Patterns of care and survival of cancer patients in Ireland 1994 to 2001:

time-trends and regional variation for breast, colorectal, lung and prostate cancer

Summary report

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A fuller version of this report, giving detailed results for each cancer site and a full description of the methods used, is available online at http://www.ncri.ie/pubs/pubs.shtml**.** The full report will not be published in printed form; however, we can provide duplicated laser-printed copies for individuals with no internet access

Patterns of care and survival of cancer patients in Ireland 1994 to 2001: time-trends and regional variation for breast, colorectal, lung and prostate cancer

SUMMARY

Main conclusions

Improvements in survival for breast, colorectal and prostate cancers, but not lung cancers, were seen at national scale between the earlier (1994-1997) and later (1998-2001) parts of the period examined. Improvements in treatment or in early diagnosis are presumably involved, but exaggeration of true survival improvements by lead-time bias cannot be ruled out, especially for prostate cancer.

Regional variation in survival is still apparent, as noted in our previous report (NicAmhlaoibh *et al*. 2004), with survival generally lowest for patients resident outside the Eastern region, except for lung cancer. This variation is partly but not wholly explained by variation in patient or tumour characteristics.

Trends in treatment appeared to be broadly in line with expectations of greater or better-targeted use of radiotherapy and chemotherapy, although no increase in radiotherapy use was seen for breast cancer. An apparent major fall in use of hormonal treatment for breast cancer may also be in line with expectations of improved targeting of appropriate treatment. This may also apply to increased use of hormone therapy and reduced use of surgery for prostate cancer.

At regional scales, there is still substantial variation in the use of particular treatment modalities. These variations are largely unexplained by patient and tumour characteristics, suggesting that geographic and institutional influences on treatment may be critical. Evidence of increased specialization or centralization of services is limited, although further analysis is required.

Introduction and methods

This is the second National Cancer Registry report focusing on treatment and survival of cancer patients in Ireland, for the four most important cancers in healthcare terms. The previous report covered the period 1994 to 1998 (NicAmhlaoibh *et al*. 2004). Coverage is provided here for the eight-year period 1994-2001, representing 49100 cancer patients with survival follow-up to December 2003.

Changes in scope or methodology from the previous report include: assessment of time-trends in survival and treatment; use of relative survival estimates and modelling (rather than crude and cause-specific equivalents); presentation of regional and other treatment comparisons as adjusted risk ratios (rather than odds ratios); and use of age-groups based on the EUROCARE-3 patient population (Capocaccia *et al*. 2003). Summary data on hospital and consultant caseloads are also presented for surgical patients. However, potential caseload, deprivation and co-morbidity influences on survival and treatment are not examined, pending further work on geo-coding and hospital-linkage of cancer registry data.

Time-trends

To allow for possible under-recording of treatments during 1994 and 1995, *trends in the proportions of patients treated are assessed for the period 1996 to 2001 only*. Patient follow-up data is complete for the period, and *survival comparisons are made between diagnosis periods 1994-97 and 1998-2001*.

Regional definitions

Results are presented for *eight regions of residence*, defined (partly for continuity with previous National Cancer Registry analyses) on the basis of the former Health Board areas plus the former Eastern Regional Health Authority area which applied during the period considered. The neutral term ‘region’ is deliberately used.

Survival

Survival is presented here as *estimates of relative survival*, i.e. the ratio of observed survival of patients to the expected survival among persons of the same age and sex in the general population. The regional estimates presented here are the first to be published for Ireland. Formal comparisons between regions, adjusted for relevant patient and tumour characteristics, are made using *relative survival modelling* (Dickman *et al*. 2004).

Treatment

Data analysed here are for treatments *administered within six months of the date of diagnosis*, if anti-tumour or tissue-destroying in effect, whether originally considered ‘curative’, ‘palliative’ or otherwise. Proportions of patients treated are summarized. Formal comparisons between years or regions are based on *logistic regression*, adjusted for relevant patient and tumour characteristics. Results (odds ratios) are *re-expressed as risk ratios* to avoid over-stating proportional differences (Zhang & Yu 1998).

Results

An overview of time-trends in relative survival and in treatment, nationally and regionally, is provided in *Table 1*. Other tables and figures summarize time-trends and regional variation in further detail.

Survival

General summary

National estimates of five-year relative survival for patients diagnosed during 1994-2001 as a whole were 75.4% for breast cancer, 49.2% for colorectal cancer, 8.6% for lung cancer and 69.5% for prostate cancer.

Time-trends in survival

Relative survival for breast, colorectal and prostate cancers showed obvious increases between the diagnosis period 1994-97 and 1998-2001 (*Table 2*), and showed a possible increase for lung cancer. Those for breast, colorectal and prostate cancers were confirmed by relative survival modelling (*Table 3*), which indicated age-adjusted reductions in excess mortality risk by 24%, 10% and 39%, respectively.

At regional scales, survival estimates showed some indication of improvement, in all regions for breast and prostate cancers and in most regions for colorectal and lung cancers (*Table 2*). Regional changes as assessed by modelling were significant for three regions for breast cancer (reduced excess risk i.e. improved relative survival in Eastern, North-Eastern and Southern regions), one region for colorectal cancer (improved survival in Western region), one region for lung cancer (reduced survival in North-Eastern region), but for seven of the eight regions for prostate cancer (improved survival) (*Table 3*).

Fuller adjustment for patient and tumour characteristics modified the national trends somewhat, but the reductions in excess risk remained significant for breast, colorectal and prostate cancer (*Table 3*). For breast cancer, the reduction in risk (improvement in survival) was less marked than in the basic model, but for colorectal cancer the reduction was more marked after fuller adjustment. For prostate cancer, the reduction in risk remained substantial.

Possible changes in patient or tumour characteristics over time thus appear to provide only a partial explanation of trends in survival. Improvements in treatment (see below) seem likely to account, in part, for the survival improvements seen. But changes in unmeasured or poorly measured factors could also be involved. For example, data on cancer stage were substantially incomplete, thus adjustment for possible improvements in early diagnosis may not have been adequate. This is particularly critical given the possibility of *lead-time bias*, whereby earlier detection of cancers through organized or unorganized screening can increase apparent survival times, even if there is no true survival benefit. Of the cancers considered here, the introduction of organized screening for breast cancer (2000/2001 onwards) should have had, at most, only a minor influence on survival trends presented here. For prostate cancer, however, major increases in both apparent survival and in numbers of diagnosed cases suggest that earlier detection through Prostate Specific Antigen (PSA) screening may already be influencing trends, although the true benefits of PSA screening are unclear.

Regional variation in survival

Apparent regional variations in relative survival estimates (*Table 2*) were confirmed for breast, colorectal and prostate cancers by relative survival modelling (*Figure 1*, *Table 4*). This indicated significantly poorer age-adjusted survival in most regions, compared with the Eastern region. Regional variation was less marked for lung cancer (and involved higher survival in several regions).

Fuller adjustment for stage and other tumour and patient variables modified and, in general, substantially reduced regional discrepancies (*Figure 2*, *Table 4*). In statistical terms, these variables appeared to 'explain' some of the differences.

This applied particularly to prostate cancer, for which little regional variation was apparent in the full model – significantly higher excess mortality (lower relative survival) among patients from the Southern region only. For breast cancer, full adjustment reduced the number of regions with significantly low survival from seven to four (Midland, Southern, South-Eastern and Western regions). For colorectal cancer, survival was significantly low among patients from the Mid-Western, Southern and South-Eastern regions. In contrast, survival of lung cancer patients was significantly high among patients from three regions (Mid-Western, North-Western and Western), although absolute differences were small for this high-fatality cancer.

No region had significantly poorer survival for all four cancers. Patients from the Southern region did have significantly poorer survival than the reference Eastern region for breast, colorectal and prostate cancers during 1994-2001 as a whole. In the most recent diagnosis period, 1998-2001, only colorectal and prostate cancers had significantly low survival in the Southern region (and also in the

Mid-Western and South-Eastern regions) (see full report).

It should be noted that prognostic and demographic variables were often substantially incomplete, and may have been correlated with the quality of diagnostic or prognostic investigations. Thus the full explanatory power of the models is difficult to assess.

Treatment

General summary of treatment

Treatments nationally and regionally are summarized in *Figure 3* (1998-2001) and treatment-combinations in *Figures 4-7* (1994-97 and 1998-2001).

For breast cancers diagnosed during 1998-2001, 96% of patients had some form of definitive or tumour-directed treatment within six months of diagnosis, 85% had surgical treatment, 45% chemotherapy, 44% radiotherapy and 43% hormonal therapy (*Figure 3*). In the same period, the most frequent treatments or combinations were surgery plus chemotherapy (18% of cases), surgery plus chemotherapy plus radiotherapy (14%), surgery plus hormonal therapy plus radiotherapy (13%), surgery plus hormone therapy (13%), and surgery only (10%) (*Figure 4*).

For colorectal cancer during 1998-2001, 84% of patients had any treatment, 77% had surgery, 33% chemotherapy and 14% radiotherapy (*Figure 3*). The main combinations were surgery only (46%), surgery plus chemotherapy (20%), and surgery plus chemotherapy plus radiotherapy (8%) (*Figure 5*).

For lung cancer during 1998-2001, 54% of patients had any treatment, 34% had radiotherapy, 16% chemotherapy and 13% surgery (*Figure 3*). Most patients had radiotherapy only (25%), surgery only (10%), or chemotherapy only (9%) (*Figure 6*).

For prostate cancer during 1998-2001, 78% of patients had any treatment, 43% had surgery, 41% hormonal therapy and 10% radiotherapy (*Figure 3*). Most had surgery only (30%), hormonal therapy only (26%), or surgery plus hormonal therapy (11%) (*Figure 7*).

Region of residence v. region of main surgical treatment

For colorectal and breast cancers, the majority of patients resident in a region received their main surgical treatment in the same region (see *Table 5* for the period 1998-2001). In contrast, most surgical cases of lung cancer from almost all regions (other than Southern region) had their main surgery in the Eastern region, albeit based on small numbers of surgical cases. For prostate cancer, regional patterns were intermediate between these extremes.

Hospital and consultant caseloads

The general trend between 1994 and 2001 was for fewer surgical patients to be treated by hospitals or consultants having small average caseloads of breast, colorectal or prostate cancer patients (*Figure 8*). These trends were strongest for breast cancer, but were not evident (or the opposite trends were seen) for lung cancer. However, such trends in caseload do not, by themselves, necessarily indicate increased specialization or centralization of services. Further studies will examine the possible influence of caseload or specialization on survival or quality of treatment.

Time-trends in treatment

The proportions of patients receiving any tumour-directed treatment showed no significant trend for breast cancer during 1996-2001, increased for lung and to a lesser extent colorectal cancer, and fell slightly for prostate cancer (*Table 6*). The use of surgical treatment increased slightly for breast cancer, fell slightly for lung and to a lesser extent colorectal cancers, and fell more markedly for prostate cancer. Radiotherapy use increased markedly for prostate and colorectal (especially rectal) cancers, and to a lesser extent for lung cancer, but showed no trend for breast cancer. For breast cancer, the recorded use of hormonal treatment fell substantially, nationally and in all regions of residence, at the same time as a significant increase in the use of chemotherapy. Chemotherapy use also increased substantially for colorectal and lung cancers, and use of hormonal treatment increased moderately for prostate cancer. Trends for each region (generally but not always consistent with national trends) are presented in the full report.

Regional variation in treatment

There was clear regional variation in the proportions of patients receiving particular treatment modalities (*Figures 9-12* and *Tables 7-8*). Where significant differences were seen, colorectal and to a lesser extent lung cancer patients resident outside the Eastern region were less likely to receive particular treatments than those from the Eastern region. This also applied to radiotherapy for breast cancer and surgery for prostate cancer. However, there was significantly higher use of hormonal treatments for breast and prostate cancers in the other regions, and significant higher use of chemotherapy for breast cancer in up to four of those seven regions. Overall treatment varied less between regions, but was significantly low for lung cancer in most regions compared to the Eastern.

In broad terms, these findings hold both for basic models (adjusted for age, sex and lung cancer cell-type) and for more complex multivariate models. Thus regional variations in treatment appeared to be largely unrelated to the patient and tumour characteristics examined. This may indicate that geographic or institutional factors were critical influences on treatment. Notably, radiotherapy use for breast cancer was highest among patients from the two regions (Eastern and Southern) that had radiotherapy centres during the period examined, and from regions immediately adjacent to the Eastern. However, regional patterns of treatment were not necessarily consistent across cancers for a given treatment modality. The most consistent patterns were high use of hormonal therapy among patients from all regions other than the Eastern (for breast and prostate cancers), low use of radiotherapy in the Western region (for breast, colorectal and lung though not prostate cancers), and low use of chemotherapy in the Mid-Western region (for breast, colorectal and lung cancers).

The link between treatment and survival

Trends or regional variations in survival are likely to reflect, in part, the provision of appropriate treatments aimed at a cure or at prolonging life. Explicitly or convincingly demonstrating this link is difficult, however, especially against a background of increased earlier detection for some cancers (notably prostate). One possible approach is to include treatment status within statistical models of survival. This has not been attempted here, in part because patients receiving and not receiving particular treatments are likely to differ in unmeasured characteristics e.g. their general health. However, further analyses are planned, to take into account available information on co-morbidity (other health conditions in the same patients).

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Table 1 Summary of age-adjusted time-trends in survival and treatment, by region of residence: significant changes in relative survival (1994-97 to 1998-2001 change) or in proportions of patients receiving tumour-directed treatment within six months of diagnosis (1996 to 2001 trend). Trends for colorectal cancer are also adjusted for sex, and for lung cancer for sex and cell-type.

Cancer	Region	Relative survival	Overall treatment	Surgery	Radiotherapy	Chemotherapy	Hormone therapy
Breast	**Total**	+		+		+	-
(female)	East	+		+		+	-
n=13383	Midland						-
	Mid-West						
	North-East	+				+	-
	North-West				-	+	-
	South	+			+	+	-
	South-East				-	+	-
	West				+	+	-
Colorectal	**Total**	+	+	-	+	+	
n=13702	East		+		+	+	
	Midland			-	+		
	Mid-West				+		
	North-East			-	+	+	
	North-West						
	South				+	+	
	South-East		+		+	+	
	West	+			+	+	
Lung	**Total**		+		+	+	
n=11663	East		+			+	
	Midland						
	Mid-West				+		
	North-East				+		
	North-West	-					
	South						
	South-East						
	West						
Prostate	**Total**	+	-	-	+		+
n=10352	East	+	-	-			
	Midland	+		-			+
	Mid-West	+	-	-			
	North-East	+					
	North-West	+	-	-	+		
	South	+		-	+		+
	South-East		-	-	+		
	West	+	-	-			-

+ = significant increase, - = significant decrease.

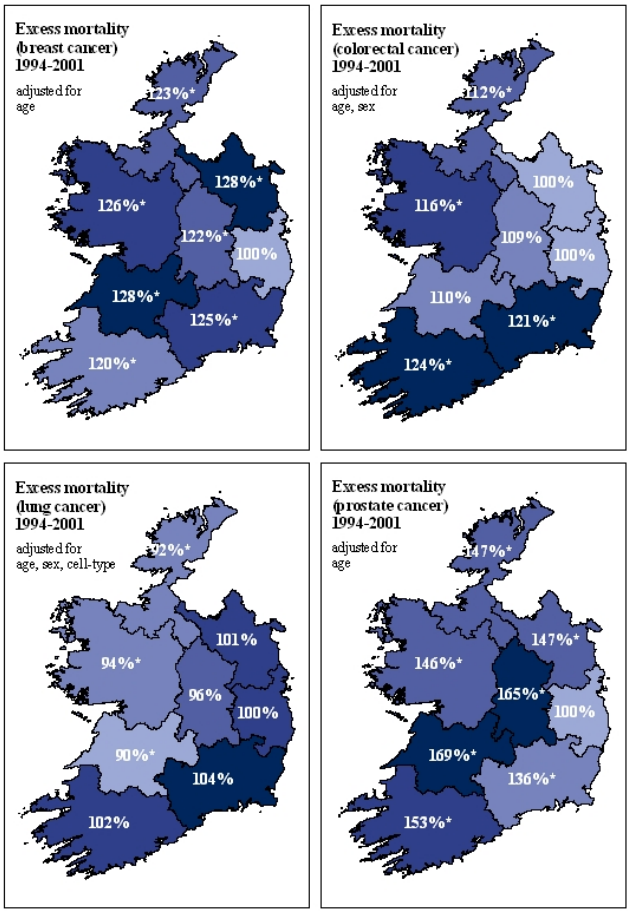
Table 2 Five-year relative survival for Irish cancer patients, unadjusted for age, by region of residence and period of diagnosis, 1994-2001. Relative survival is the survival of cancer patients as a percentage of the expected survival of persons of the same age and sex in the general population (from the same region for regional estimates).

Cancer	Region	1994-2001		1994-1997			1998-2001	
		survival	(95% CI)	survival	(95% CI)		survival	(95% CI)
Breast	**total**	**75.4%**	(74.4%-76.3%)	**72.9%**	(71.6%-74.2%)	+	**78.2%**	(76.8%-79.6%)
(female)	E	78.6%	(77.1%-80.0%)	76.1%	(73.9%-78.1%)	+	81.4%	(79.1%-83.5%)
	M	74.1%	(69.9%-77.9%)	73.2%	(67.5%-78.3%)		76.3%	(69.8%-81.8%)
	MW	73.0%	(69.4%-76.2%)	71.6%	(66.8%-76.0%)		75.1%	(69.5%-80.0%)
	NE	72.3%	(68.5%-75.7%)	68.6%	(63.3%-73.4%)	+	75.6%	(69.9%-80.7%)
	NW	74.1%	(69.8%-78.0%)	71.9%	(66.0%-77.1%)		76.3%	(69.6%-82.1%)
	S	74.7%	(72.2%-77.0%)	70.8%	(67.3%-74.0%)	+	79.3%	(75.6%-82.6%)
	SE	73.5%	(70.3%-76.4%)	72.0%	(67.6%-76.0%)		74.0%	(68.9%-78.5%)
	W	74.1%	(70.8%-77.0%)	71.4%	(67.0%-75.5%)		78.8%	(74.1%-82.8%)
Colorectal	**total**	**49.2%**	(48.1%-50.3%)	**47.7%**	(46.1%-49.1%)	+	**51.0%**	(49.3%-52.6%)
	E	51.9%	(50.0%-53.8%)	50.3%	(47.7%-52.8%)		54.3%	(51.4%-57.1%)
	M	48.8%	(44.2%-53.3%)	47.8%	(41.8%-53.7%)		50.2%	(42.9%-57.2%)
	MW	49.7%	(45.7%-53.6%)	51.0%	(45.4%-56.5%)		48.2%	(42.2%-54.0%)
	NE	52.4%	(48.6%-56.0%)	53.1%	(47.8%-58.3%)		51.5%	(45.9%-56.9%)
	NW	49.3%	(45.1%-53.4%)	45.7%	(40.2%-51.1%)		53.5%	(47.0%-59.9%)
	S	47.1%	(44.4%-49.7%)	46.0%	(42.3%-49.5%)		47.9%	(43.9%-51.8%)
	SE	46.4%	(43.2%-49.6%)	44.6%	(40.2%-48.8%)		48.4%	(43.3%-53.3%)
	W	46.3%	(43.0%-49.6%)	41.0%	(36.7%-45.4%)	+	51.8%	(46.7%-56.8%)
Lung	**total**	**8.6%**	(8.0%-9.2%)	**8.2%**	(7.4%-9.0%)		**9.0%**	(8.1%-9.9%)
	E	9.0%	(8.0%-9.9%)	8.3%	(7.1%-9.5%)		9.6%	(8.1%-11.2%)
	M	9.4%	(6.9%-12.4%)	8.9%	(5.5%-13.2%)		10.1%	(6.6%-14.4%)
	MW	8.2%	(6.2%-10.5%)	7.8%	(5.1%-11.1%)		8.5%	(5.6%-12.2%)
	NE	9.0%	(6.9%-11.2%)	8.6%	(5.8%-11.9%)		9.6%	(6.8%-12.8%)
	NW	9.9%	(7.5%-12.5%)	11.3%	(7.9%-15.3%)		7.9%	(4.7%-11.9%)
	S	7.3%	(5.9%-8.9%)	6.5%	(4.7%-8.5%)		8.7%	(6.4%-11.2%)
	SE	8.7%	(6.9%-10.6%)	9.3%	(6.8%-12.1%)		7.8%	(5.4%-10.7%)
	W	8.1%	(6.2%-10.2%)	7.4%	(5.0%-10.3%)		8.8%	(6.0%-12.1%)
Prostate	**total**	**69.5%**	(67.9%-70.9%)	**63.0%**	(60.8%-65.1%)	+	**75.9%**	(73.7%-77.9%)
	E	77.4%	(74.7%-79.9%)	70.8%	(66.9%-74.6%)	+	84.1%	(80.4%-87.5%)
	M	63.5%	(57.1%-69.7%)	53.1%	(44.5%-61.7%)	+	72.3%	(62.8%-81.2%)
	MW	62.3%	(56.9%-67.5%)	56.9%	(49.9%-63.8%)	+	70.2%	(61.6%-78.2%)
	NE	67.3%	(61.9%-72.5%)	61.0%	(53.6%-68.1%)	+	74.1%	(66.1%-81.4%)
	NW	64.5%	(58.8%-70.0%)	58.2%	(50.1%-66.2%)	+	68.1%	(59.4%-76.3%)
	S	67.8%	(63.9%-71.5%)	59.3%	(53.9%-64.6%)	+	75.7%	(70.1%-80.8%)
	SE	69.0%	(64.8%-73.1%)	65.2%	(59.1%-70.9%)		72.3%	(66.0%-78.2%)
	W	66.4%	(61.8%-70.8%)	60.3%	(54.1%-66.4%)	+	73.7%	(66.9%-80.0%)

+ Significant improvement in survival, based on modeling adjusted for age, or age and sex (*Table 3*).

Explanatory note

Relative survival: This is the *survival observed in a particular group of patients as a percentage or proportion of the survival expected among persons of the same age and sex in the general population*. For example, if the expected five-year survival of a group of persons of a given age is 80%, and the observed survival of a group of cancer patients of the same age is 60%, the five-year relative survival of the cancer patients is expressed as (60/80)% = 75%. Use of relative survival allows assessment of the influence of a given diagnosis (e.g. breast cancer) on survival, over and above other potential causes of death, without needing to know (or rely on) the actual cause of death for any patients who die.

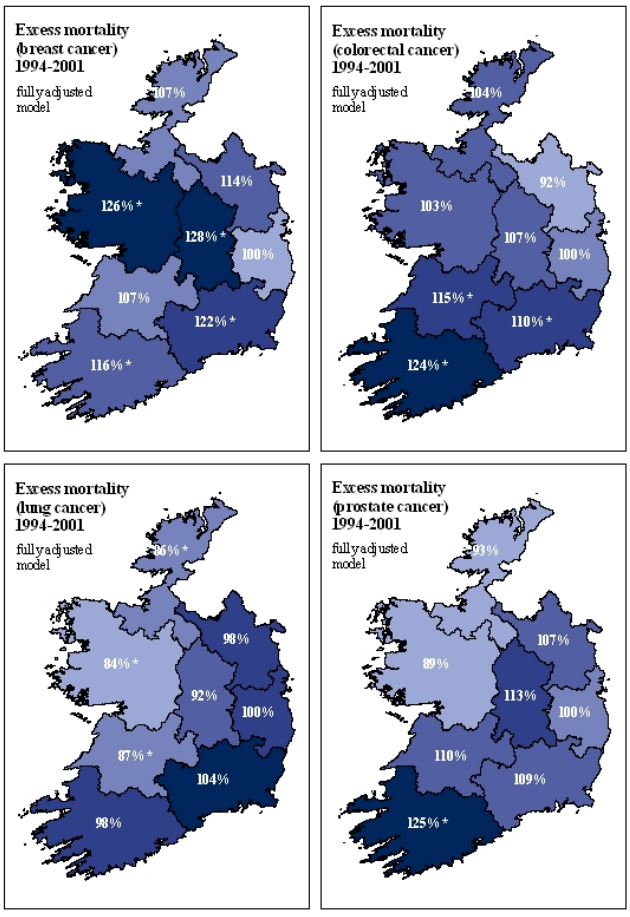


Explanatory note

Excess mortality hazard: This is the 'extra' mortality among a group of patients with a specific disease, having allowed for the expected mortality rate among persons of the same age and sex in the general population. It is the equivalent, for relative survival, of the hazard used in Cox regression modelling of crude or cause-specific survival.

Excess hazard ratio: When comparing two or more patient groups, the ratio of excess mortality hazards is calculated, generally by a statistical model which allows adjustment for age or other patient characteristics – see *Tables 3-4*. Excess hazard ratios thus involve two comparisons: between patients and general population in a given region (to estimate the excess mortality rate), then between patients in different regions (to compare the excess mortality rates, as an excess hazard ratio). Excess hazard ratios in this report are expressed in comparison with patients from the Eastern region. To simplify presentation in *Figures 1-2*, a ratio of 1.21 has been mapped as 121%, for example (compared with 100% for Eastern region).

Figure 1 Regional variation in excess mortality hazards (based on relative survival) adjusted for age, sex and lung cancer cell-type, expressed in comparison to patients from the Eastern region (100%). * = significantly high or low excess mortality (P<0.05). Low excess mortality = high relative survival, high excess mortality = low survival. Excess mortality = in relation to persons of same age and sex in general population. See also *Table 4*.



Explanatory note

Adjustment: In simple terms, adjusting two or more datasets being compared helps ensure that we are comparing like with like. For example, if two groups of patients differ substantially in their average age, survival will tend to be highest for the younger group, other factors being equal.

Figure 2 Regional variation in excess mortality hazards (based on relative survival), fully adjusted for patient and tumour characteristics, expressed in comparison to patients from the Eastern region (100%). * = significantly high or low excess mortality (P<0.05). See also *Table 4*.

Table 3 Changes in relative survival (expressed in terms of excess hazard ratios) between diagnosis periods 1994-97 and 1998-2001, nationally and by region of residence. Analysis is based on survival up to five years from diagnosis. Excess hazard ratios in bold = significant change in excess hazard compared with 1994-97 (<1 = lower excess risk of death i.e. higher survival, >1 = higher excess risk i.e. lower survival). *For example, the excess age-adjusted mortality associated with a breast cancer diagnosis in 1998-2001 was 76.4% that in 1994-1997 (i.e. 23.6% lower).*

Region	Breast cancer [a]EHR (95% CI)	Colorectal cancer EHR (95% CI)	Lung cancer EHR (95% CI)	Prostate cancer EHR (95% CI)
basic model: age-, (lung celltype-), sex-adjusted				
total	**0.764** (0.703-0.831)	**0.903** (0.856-0.952)	0.996 (0.958-1.036)	**0.614** (0.552-0.683)
E	**0.722** (0.623-0.836)	0.923 (0.838-1.017)	0.982 (0.922-1.044)	**0.575** (0.454-0.728)
M	0.994 (0.710-1.391)	0.892 (0.711-1.119)	1.017 (0.853-1.214)	**0.486** (0.335-0.706)
MW	0.853 (0.645-1.128)	1.080 (0.891-1.309)	0.937 (0.812-1.081)	**0.690** (0.493-0.964)
NE	**0.738** (0.551-0.989)	1.063 (0.878-1.285)	**1.172** (1.014-1.353)	**0.697** (0.492-0.987)
NW	0.747 (0.532-1.050)	0.827 (0.675-1.012)	1.091 (0.930-1.280)	**0.588** (0.411-0.842)
S	**0.700** (0.568-0.862)	0.903 (0.797-1.023)	0.964 (0.869-1.069)	**0.639** (0.503-0.811)
SE	0.825 (0.641-1.061)	0.854 (0.730-1.000)	1.043 (0.921-1.181)	0.760 (0.566-1.019)
W	0.811 (0.625-1.051)	**0.710** (0.605-0.832)	0.954 (0.832-1.094)	**0.604** (0.445-0.819)
final multivariate model[b]				
total	**0.906** (0.834-0.985)	**0.781** (0.703-0.867)	0.999 (0.960-1.040)	**0.584** (0.475-0.718)

[a,b]See Table 4.

Table 4 Variation in relative survival, by region of residence (compared to Eastern region), for patients diagnosed with cancer during 1994-2001. Analysis is based on survival up to five years from diagnosis. Excess hazard ratios in bold = significant difference from Eastern region (<1 = lower excess hazard thus higher relative survival than in Eastern region, >1 = higher excess hazard thus lower relative survival). *For example, the excess age-adjusted mortality associated with a breast cancer diagnosis was 22.4% higher in patients from the Midland compared to the Eastern region.*

Region	Breast cancer [a]EHR (95% CI)	Colorectal cancer EHR (95% CI)	Lung cancer EHR (95% CI)	Prostate cancer EHR (95% CI)
basic model: age-, (lung celltype-), sex-adjusted				
E	1.000	1.000	1.000	1.000
M	**1.224** (1.022-1.466)	1.087 (0.963-1.227)	0.957 (0.872-1.050)	**1.646** (1.329-2.040)
MW	**1.281** (1.098-1.493)	1.102 (0.990-1.227)	**0.896** (0.828-0.970)	**1.690** (1.391-2.053)
NE	**1.281** (1.092-1.502)	0.995 (0.895-1.106)	1.008 (0.933-1.088)	**1.470** (1.196-1.807)
NW	**1.226** (1.025-1.467)	**1.124** (1.006-1.256)	**0.915** (0.841-0.995)	**1.470** (1.194-1.811)
S	**1.203** (1.062-1.362)	**1.236** (1.143-1.337)	1.017 (0.958-1.080)	**1.529** (1.301-1.798)
SE	**1.248** (1.081-1.440)	**1.205** (1.100-1.321)	1.038 (0.969-1.112)	**1.356** (1.130-1.627)
W	**1.263** (1.091-1.461)	**1.158** (1.055-1.271)	0.939 (0.871-1.011)	**1.455** (1.211-1.749)
final multivariate model[b]				
E	1.000	1.000	1.000	1.000
M	**1.277** (1.068-1.527)	1.066 (0.939-1.210)	0.924 (0.841-1.015)	1.128 (0.923-1.377)
MW	1.069 (0.914-1.250)	**1.152** (1.032-1.286)	**0.871** (0.804-0.943)	1.104 (0.913-1.335)
NE	1.139 (0.971-1.336)	0.917 (0.825-1.020)	0.976 (0.903-1.055)	1.072 (0.889-1.292)
NW	1.066 (0.894-1.271)	1.038 (0.929-1.160)	**0.855** (0.785-0.931)	0.934 (0.772-1.129)
S	**1.162** (1.025-1.317)	**1.240** (1.145-1.343)	0.978 (0.919-1.039)	**1.248** (1.073-1.450)
SE	**1.222** (1.061-1.407)	**1.100** (1.003-1.206)	1.035 (0.966-1.109)	1.086 (0.919-1.284)
W	**1.262** (1.093-1.457)	1.027 (0.935-1.129)	**0.839** (0.779-0.905)	0.894 (0.755-1.057)

[a]EHR = excess hazard ratio estimated by a generalized linear model (GLM).
[b]Final (full) multivariate models, including some or all of the following (if they contributed significantly to model-fit): *sex* (for colorectal and lung cancers); *age-group*; *T, N, M categories*; *tumour grade*; *lung cancer cell-type*; *breast tumour morphology*; *colorectal site*; *microscopic verification status*; *method of presentation*; *smoking status*; *marital status*; individual *year of diagnosis*.

Explanatory note **Why compare hazards, not survival proportions?** Hazards (mortality rates) have technical advantages for statistical modelling to quantify differences in survival, typically with adjustment for patient and tumour characteristics that might complicate comparisons. Model-based comparison of hazards also allows a fuller description of differences in survival between patient groups, throughout follow-up, rather than reflecting simply the percentages of patients who survive to fixed points, e.g. five years, after diagnosis.

Table 5 Breakdown of surgical treatment for cancers diagnosed during 1998-2001, by region of residence and region where main surgery was performed, expressed as percentages of surgically-treated cases.

Region where surgically treated		Region of residence								
		E	**M**	**MW**	**NE**	**NW**	**S**	**SE**	**W**	**Total**
Breast cancer										
Eastern	%	**99.2**	31.2	6.8	35.1	13.6	1.1	17.5	4.6	**46.6**
Midland	%	0.7	**55.8**	1.3	2.3	0.3	0.0	0.2	0.2	3.8
Mid-Western	%	0.0	0.3	**69.3**	0.0	0.0	0.2	0.8	0.0	5.5
North-Eastern	%	0.1	0.6	0.0	**62.7**	1.5	0.0	0.0	0.0	5.1
North-Western	%	0.0	0.0	0.0	0.0	**77.1**	0.0	0.0	0.9	4.3
Southern	%	0.0	0.0	6.2	0.0	0.0	**98.7**	4.3	0.0	15.9
South-Eastern	%	0.0	1.7	4.7	0.0	0.0	0.0	**77.3**	0.0	8.2
Western	%	0.0	10.5	11.7	0.0	4.5	0.0	0.0	**94.3**	10.5
Northern Ireland	%	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.2
Colorectal cancer										
Eastern	%	**98.4**	13.0	5.7	21.7	10.7	0.8	8.2	3.7	**37.5**
Midland	%	0.4	**78.5**	0.9	0.4	0.8	0.0	0.7	0.2	4.3
Mid-Western	%	0.0	0.4	**79.3**	0.0	0.0	0.2	0.7	0.0	6.9
North-Eastern	%	0.6	1.1	0.0	**77.0**	4.0	0.0	0.0	0.0	7.6
North-Western	%	0.1	0.0	0.0	0.4	**83.5**	0.0	0.2	2.1	6.1
Southern	%	0.2	0.0	5.5	0.0	0.0	**98.7**	4.1	0.0	17.1
South-Eastern	%	0.3	0.4	4.6	0.2	0.0	0.2	**86.0**	0.0	9.5
Western	%	0.2	6.7	4.1	0.2	0.5	0.0	0.0	**94.1**	10.9
Northern Ireland	%	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
Lung cancer										
Eastern	%	**100.0**	**100.0**	**54.3**	**95.6**	**92.3**	4.2	**76.5**	**58.1**	**80.2**
Midland	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mid-Western	%	0.0	0.0	6.5	0.0	0.0	0.0	0.0	0.0	0.4
North-Eastern	%	0.0	0.0	0.0	4.4	0.0	0.0	0.0	0.0	0.4
North-Western	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Southern	%	0.0	0.0	30.4	0.0	0.0	**95.8**	19.1	0.0	15.4
South-Eastern	%	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.4
Western	%	0.0	0.0	8.7	0.0	7.7	0.0	0.0	41.9	3.3
Prostate cancer										
Eastern	%	**99.3**	**63.2**	17.0	**75.6**	40.4	3.1	**49.2**	30.5	**62.0**
Midland	%	0.4	32.2	0.7	0.0	0.0	0.0	0.0	0.0	2.4
Mid-Western	%	0.1	1.2	**55.1**	0.0	0.0	0.3	0.8	0.0	3.4
North-Eastern	%	0.2	0.0	0.0	23.3	0.0	0.0	0.0	0.0	2.5
North-Western	%	0.0	0.0	0.0	0.8	**53.9**	0.0	0.0	3.7	2.2
Southern	%	0.0	0.0	17.0	0.0	0.0	**96.6**	3.9	0.0	15.0
South-Eastern	%	0.0	1.2	5.4	0.4	0.0	0.0	46.1	0.0	6.9
Western	%	0.0	2.3	4.8	0.0	1.1	0.0	0.0	**65.8**	5.3
Northern Ireland		0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	0.2

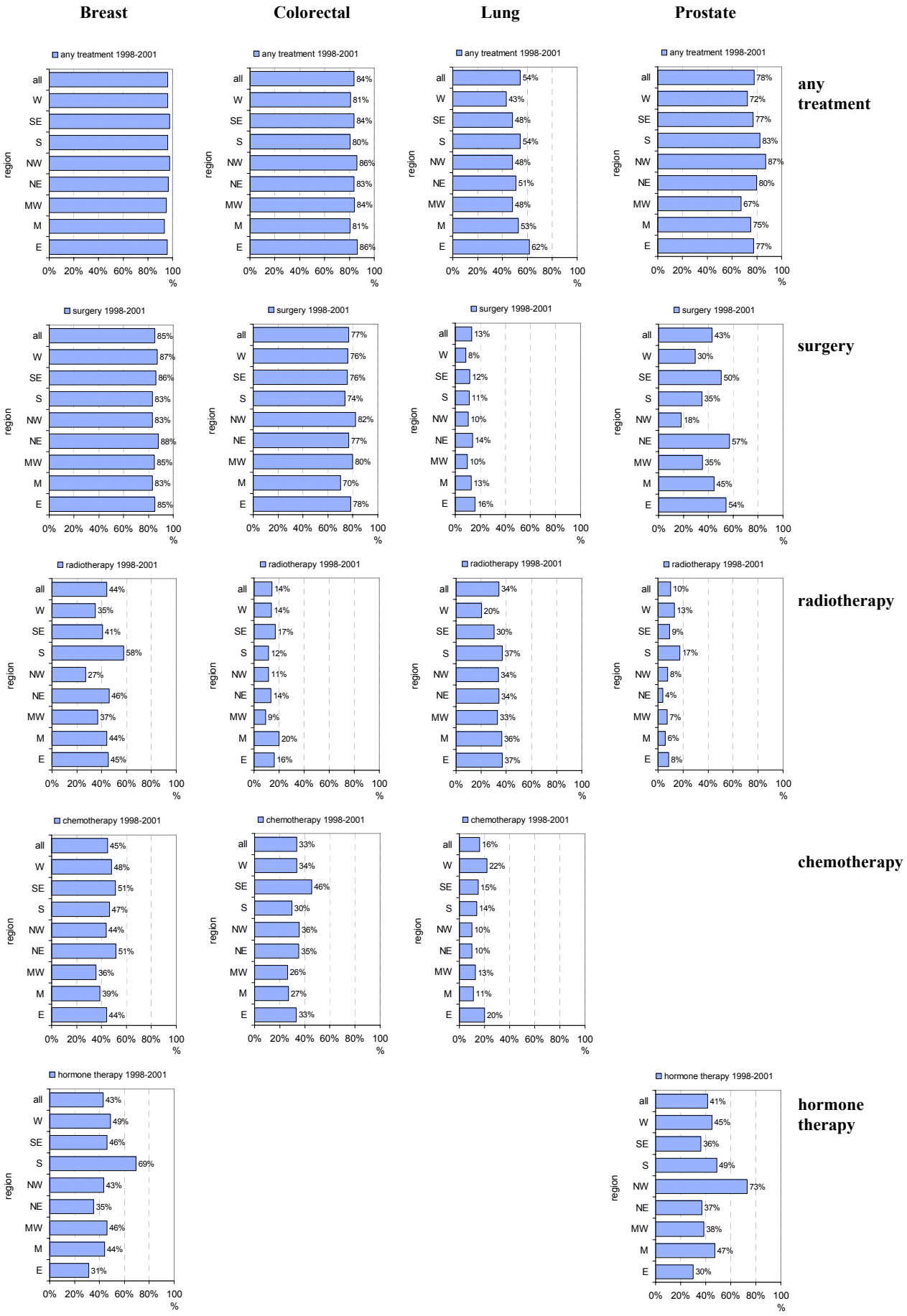


Figure 3 Proportions of cancer patients resident in each region who had tumour-directed treatment within six months of diagnosis, 1998-2001. Note: Results are shown only for standard treatment modalities for a given cancer.

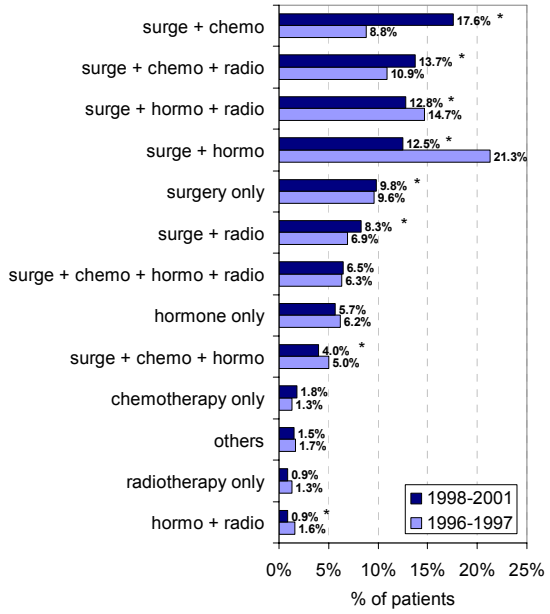


Figure 4 Treatment combinations for breast cancer.
*Significant changes between diagnosis periods.

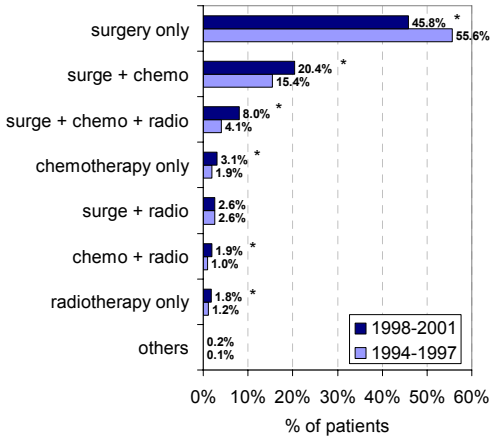


Figure 5 Treatment combinations for colorectal cancer.

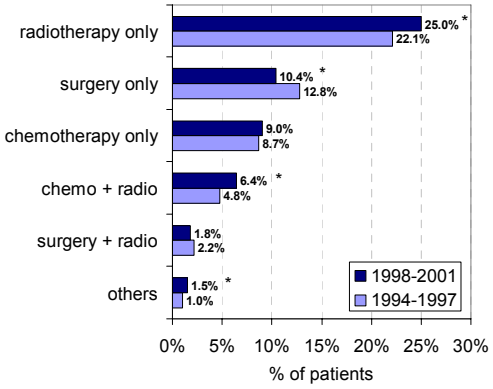


Figure 6 Treatment combinations for lung cancer.

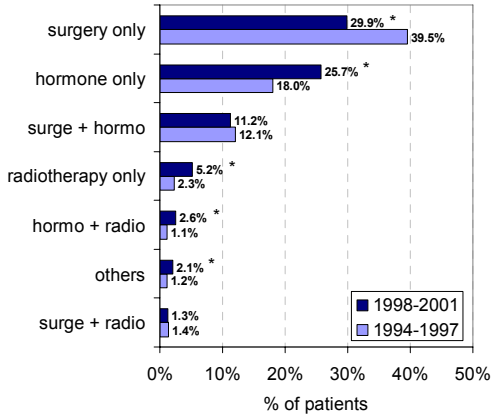


Figure 7 Treatment combinations for prostate cancer.

Table 6 Average annual percentage changes (1996-2001) in proportions of cancer patients having tumour-directed treatment within six months of diagnosis, adjusted for age and sex only (also cell-type for lung cancer). Statistically significant trends are highlighted in bold. In general, further adjustment for stage-related and other variables had only minor effects on the direction, magnitude and statistical significance of these trends.

Treatment modality	Diagnosis period	Breast cancer trend (95% CI)	Colorectal cancer trend (95% CI)	Lung cancer trend (95% CI)	Prostate cancer trend (95% CI)
Overall treatment	1996-2001	-0.1% p.a. (-0.4%, +0.2%)	**+0.6%** p.a. (+0.0%, +1.2%)	**+2.5%** p.a. (+1.1%, +3.9%)	**-1.4%** p.a. (-2.1%, -0.8%)
Surgery	1996-2001	**+0.5%** p.a. (+0.0%, +1.1%)	**-0.7%** p.a. (-1.4%, -0.1%)	**-3.4%** p.a. (-6.5%, -0.2%)	**-7.6%** p.a. (-8.7%, -6.5%)
Radiotherapy	1996-2001	-0.4% p.a. (-1.7%, +1.0%)	**+10.8%** p.a. (+7.4%, +14.2%)	**+2.2%** p.a. (+0.3%, +4.2%)	**+13.2%** p.a. (+8.3%, +18.3%)
Chemotherapy	1996-2001	**+12.6%** p.a. (+10.7%, +14.5%)	**+12.3%** p.a. (+10.1%, +14.6%)	**+6.4%** p.a. (+2.9%, +10.0%)	
Hormone therapy	1996-2001	**-8.9%** p.a. (-9.9%, -7.8%)			**+3.3%** p.a. (+1.5%, +5.0%)

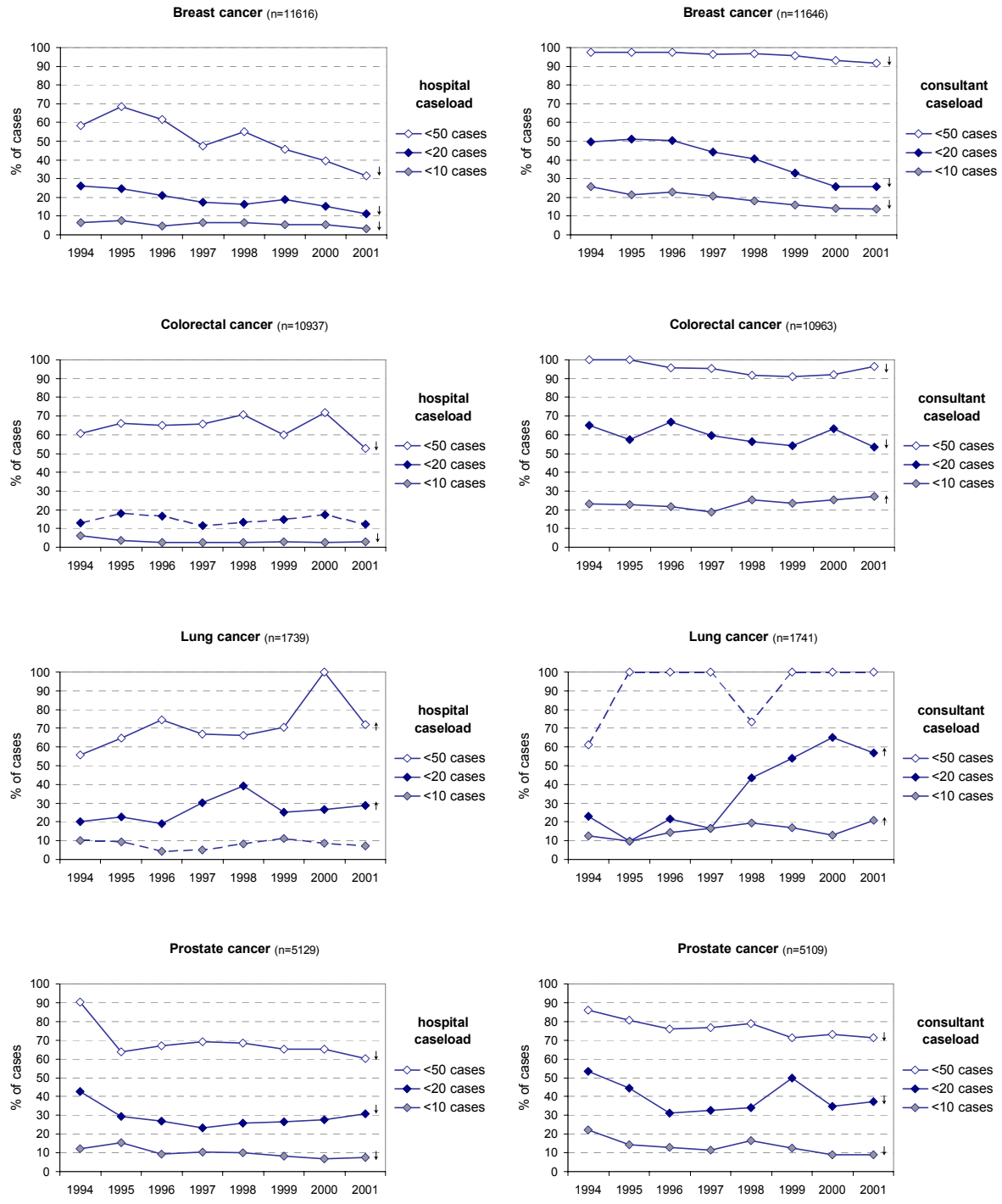
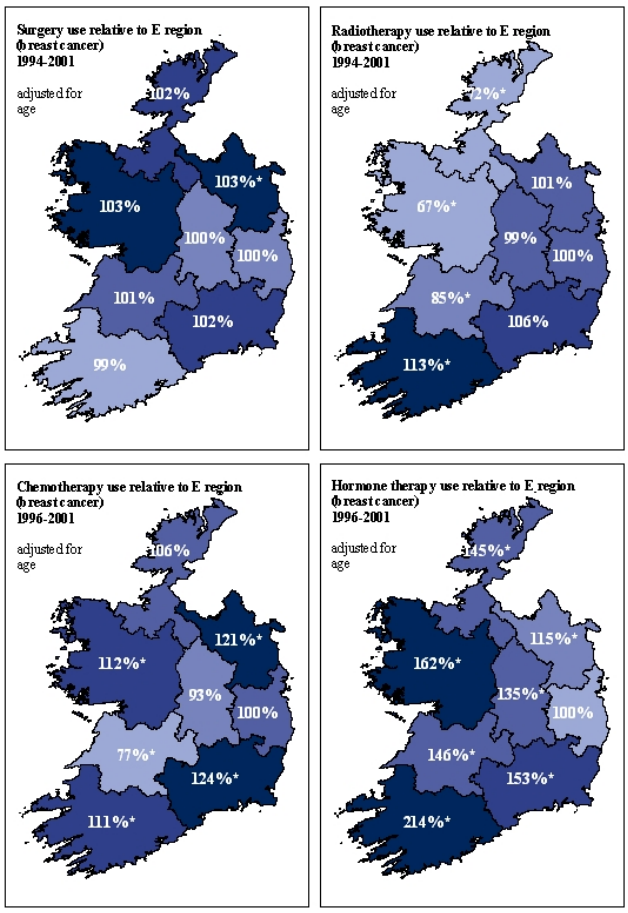


Figure 8 Proportions of surgical patients who had surgery in hospitals which treated, or under a consultant with responsibility for, <10, <20 or <50 surgical patients in a given year, for a given cancer. For this analysis, patients are counted once for each relevant hospital or consultant within six months of diagnosis, for surgical procedures only. Hospitals or consultants outside of the Republic of Ireland are excluded. Significant overall trends (based on Mantel's trend test for proportions) are indicated by solid lines.



Explanatory note

Relative risk (of treatment): In simple terms, if 50% of one group of cancer patients receive a particular treatment within a given time after diagnosis, compared with 40% of another group, the relative risk (RR) for treatment of the first group is (50/40) = 1.25, i.e. patients from the first group are 25% more likely to have been treated. This can be also expressed as a RR of 125% (as in *Figures 9-12*). If the age-composition or other characteristics of two groups of patients differ, those characteristics may also influence the proportion of patient treated. Thus, to examine the effect of, say, region of residence on treatment, it will generally be important to *adjust* for other factors that may complicate comparisons (or help 'explain' some of the apparent differences between regions).

Figure 9 Regional variation in breast cancer treatment, expressed relative to patients from the Eastern region (100%), adjusted for age.
* = significantly high or low values (P<0.05).

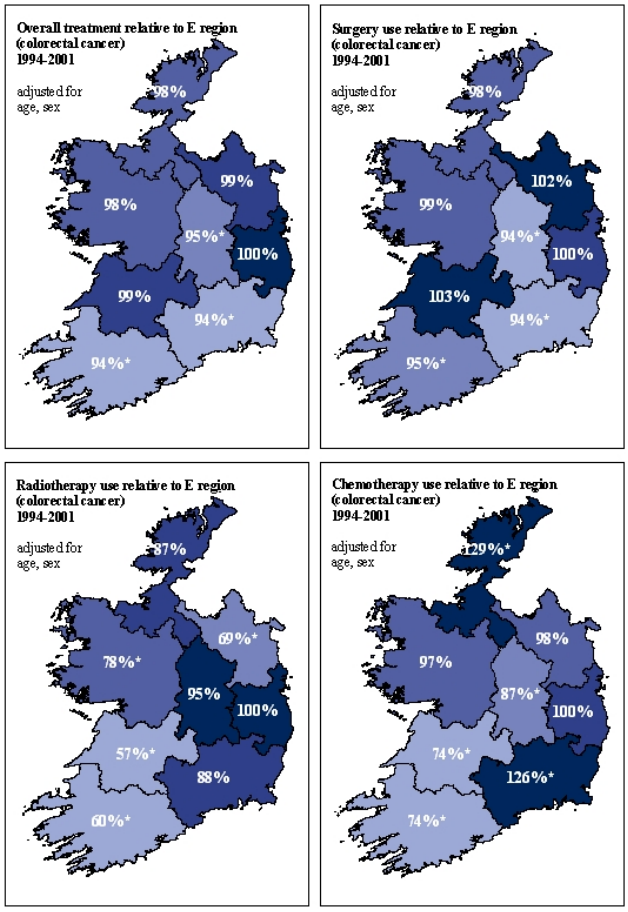


Figure 10 Regional variation in colorectal cancer treatment, expressed relative to patients from the Eastern region (100%), adjusted for age and sex.
* = significantly high or low values (P<0.05).

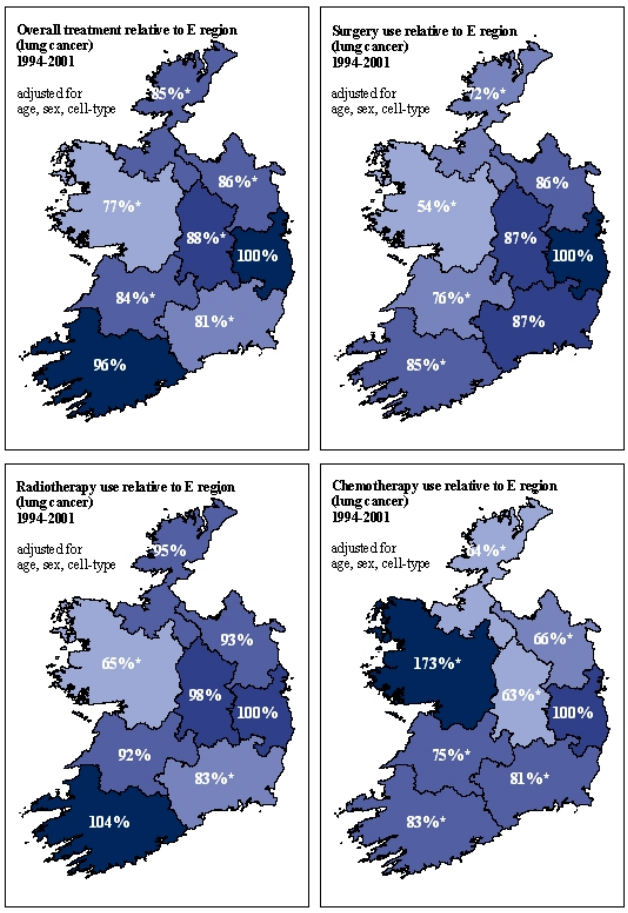


Figure 11 Regional variation in lung cancer treatment, expressed relative to patients from the Eastern region (100%), adjusted for age, sex and cell-type. * = significantly high or low values (P<0.05).

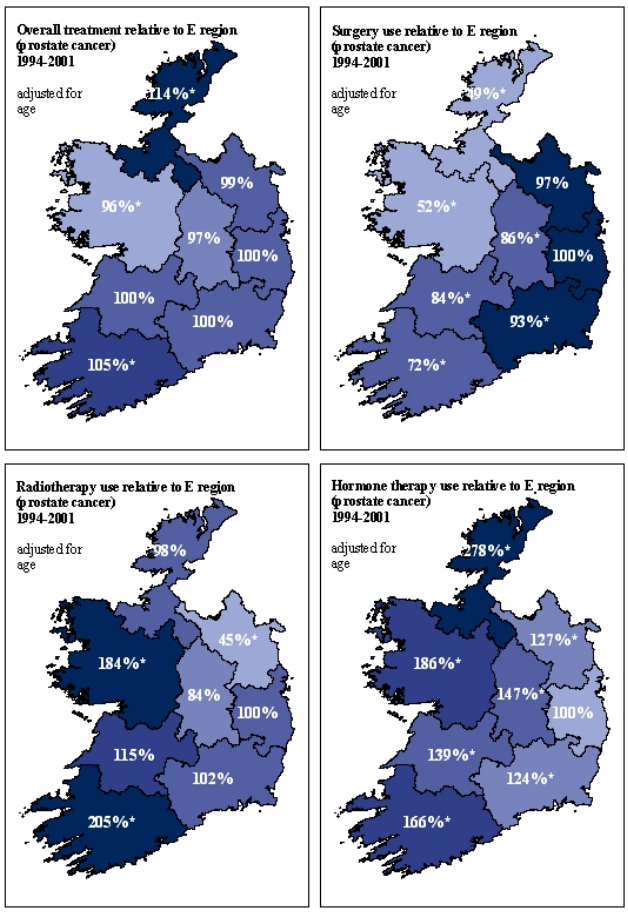


Figure 12 Regional variation in prostate cancer treatment, expressed relative to patients from the Eastern region (100%), adjusted for age.
* = significantly high or low values (P<0.05).

Table 7 Variation in treatment, by region of residence (compared to Eastern region), for patients diagnosed with invasive cancer during 1994-2001, adjusted for age and sex only (also cell-type for lung cancer). Analysis is based on tumour-directed treatments received within six months of diagnosis. Relative risks in bold = significant difference from Eastern region (RR <1 = lower use of treatment than in Eastern region, RR >1 = higher use).

Treatment modality	Region	Breast cancer [a]RR (95% CI)	Colorectal cancer RR (95% CI)	Lung cancer RR (95% CI)	Prostate cancer RR (95% CI)
Overall treatment	E	1.000	1.000	1.000	1.000
	M	0.989 (0.967-1.006)	**0.950** (0.911-0.984)	**0.878** (0.798-0.958)	0.974 (0.923-1.020)
	MW	1.003 (0.986-1.015)	0.989 (0.957-1.017)	**0.837** (0.767-0.908)	0.999 (0.954-1.040)
	NE	1.007 (0.991-1.019)	0.991 (0.961-1.018)	**0.861** (0.793-0.928)	0.989 (0.944-1.030)
	NW	**1.023** (1.010-1.032)	0.982 (0.949-1.011)	**0.854** (0.780-0.928)	**1.140** (1.105-1.169)
	S	1.009 (0.998-1.018)	**0.936** (0.910-0.961)	0.959 (0.906-1.010)	**1.052** (1.021-1.081)
	SE	**1.022** (1.011-1.030)	**0.937** (0.906-0.965)	**0.805** (0.744-0.866)	0.998 (0.960-1.033)
	W	1.005 (0.990-1.016)	0.977 (0.949-1.002)	**0.773** (0.708-0.839)	**0.960** (0.919-0.998)
Surgery	E	1.000	1.000	1.000	1.000
	M	0.995 (0.957-1.029)	**0.943** (0.898-0.984)	0.868 (0.694-1.077)	**0.862** (0.789-0.936)
	MW	1.009 (0.977-1.036)	1.029 (0.993-1.060)	**0.760** (0.613-0.935)	**0.839** (0.772-0.907)
	NE	**1.034** (1.004-1.059)	1.016 (0.981-1.047)	0.864 (0.716-1.037)	0.974 (0.908-1.039)
	NW	1.016 (0.982-1.045)	0.979 (0.940-1.015)	**0.720** (0.573-0.899)	**0.491** (0.433-0.554)
	S	0.988 (0.963-1.011)	**0.948** (0.919-0.976)	**0.846** (0.733-0.974)	**0.715** (0.665-0.766)
	SE	1.020 (0.992-1.044)	**0.942** (0.907-0.974)	0.865 (0.729-1.021)	**0.929** (0.872-0.985)
	W	1.027 (0.999-1.051)	0.992 (0.960-1.022)	**0.544** (0.433-0.680)	**0.520** (0.469-0.574)
Radiotherapy	E	1.000	1.000	1.000	1.000
	M	0.986 (0.901-1.074)	0.952 (0.778-1.157)	0.975 (0.857-1.099)	0.839 (0.584-1.196)
	MW	**0.853** (0.781-0.928)	**0.565** (0.454-0.700)	0.920 (0.821-1.026)	1.149 (0.869-1.508)
	NE	1.007 (0.930-1.085)	**0.692** (0.570-0.836)	0.928 (0.831-1.030)	**0.452** (0.299-0.680)
	NW	**0.724** (0.645-0.808)	0.865 (0.710-1.048)	0.949 (0.843-1.062)	0.983 (0.716-1.339)
	S	**1.127** (1.068-1.186)	**0.600** (0.512-0.702)	1.036 (0.958-1.117)	**2.049** (1.720-2.428)
	SE	1.057 (0.987-1.127)	0.882 (0.753-1.029)	**0.832** (0.749-0.921)	1.021 (0.798-1.300)
	W	**0.667** (0.605-0.733)	**0.783** (0.661-0.923)	**0.649** (0.568-0.737)	**1.836** (1.491-2.246)
Chemotherapy[b]	E	1.000	1.000	1.000	-
	M	0.932 (0.820-1.049)	**0.867** (0.751-0.994)	**0.626** (0.472-0.822)	-
	MW	**0.769** (0.679-0.866)	**0.738** (0.646-0.839)	**0.750** (0.598-0.934)	-
	NE	**1.205** (1.099-1.312)	0.982 (0.878-1.092)	**0.664** (0.530-0.826)	-
	NW	1.060 (0.939-1.184)	**1.285** (1.154-1.420)	**0.641** (0.497-0.820)	-
	S	**1.105** (1.024-1.187)	**0.735** (0.665-0.811)	**0.834** (0.713-0.971)	-
	SE	**1.241** (1.143-1.338)	**1.255** (1.148-1.365)	**0.808** (0.669-0.971)	-
	W	**1.120** (1.022-1.220)	0.972 (0.876-1.075)	**1.725** (1.493-1.976)	-
Hormone therapy[b]	E	1.000	-	-	1.000
	M	**1.346** (1.215-1.478)	-	-	**1.474** (1.314-1.642)
	MW	**1.463** (1.348-1.577)	-	-	**1.385** (1.241-1.537)
	NE	**1.148** (1.038-1.262)	-	-	**1.268** (1.130-1.415)
	NW	**1.453** (1.321-1.585)	-	-	**2.777** (2.630-2.913)
	S	**2.139** (2.063-2.212)	-	-	**1.662** (1.543-1.783)
	SE	**1.534** (1.430-1.638)	-	-	**1.236** (1.118-1.361)
	W	**1.617** (1.509-1.723)	-	-	**1.859** (1.722-1.997)

[a]Risk ratios, compared with Eastern region, were derived using the method of Zhang & Yu (1998) from adjusted odds ratios calculated by logistic regression adjusted for the following patient and tumour variables: *sex* (for colorectal and lung cancers); *age-group* 15-44, 45-54, 55-64, 65-74, or 75+ (ages 15-54 to 85+ for prostate cancer); *lung tumour morphology* - non-small-cell (NSCLC), small- cell (SCLC), or other/unspecified.
[b]For breast cancer, data on use of chemotherapy and hormone therapy are for 1996-2001 only.

Table 8 Variation in treatment, by region of residence (compared to Eastern region), for patients diagnosed with invasive cancer during 1994-2001, adjusted for detailed patient and tumour characteristics. Analysis is based on tumour-directed treatments received within six months of diagnosis. Relative risks in bold = significant difference from Eastern region (RR <1 = lower use of treatment than in Eastern region, RR >1 = higher use).

Treatment modality	Region	Breast cancer [a]RR (95% CI)	Colorectal cancer RR (95% CI)	Lung cancer RR (95% CI)	Prostate cancer RR (95% CI)
Overall treatment	E	1.000	1.000	1.000	1.000
	M	**0.971** (0.937-0.995)	**0.916** (0.852-0.971)	**0.867** (0.783-0.950)	0.972 (0.918-1.021)
	MW	**1.015** (1.000-1.026)	1.013 (0.971-1.047)	**0.835** (0.762-0.908)	**1.073** (1.032-1.110)
	NE	1.005 (0.985-1.019)	0.992 (0.951-1.027)	**0.882** (0.811-0.952)	0.992 (0.944-1.036)
	NW	**1.025** (1.010-1.035)	0.992 (0.946-1.030)	**0.856** (0.778-0.934)	**1.161** (1.127-1.189)
	S	1.006 (0.991-1.017)	0.989 (0.955-1.018)	0.965 (0.910-1.020)	**1.061** (1.027-1.092)
	SE	**1.021** (1.007-1.031)	**0.944** (0.900-0.982)	**0.762** (0.699-0.826)	0.994 (0.952-1.032)
	W	1.002 (0.983-1.016)	1.030 (0.999-1.057)	**0.788** (0.720-0.857)	0.996 (0.955-1.034)
Surgery	E	1.000	1.000	1.000	1.000
	M	0.965 (0.907-1.013)	**0.880** (0.801-0.951)	0.774 (0.577-1.024)	**0.916** (0.833-0.999)
	MW	**1.059** (1.025-1.087)	**1.091** (1.047-1.127)	**0.715** (0.543-0.931)	1.052 (0.972-1.129)
	NE	1.037 (0.996-1.070)	1.032 (0.983-1.075)	0.863 (0.676-1.090)	1.054 (0.979-1.126)
	NW	1.031 (0.982-1.069)	0.950 (0.885-1.006)	**0.641** (0.477-0.851)	**0.509** (0.443-0.582)
	S	**0.954** (0.913-0.991)	0.988 (0.944-1.028)	0.840 (0.699-1.005)	**0.754** (0.695-0.815)
	SE	1.006 (0.965-1.040)	**0.952** (0.900-0.999)	**0.778** (0.625-0.962)	0.955 (0.890-1.020)
	W	**1.057** (1.024-1.084)	**1.069** (1.029-1.104)	**0.549** (0.415-0.719)	**0.523** (0.466-0.584)
Radiotherapy	E	1.000	1.000	1.000	1.000
	M	0.982 (0.895-1.071)	1.046 (0.826-1.313)	0.969 (0.850-1.096)	0.821 (0.567-1.179)
	MW	**0.890** (0.815-0.967)	**0.508** (0.395-0.651)	0.936 (0.833-1.044)	1.229 (0.918-1.631)
	NE	1.003 (0.923-1.083)	**0.729** (0.587-0.899)	0.950 (0.850-1.055)	**0.491** (0.323-0.742)
	NW	**0.727** (0.647-0.813)	0.997 (0.801-1.231)	0.934 (0.826-1.049)	0.953 (0.684-1.319)
	S	**1.136** (1.075-1.198)	**0.552** (0.461-0.660)	1.055 (0.972-1.140)	**2.093** (1.730-2.516)
	SE	1.063 (0.991-1.135)	0.852 (0.712-1.017)	**0.834** (0.749-0.926)	1.117 (0.868-1.430)
	W	**0.684** (0.619-0.751)	**0.681** (0.561-0.822)	**0.636** (0.555-0.725)	**1.831** (1.472-2.262)
Chemotherapy[b]	E	1.000	1.000	1.000	-
	M	0.871 (0.750-1.000)	0.883 (0.751-1.030)	**0.606** (0.451-0.805)	-
	MW	**0.751** (0.651-0.858)	**0.714** (0.612-0.827)	**0.767** (0.609-0.959)	-
	NE	**1.153** (1.031-1.275)	1.014 (0.897-1.140)	**0.706** (0.561-0.882)	-
	NW	0.941 (0.811-1.078)	**1.315** (1.169-1.467)	**0.640** (0.493-0.824)	-
	S	1.041 (0.947-1.136)	**0.762** (0.682-0.849)	0.854 (0.725-1.001)	-
	SE	**1.143** (1.033-1.255)	**1.257** (1.139-1.380)	**0.800** (0.658-0.967)	-
	W	1.089 (0.978-1.203)	0.920 (0.816-1.032)	**1.743** (1.503-2.003)	-
Hormone therapy[b]	E	1.000	-	-	1.000
	M	**1.305** (1.167-1.446)	-	-	**1.407** (1.235-1.589)
	MW	**1.482** (1.357-1.606)	-	-	**1.488** (1.321-1.664)
	NE	**1.184** (1.063-1.308)	-	-	**1.209** (1.061-1.367)
	NW	**1.344** (1.206-1.485)	-	-	**2.814** (2.654-2.960)
	S	**2.120** (2.034-2.200)	-	-	**1.658** (1.523-1.797)
	SE	**1.491** (1.378-1.604)	-	-	**1.279** (1.146-1.420)
	W	**1.581** (1.464-1.697)	-	-	**2.015** (1.860-2.169)

[a]Risk ratios, compared with Eastern region, were derived using the method of Zhang & Yu (1998) from adjusted odds ratios calculated by logistic regression adjusted for the following patient and tumour variables (if they contributed significantly to model-fit): *sex* (for colorectal and lung cancers); *age-group*; *T, N and M categories of stage*; *tumour grade*; *tumour morphology* (for lung and breast cancers); *colorectal site*; *microscopic verification status; method of presentation*; *smoking status*; *marital status*; individual *year of diagnosis*.
[b]For breast cancer, data on use of chemotherapy and hormone therapy are for 1996-2001 only.