



# The effect of socioeconomic status on survival from colorectal cancer in the Melbourne Collaborative Cohort Study

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## ABSTRACT

Previous research relating lower socioeconomic status (SES) with poorer survival from colorectal cancer has varied in adjustment for confounding factors and in the use of individual-level or aggregate-level indicators of SES. We investigated the effect of SES and country of birth on survival from colorectal cancers diagnosed in participants of the Melbourne Collaborative Cohort Study. A total of 526 colorectal cancer cases diagnosed since baseline were followed from diagnosis to 1 June 2006 or death. Information on tumour site and stage, and treatments given were obtained from systematic medical record review. SES at diagnosis was assigned using both an area-based measure of social disadvantage and individual level of educational attainment. Cox regression models were used to estimate hazard ratios associated with socioeconomic disadvantage, educational attainment, and country of birth. During an average follow-up of 5.6 years from diagnosis, 230 deaths occurred, 197 from colorectal cancer. After adjusting for age, sex, tumour stage, waist circumference and adjuvant chemotherapy and radiotherapy, the hazard ratios of dying from all causes and from colorectal cancer associated with living in the least disadvantaged areas compared with most disadvantaged areas were 0.73 (95% CI 0.53–1.00,  $p$  for trend = 0.06) and 0.80 (95% CI 0.57–1.12,  $p$  for trend = 0.22) respectively. Further adjustment for hospital case-load, tumour characteristics, and lifestyle factors did not change the estimates materially. Level of educational attainment and country of birth were not independent predictors of the risk of dying from colorectal cancer. Despite a universal health care system in Australia, socioeconomic inequalities in survival from colorectal cancer exist, and an enduring challenge is to ensure that improvements in colorectal cancer survival are shared equally across the population.

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## Introduction

Colorectal cancer (CRC) is a major public health problem in westernised countries. Further, relative inequalities in total mortality between socioeconomic groups have increased over time and while cardiovascular disease mortality continues to contribute substantially to total inequalities, the contribution of cancer is increasing (Fawcett & Blakely, 2007; Mackenbach et al., 2003).

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For most common cancers of adults, survival varies by socioeconomic status (SES), a finding that has been demonstrated across several decades although the explanations for SES differences in survival are less well documented (Kogevinas & Porta, 1997; Woods, Rachet, & Coleman, 2006). Whilst the effect of SES on survival is generally greatest for cancers such as those of the breast, large bowel, bladder and body of the uterus (Kogevinas & Porta, 1997) which have a relatively better prognosis and for which stage at diagnosis is a key prognostic factor, survival inequalities vary between countries (Engholm et al., 2007). The possible underlying causes for socioeconomic differences in cancer survival include factors relating to the tumour, the patient, and the health care system (Auvinen & Karjalainen, 1997); or as reviewed in the context of colorectal cancer and presented in the Oncology health disparities model of Polite, Dignam, and Olopade (2006), cancer-specific mortality is influenced by diagnosis (higher incidence, advanced stage), receipt of treatment and benefit of treatment, with each of these main factors in turn influenced by other variables. However, the capacity for studies to control for prognostic factors in survival analyses, especially individual-level lifestyle factors or body characteristics that may vary across socioeconomic groups, has been limited.

Recent research in the Melbourne Collaborative Cohort Study (MCCS) has identified lack of regular exercise prior to diagnosis, increasing body fat, and increasing waist circumference to be associated with poorer overall and CRC-specific survival (Haydon, MacInnis, English, & Giles, 2006). Here, we investigate for incident CRC cases from the MCCS the effect of SES on survival using relative socioeconomic disadvantage as an area-level measure and highest level of educational attainment as an individual-level measure and country of birth as an indicator of ethnicity.

## Methods

### *Study population*

The MCCS is a prospective cohort study of 41,528 people (17,049 men) aged between 27 and 75 years at baseline (99.3% aged 40–69 years) (Giles & English, 2002). Recruitment to the MCCS occurred between 1990 and 1994. Subjects were recruited to the study via the Electoral Rolls (registration to vote is compulsory for Australian adults) through mailed invitation, and through media such as advertisements and community announcements. People born in Italy and Greece were purposively recruited to increase the variety of dietary intake and genetic variability. Subjects gave written consent to participate and for the investigators to obtain access to their medical records. The Cancer Council Victoria's Human Research Ethics Committee approved the MCCS study protocol. For this analysis, 203 participants were excluded as they had a diagnosis of CRC before baseline.

We identified cases of adenocarcinoma of the colon or rectum that were diagnosed during follow-up to 1 August 2002 by matching participants to the Victorian Cancer Registry, a population-based registry that receives mandatory notifications of cancer. Information on tumour characteristics

(site, size, degree of differentiation), stage, adjuvant treatments, recurrences and deaths were obtained from medical records. Victorian deaths were identified from the Victorian Registry of Births, Deaths and Marriages. Deaths in other states were identified by linkage to the National Death Index (NDI). Victorian deaths were complete to 1 June 2006 and for other states to 31 December 2004. Only two participants diagnosed with CRC are known to have left Victoria after diagnosis.

### *Socioeconomic status and country of birth*

Relative socioeconomic disadvantaged groups were defined using the Index of Relative Disadvantage, an area-based Socio-Economic Indexes for Areas (SEIFA) score derived from attributes such as low income, low educational attainment, high unemployment, jobs in relatively unskilled occupations, and other variables that reflect disadvantage, as determined through the five-yearly national census (ABS, 2001). The Index of Relative Disadvantage scores were divided into tertiles of the Victorian population, and each individual subject was assigned an SES tertile based on residential postal area code at diagnosis and according to the census that was closest to their date of diagnosis. Reported highest level of educational attainment was collected at the time of enrolment and categorised into four groups including 'primary school', 'started high school', 'completed high school' and 'degree or diploma'. Country of birth was categorised into three groups on the basis of reported country of birth as 'Australia, New Zealand, and United Kingdom', 'Italy', or 'Greece'.

### *Colorectal cancer characteristics*

Stage was categorised into four groups based on the American Joint Committee on Staging (AJCC) staging system: stage I ( $T_{1-2}$ ,  $N_0$ ,  $M_0$ ), stage II ( $T_{3-4}$ ,  $N_0$ ,  $M_0$ ), stage III ( $T_{any}$ ,  $N_1$ ,  $M_0$ ), and stage IV ( $T_{any}$ ,  $N_{any}$ ,  $M_1$ ). In the case of synchronous cancers, the characteristics of the tumour with the higher stage (or the larger tumour if they were of the same stage) were used. Deaths due to CRC, or as a direct result of treatment for it, were termed 'CRC-specific deaths'.

### *Colorectal cancer treatment*

Standard treatment for potentially curable CRC involves surgical resection of the primary tumour and regional lymph nodes, which may be followed by adjuvant chemotherapy and/or radiotherapy to reduce the risk of recurrence of the disease (Haydon, 2003; Wolpin, Meyerhardt, Mamon, & Mayer, 2007). Australian CRC management guidelines in use at the time of the study (National Health and Medical Research Council, 1999) recommended adjuvant chemotherapy be offered to people with stage III colon cancer, did not recommend adjuvant chemotherapy uniformly for stage II colon cancer but that it be considered for patients with 'high-risk' stage II disease, and did not recommend adjuvant chemotherapy for stage I disease. Patients with high-risk stage II or stage III rectal cancer were recommended to undergo further treatment with chemoradiotherapy, which was either entirely post-operative or pre-operative chemoradiotherapy followed by

post-operative chemotherapy. As for colon cancer, no adjuvant therapy was recommended for stage I rectal cancer (National Health and Medical Research Council, 1999). During the time period that MCCS CRC cases were initially diagnosed, fluorouracil (5FU) was the only chemotherapeutic agent available for the adjuvant treatment of colorectal cancer and was routinely given for six months (Haydon, 2003). Metastatic disease (stage IV) is generally treated with palliative chemotherapy and/or radiotherapy.

We defined overall hospital CRC case-load in tertiles (high/medium/low) based on ranking of treating hospitals (excluding centres with restricted function, e.g. endoscopy centres, predominantly radiotherapy centres, and hospices) by total number of tumour notifications to the Victorian Cancer Registry for all Victorians living in the MCCS catchment area and who were diagnosed with CRC during the study period. The MCCS CRC cases were allocated to a tertile according to the highest case-load hospital attended by that case, on the basis that these higher case-load hospitals are likely to offer the greatest potential for multidisciplinary management.

#### *Lifestyle factors and body composition*

At enrolment, a structured questionnaire was used to collect detailed information about demographic and lifestyle characteristics including frequency of vigorous and non-vigorous non-occupational physical activity, smoking and alcohol intake; and height, weight, and waist circumference were measured at baseline according to standardised procedures (Haydon et al., 2006).

#### *Statistical analysis*

Follow-up and calculation of person-time began at diagnosis and ended at death, 1 June 2006 (the date that ascertainment of deaths by the Victorian Cancer Registry was complete), or, if they moved interstate from 1 January 2005, 31 December 2004 (the date that ascertainment of deaths by the NDI was complete), whichever came first. In the state of Victoria in 2004, relative survival from rectal cancer and from colon cancer was similar; the 5-year relative survival was 63% for people with colon cancer and 63% for people with rectal cancer (English, Farrugia, Thursfield, Chang, & Giles, 2007). Interaction terms were fitted to test for any differences in association between SES and CRC survival by anatomic subsite (colon and rectum). None of these tests reached statistical significance, therefore survival analysis was not undertaken for colon and for rectal cancer separately.

Kaplan–Meier methods were used to create curves of overall and CRC-specific survival and the log rank test was used to test for the association between survival and the risk factors. Cox's proportional hazard regression models were used to estimate the hazard ratios (HR) and 95% confidence intervals (95% CI) for overall survival and CRC-specific survival associated with SES at diagnosis, educational attainment at baseline, and country of birth.

All models were adjusted for age at baseline and waist circumference as continuous variables, and sex, stage of disease at diagnosis, and adjuvant chemotherapy and

radiotherapy as categorical variables. A separate category was used for cases with missing stage. Waist circumference was also categorised as 'healthy' (males <94 cm, females <80 cm) and 'action level' (males ≥94 cm, females ≥80 cm) according to commonly used levels of abdominal fat accumulation (Vainio & Bianchini, 2002). Further adjustment was made for other possible confounding factors of degree of differentiation (well, moderately, poorly, unknown), hospital CRC case-load (high, medium, low, unknown), physical activity (non-exercisers, exercisers (regularly exercise ≥once per week)), smoking status (never, former, current), and alcohol intake (0, 1–39 (male) 1–19 (female), 40–59 (male) 20–39 (female), 60+ (male) 40+ (female) g/day) (Haydon et al., 2006). Tests based on Schoenfeld residuals (Collett, 2003) showed no evidence that the proportional hazard assumptions were violated for any analysis. Statistical analyses were performed using Stata version 10 (StataCorp, 2007).

## **Results**

During follow-up of the cohort to 1 August 2002, 526 incident cases of CRC were diagnosed among 41,325 people who did not have CRC prior to baseline. Medical records were reviewed for 520 (99%) cases; records could not be accessed for six remaining cases due to clinician refusal. Of the cases, 270 (51%) were males and 256 (49%) females. The mean age at diagnosis was 66 years (range, 42–79 years). The site of primary tumour was colon ( $n = 336$ , 63%), rectum ( $n = 175$ , 33%) and unknown ( $n = 15$ , 3%). Details of the tumour characteristics of the cases have been previously reported (Haydon et al., 2006). During a mean follow-up of 5.6 years from diagnosis, 230 cases had died (197 attributable to CRC), including 126 (24%) during the first two years of follow-up. The mean age at death was 69 years (range, 42–80 years).

MCCS participants represented the spectrum of relative socioeconomic disadvantage for the whole of Melbourne area from which the MCCS was recruited; 40%, 27% and 33% were in the most, intermediate and least socioeconomically disadvantaged population-based tertiles respectively. A similar pattern was observed for CRC cases in the study sample with 42%, 22%, and 36% in the most, intermediate, and least socioeconomically disadvantaged groups respectively (Table 1). Table 1 shows the distribution of sex, educational attainment, country of birth, AJCC stage, waist circumference, adjuvant chemotherapy and radiotherapy, and hospital case-load by relative socioeconomic disadvantage. A greater proportion of least socioeconomically disadvantaged subjects had higher educational attainment and received adjuvant chemotherapy, and a lower proportion received adjuvant radiotherapy and were AJCC stage IV at diagnosis, compared with the more socioeconomically disadvantaged groups. The proportion of socioeconomic groups treated in low CRC case-load hospitals was similar. A lower proportion of the most socioeconomically disadvantaged group was treated in high CRC case-load hospitals compared with intermediate and least disadvantaged groups.

Five-year overall survival proportions were 63%, 54% and 68% for the most, intermediate and least disadvantaged respectively (Fig. 1; log rank test for equality of survivor

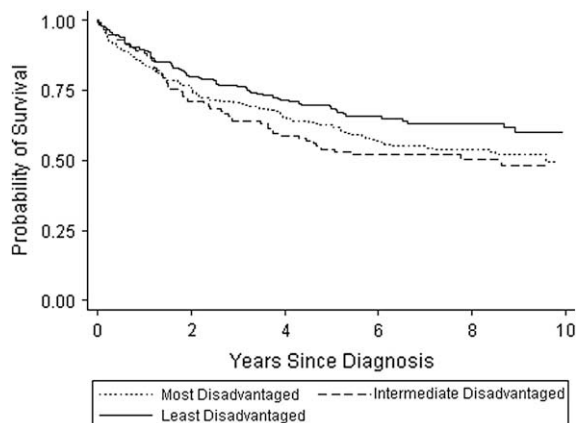
**Table 1**

Characteristics of participants diagnosed with colorectal cancer by area-level socioeconomic disadvantage.

	Relative socioeconomic disadvantage, N (%)			Total, N = 526
	Most disadvantaged, N = 220 (42)	Intermediate disadvantaged, N = 117 (22)	Least disadvantaged, N = 189 (36)	
Age at diagnosis, mean (SD) years	65 (7.8)	66 (7.7)	65 (7.4)	65 (7.6)
Sex, n (%)				
Male	126 (57)	56 (48)	88 (47)	270 (51)
Female	94 (43)	61 (52)	101 (53)	256 (49)
Highest level of education, n (%)				
Primary school	80 (36)	23 (20)	24 (13)	127 (24)
Started high school	82 (37)	55 (47)	77 (41)	214 (41)
Completed high school	43 (20)	24 (21)	34 (18)	101 (19)
Degree or diploma	15 (7)	15 (13)	54 (28)	84 (16)
Country of birth, n (%)				
Australia/NZ/UK/Other	140 (64)	93 (79)	165 (87)	398 (76)
Italy	49 (22)	12 (10)	11 (6)	72 (14)
Greece	31 (14)	12 (10)	13 (7)	56 (11)
AJCC stage, n (%)				
I	54 (25)	22 (19)	47 (25)	123 (23)
II	66 (30)	38 (32)	45 (24)	149 (28)
III	51 (23)	32 (27)	65 (34)	148 (28)
IV	43 (20)	22 (19)	27 (14)	92 (17)
Unknown	6 (3)	3 (3)	5 (3)	14 (3)
Waist circumference, cm, n (%)				
Males <94 cm, females <80 cm	71 (32)	46 (39)	97 (51)	214 (41)
Males ≥94 cm, females ≥80 cm	149 (68)	71 (61)	92 (49)	312 (59)
Any adjuvant chemotherapy, <sup>a</sup> n (%)				
No	56 (48)	36 (51)	46 (42)	138 (46)
Yes	58 (50)	34 (49)	63 (57)	155 (52)
Unknown	3 (2)	0 (0)	1 (1)	4 (1)
Any adjuvant radiotherapy, <sup>a</sup> n (%)				
No	93 (79)	54 (77)	96 (87)	243 (82)
Yes	21 (18)	16 (23)	13 (12)	50 (17)
Unknown	3 (3)	0 (0)	1 (1)	4 (1)
Hospital CRC case-load				
Low	33 (15)	16 (14)	23 (12)	72 (14)
Medium	104 (47)	45 (38)	75 (40)	224 (43)
High	59 (27)	49 (42)	75 (40)	183 (35)
Unknown	24 (11)	7 (6)	16 (8)	47 (9)

<sup>a</sup> Stage II and III cases only.

functions,  $p = 0.06$ ). Five-year CRC-specific survival proportions were 64%, 58% and 71% for the most, intermediate and least disadvantaged respectively (log rank test for equality of survivor functions,  $p = 0.15$ ).



**Fig. 1.** Kaplan-Meier curves for overall survival by relative socioeconomic disadvantage group. Log rank test for equality of survivor functions,  $p = 0.06$ .

**Table 2** shows the associations between relative socioeconomic disadvantage, education, and country of birth with risk of dying from any cause and from CRC. After adjusting for age, sex, AJCC stage, waist circumference, and adjuvant chemotherapy and radiotherapy, the risk of dying from any cause for residents of relatively less disadvantaged areas was 27% lower than the risk for subjects from the most disadvantaged areas (HR 0.73; 95% CI 0.53–1.00); the  $p$  for trend was 0.06. Subjects with CRC who had tertiary (degree or diploma) level of education had 26% lower risk of dying than those who had primary-level education only (HR 0.74; 95% CI 0.48–1.14), although the association with education was not statistically significant. The associations with relative socioeconomic disadvantage and education level were slightly weaker for CRC-specific survival, and none of the differences were statistically significant. Country of birth was not associated with overall survival or CRC-specific survival.

Further adjustment for other possible confounding factors of tumour differentiation, hospital CRC case-load, physical activity, smoking status, and alcohol intake altered the hazard ratios by less than 5% and were not included in the final model. Similar results were obtained when cases

**Table 2**

Hazard ratios of dying from any cause and from colorectal cancer by relative socioeconomic disadvantage, education and country of birth.

	Person years	Any cause of death			Colorectal cancer death		
		No. deaths	HR (95% CI) <sup>a</sup>	<i>p</i>	No. deaths	HR (95% CI) <sup>a</sup>	<i>p</i>
Socioeconomic disadvantage							
Most disadvantaged	1258	105	1.00	0.06 <sup>b</sup>	86	1.00	0.22 <sup>b</sup>
Intermediate disadvantaged	594	57	1.09 (0.78–1.51)		50	1.12 (0.79–1.60)	
Least disadvantaged	1067	68	0.73 (0.53–1.00)		61	0.80 (0.57–1.12)	
Highest education level							
Primary school	700	56	1.00	0.25 <sup>b</sup>	50	1.00	0.33 <sup>b</sup>
Started high school	1249	91	1.08 (0.76–1.52)		74	0.95 (0.65–1.37)	
Completed high school	522	48	1.11 (0.75–1.66)		39	0.95 (0.62–1.47)	
Degree or diploma	449	35	0.74 (0.48–1.14)		34	0.79 (0.50–1.23)	
Country of birth							
Australia/NZ/UK/other	2227	172	1.00	0.63	142	1.00	0.22
Italy	392	32	0.97 (0.66–1.43)		31	1.12 (0.75–1.66)	
Greece	300	26	1.18 (0.77–1.80)		24	1.34 (0.86–2.08)	

<sup>a</sup> Estimates from the Cox regression model are adjusted for age, sex, AJCC stage, waist circumference, and receipt of adjuvant chemotherapy and radiotherapy.

<sup>b</sup> *p* value from the likelihood ratio test for trend.

that occurred during the first two years of follow-up were excluded (data not shown). Overall survival across level of educational attainment or country of birth did not differ by sex (data not shown), whereas the relative risk of dying for the least disadvantaged group compared with the most disadvantaged group was significantly greater for males (HR 0.63; 95% CI 0.41–0.97) but not for females (HR 0.87; 95% CI 0.53–1.42). However, the test for heterogeneity by sex was not statistically significant. Similar results by sex were obtained for CRC-specific survival (data not shown). The effect of relative socioeconomic disadvantage on overall survival did not differ by tumour subsite. Hazard ratios for overall survival in the least versus most socioeconomically disadvantaged tertile were similar for colon and rectal cancer cases (HR 0.75; 95% CI 0.51–1.11 and 0.67; 95% CI 0.38–1.19 respectively). The likelihood ratio test of the interaction between socioeconomic disadvantage and tumour site was non-significant ( $p = 0.54$ ).

## Discussion

After adjusting for age, sex, AJCC stage, and waist circumference, and adjuvant chemotherapy and radiotherapy, participants with CRC who resided in the least disadvantaged areas or who had tertiary-level education had higher overall and CRC-specific survival compared with participants from the most disadvantaged areas or who had lower educational attainment respectively. The statistical evidence for an association of relative socioeconomic disadvantage with overall survival was weak ( $p = 0.06$ ) and weaker again for CRC-specific survival ( $p = 0.22$ ). Further adjustment for tumour characteristics, hospital case-load and lifestyle factors made minimal difference to this association.

The major strength of our study is the completeness of the data on the tumour characteristics and treatments received, and identification of all CRC cases and all deaths that occurred in the follow-up period through state and national cancer and death registries. Moreover, we had extensive information on important known or possible

confounding factors. We could, therefore, adjust our analyses for conventional prognostic factors relating to tumour characteristics and treatment, as well as for individual-level body composition and lifestyle factors such as waist circumference, smoking, alcohol, and physical activity; and assess the effect of both an area- and individual-level measure of SES on survival.

Socioeconomic characteristics that influence health include education, income, wealth, occupation, marital and family status, labour force participation, housing, ethnic origin and characteristics of the area of residence (AIHW, 2006). Individual-level and area- or neighbourhood-level characteristics of SES can influence health and the consideration of characteristics of both in relation to health effects is recommended (Braveman et al., 2005). In our study, the area-level effect of relatively less socioeconomic disadvantage was of a similar magnitude to that conferred by relatively higher level of individual educational attainment. This was observed despite the different dimensions of the measures (relatively less socioeconomic disadvantage occurring when the residential area has few families of low income and few people with little training and in unskilled occupations as measured by the Index of Relative Socioeconomic Disadvantage (ABS, 2001)). This is not to suggest that these measures are interchangeable; and individual-level education can influence health in ways other than through greater income and material resources, such as through general or health-related knowledge, literacy, problem-solving skills and personal influence (Braveman et al., 2005).

Because our sample was composed of mature adults, they were unlikely to have undertaken further formal education after baseline, so level of education collected at that time is likely to reflect educational attainment at diagnosis. Country of birth does not change over time. Relative socioeconomic disadvantage was based on residential postal code at diagnosis of CRC, and any changes after diagnosis are likely to be due to reverse causation (ill-health leading to greater socioeconomic disadvantage).

Our study had some limitations. Measurement of demographic, lifestyle, and anthropometric prognostic



factors was undertaken at baseline, prior to diagnosis, and we do not know whether change in these factors after diagnosis may also have influenced the outcome. There are limitations for aggregate measures of SES whereby heterogeneity within areas may result in misclassification of subjects with respect to their SES, although misclassification at the postal area level as used in our study is likely to underestimate the extent of the relationship between SES and health-related measures (Hyndman et al., 1995). Further, we did use an individual-level measure of SES and found a similar pattern of relationship with survival, although the association was weaker.

Residual confounding within stage categories has been suggested as a possible explanation for differentials in cancer survival by SES, in that more disadvantaged persons may not be as fully investigated as less disadvantaged persons, and their tumour is classified as local when it is actually more advanced, resulting in poorer stage-specific and stage-adjusted survival for deprived persons (Woods et al., 2006). We were not able to address this possibility with the available data. We did not have information on comorbid medical conditions at diagnosis, a factor that has been associated with poorer CRC-specific (Munro & Bentley, 2004) and non-CRC (Wrigley et al., 2003) survival. The effect of socioeconomic disadvantage and lower education on CRC-specific survival was similar to that on overall survival, but the smaller number of CRC-specific deaths resulted in wider confidence intervals and no significant associations. Because the sample was relatively small, the estimates (as indicated by the wide confidence intervals) were imprecise.

Our finding of a relationship between socioeconomic disadvantage and poorer survival from CRC, and the magnitude of the association (Brenner, Mielck, Klein, & Ziegler, 1991; Hole & McArdle, 2002; Munro & Bentley, 2004; Wrigley et al., 2003), is consistent with that of previous studies from several countries that have used aggregate measures of socioeconomic status including the Townsend (Wrigley et al., 2003), Carstairs (Hole & McArdle, 2002; Munro & Bentley, 2004), Scottish Area Deprivation (Munro & Bentley, 2004), or Relative Socioeconomic Disadvantage (Hall et al., 2005; Morris, Iacopetta, & Platell, 2007) indices; and also of studies that have used other measures of disadvantage and found that relatively deprived area of general practice attended (in females) (Whynes, Frew, Manghan, Scholefield, & Hardcastle, 2003), increased distance to cancer centre (Dejardin et al., 2006, 2008), lower educational attainment (Rosso, Faggiano, Zanetti, & Costa, 1997), occupational status of farming for both genders or males without occupation (Desoubaux, Herbert, Launoy, Maurel, & Gignoux, 1997), lower level of housing comfort (Monnet, Boutron, Faivre, & Milan, 1993), or treatment in a private hospital (Hall et al., 2005; Morris et al., 2007) are associated with poorer survival from CRC. There is no single best indicator of socioeconomic status or position that is suitable for addressing all study aims, health outcomes, and applicable in all settings (Galobardes, Shaw, Lawlor, Lynch, & Davey Smith, 2006).

Few studies, however, have considered both area- and individual-level measures of SES in the same study or have adjusted for lifestyle and anthropometric factors. In

contrast to our study, Steenland, Henley, Calle, and Thun (2004) found a significant trend between individual-level education, but not area-level SES, and all-cancer mortality after adjustment for individual-level non-SES risk factors, but this study did not look specifically at CRC. Using multilevel analysis, all-cause cancer mortality, adjusted for age and occupation, was highest in the most socioeconomically disadvantaged areas for men and women nationally in Australia. Individual socioeconomic position based on occupation determined through decedent's job at time of death was independently associated with all-cause cancer mortality and this did not differ by area-level disadvantage. Specific cancer mortalities other than for lung cancer were not studied (Bentley, Kavanagh, Subramanian, & Turrell, 2008). However, whilst Steenland et al. (2004) and our study adjusted for several prognostic factors, no adjustment was made for tumour characteristics or stage at diagnosis in the study by Bentley et al. (2008). Few studies have reported no association between SES and CRC survival; and consistency in type and quality of hospital treatment within a single UK health district (Lyratzopoulos, Sheridan, Michie, McElduff, & Hobbiss, 2004) or small sample size (Ciccone, Prastaro, Ivaldi, Giacometti, & Vineis, 2000) may have explained the finding.

Socioeconomic status is one of the important factors contributing to the poorer survival from CRC between African Americans and whites in the United States (Du, Meyer, & Franzini, 2007; Polite et al., 2006). While African Americans were 50% more likely to die from colon cancer than were whites, the excess cancer mortality reduced to 20% when stage was adjusted for, but inclusion of individual socioeconomic variables did not further explain the survival disadvantage (Mayberry et al., 1995). Differences in tumour characteristics such as stage and grade and socioeconomic factors derived from census data each explained approximately one-third of the excess risk of colorectal cancer death among blacks compared with whites, and within any stage blacks were at greater risk of dying than their white counterparts (Marcella & Miller, 2001). A meta-analysis of racial disparities in survival from colon cancer found that after adjusting for socioeconomic factors and treatment the disparities in survival between African Americans and Caucasians were only marginally significant (Du et al., 2007). Our assessment of ethnicity was based on country of birth (two Mediterranean and an Anglo Celtic group) and our finding of no association between country of birth and survival from CRC suggests that our study groups may be more homogeneous with respect to survival from CRC than racial groupings in the United States.

Approaches to health care delivery may be important. Australia has a mix of health care systems: a universal medical and pharmaceutical benefits scheme and a private hospital system that manages patients with private health insurance which has 43.5% coverage nationally (PHIAC, 2007). Whilst, residency in lower socioeconomic areas, locational status and access to private health care did not significantly impact on the likelihood of surgical treatment for CRC, overall survival was marginally but non-significantly worse for persons residing in more socioeconomically disadvantaged areas (Hall et al., 2005), and patients with CRC treated in a private hospital, compared with a public

hospital, had improved overall and CRC-specific survival (Morris et al., 2007). As has been previously observed internationally, access to services in countries that offer systems with universal health care coverage does not guarantee equal chances of survival for all persons with CRC (Ciccone et al., 2000; Dejardin et al., 2006; Schrijvers, Coebergh, van der Heijden, & Mackenbach, 1995).

Difference in survival across socioeconomic groups may be attributable to greater CRC screening uptake in areas of high SES. In the UK, compliance with screening was shown to be associated with earlier diagnosis and improved survival, but deprived persons, based on area-level measure of general practice at diagnosis, were less likely to accept an invitation to be screened. Poorer survival, once age and participation in screening were adjusted for, was limited to females (Whynes et al., 2003). Lower SES, level of education, health care coverage and age, and male gender have been associated with lower levels of participation in CRC screening in the US (Ioannou, Chapko, & Dominitz, 2003); and males, single persons and those residing in a lower socioeconomic region were less likely to participate in an invited CRC screening program in Australia (Forbes, Fritschi, Mendelson, Foster, & Edwards, 2004). A national bowel cancer screening program that is being phased in (DoHA, 2005) offers the opportunity to significantly reduce the impact of CRC, and to monitor the effect of SES on screening uptake and outcomes.

In conclusion, we have observed that after adjustment for a range of possible confounding factors, SES was associated with poorer survival for people with CRC in a relationship that was of borderline statistical significance, and this association was stronger for relative disadvantage and overall survival than for CRC-specific survival, and less marked when based on education as a measure of SES. Country of birth was not associated with survival from CRC. In a country with universal access to health care, an enduring challenge is to ensure that improvements in CRC survival are shared equally across the population.

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