

## 10. Survival

### 10.1. Introduction

It is commonly accepted that different types of cancer can have very different prognoses and that the outlook for any patient is influenced by a number of factors, most notably the stage of the cancer at diagnosis and the sex and age of the patient.<sup>39</sup> In this chapter, we will present a survival analysis of each of the nine major cancers listed in Section 2.2.1 Overall survival – that is, survival for all cancers combined – depends on the relative incidence of each cancer, is not meaningful and will not be described here.

Two measures of survival are presented

- cancer survival, which describes the proportion of patients still alive, or have died from causes other than cancer, at a specified time after diagnosis;
- relative survival, a comparison of the survival of the selected patients with that of the general population (see A2.1.3 for more detailed information).

All analyses will be presented separately for males and females, and consideration given to the stage of cancer at diagnosis and patient age.

## 10.2. Data

The cases analysed were all patients in Ireland diagnosed as having malignant cancer between 1 January 1994 and 31 December 1998, with a censoring date of 31 December 1999 (Table 10.1). Details of methods, and inclusion and exclusion criteria, are to be found in section A2.1.3.

Table 10.1 Cancers diagnosed in 1994 – 1998 and included in survival analysis.

	1994	1995	1996	1997	1998	RECORDS DROPPED	RECORDS ANALYSED
colorectal	1701	1595	1592	1701	1701	1	8290
breast	1498	1509	1564	1588	1658	12	7817
lung	1477	1346	1365	1383	1446	8	7017
prostate	1042	1080	1111	1114	1196	87	5543
lymphoma	438	393	445	472	500	11	2248
stomach	457	449	452	443	429	157	2230
bladder	496	422	454	438	375	28	2185
melanoma	371	354	345	396	375	40	1832
leukaemia	308	276	284	312	301	36	1481
all above sites	7788	7415	7612	7847	7981	380	38643

### 10.3. Cancer survival

#### 10.3.1. Cancer survival by sex

The Kaplan-Meier survival curves, stratified by sex, are presented in Figure 10.1. These plots represent the probability of a patient surviving up to 5 years after diagnosis. The data for these survival curves are summarised in Table 10.2 which shows survival from each cancer at five years after diagnosis. Confidence intervals (C.I.) for each survival estimate are also given, at the 95% level. The “p-value” indicates whether there was a statistically significant difference between the survival for males and females, with  $p \leq .05$  indicating a significant difference and  $p \leq .01$  a highly significant difference.

Melanoma had the best survival with 85% (95% confidence interval 82% – 87%) of women and 68% (C.I. 62% – 72%) of men surviving at least 5 years after diagnosis. The poorest prognosis was for lung cancer with only 10% (C.I. 9% – 12%) of women and 8.5% (C.I. 7.5% – 9.5%) of men surviving more than 5 years after diagnosis, while the results for stomach cancer were somewhat better with a 5 - year survival of 20% (C.I. 17% – 24%) for men and 15% (C.I. 13% – 18%) for women. Breast, prostate and bladder cancer, and lymphoma each have a reasonable prognosis with a 5 - year survival of at least 50% (Table 10.2), with the prognosis for colorectal cancer and leukaemia being slightly worse (43% and 44% for males; 48% and 46% for females).

As can be seen from Table 10.2 and Figure 10.1, the prognosis was different for men and women for most of the cancers considered, with the notable exception of leukaemia. Women had significantly better survival for colorectal cancer, melanoma and lymphoma, and somewhat better survival (although not statistically significant) for stomach and lung cancer. The exception was bladder cancer, where women had significantly worse survival than men.

To test whether these observed male-female differences might be due in part to age at diagnosis, we performed a Cox regression. Age differences did not account for the observed survival differences in any of the cancers studied. For lymphoma, the age-adjusted survival advantage for women was even greater, with a hazard ratio of 1.33 (95% C.I. 1.17-1.53,  $p < .001$ ) compared to the crude hazard ratio of 1.17 (95% C.I. 1.03-1.34,  $p = .02$ ).

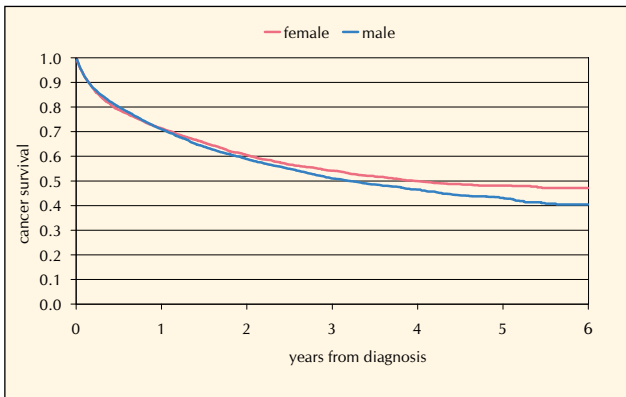
Table 10.2 Five-year cancer survival by cancer type and sex with 95% confidence intervals.

TYPE	FEMALE	MALE	*P-VALUE
stomach	20% (17% – 24%)	15% (13% – 18%)	.14
colorectal	48% (46% – 50%)	43% (41% – 45%)	.02
lung	10% (9% – 12%)	8.5% (7.5% – 9.5%)	.16
melanoma	85% (82% – 87%)	68% (62% – 72%)	<.0001
breast	71% (70% – 72%)		
prostate		56% (54% – 58%)	
bladder	61% (56% – 66%)	64% (61% – 67%)	.01
lymphoma	59% (55% – 62%)	54% (50% – 57%)	.03
leukaemia	46% (41% – 52%)	44% (39% – 49%)	.94

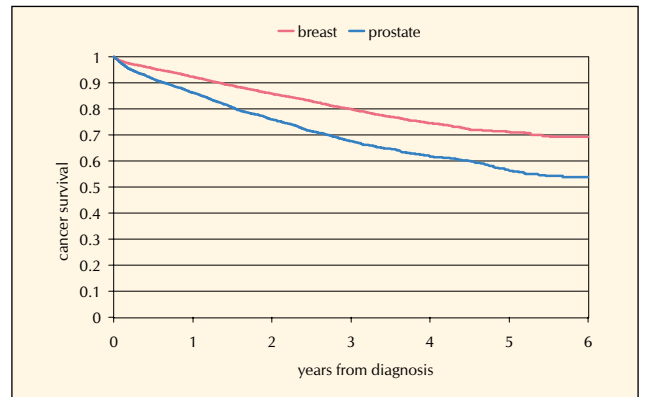
Figure 10.1 Cancer survival: by site and sex

colorectal

$p = .02$

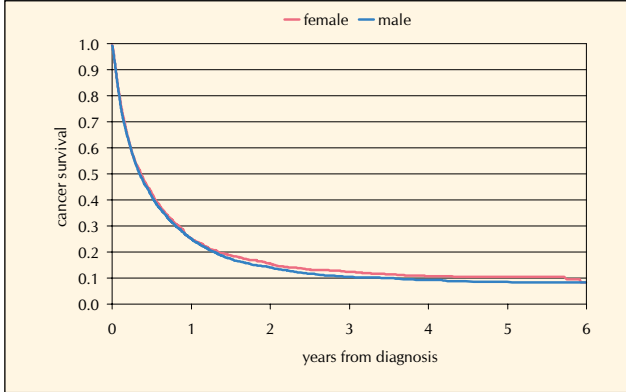


breast/prostate



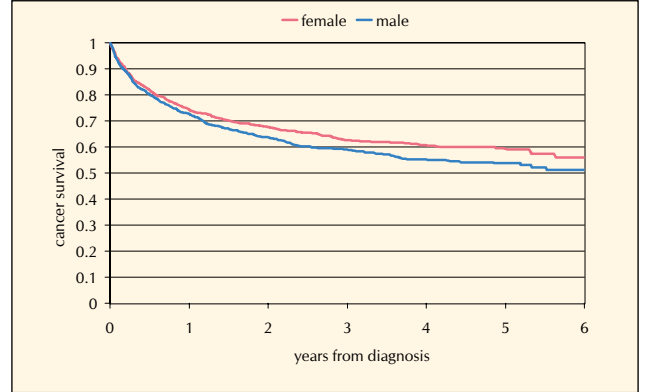
lung

$p = .16$



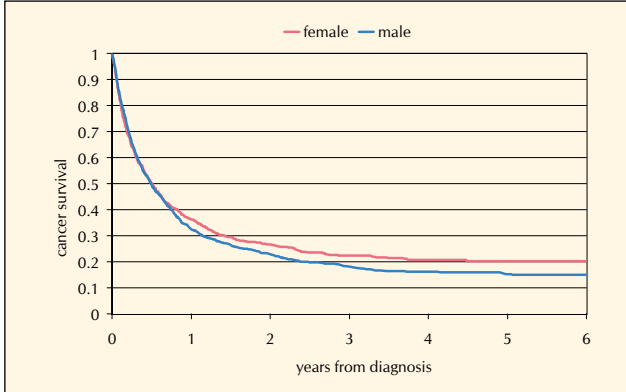
lymphoma

$p = .03$



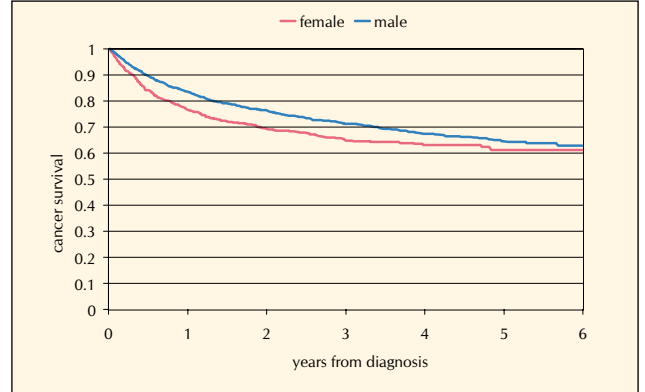
stomach

$p = .14$



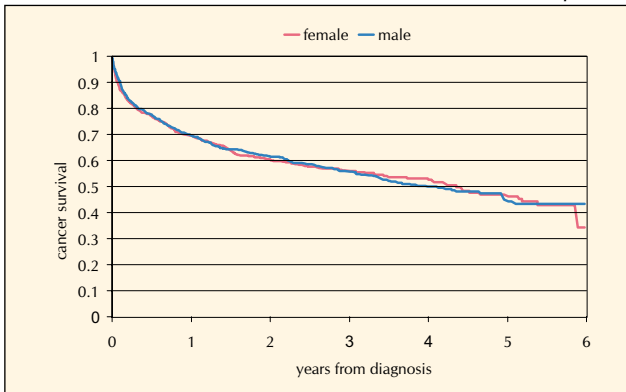
bladder

$p = .01$



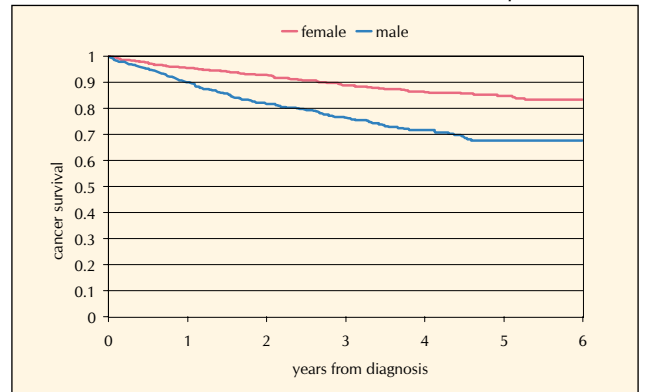
leukaemia

$p = .94$



melanoma

$p = < .0001$



### 10.3.2. Cancer survival by age

Kaplan-Meier survival plots stratified by age are presented in Figure 10.2. For each cancer, patients were aggregated into age groups which had reasonable numbers of cases; neighbouring age groups were further aggregated if their survival curves were similar. In this way we assigned patients to four age categories for most cancers, five for prostate and leukaemia, and six for lymphoma.

For all cancers, a younger age at diagnosis conferred a survival advantage for both men and women, although the magnitude of this advantage varied with the cancer type. The maximum age effects were observed for bladder cancer and lymphoma, with very small age effects being observed for melanoma, particularly in women. The one-year and five-year survival probabilities are displayed in Table 10.3 for each cancer for four age groups.

- For colorectal cancer, women of all ages had a higher 5-year survival than men, and women aged less than 80 had a higher one-year survival, in keeping with the significant survival advantage noted for women overall in Figure 10.1.
- For breast and prostate cancer, the effect of age was more pronounced on five-year survival than on one-year survival. This same pattern was exhibited by bladder cancer, with men aged 80 or over having marginally better survival than women.
- For lung cancer, the 5-year survival dropped by 50% for patients older than 50 (both men and woman).
- For stomach cancer this dramatic drop in survival was observed only for males over 80 years, with women in this age group and all other age groups having better survival than their male counterparts.
- Women diagnosed with melanoma up to the age of 70 have a very good one-year and five-year survival ( $\geq 87\%$ ) which was never less than 75% even in the oldest women. In contrast, the five-year survival for men dropped from 87% to 67% after age 40 and was only 53% in the oldest age group (80+).
- For lymphoma, the effects of age on one-year and five-year survival was similar in men and women, although women aged 80 and over had somewhat better survival. In contrast the one-year and five-year survival did not vary much with age for either men or women.

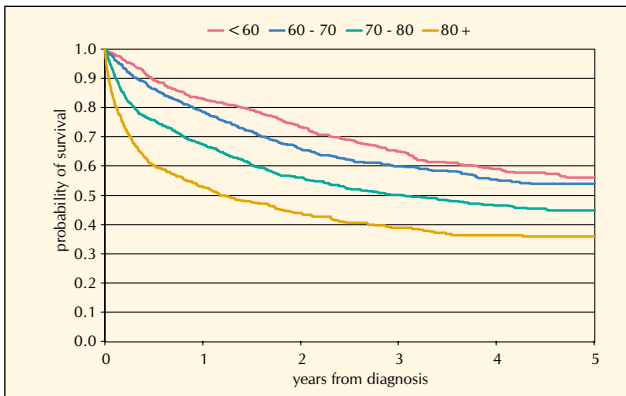
Table 10.3 One-year (five-year) survival for four age groups\* for each cancer, stratified by sex

CANCER SITE	SEX	AGE GROUPS*			
		< 60	60 – 70	70 – 80	80 +
colorectal	male	.79 (.47)	.75 (.48)	.67 (.39)	.55 (.33)
	female	.83 (.56)	.79 (.54)	.67 (.45)	.53 (.36)
breast	female	.96 (.76)	.92 (.69)	.87 (.66)	.80 (.54)
bladder	male	.94 (.83)	.87 (.72)	.80 (.56)	.69 (.38)
	female	.91 (.83)	.86 (.67)	.74 (.55)	.54 (.39)
prostate		< 60	60 – 70	80 – 85	85 +
	male	.95 (.69)	.92 (.65)	.76 (.44)	.71 (.36)
lung		< 50	50 – 70	70 – 80	80 +
	male	.39 (.19)	.27 (.09)	.23 (.07)	.16 (.05)
	female	.41 (.23)	.29 (.12)	.21 (.08)	.15 (.04)
stomach	male	.49 (.26)	.35 (.19)	.32 (.12)	.20 (.06)
	female	.55 (.23)	.44 (.24)	.33 (.18)	.28 (.17)
melanoma		< 40	40 – 70	70 – 80	80 +
	male	.96 (.87)	.89 (.67)	.88 (.59)	.87 (.53)
	female	.97 (.90)	.95 (.87)	.94 (.78)	.97 (.75)
lymphoma		< 40	40 – 50	70 – 80	80 +
	male	.88 (.74)	.82 (.69)	.57 (.36)	.46 (.20)
	female	.97 (.93)	.89 (.71)	.62 (.41)	.40 (.28)
leukaemia		< 40	40 – 60	70 – 80	80 +
	male	.72 (.46)	.77 (.55)	.65 (.42)	.52 (.33)
	female	.78 (.58)	.76 (.56)	.60 (.41)	.64 (.37)

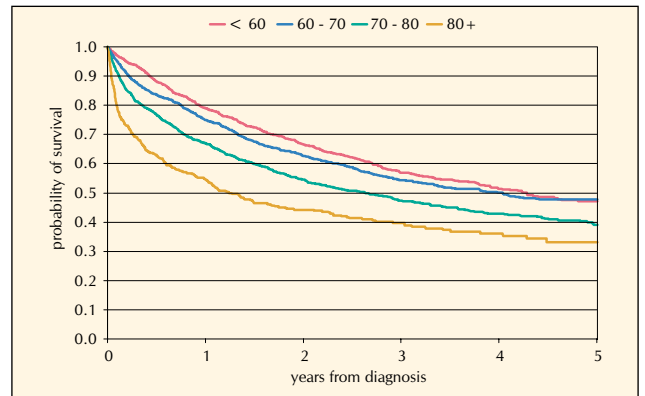
\*For cancers where more than four age groups were used in the graphical analysis of Figure 10.2, the two youngest and two eldest age groups are included.

Figure 10.2 Crude survival by age group

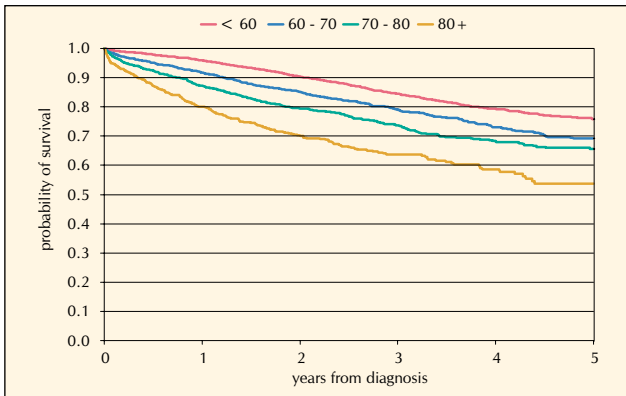
colorectal female



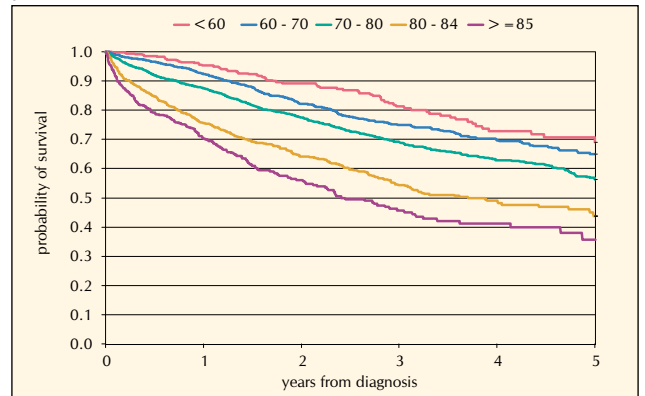
colorectal male



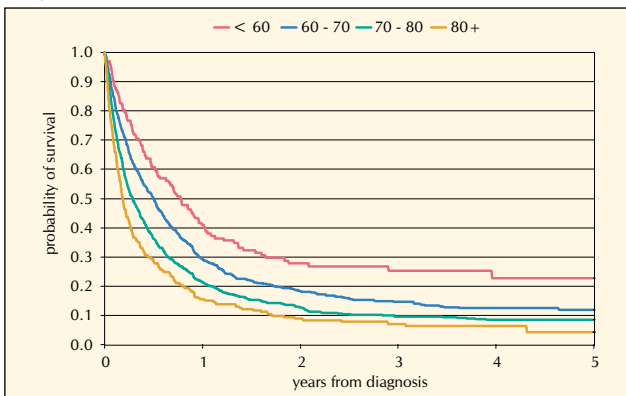
breast



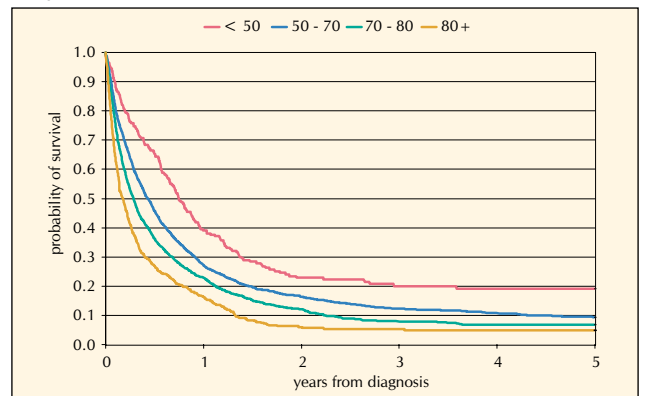
prostate



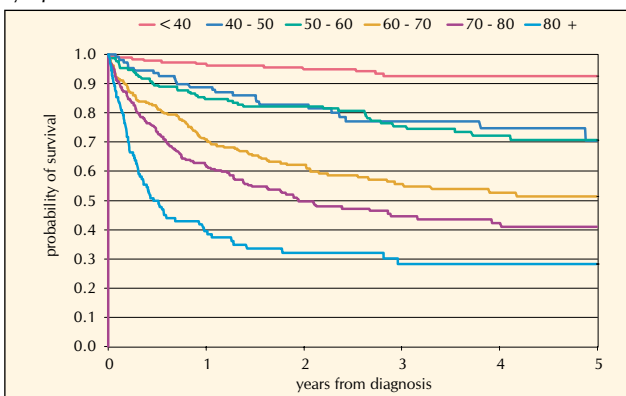
lung female



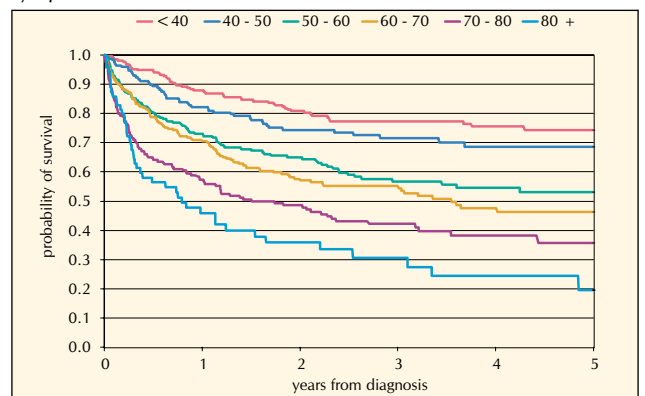
lung male



lymphoma female

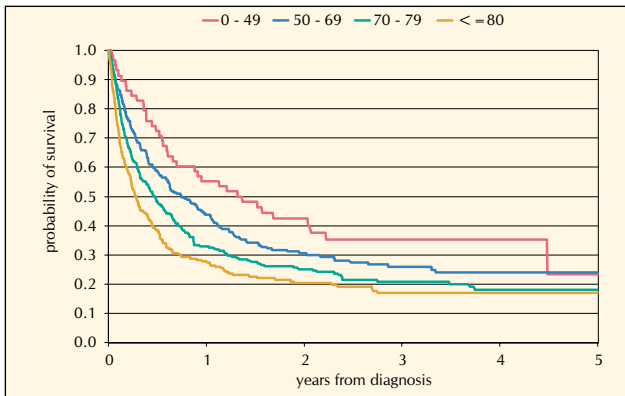


lymphoma male

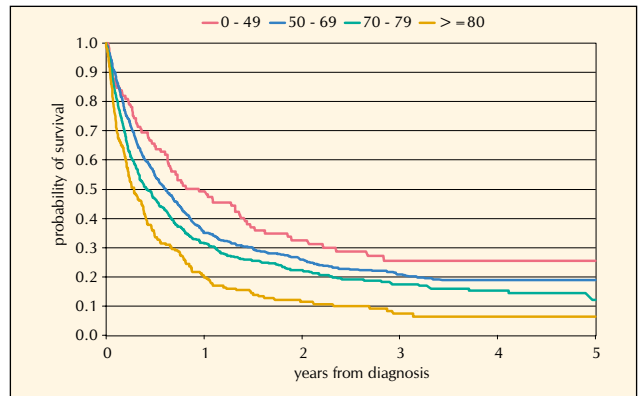


**CONTINUED** Figure 10.2 Crude survival by age group

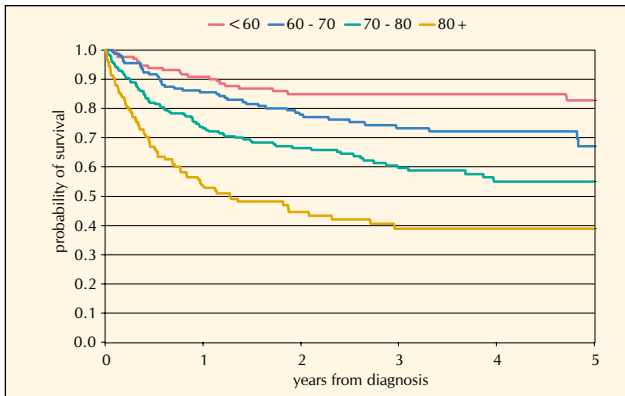
stomach female



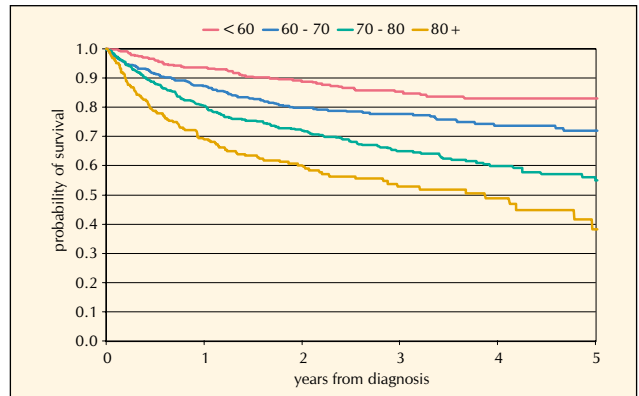
stomach male



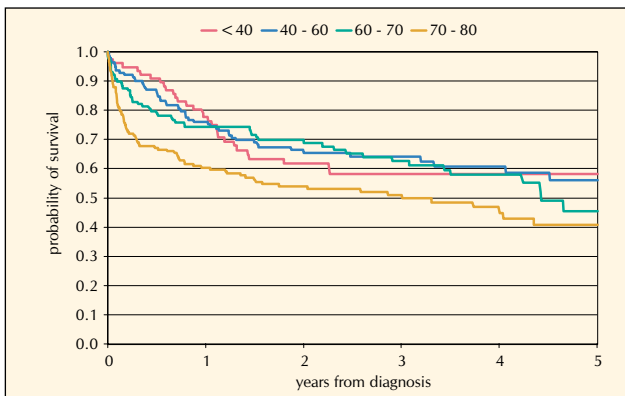
bladder female



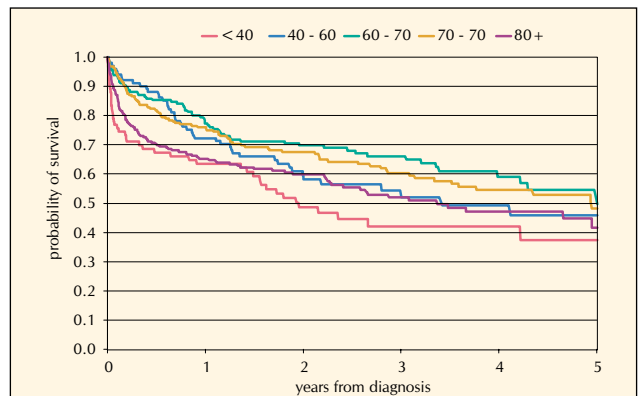
bladder male



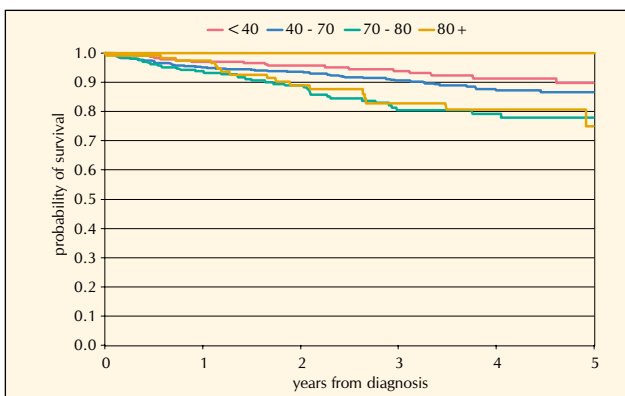
leukaemia female



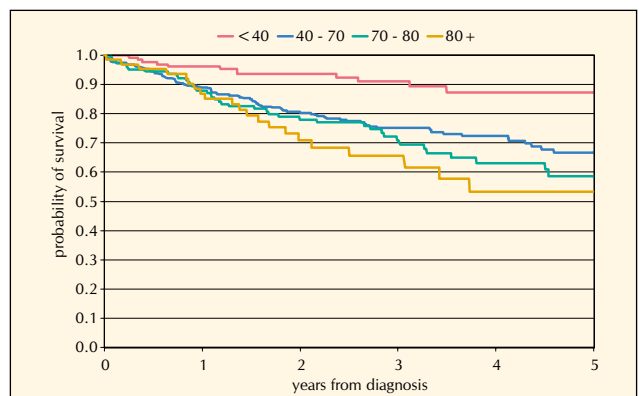
leukaemia male



melanoma female



melanoma male



### 10.3.3. Cancer survival by stage

The survival plots presented in Figure 10.1 and Figure 10.2 are useful indicators of the impact of cancer on population survival. However, for a given patient, an important prognostic factor is the stage of disease at diagnosis. Hence it is important to consider stage in order to obtain estimates of prognosis that are clinically useful. In this section, we will investigate the stage-specific survival. For prostate cancer we will use grade and, for leukaemia, cell type (lymphoid, myeloid, other) instead of stage, as these are more useful prognostic factors.

The stratified Kaplan-Meier survival plots are presented in Figure 10.3. For all cancers, stage IV carries a very poor prognosis, as is well known.

- For melanoma, lung cancer and bladder cancer in females the prognosis for stage III was not much better than stage IV, and this pattern was also seen for grade III and IV prostate cancer.
- For colorectal cancer, breast cancer and lymphoma (particularly lymphoma in males) stages I, II and III have gradually deteriorating survival, but are clearly better than stage IV, while for stomach cancer the four stages yield approximately equally spaced survival curves.
- Bladder cancer was an interesting exception, with stage III carrying a poor prognosis for women (similar to stage IV) but a reasonably good prognosis for men (similar to stage II).
- Lymphoid leukaemia has the best prognosis, and myeloid the worst, with other leukaemia types having intermediate survival, although closer to that of myeloid.

To adjust for sex differences, and the age differences already presented in Figure 10.2, we used Cox regression to estimate the adjusted hazard ratio for stage 2, 3 and 4 cancer relative to stage 1 and the results of this analysis are presented in Table 10.4 and 1.5.

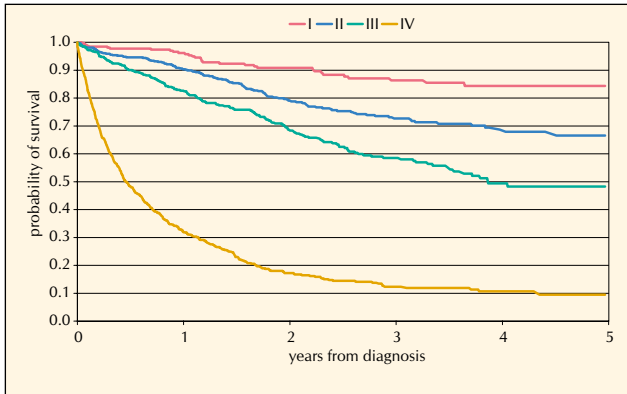
Table 10.4 Hazard ratios (95% confidence intervals) for cancer stage, adjusted for age and sex effects

CANCER TYPE	Hazard Ratios (95% C.I.) relative to stage I		
	Stage II	Stage III	Stage IV
colorectal	1.9 (1.5, 2.5)	3.7 (2.9, 4.7)	17.6 (14.0, 22.0)
lung	1.4 (1.0, 1.9)	2.4 (2.0, 3.0)	5.2 (4.3, 6.2)
breast	1.9 (1.3, 2.6)	4.9 (3.4, 7.1)	20.7 (15.0, 28.0)
stomach	2.2 (1.4, 3.4)	3.6 (2.4, 5.4)	9.7 (6.7, 14.1)
bladder	2.7 (1.5, 4.7)	7.5 (3.7, 15.5)	15.8 (9.6, 25.9)
melanoma	1.7 (0.8, 3.5)	12.3 (5.1, 29.5)	25.2 (13.1, 48.7)
lymphoma	1.3 (1.0, 1.6)	1.7 (1.3, 2.2)	2.7 (2.2, 3.4)
Hazard Ratios (95% C.I.) relative to grade 1			
	Grade 2	Grade 3	Grade 4
prostate	1.8 (1.5, 2.2)	3.8 (3.2, 4.6)	5.5 (3.8, 8.0)
Hazard Ratios (95% C.I.) relative to lymphoid leukaemia			
	Myeloid	Others	
leukaemia	6.4 (3.4, 11.9)	3.4 (2.8, 4.0)	

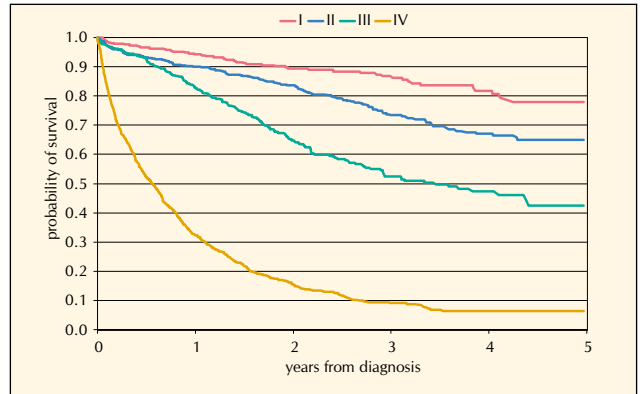
Note: All effects are statistically significant ( $p \leq .001$ ) except stage II melanoma ( $p = .17$ ) and stage II lymphoma ( $p = .07$ ).

Figure 10.3 Crude survival: by site and stage

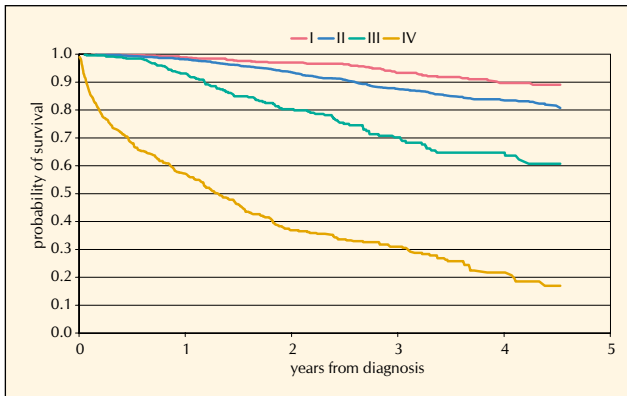
colorectal female



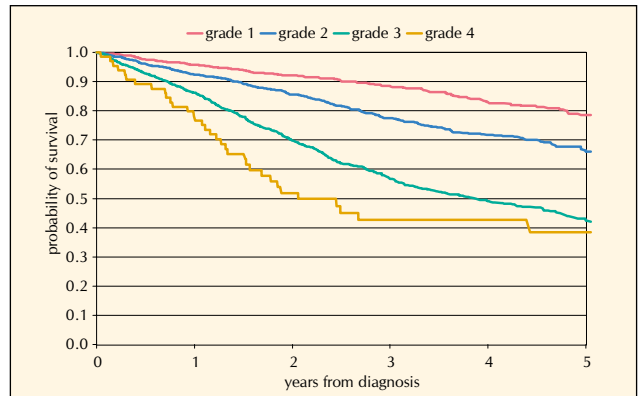
colorectal male



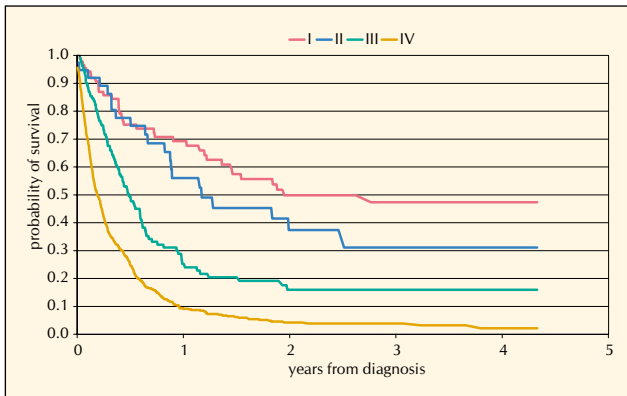
breast



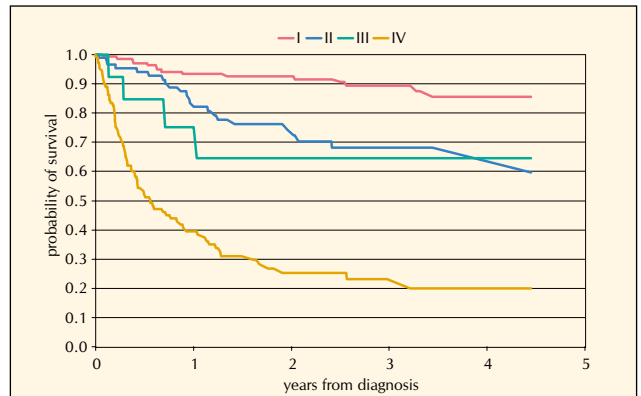
prostate



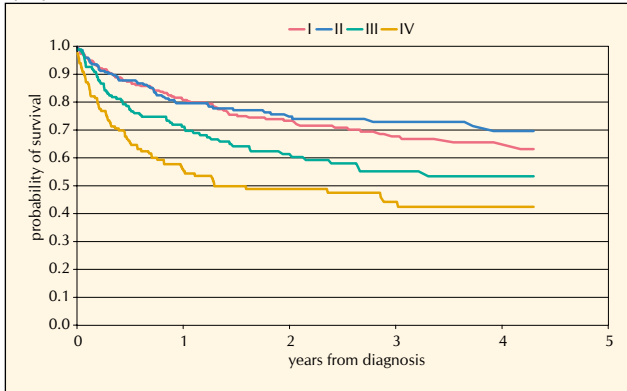
lung female



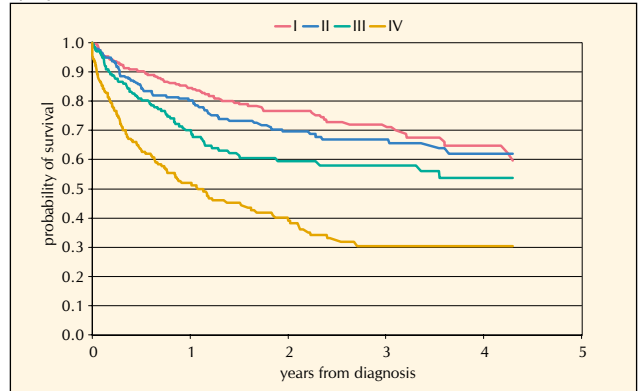
lung male



lymphoma female

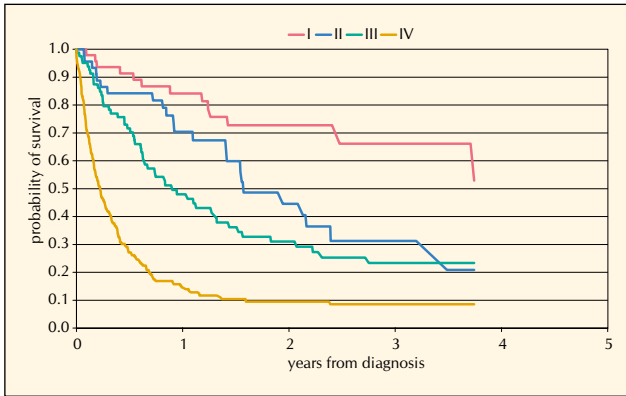


lymphoma male

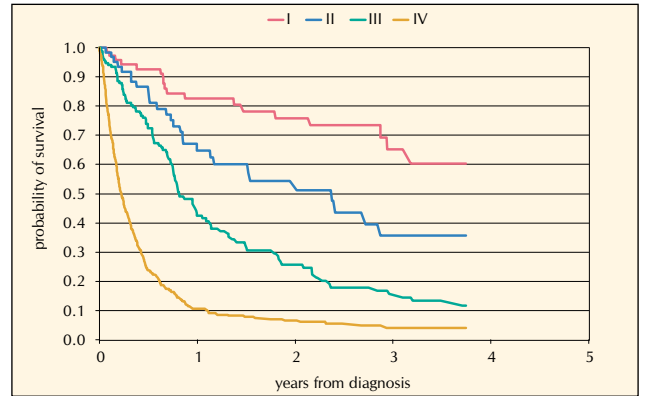


CONTINUED Figure 10.3 Crude survival: by site and stage

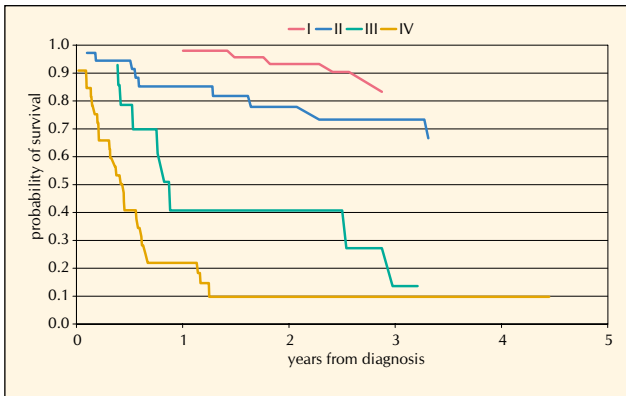
stomach female



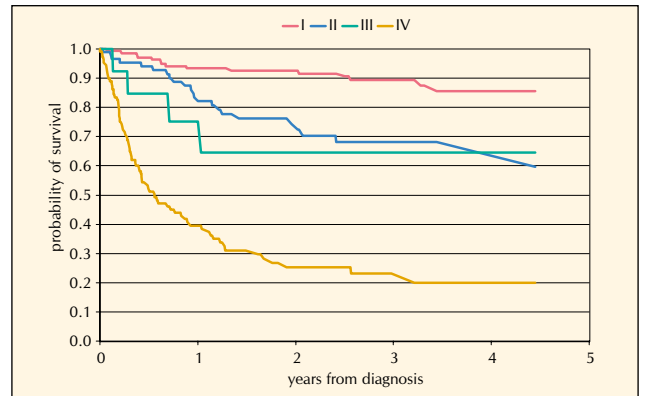
stomach male



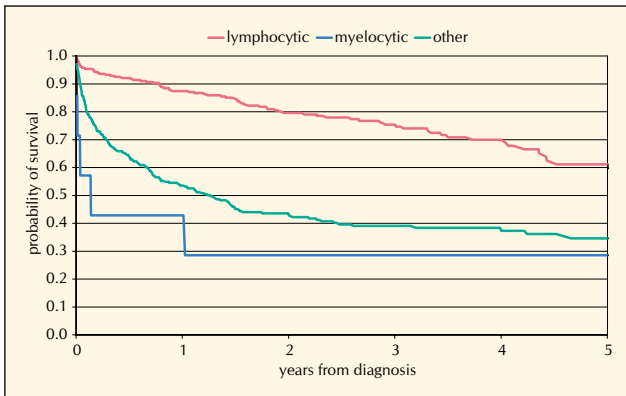
bladder female



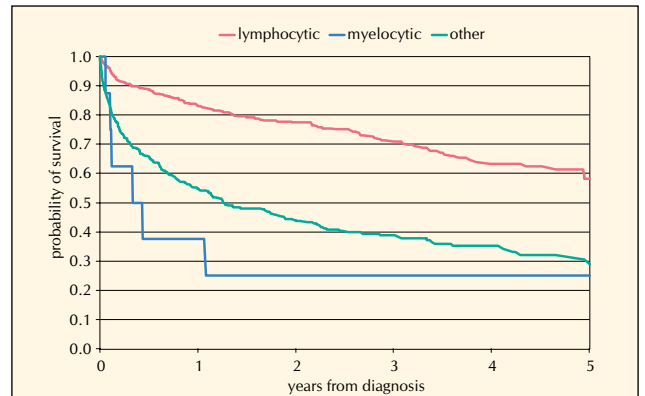
bladder male



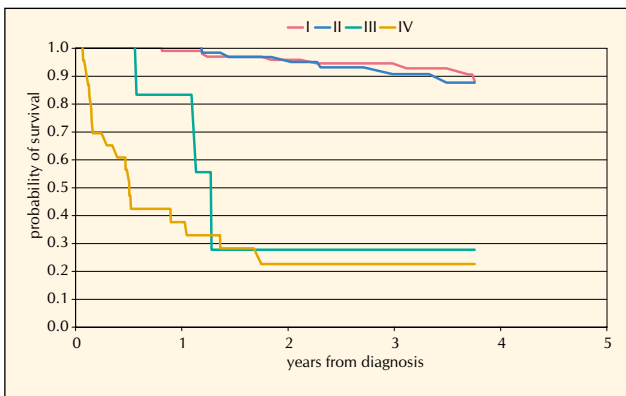
leukaemia female



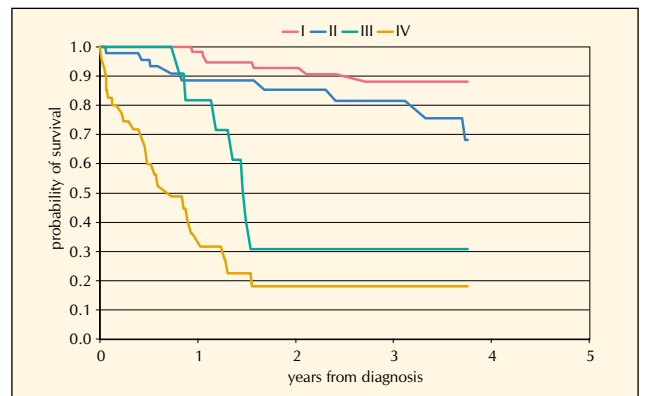
leukaemia male



melanoma female



melanoma male



## 10.4. Relative Survival

It is of interest to compare the survival of cancer patients to the overall survival of the Irish population. Such a comparison is made by the use of “relative survival” methods. In computing relative survival, we consider all – cause mortality in the cancer patients and in the general population. This contrasts with the Kaplan-Meier and Cox regression survival analyses presented earlier in this chapter where cancer mortality was studied and deaths due to other causes were “censored”. Thus relative survival offers a very useful tool for the study of the impact of cancer on mortality in situations where cause-of-death information is incomplete or unreliable. At the National Cancer Registry the cause-of-death information is effectively complete, but it is nonetheless useful and interesting to study relative survival, both for the context it provides for the impact of cancer in Ireland, and for the potential to compare with relative survival in other countries. The relative survival can be understood as the reduction in survival that is attributable to cancer. For example, a 5-year relative survival of 74% for breast cancer patients indicates that the probability of a woman diagnosed with breast cancer surviving 5 years is 74% of the 5-year survival probability for women without cancer (see section A2.6.11).

Of the 38643 records used in the previous sections, 133 had no known date of birth, and had to be excluded from relative survival calculations (see section A2.1.3) so the final data set for relative survival analysis had 38510 records (Table 10.5).

Table 10.5 Records used in relative survival analysis

CANCER TYPE	SEX		
	female	male	both sexes
number of records	18006	20504	38510
number of deaths	7619	12094	19713

The relative survival estimates, stratified by sex, for the various cancers are presented in Table 10.6 and Figure 10.4. The pattern observed in the relative survival was similar to that seen for cancer survival in Figure 10.1.

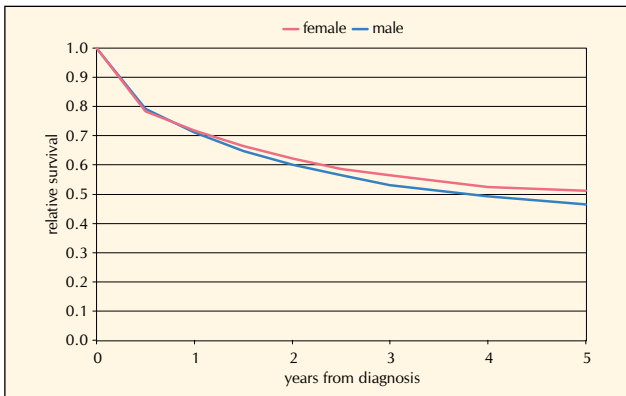
- Lung cancer had the poorest relative survival with stomach cancer being marginally better (5-year relative survival approx. 10% and 20% respectively), with most of the mortality occurring in the first 1 – 2 years after diagnosis.
- In contrast, prostate cancer, breast cancer, bladder and lymphoma had much more gradual and uniform mortality with relative survival at 5-years being 60% – 70%.
- Colorectal cancer and leukaemia had slightly worse relative survival (approx. 50% and 40% at five years respectively) with much of this mortality occurring in the first two years.
- Women had a small relative survival advantage for all cancers except bladder, although this difference was negligible for lung cancer, stomach cancer and leukaemia. For bladder cancer, women had slightly worse relative survival, consistent with the results from the cancer survival analysis presented earlier.

Table 10.6 One year (five year) relative survival by sex

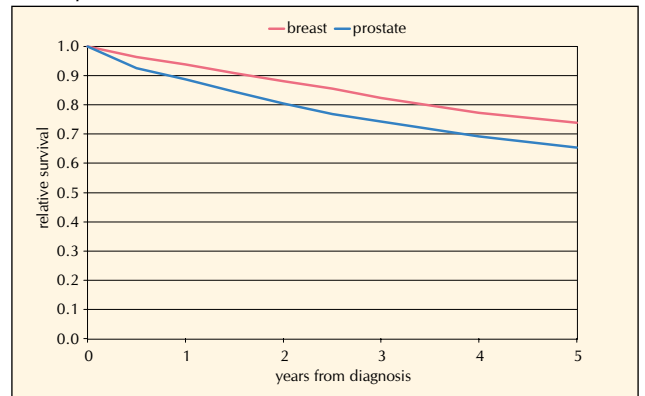
	FEMALE	MALE
colorectal	76.6 (53.9)	75.9 (48.2)
breast	95.2 (74.2)	
lung	27.9 (11.0)	27.7 (8.7)
prostate		91.2 (65.9)
lymphoma	77.7 (63.5)	75.0 (56.3)
stomach	38.2 (22.5)	35.6 (17.0)
bladder	81.5 (70.2)	86.6 (74.1)
leukaemia	73.4 (48.3)	73.2 (45.1)
melanoma	96.6 (89.7)	93.4 (75.7)

Figure 10.4. Relative survival, by sex and site

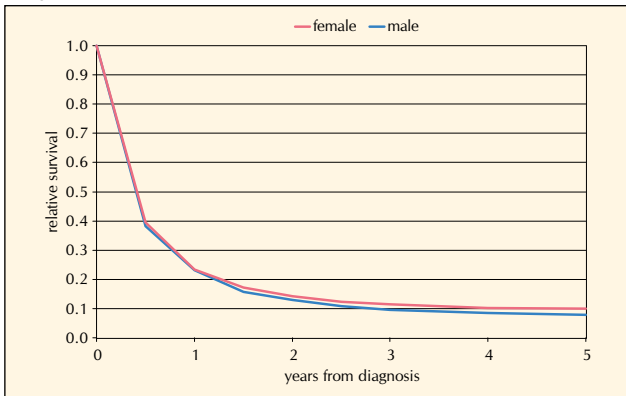
colorectal



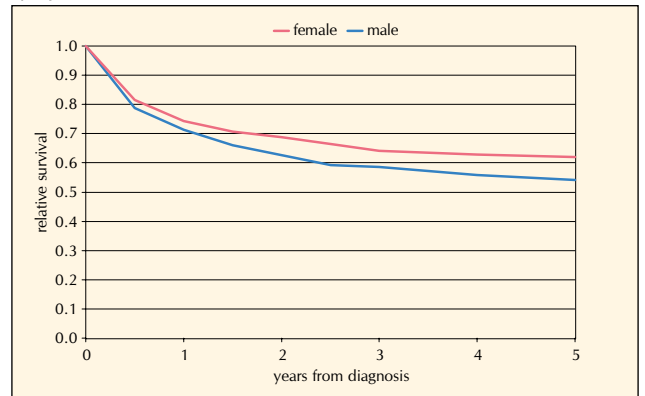
breast/prostate



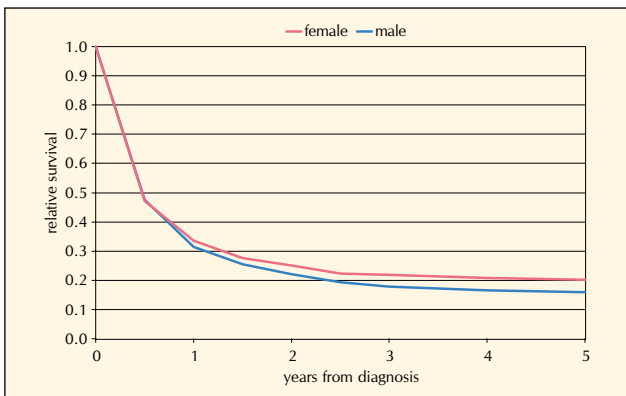
lung



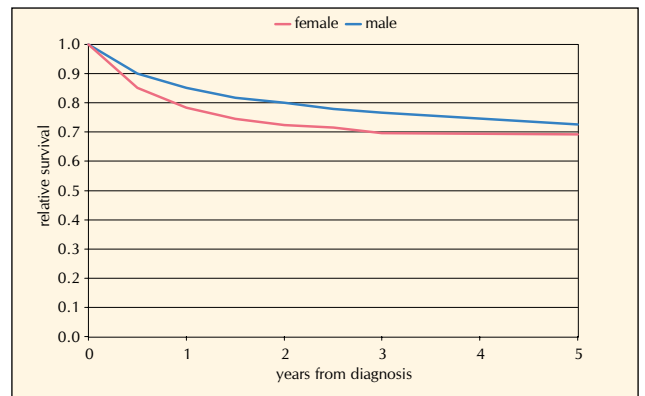
lymphoma



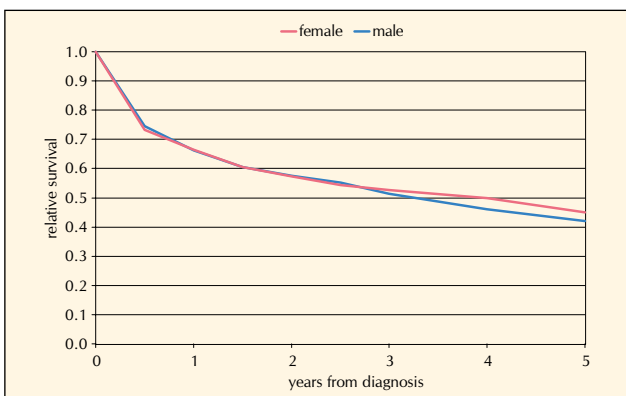
stomach



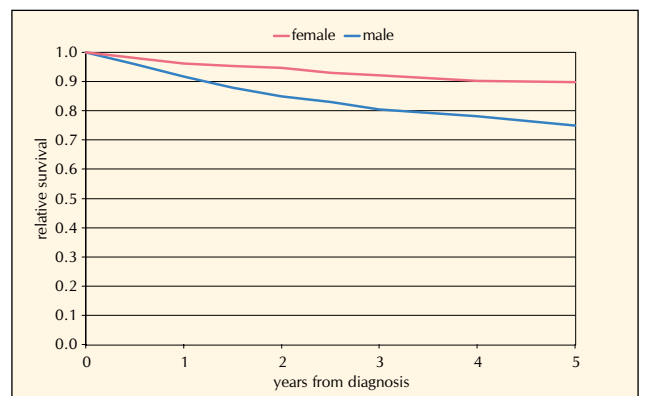
bladder



leukaemia



melanoma



### 10.4.1. Relative survival by stage

Relative survival curves, stratified by stage, are presented in Figure 10.5 for all of the cancers except melanoma, where the data were too sparse to provide meaningful estimates of stage-specific estimates. The data in these curves are summarized in Table 10.7, which shows five-year survival figures by site, sex and stage.

In keeping with the stage-specific survival presented earlier (Figure 10.2), stage IV cancers had poor relative survival for all cancers.

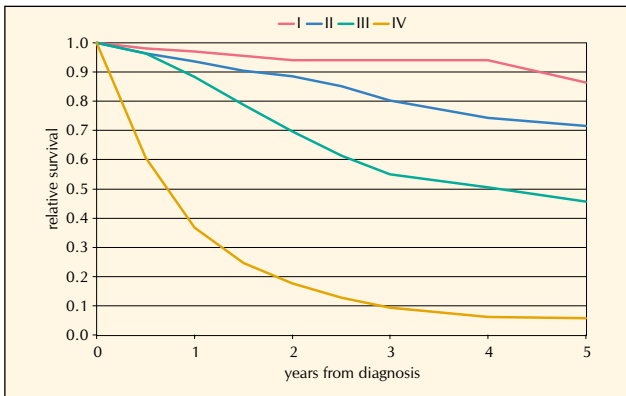
- For male lung cancer and female bladder cancer, stage 3 does not offer much improvement in relative survival over stage IV, and a similar pattern holds for grade 3 and 4 prostate cancer.
- For colon cancer, breast cancer, lymphoma and male bladder cancer, stages I to III have clearly better prognosis than stage IV with the drop in relative survival between stages II and III being somewhat worse than between stages I and II.
- For stomach cancer, the relative survival curves for the four stages are approximately equally spaced, with the exception of stage II cancer for females which has a relative survival that drops sharply after 1 – 2 years to become similar to that for stage III cancer.
- As before, we see the different survival pattern for males and females with bladder cancer, with females with stage III cancer having very poor prognosis.

Table 10.7 Relative survival: by site, stage and sex

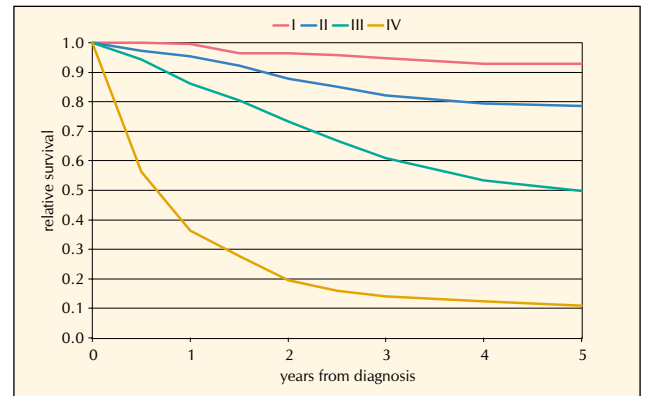
	FEMALE				MALE			
	I	II	III	IV	I	II	III	IV
colorectal	92.8%	78.5%	49.9%	10.9%	86.4%	71.7%	45.7%	5.8%
breast	90.9%	81.2%	60.9%	20.1%				
lung	49.0%	22.9%	11.5%	2.4%	34.4%	21.8%	4.9%	2.6%
lymphoma	49.0%	22.9%	11.5%	2.4%	34.4%	21.8%	4.9%	2.6%
stomach	66.3%	13.5%	22.1%	7.2%	62.9%	43.3%	13.4%	2.1%
bladder	98.1%	61.4%	11.6%	10.6%	93.8%	72.8%	45.2%	15.8%
	lymphoid	myeloid	other		lymphoid	myeloid	other	
leukaemia	65.0%	32.0%	38.6%		61.3%	24.5%	33.8%	
					GRADE 1	GRADE 2	GRADE 3	GRADE 4
prostate					89.3%	77.0%	49.2%	51.2%

Figure 10.5 Relative survival; by site and stage

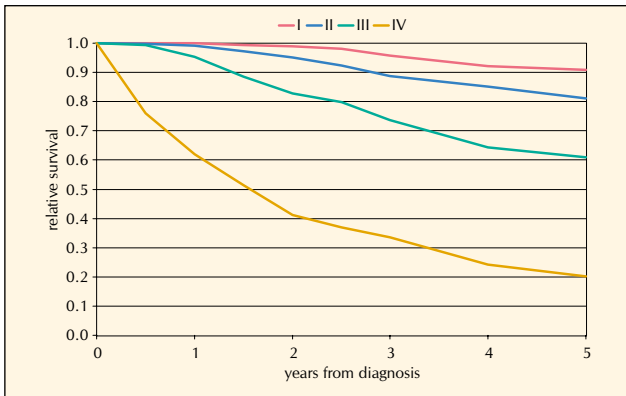
colorectal female



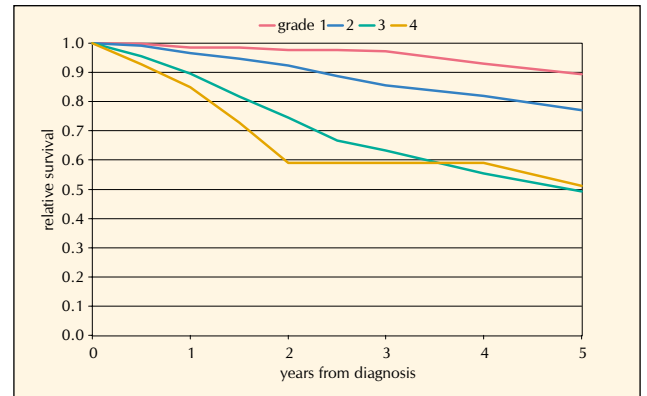
colorectal male



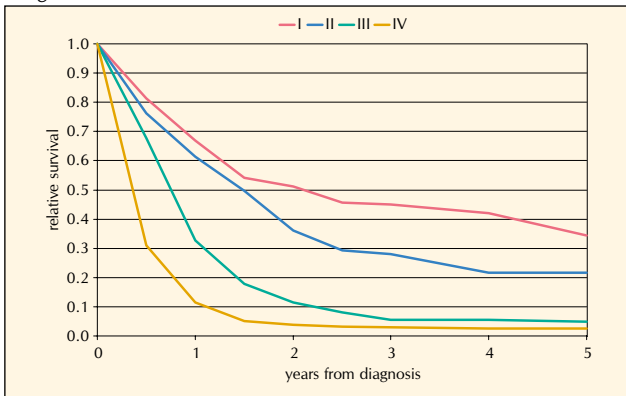
breast



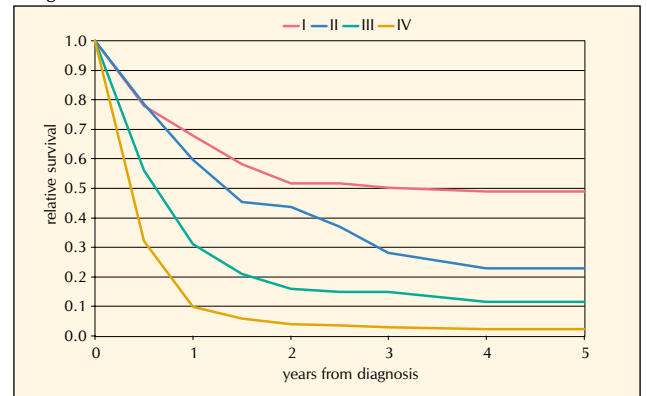
prostate



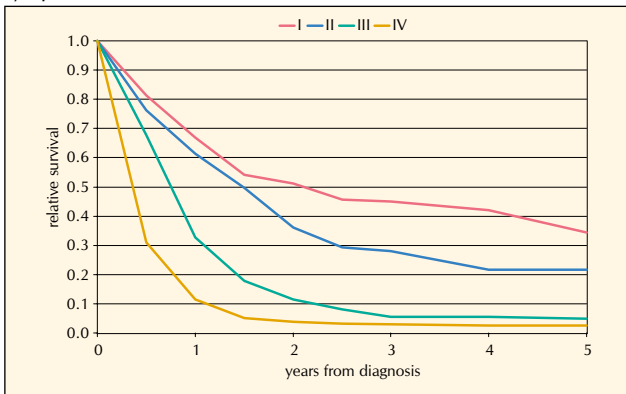
lung female



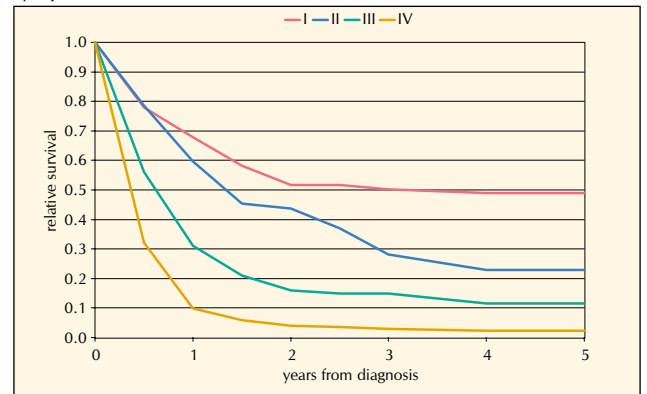
lung male



lymphoma female

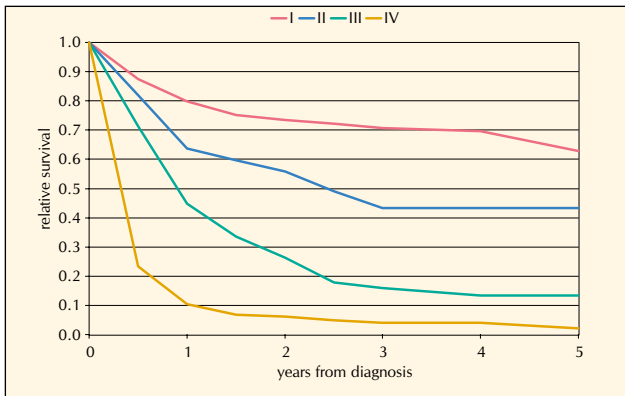


lymphoma male

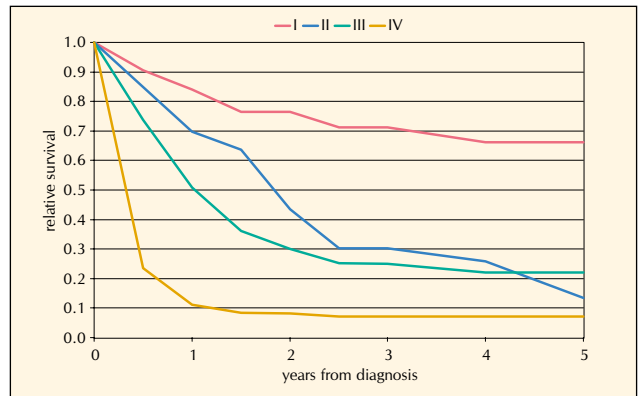


**CONTINUED** Figure 10.5 Relative survival; by site and stage

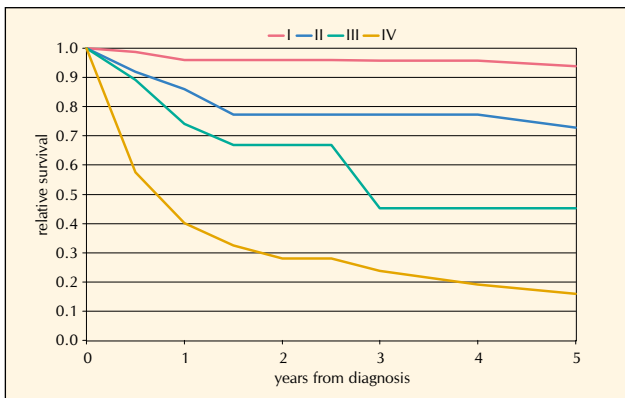
stomach female



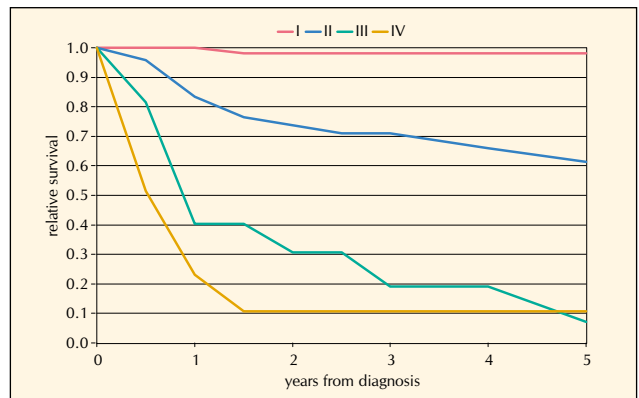
stomach male



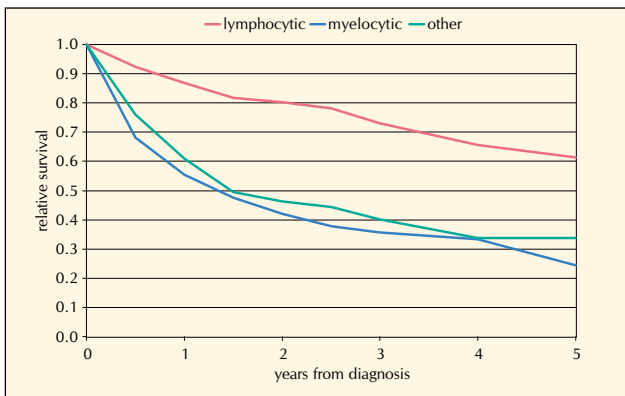
bladder female



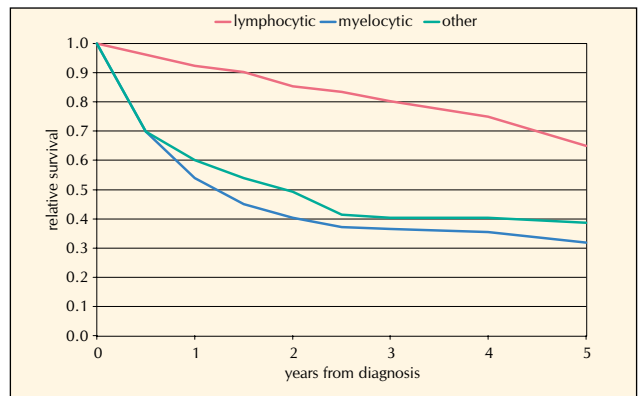
bladder male



leukaemia female



leukaemia male



#### 10.4.2. Changes in relative survival over time

To examine whether relative survival was improving over time, we compared the stage-specific one-year and two-year relative survival for cancers diagnosed in 1994 – 1995 with those diagnosed in 1996 – 1997. The results of this analysis for the more common cancers are presented in Table 10.8, and suggest a trend of improvement in relative survival between the periods 1994 – 95 and 1996 – 97 for male colorectal cancer (but not for females) and in one-year relative survival for male and female stage I lung cancer.

Further analysis by age (data not shown) revealed a small improvement in the one-year relative survival as year of incidence went from 1994 to 1997

- for males aged under 70 with colorectal cancer,
- for prostate cancer
- for lung cancer in females under 70.

These observations suggest that male colorectal cancer may have been more successfully treated in recent years, and that some small improvement in treatment of stage I lung cancer may be conferring a small increase in relative survival.

However, these results are only tentative as the Registry has only five years of complete data, which is a very short time span for studies of time trends in prognosis. Furthermore, the numbers of cancers and deaths for a specific stratum (cancer site, calendar year of diagnosis, and stage) are small, so that there is insufficient power to ascertain with confidence if observed trends are real. Further analysis of this nature will become more meaningful as data accrues over the coming years and it is reasonable to expect that a 10 – year analysis should show improvements in prognosis over time. A 10 – year interval not only provides more data for analysis but it is a meaningful time span in terms of advancements in cancer treatment.

Table 10.8 Comparison of one-year and two-year relative survival for cancers diagnosed in 1994 – 1995 and 1996 – 1997.

			STAGE I	STAGE II	STAGE III	STAGE IV
colorectal	male					
	1 – year	94 – 95	.95	.95	.83	.37
		96 – 97	.98	.95	.93	.36
	2 – year	94 – 95	.89	.89	.62	.16
		96 – 97	.97	.88	.77	.16
	female					
	1 – year	94 – 95	1.00	.95	.87	.34
		96 – 97	.95	.95	.85	.32
	2 – year	94 – 95	.98	.84	.72	.17
		96 – 97	.92	.87	.69	.19
lung	male					
	1 – year	94 – 95	.60	.59	.36	.09
		96 – 97	.74	.58	.34	.12
	2 – year	94 – 95	.46	.37	.16	.04
		96 – 97	.52	.18	.11	.02
	female					
	1 – year	94 – 95	.69	.62	.28	.09
		96 – 97	.74	.58	.28	.11
	2 – year	94 – 95	.60	.56	.17	.03
		96 – 97	.46	.33	.15	.05
breast	female					
	1 – year	94 – 95	1.00	.99	.95	.62
		96 – 97	1.00	.99	.95	.59
	2 – year	94 – 95	.98	.95	.77	.44
		96 – 97	.99	.94	.84	.34
prostate			GRADE 1	GRADE 2	GRADE 3	GRADE 4
	1 – year	94 – 95	.99	.96	.90	.79
		96 – 97	.98	.97	.88	.86
	2 – year	94 – 95	.98	.89	.72	.52
		96 – 97	.96	.93	.72	.55

