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Breast, lung and colorectal cancer incidence and survival in South Thames Region, 1987–1992: the effect of social deprivation

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Abstract

Background This paper describes the relationship between social deprivation and incidence of, and survival from, breast, lung, and colorectal cancers among residents of the South Thames regions. We analysed 23 505 cases of breast cancer, 29 903 cases of lung cancer and 21 905 cases of colorectal cancer, aged 40–99 inclusive at diagnosis and diagnosed between 1 January 1987 and 31 December 1992.

Methods Using the 1991 Census in conjunction with the Townsend index on social deprivation, we derived proxy indicators of deprivation based on patients' home postal codes. Cumulative relative five-year survival rates (per cent) were calculated for each cancer. We then compared our results with the relevant standardized incidence and mortality ratios by deprivation status.

Results A clear trend was observed in standardized mortality rates across deprivation tenths for the three tumour sites: mortality increased with deprivation. A strong positive correlation was found between deprivation and the incidence of lung cancers ($p < 0.0001$), but no association was found between deprivation and incidence of breast and colorectal cancers. Significantly lower five-year relative survival rates were found for breast and colorectal cancer patients in the most deprived Townsend tenths. Breast cancer patients resident in the most affluent tenth of enumeration districts had a 70 per cent relative survival ratio compared with 57 per cent in the most deprived tenth. The corresponding figures for colorectal cancer patients were 40 per cent and 32 per cent, respectively.

Conclusion Survival differences by deprivation status exist in South Thames among patients suffering from breast or colorectal cancers and are not explained by differences in the incidences of these diseases. For lung cancer, incidence and mortality were positively correlated with deprivation, but no socio-economic gradient was found for survival.

Keywords: cancer, survival, incidence, social deprivation

Introduction

Studies of the relationship between cancer survival and deprivation suggest that the difference in survival rates between deprived and affluent groups of patients is widening.[1–4] A recent review from the Netherlands of 14 studies of cancer survival by socio-economic status found survival advantages for patients in more affluent groups suffering from colorectal, lung or breast cancers.[2] Survival differences for some cancers (such as lung cancer) may be strongly correlated with differences in incidence; but for others (such as breast cancer) no differences in incidence have been found, suggesting that there may be differences in patient groups' access to, or use of, the health services.

This paper describes the results of a study set up to investigate the relationship between social deprivation and the incidence of, and survival from, breast, lung, and colorectal cancers (ICD-9 153, 154, 163, 174) in South Thames region between 1987 and 1992. Data on deprivation came from the 1991 Census. A number of recent studies have used census data to examine socio-economic differences in morbidity and mortality for a variety of conditions.[4–13] Most use the census characteristics of the electoral wards in which cases reside as proxy measures of patient deprivation. A paper by Majeed *et al.* describes how enumeration districts can also be used.[14] Enumeration districts are the smallest geographical area for which census data are published, with populations of 200–600 people (electoral wards typically contain 5000–15 000 people). Analysis of deprivation by enumeration district is thus more valid than a ward-based analysis. This paper uses the methods described by Majeed *et al.*[7,14]

Methods

1991 Census data

Using the SASPAC computer program, two sets of data from the 1991 Census were extracted from the University of Manchester Computing Centre on all enumeration districts in the South Thames region ($n = 14\,639$).[15] The first set comprised total numbers of people aged 40–99 inclusive living in each

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enumeration district broken down by age (in five-year bands) and sex. The second set comprised variables required to calculate the Townsend deprivation index.[16] [These were: the percentage of economically active residents aged 16–64 (for men) or 16–59 (for women) who are unemployed; the percentage of private households lacking a car; the percentage of private households not owner-occupied; and the percentage of private households subject to overcrowding, defined as households with more than one person per room.] Each of the four Townsend variables was normalized. The Townsend deprivation score for each enumeration district was the unweighted sum of the four transformed variables.

The enumeration districts were then divided into tenths, on the basis of their Townsend score, with the first tenth containing the lowest 10 per cent of Townsend scores (i.e. the most affluent enumeration districts) and the last tenth containing the highest 10 per cent of Townsend scores (i.e. the most deprived enumeration districts). The population of each of the ten groups of enumeration districts, broken down by age and sex, was used as the denominator in the calculation of standardized incidence and mortality ratios.

Thames Cancer Registry data

Data were extracted on all patients for whom a diagnosis of cancer to the breast, lung or colorectum was first made between 1 January 1987 and 31 December 1992 inclusive aged 40–99 at diagnosis. Variables used were: age at diagnosis, sex, ICD-9 code, home postcode, district of residence, district of treatment and source of registration (case notes or death certificates). Each patient was assigned to an enumeration district using a postcode to enumeration district lookup table. Where postcodes lay in more than one enumeration district, patients were assigned to the 'pseudo-enumeration' district for the postcode (the pseudo-enumeration district for a postcode is the enumeration district in which most people at a postcode live; there is only one pseudo-enumeration district per postcode). Age- and sex-specific incidence and mortality rates were calculated for each tumour site for all enumeration districts. These rates were then applied to the populations of each of the ten groups of enumeration districts to derive the expected number for each tenth and compared with the observed number to obtain standardized incidence and mortality ratios. Ninety-five per cent confidence intervals were calculated for each standardized ratio using the method described by Gardner and Altman.[17]

Cumulative, relative five-year survival rates were estimated for each tumour site by Townsend tenth, using the Hakulinen computer program.[18] Relative survival is the ratio of the survival observed in a group of cancer patients to the survival expected if they were only subject to the general (all cause) mortality in a standard population. The standard population used in this study was the England and Wales population. Cases alive on 31 December 1992 were treated as withdrawals.

Cases registered by 'death certificate only' (DCOs) were excluded from survival analysis, as it was not possible to confirm a date of diagnosis for them. (This is normal practice in the survival analysis of cancer registry data.[19]) In a previous study of Thames Cancer Registry data, 1987–1989, we found that 24 per cent of all registrations were DCOs.[20] Poor survival, old age, district of residence and place of death were all associated with DCO registrations. To establish whether the exclusion of DCO registrations was having a differential impact on each Townsend tenth's survival rate, we calculated the odds of being registered by DCO for each Townsend tenth. For each tumour site, the proportion of DCOs for the most affluent group was taken as the baseline for all subsequent tenths.

A correlation table was produced to show the proportion of the variance in each outcome variable that was due to variance in deprivation score (not tenth).

Results

Numerator data

The Thames Cancer Registry provided data on 23 505 cases of breast cancer, 29 903 cases of lung cancer and 21 905 cases of colorectal cancer. All first diagnoses were made between 1 January 1987 and 31 December 1992 on patients aged 40–99 inclusive at diagnosis. Around 5 per cent of cases had to be excluded from analysis because of missing postcodes, unrecognized postcodes, or because they resided in enumeration districts for which no data were published. Table 1 lists the total number of incident cases for each tumour site and gives the number and cause of exclusion for excluded cases; 13 893 (18 per cent) DCO cases were excluded from survival analysis.

Denominator data

Census variables were available for 13 715/14 639 (94 per cent) enumeration districts in South Thames region. Data were not published for 507 'special enumeration districts' (communal establishments with populations of at least 100 people): 12 780

Table 1 Total numbers of incident cases, with excluded cases; by tumour site and, where applicable, cause of exclusion

	Breast	Lung	Colorectal
n	23 505	29 903	21 905
Missing postcode	553	884	636
Unrecognized postcode	128	124	77
'Special' enumeration district	112	98	103
'Shipping' enumeration district	0	1	1
Suppressed data	383	412	295
Total cases used	22 329	28 384	20 793
(%)	(95)	(95)	(95)
DCO cases	2443	7060	4389
Cases alive on 31 Dec. 1992	14 884	3072	8068

Table 2 Breast cancer in South Thames region, 1987–1992; females only; standardized incidence and mortality ratios, five-year relative survival and odds of being registered by DCO; by Townsend tenths and tumour site

Townsend tenths	Standardized mortality ratio	Standardized incidence ratio	5 year RSR (%)	Odds of being registered DCO
n	23 505	23 505	21 062	2443
1 (most affluent)	99 (84, 116)	105 (95, 115)	70 (67, 74)	Reference
2	94 (80, 110)	100 (90, 110)	71 (68, 74)	1.11 (0.92, 1.34)
3	98 (84, 115)	103 (93, 114)	68 (64, 71)	1.09 (0.91, 1 31)
4	96 (82, 113)	102 (93, 113)	70 (66, 73)	0.99 (0.85, 1.21)
5	97 (82, 113)	99 (89, 110)	66 (63, 70)	1.30 (1.09, 1.56)
6	100 (85, 117)	101 (91, 112)	70 (66, 73)	1.13 (0.94, 1.36)
7	102 (87, 120)	100 (91, 111)	68 (64, 71)	1.19 (0.99, 1.43)
8	103 (87, 121)	98 (88, 109)	64 (60, 67)	1.24 (1.03, 1.50)
9	104 (88, 122)	94 (83, 105)	60 (56, 64)	1.19 (0.98, 1.44)
10 (most deprived)	111 (93, 132)	95 (84, 107)	57 (53, 61)	1.22 (1.00, 1.49)

South Thames residents aged 40–99 were living in special enumeration districts at the time of the 1991 Census. Data were also unavailable for 50 'shipping enumeration districts,' covering people resident on ships at the time of the 1991 Census. No residents of South Thames shipping enumeration districts were aged 40–99, and therefore no numbers were lost for denominators. Three hundred and sixty-seven enumeration districts were subject to 'data suppression' because their populations numbered fewer than 50 residents or 16 households. As no data were published on the size of these populations, we could not calculate exactly how many people were excluded from our population denominators because of data suppression. The maximum number is 17 983 (367 × 49). In total, the maximum number of people excluded from denominators is 30 763 (12 780 + 17 983). The number of people included in population denominators was 3 022 903. This means that a maximum of 1.01 per cent, i.e. [(30 763/(3 022 903 + 30 763)] × 100, of the population were not included in our denominators. (The true figure is probably lower.)

Incidence, mortality survival and DCOs by deprivation tenth

Figure 1 shows the survival of the most affluent and the most deprived tenths for each of the three tumour sites. Tables 2–4 set out standardized incidence and mortality ratios, five-year relative survival and the odds of being registered by DCO for each Townsend tenth for breast, lung and colorectal tumours, respectively. The highest mortality ratios were found in the most deprived tenths for all three tumour sites. For lung cancer, this disproportionate share of deaths was founded on a very high positive correlation between deprivation and standardized incidence ratios ($p < 0.0001$): patients in more deprived enumeration districts were more likely to have lung cancer and, because of its lethal nature, more of them died of it. In spite of this, significantly lower five-year survival rates were found for breast and colorectal cancer patients in the most deprived Townsend tenths. Breast cancer patients resident in the most affluent tenth of enumeration districts had a 70 per cent RSR compared with only 57 per cent RSR in the most deprived tenth.

Table 3 Lung cancer in South Thames region, 1987–1992; males and females; standardized incidence and mortality ratios, five-year relative survival and odds of being registered by DCO; by Townsend tenths and tumour site

Townsend tenths	Standardized mortality ratio	Standardized incidence ratio	5 year RSR (%)	Odds of being registered DCO
n	29 903	29 903	22 842	7061
1 (most affluent)	63 (56, 71)	63 (57, 71)	7 (5, 9)	Reference
2	76 (69, 84)	76 (69, 84)	7 (5, 9)	1.11 (0.96, 1.28)
3	79 (72, 88)	79 (72, 87)	5 (3, 6)	1.11 (0.97, 1.27)
4	87 (79, 96)	87 (79, 95)	7 (6, 9)	1.13 (0.98, 1.30)
5	94 (85, 103)	93 (85, 102)	5 (4, 7)	1.12 (0.98, 1.28)
6	99 (90, 108)	99 (90, 108)	6 (5, 8)	1.08 (0.94, 1.23)
7	111 (101, 121)	111 (102, 121)	6 (5, 8)	1.12 (0.98, 1.28)
8	124 (114, 135)	125 (114, 135)	6 (5, 8)	1.16 (1.02, 1.32)
9	133 (122, 145)	133 (122, 144)	5 (4, 6)	1.28 (1.12, 1.46)
10 (most deprived)	159 (146, 173)	159 (147, 173)	6 (5, 7)	1.23 (1.08, 1.40)

Table 4 Colorectal cancer in South Thames region, 1987–1992; males and females; standardized incidence and mortality ratios, five-year relative survival and odds of being registered by DCO; by Townsend tenths and tumour site

Townsend tenths	Standardized mortality ratio	Standardized incidence ratio	5 year RSR (%)	Odds of being registered DCO
n	21 905	21 905	17 516	4389
1 (most affluent)	97 (85, 111)	100 (90, 111)	40 (37, 44)	Reference
2	96 (84, 108)	97 (88, 108)	40 (36, 43)	1.04 (0.90, 1.20)
3	95 (84, 108)	99 (90, 110)	42 (38, 45)	1.03 (0.90, 1 18)
4	96 (85, 109)	98 (88, 108)	37 (33, 41)	1.11 (0.96, 1.29)
5	97 (85, 110)	98 (88, 109)	39 (35, 43)	1.05 (0 92, 1.20)
6	102 (90, 115)	103 (92, 114)	40 (36, 43)	1.05 (0.90, 1.23)
7	106 (93, 120)	104 (93, 115)	37 (34, 41)	0 98 (0.86, 1.11)
8	105 (92, 119)	103 (92, 114)	34 (31, 38)	1.01 (0.92, 1.11)
9	104 (91, 119)	101 (90, 112)	33 (29, 36)	1.00 (0.83, 1.23)
10 (most deprived)	104 (91, 120)	98 (87, 111)	32 (29, 36)	1.13 (0.97, 1.32)

The corresponding figures for colorectal cancer patients were 40 per cent and 32 per cent, respectively.

With the exception of DCO registration among colorectal cancer patients, all outcome variables were significantly associated with deprivation score (Table 5). Relative survival was inversely correlated with deprivation score ($p < 0.0001$ in all cases). For cancers of the lung and colorectum, incidence increased with deprivation but for female breast cancer, it decreased.

Discussion

Residents with breast or colorectal cancer from deprived areas experienced poorer survival than patients from affluent areas. There were no significant differences in standardized incidence or mortality across deprivation groups, suggesting that even for moderate survival cancers, mortality indicators are a poor survival measure. There were no significant differences in the survival rates of lung cancer patients. This might be accounted for by the higher number of lung cancer cases registered from death certificates only lost to survival analysis.

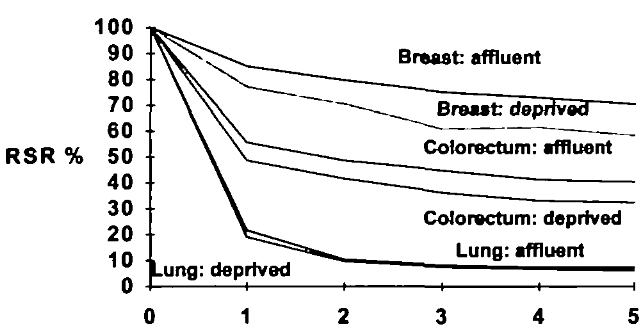

Figure 1 Cancer in South Thames RHA, 1987–1992. A comparison of relative survival rates for the most affluent and most deprived 10 per cent of enumeration districts.

A number of studies have documented socio-economic gradients in survival from breast and lung cancers. For breast cancer, gradients have been reported in both directions. Kogevinas *et al.* reported a gradient favouring women from deprived areas diagnosed with breast cancer.[5] However, in a more recent study of breast cancer in South Thames Regions between 1980 and 1989 (using the 1981 Census), Schrijvers *et al.* found that women in the most deprived category had a 35 per cent greater hazard of death than women from the most affluent areas after adjustment for stage at diagnosis, morphological type and type of treatment.[3] Carnon *et al.* also reported survival advantages for patients from affluent areas that could not be explained by differences in tumour stage or biology.[4]

Our findings on breast cancer almost exactly mirror the results of the study by Schrijvers *et al.*,[3] which analysed survival among the same population over an earlier time period. Schrijvers *et al.* reported five-year RSR per cent of 71 per cent [95 per cent confidence intervals (CIs) 69–73 per cent] for the most affluent quintile, but only 60 per cent (95 per cent CIs 57–63 per cent) for the most deprived quintile. These figures compare with our RSR per cents of 70 per cent (95 per cent CIs 67–74 per cent) for the two most affluent tenths and 58 per cent (95 per cent CIs 55–61 per cent) for the two most deprived tenths. These similarities notwithstanding, our findings on breast cancer survival and deprivation are new in at least two respects. First, they are based on more recent data. Second, they have the advantage of using the more accurate 1991 Census lookup table for matching postcodes to enumeration districts. Schrijvers *et al.* used the 1981 postcode to enumeration districts lookup table. A study by Reading *et al.* found that computerized matching of postcodes to enumeration districts using the 1981 Census was highly inaccurate.[21] This might have affected the allocation of deprivation scores in the study of earlier South Thames data.

The strong gradients in lung cancer incidence and mortality by deprivation category reported here are in accord with recent studies. The socio-economic gradient in the prevalence of

Table 5 Correlation between cancer outcome variables and Townsend deprivation score

	SMR	SIR	RSR	DCO
Female breast cancer				
R	0.87	−0.87	−0.88	0.015
R^2	0.76	0.76	0.77	0.0002
p	0.0001	0.0001	0.0001	<0.03
Lung cancer				
R	0.98	0.98	−0.33	0.026
R^2	0.96	0.96	0.12	0.009
p	0.0001	0.0001	0.0001	0.0001
Colorectal cancer				
R	0.80	0.32	−0.87	0.003
R^2	0.64	0.10	0.76	0.00009
p	0.0001	0.0001	0.0001	NS

SMR, standardized mortality ratio; SIR, standardized incidence ratio; RSR, relative survival rate; DCO, death certificate only. NS, not significant.

smoking has been shown to contribute to this. However, smoking is not the only factor associated with mortality gradients by deprivation status. A recent study in the Netherlands reported poorer lung cancer survival among patients of low socio-economic status that could not be reduced to differences in smoking habits.[22] The high rate of DCO registrations among lung cancer patients makes our results on survival difficult to interpret. There was a strong positive association between DCO proportions for lung cancer and deprivation so the exclusion of DCOs may have flattened a true survival gradient.

The discovery of significantly lower survival for colorectal cancer patients living in deprived areas is a new finding for the United Kingdom. Kogevinas *et al.* analysed the relationship between age- and sex-standardized cancer fatality ratios and housing tenure among subjects recruited to the OPCS Longitudinal Study (approximately 1 per cent of those enumerated in England and Wales in the 1971 Census).[5] For colon tumours among men and women and for rectal tumours among men they found that owner-occupiers had lower case fatality ratios than council tenants, but the differences were not statistically significant. Although the cases analysed by Kogevinas *et al.* were diagnosed between 1971 and 1983, the population denominators used derived from the 1971 Census only. This might have attenuated any true gradient. Studies outside the United Kingdom have found significant negative associations between colorectal cancer survival and socio-economic status. Workers in Australia and Finland have reported survival advantages for colon cancer patients from more affluent socio-economic groups in those countries, and a study of survival in Germany has found higher relative hazard of death ratios for colon and rectal cancer patients.[23–25] The unit of observation in each of these studies was the individual patient using area-based proxy measures of deprivation. Only the study from Finland controlled for tumour severity.

Sources of bias in survival gradients

The survival gradients reported in this study might result from a number of artefactual sources, including: (1) the use of an area-based proxy measure of deprivation and (2) the exclusion of DCO cases. We will consider these in turn.

The use of an area-based proxy measure for deprivation status

Individual measures of deprivation (through occupation) were not available for this study. Where possible, the Thames Cancer Registry records social class as given on the death certificate, but to date death certificate information for this variable is extremely incomplete: for colorectal cancer cases diagnosed between 1982 and 1992, social class was unavailable for 30 910/40 129 (77 per cent) cases. The disadvantage of proxy measures is that some patients are bound to be wrongly classified, but this would lead to underestimation of the survival gradient. The use of enumeration district based rather than ward-based scores and the aggregation of scores into tenths should reduce misclassification.

The exclusion of DCO cases

Only among lung cancer patients was DCO registration significantly associated with deprivation. A study of the factors associated with DCO registration in South East England found more DCOs among patients with more lethal cancers. We might expect to find a higher proportion of low-survival cases among DCOs, as there would be less time to register these in life. It therefore seems likely that a larger number of low-survival cases were excluded from the survival analysis of lung cancer patients from deprived areas. This would offset any gradient in survival by deprivation tenth.

The life tables used in this study were organized in five-year age bands by age and sex. Four tables were used for deaths occurring from 1987 to 1990 inclusive. The 1990 life table was used for patients dying between 1 January 1991 and 31 December 1992 (the life tables for those years were not available). As the numbers of cases in each deprivation tenth were roughly similar in each year, the relationship between survival and deprivation is not likely to have been distorted.

True sources of survival gradients

True differences in survival might result from differences by deprivation status in health care factors, psycho-social factors or biological factors.

Health care factors

Health care factors might vary at two levels to produce survival gradients by deprivation status. First, there might be differences in patient groups' access to, or use of, primary care services. It may be that some groups are more likely to be diagnosed at an earlier stage in the natural history of the disease and, on account of this lead, experience more effective follow-up and better survival. Adapting this hypothesis to our results, we might conjecture that women from the most deprived areas with breast cancer present for diagnosis at a later stage because they are screened less frequently or less effectively. A recent US study found that low income was a strong predictor of mammography underuse.[26] Similar findings have been reported in the United Kingdom for both cervical and breast cancer screening. In two recent studies, Majeed *et al.* found significant negative correlations between breast and cervical cancer screening rates in a South Thames health commission and variables used in the calculation of the Townsend index, such as overcrowding, not owning a car, and unemployment.[7] They also found that some general practice factors were associated with higher uptake rates. No comparable programmes of mass screening exist for tumours of the lung or colorectum.

There might also be differences by area deprivation status in access to hospital services. We recently undertook a study of hospital episode statistics data on all South Thames finished consultant episodes with a mention of colorectal cancer completed between 1 January 1989 and 31 December 1993, and found that patients from deprived areas were less likely to be admitted as day case in-patients and were less likely to receive certain diagnostic procedures, for example, sigmoidoscopy (unpublished data). In a recent US study of breast cancer patients by Eley *et al.*, it was found that stage, tumour characteristics and comorbid conditions accounted for 75 per cent of black/white differences in relative risk of mortality; treatment was not a contributing factor once these were taken into account.[27] These findings warrant further investigation and should be extended to cover other tumour sites.

At both these levels, there may be variations in the quality of care available in each tenth. Again, further investigation is warranted.

Biological and psychosocial factors

There is some evidence that psychosocial factors influence outcomes of breast cancer treatment. Maunsell *et al.* interviewed Canadian women with local or regional stage breast cancer three months after surgery and found that, over a seven-year period, women who used confidants were at significantly reduced risk of dying compared with women who did not.[28]

We were unable to consider tumour stage or morphology in this study. Recent studies using the Thames Cancer Registry as a sampling frame have found that stage could not be reliably reconstructed from casenotes in approximately half of all cases.[29,30] For this reason, we chose not to use the data on stage supplied by the Thames Cancer Registry.

There is evidence to suggest that people from deprived areas suffer greater morbidity than people from affluent areas. Townsend *et al.* reported a strong association between deprivation status and (self-reported) permanent sickness. Eames *et al.* analysed the relationship between mortality and deprivation in 14 English health regions from all causes, coronary heart disease, and smoking-related diseases in men and women.[31] They recorded significantly higher mortality rates for people resident in deprived wards. Poor survival of the most deprived enumeration districts may be associated with higher comorbidity in those groups. This too warrants further research.

Conclusion

These results suggest that different interventions will be required to reduce mortality from these diseases. Reductions in lung cancer mortality require continuing health promotion activities aimed at the most vulnerable groups. For breast and colorectal cancers, more work is required to see whether variation exists by deprivation status in disease stage at presentation and in the patterns of investigations and treatments received by each patient group, and whether, for each disease stage, survival varies by deprivation status.

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