RR (5-year)	US	I: **1.36**[c] *Both sexes*	
		Poverty (P)			P: **1.46** *Both sexes*	
				Canada	I: 1.07 *Both sexes*	
					P: 1.05 *Both sexes*	
Hussain et al., 2008[43]	Sweden, 1990–2004	Education	Hazard ratio		**1.23 (1.08–1.41)**	**1.33 (1.12–1.59)**
Le et al., 2008[50]	US, 1994–2003	Education, income and occupation	Hazard ratio		**1.26 (1.20–1.32)** *Both sexes*	
Meulenbeld et al., 2008[32]	The Netherlands, 1990–2004	Housing and income	Hazard ratio		1.02 (0.91–1.16)	
Yu, 2008[52]	Australia, 1996–2000	Education and occupation	Relative excess risk of death		**1.14** *Both sexes*	
Rectal						
Auvinen et al., 1995[41]	Finland 1971–1985	Occupation	RR		**1.54 (1.18–2.00)**	**1.79 (1.35–2.38)**
Dickman et al., 1998[91]	Finland, 1977–1985	Occupational status	Excess risk of death		38% (28–47) *Both sexes*	
Zhang-Salomons et al., 2006[40]	US, 1988–1992, Canada, 1989–1993	Income (I)	RR (5-year)	US	I: **1.61** *Both sexes*	
		Poverty (P)			P: **1.57** *Both sexes*	
				Canada	I: 1.20 *Both sexes*	
					P: 1.00 *Both sexes*	
Hussain et al., 2008[43]	Sweden, 1990–2004	Education	Hazard ratio		1.15 (0.96–1.37)	1.20 (0.91–1.59)
Le et al., 2008[50]	US, 1994–2003	Education, income and occupation	Hazard ratio		**1.33 (1.24–1.42)** *Both sexes*	
Yu et al., 2008[52]	Australia, 1996–2000	Education and occupation	Relative excess risk of death		**1.11** *Both sexes*	

[a] RR: relative risk or risk ratio [brackets represent relative risks calculated from the data].
[b] 95% CI: 95% confidence interval.
[c] Values in bold are statistically significant.

Table 4A – Associations between mortality from colorectal cancer and socioeconomic status, US.

Author, year	Study base	Indicators	Type of measurement		Relative risk of dying, low versus high SES	
					Males	Females
Colorectal						
Singh et al., 2002[56]	US, 1950–1998	Education, income, occupation, unemployment, housing, access to phone, households without plumbing	RR[a]/100,000 (95% CI)[b]	25–64 years: 1950	**0.44 (0.38–0.51)[c]**	**0.56 (0.49–0.64)**
				1998	**1.26 (1.13–1.39)**	**1.22 (1.07–1.36)**
				>65 years: 1950	**0.40 (0.36–0.45)**	**0.58 (0.53–0.65)**
				1990	**0.78 (0.72–0.83)**	**0.88 (0.83–0.94)** (1992)
Steenland et al., 2002[57]	US, 1959–1972 and 1982–1996	Education	Mortality rate ratios	1959–1972	0.96 (0.86–1.08)	**1.27 (1.12–1.44)**
				1982–1996	1.10 (0.97–1.25)	**1.21 (1.01–1.40)**
Singh et al., 2003[70]	US, 1995–1999	Poverty	Mortality rate/100,000		26.16 versus 25.54 [RR = 1.0][a]	17.82 versus 18.14 [RR = 1.0]
Steenland et al., 2004[58]	US, 1984–1997	Occupation and Nam-Powers score[d]	RR		**1.21 (1.16–1.27)**	**0.91 (0.86–0.96)**
Albano et al., 2007[69]	US, 2001	Education	RR		**1.81 (1.73–1.89)**	**1.7 (1.63–1.82)**
Chu et al., 2007[92]	US, 1990–2000	% Below poverty	Mortality rate/100,000	1990–1994	27.8 versus 29.7 [RR = 0.9]	18.8 versus 20.1 [RR = 0.9]
				1995–2000	25.8 versus 25.6 [RR = 1.0]	17.5 versus 17.9 [RR = 1.0]
Kinsey et al., 2008[93]	US, 1993–2001	Education	RR/100,000 population		1993: **1.5 (1.4–1.6)**	1993: **1.4 (1.3–1.6)**
					2001: **2.0 (1.9–2.2)**	2001: **1.9 (1.7–2.1)**

[a] RR: relative risk or risk ratio [square brackets represent relative risks calculated from the data].
[b] 95% CI: 95% confidence interval.
[c] Values in bold are statistically significant.
[d] Nam-Powers score: income and education.

Table 4B – Associations between mortality from colon and rectal cancer and socioeconomic status, Europe, Japan and Australia.

Author, year	Study base	Indicators	Type of measurement		Relative risk of dying, low versus high SES	
					Males	Females
Colon						
Faggiano et al., 1995[61]	Italy, 1981	Education	RR[a] (95% CI)[b]		0.62 (0.38–1.02)	**0.37 (0.20–0.69)[c]**
Smith et al., 1996[60]	Australia, 1987–1991	Income, education, occupation	Odds ratio		1.05 (0.92–1.22)	1.15 (0.99–1.33)
Burnley, 1997[25]	Australia, 1986–1993	Occupation (O) Income (I) Jarman index (J)[d]	Deaths/100,000 (O) Standardised mortality rate (I) Correlation with mortality rates (J)	1986–1989 1990–1993 1985–1991	20.6 versus 32.1 [RR = 0.6][a] 29.1 versus 41.8 [RR = 0.7] **0.91 versus 1.04** −0.17	
Menvielle et al., 2005[62]	France, 1975–1990	Education Occupational class	Relative index of inequality		0.9 (0.6–1.6) 1.6 (1.0–2.7)	1.0 (0.5–1.8) 0.6 (0.3–1.4)
Lawlor et al., 2006[63]	Sweden, 1970–2001	Parents' occupation	Hazard ratio		0.96 (0.80–1.16)	0.97 (0.80–1.18)
Puigpinós et al., 2009[64]	Spain, 1992–2003	Education	Relative index of inequality	1992–1994 1995–1997 1998–2000 2001–2003	1.25 (0.94–1.65) 1.09 (0.84–1.41) 1.01 (0.79–1.28) 1.05 (0.82–1.34)	0.94 (0.68–1.31) 1.41 (1.00–1.97) 1.19 (0.88–1.63) **1.47 (1.06–2.04)**
Rectal						
Faggiano et al., 1995[61]	Italy, 1981	Education	Mortality Rate ratio		0.52 (0.25–1.11)	1.69 (0.82–3.51)
Smith et al., 1996[60]	Australia, 1987–1991	Income, education, occupation	Odds ratio		**0.78 (0.65–0.94)**	0.94 (0.75–1.19)
Menvielle et al., 2005[62]	France, 1975–1990	Education Occupational class	Relative index of inequality		**2.9 (1.3–6.4)** **3.1 (1.4–6.8)**	1.0 (0.4–2.6) Not available
Puigpinós et al., 2009[64]	Spain, 1992–2003	Education	Relative index of inequality	1992–1994 1995–1997 1998–2000 2001–2003	1.44 (0.87–2.40) 1.57 (0.96–2.57) **2.85 (1.76–4.60)** **1.66 (1.05–2.63)**	1.28 (0.67–2.44) 1.80 (0.95–3.43) 1.40 (0.77–2.56) 0.96 (0.53–1.73)
Colorectal						
Pollock and Vickers, 1997[71]	UK, 1987–1992	Townsend deprivation score[d]	Standardised mortality ratio		104 versus 100 [RR = 1.0] *Both sexes*	
Rosengren and Wilhelmsen, 2004[94]	Sweden, 1970–1990	Occupation	Mortality/100,000 person years		51 versus 29 [RR = 1.8]	
Shaw et al., 2006[95]	Australia, 1981–1999	Income Education	Relative index of inequality		**1.72 (1.27–2.33)** 1.39 (0.94–2.06)	1.41 (1.0–1.98) 1.28 (0.95–1.74)
Menvielle et al., 2007[59]	France, 1968–1996	Occupational class	Relative index of inequality	1968–1974 1975–1981 1982–1988 1990–1996	**2.53 (1.08–5.92)** **3.13 (1.29–7.57)** 2.07 (0.81–5.28) **2.48 (1.06–5.82)**	1.28 (0.67–2.44) 1.80 (0.95–3.43) 1.40 (0.77–2.56) 0.96 (0.53–1.73)

Study	Location, years	SES measure	Inequality measure		
Ezendam et al., 2008[96]	Poland: 2001–2003 Lithuania: 2000–2002 Estonia 1998–2002 Finland: 1990–2000 Sweden: 1990–2000	Education	Relative index of inequality	Poland Lithuania Estonia Finland Sweden	**1.19 (1.11–1.28)** **0.66 (0.52–0.83)** 0.91 (0.70–1.19) 0.94 (0.81–1.09) **1.10 (1.01–1.20)**	**1.12 (1.03–1.21)** 1.16 (0.90–1.49) 0.83 (0.64–1.08) 1.03 (0.88–1.21) **1.29 (1.17–1.41)**
Menvielle et al., 2008[8]	12 European regions, 1990s	Education	Relative index of inequality (RII)	RII > 1.0 in 9 out of 12 regions, range: 0.92 (0.69–1.24) to 1.58 (1.06–2.34)	RII > 1.0 in 10 out of 12 regions, range: 0.77 (0.44–1.33) to 1.36 (1.00–1.84)
Nishi et al., 2008[97]	Japan, 1980–2003	Education	Hazard ratio	1.14 (0.72–1.79)	0.71 (0.31–1.67)

a RR: relative risk or risk ratio [brackets represent relative risks calculated from the data].
b 95% CI: 95% confidence interval.
c Values in bold are statistically significant.
d Jarman index: elderly living alone, one parent families, unskilled, unemployment, overcrowding and townsend deprivation score: unemployment, owning car, owning house, overcrowding.

mortality rates among those with a low SES since 1950 onwards (among men rate ratios increased from 0.4 to 1.3 for low versus high SES between 1950 and 1998) (Table 4A),[56] but another US study showed this only for men (RR 0.96 and 1.2 for patients diagnosed in 1959–1972 and 1982–1996, respectively), but not women (RR 1.3 and 0.9)[57,58] whereas in France the rate ratio was 2.5 for men diagnosed between 1968 and 1974, also for those diagnosed between 1990 and 1996[59] (Table 4B).

In Europe, associations between SES and mortality from rectal cancer than for colon cancer when studied separately (rate ratios up to 3.1 for rectal cancer and up to 1.6 for colon cancer).[25,60–64]

4.   Discussion

A higher incidence of colorectal cancer was observed among low SES groups compared to high SES groups in the US and Canada, but not in Europe, where higher SES classes were at increased risk. Treatment, survival and mortality all showed less favourable results for people with a lower socioeconomic status: patients with a low SES had less chance of receiving (neo)adjuvant chemotherapy, had worse survival and mortality rates thus were highest in the lowest SES groups.

A high colon cancer incidence among individuals with a high SES had been demonstrated previously in articles published up to 1995.[7] We have now confirmed the higher incidence of both colon and rectal cancer among those with a high SES in Europe, Australia and South Korea. In the US and Canada an inverse association was found with a lower incidence among patients with a high SES, although the results from the relatively small number of articles suggest that the incidence disparities in the US and Canada were narrowing over time. SEER data revealed no consistent pattern of poverty areas and CRC incidence from 1975 to 1999 but the inequalities decreased over time. Despite a previous report of this intercontinental discrepancy in CRC incidence,[7] exact causes remain unclear. Several mechanisms may play a role. Firstly, lifestyle (risk) factors may be related to SES in different ways and thereby affect incidence, e.g. physical activity and diet. As far as we know, there are no international studies that show different SES gradients for lifestyle factors between different continents.

Secondly, screening participation strongly varies across the continents. The compliance for colonoscopy in the German national screening program among inhabitants aged 55 and older was only 12%.[65] In contrast, 51% of the US population of 50 years and older underwent opportunistic endoscopy from 1995 to 2004.[66] This may have resulted in a decreasing incidence due to removal at a precancerous stage (i.e. polyps). This effect may be observed predominantly among those with a high SES, because higher screening rates were found for the higher social classes.[56,62,67–71] However, the use of screening may also result temporarily in a higher incidence. Therefore, the introduction of opportunistic screening (and thereby early detection) has possibly contributed to the changing patterns in incidence that were observed in the US and Canada.

Socioeconomic inequalities in treatment may result from differences in access to and use of medical care, as well as

the quality and type of care.[56,61,67–69,71–75] A high SES was associated with earlier stage at diagnosis, largely resulting from greater health awareness and higher screening participation.[68,76–78] Since treatment is also determined by stage at diagnosis, socioeconomic inequalities may arise in non stage-specific analyses of treatment disparities. In addition, the presence and severity of co-morbidity may influence treatment. Since a SES gradient for the presence of co-morbidity has been observed (Louwman and colleagues, 2009), treatment may be influenced by SES through other concomitant diseases.

Survival rates were consistently worse among patients with a low SES, which has been demonstrated previously in a review including articles published up to 1996.[79] Suggested causes for the socioeconomic gradient in survival are related to stage at diagnosis, number of co-morbidities and treatment. The precise impact of these factors is difficult to assess, because data from the studies included are often adjusted for different combinations of factors (see Supplementary material for comprehensive overview). One study reported that stage at diagnosis explained part of the survival inequalities,[70] while other studies reported a significant association with SES after adjustment for stage, co-morbidity and/or therapy.[42,44,45] Recently, improved survival from colon cancer was found to be related to better access to optimal treatment for those with a high SES;[55] this effect was remained after adjustment for stage at diagnosis in another study.[80] Co-morbidity and, to a lesser extent, lifestyle characteristics explained most of the excess risk of 30-day postoperative death among those with a low SES, whereas treatment and disease factors explained only a negligible part.[81,82]

Socioeconomic gradients may change due to the upcoming programs for screening in Europe and Australia. Incidence will first rise and then decrease after several years of screening. Given the low incidence rates among low SES groups before the screening has started, incidence rates may increase among these persons. Detection will be advanced by screening and is indeed associated with earlier stage at diagnosis.[83] Subsequently survival will improve and lower mortality from colorectal cancer is expected.[84] Thus, the introduction of screening may improve the disadvantages for people with a low SES and may result in a narrowing of the socioeconomic gap in detection and outcomes of CRC. However, this is only the case if all SES groups participate equally in screening, although higher attendance rates have been observed among those with a high SES.[85] If uptake is not distributed equally, screening may even result in widening of the socioeconomic inequalities. Therefore, ensuring high uptake is very important, especially among those with a low SES. It is important to address barriers to CRC screening, i.e. lack of trust in doctors, lack of symptoms, lack of doctor's recommendation to participate, and fatalistic views of cancer.[86]

To conclude, we observed a quite consistent trend favouring individuals with a high SES compared to those with a low SES that still remains in terms of treatment, survival and thus also mortality. We did not find evidence that the low/high SES gradients for treatment chosen and outcome are decreasing. To meet increasing inequalities in colorectal cancer mortality from CRC in Europe for people with a low SES and to make mass screening successful, a high participation rate needs to be realised of low SES people in the soon starting screening program.

Conflict of interest statement

None declared.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.ejca.2010.04.026.

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