



Cancer survival increases in Europe, but international differences remain wide

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Abstract

The EURO CARE project analysed cancer survival data from 45 population-based cancer registries in 17 European countries, revealing wide international differences in cancer survival. We calculated 5-year relative survival for 1 836 287 patients diagnosed with one of 13 cancers during the period 1978–1989. The data, from 20 cancer registries in 13 countries, were grouped into four regions: Finland, Sweden, Iceland (Northern Europe); Denmark, England and Scotland (UK and Denmark); France, The Netherlands, Germany, Italy and Switzerland (Western Europe); Estonia and Poland (Eastern Europe), and broken down into four periods (1978–1980, 1981–1983, 1984–1986, 1987–1989). For each cancer, mean European and regional survival was estimated as the weighted mean of 5-year relative survival in each country. Survival increased with time for all tumours, particularly for cancers of testis (12% increase, i.e. from 79.9 to 91.9%), breast, large bowel, skin melanoma (approximately 9–10%), and lymphomas (approximately 7%). For most solid tumours, survival was highest in Northern Europe and lowest in Eastern Europe, and also low in the UK and Denmark. Regional variation was less marked for the lymphomas. Survival improved more in Western than Northern Europe, and the differences between these regions fell for bowel cancer (from 8.0% for those diagnosed in 1978–1980 to 2% for those diagnosed in 1987–1989), breast cancer (from 7.4% to 3.9%), skin melanoma (from 13.4% to 11.0%) and Hodgkin's disease (from 7.2 to 0.6%). For potentially curable malignancies such as Hodgkin's disease, large bowel, breast and testicular cancers, there were substantial increases in survival, suggesting an earlier diagnosis and more effective treatment. The persisting regional differences suggest there are corresponding differences in the availability of diagnostic and therapeutic facilities, and in the effectiveness of healthcare systems. © 2001 Elsevier Science Ltd. All rights reserved.

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1. Introduction

Population-based cancer survival figures are key indicators of the overall effectiveness of healthcare systems in managing cancer patients. Cancer registries are the

only source of this type of information [1]. EURO CARE is the first large-scale international project to compare cancer survival across Europe, using data from population-based cancer registries supplied according to a common protocol, with standardised quality control and analysis.

The EURO CARE project revealed wide international differences in survival among cancer patients diagnosed in 12 European countries between 1978 and 1985 [2], and among patients diagnosed in 17 European countries

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between 1985 and 1989 [3,4]. In this report, we present survival trends over the 17-year period up to the end of 1994, for patients diagnosed with one of 13 cancers during the period 1978–1989, both for Europe as a whole (the entire pool of cases) and for countries grouped into four broad geographical regions.

2. Patients and methods

We analysed survival trends by age and calendar period of diagnosis for 1 836 287 cancer patients aged 15–99 years from 13 European countries who were diagnosed between 1978 and 1989 and followed-up for at least 5 years. Data were contributed by 20 cancer registries selected as having at least 5 years of follow-up data for patients diagnosed at any time during 1980–1987, and preferably the whole period 1978–1989. Trends in survival were constructed from the results of primary analyses, published on CDROM [5]. Analyses were restricted to 13 major cancers: stomach, colon and rectum combined (large bowel), lung, melanoma of skin, breast (women only), cervix, ovary, prostate, testis, kidney, brain, Hodgkin's disease and non-Hodgkin's lymphoma. Most of these malignancies have a major impact on public health. They can be divided into those mainly treated by surgery (cancers of the digestive tract, breast and kidney, and melanoma of skin), those mainly treated by chemotherapy (the lymphomas), and those treated by combined therapies (ovary, prostate). Two less common tumours (testicular cancer, Hodgkin's disease) were selected for their curability: national survival rates for these tumours may be considered as an indicator of the overall effectiveness of a country's health-care system.

Detailed descriptions of the EURO CARE inclusion criteria, quality control methods, follow-up and statistical analyses have been published elsewhere [2,4]. The proportion of the national population covered by the contributing cancer registries ranged from 100% for Finland, Iceland, Denmark, Estonia and Scotland, to less than 20% for Sweden, The Netherlands, Germany, Switzerland, France, Italy and Poland. Sweden has a national registry, but only data for Southern Sweden were included here. England also has national coverage, but the participating registries represented only 50% of the population.

Relative survival expresses the probability of cancer survival after adjustment for competing causes of death. Age-, sex- and country-specific 5-year relative survival rates were estimated for each cancer as the ratio of the observed (crude) survival to the expected survival for the corresponding general population of the same age and sex, using the Hakulinen method [6]. Age-specific mortality rates for each year of age at death were taken from general population life tables, or estimated from

5-year (abridged) life tables, for each country or region and calendar period. Overall survival rates (for all adults aged 15–99 years at diagnosis) for each country or region were standardised to the age distribution of all cases included in the Europe-wide analyses for a given cancer, using four age groups (15–44 years, 45–54 years, 55–64 years and 65–99 years); age-standardised survival rates for a given country could only be calculated if there was at least one case in every age class. Overall survival comparisons for each cancer thus take due account of international differences in the background mortality of the general population, and in the age distribution of cancer patients. Survival rates are also presented for two broad age groups: age 15–54 years and age 65–99 years at diagnosis.

European average survival rates for each cancer were estimated for patients diagnosed in each of four consecutive 3-year periods (1978–1980, 1981–1983, 1984–1986, 1987–1989), as a weighted mean of the relative survival rates for each country, using the estimated annual number of cases in each country over the whole period of 1978–1989 as weightings.

Data from the 13 countries were grouped into four geographical regions characterised by similar patterns of survival: Finland, Sweden, Iceland (Northern Europe); France, The Netherlands, Germany, Italy and Switzerland (Western Europe); Estonia and Poland (Eastern Europe); Denmark, England and Scotland [4]. Weighted mean survival rates were calculated for each region, using the estimated annual number of cases in each country in that region as weightings. Detailed analyses of time trends in survival by country are given elsewhere [7].

Standard errors of the weighted survival rates were calculated, for both Europe and European regions, as the square root of the weighted mean of the corresponding variances.

World-standardised mortality rates for each country included in this study were obtained from the World Health Organization (WHO) database [8]. Countries were grouped as for the survival analysis, except Eastern Europe, where the mortality trend analysis was performed for Poland only, since mortality data for Estonia were only available from 1990.

3. Results

For each of the 13 cancers considered, the European average 5-year survival rate was approximately 2–12% higher for adults diagnosed in 1987–1989 than for those diagnosed in 1978–1980, an average of 9 years earlier (Table 1). The largest absolute increases were for cancers of the testis (12.0%, from 79.9 to 91.9%), large bowel (10.3%), breast (8.9%), skin melanoma (8.6%) and Hodgkin's disease (7.5%). The average 5-year sur-

vival rate in Europe increased by approximately 4–7% for cancers of the prostate, stomach, ovary and kidney, and for non-Hodgkin's lymphoma. Survival rates for cancers of the lung, brain and cervix each rose by only 1.6% over the same period, and the average 5-year survival rate for lung cancers was still below 10% for patients diagnosed in 1987–1989.

Older patients (aged 65–99 years at diagnosis) generally had a lower survival than younger patients (15–54 years). Gains in survival were more marked among younger patients for tumours of ovary, kidney and brain, melanoma of the skin and for non-Hodgkin's lymphoma. Improvements were more marked among older patients, however, for cancers of stomach, breast, prostate, cervix and testis (55–99 years), and for Hodgkin's disease. The small overall increase of 1.6% for cervical cancer conceals diverse age-specific trends (+3.8% for women aged 15–44 years, –1.0% for those aged 45–54 years, –6.2% for those aged 55–64 years and +4.5% for those aged 65–99 years). For cancers of the large bowel and lung, gains in survival were similar in younger and older patients.

Survival was generally highest in Northern Europe, followed by Western Europe, Denmark and the UK, and the Eastern European countries of Estonia and Poland. Trends in age-adjusted 5-year survival varied widely in the four regions (Table 2). Cancer survival improved in all four regions, but most of the regional differences persisted, with the exception of those between Northern and Western Europe, which narrowed over time for most cancers. Survival in Northern

Europe was already high for patients diagnosed in 1978–1980, and it increased steadily, but increases in survival were greater in Western Europe for tumours of the stomach, large bowel, breast and kidney, Hodgkin's disease and for melanoma of the skin. For patients diagnosed with these tumours during 1987–1989, the survival differences between Western and Northern European countries were lower than for patients diagnosed 9 years earlier. Survival also increased in Denmark and the UK, but more slowly than in Western Europe. In the Eastern European countries, improvements in survival were generally modest, although survival rose sharply for breast cancer and melanoma of the skin and, in Estonia, for non-Hodgkin's lymphomas. Regional trends are not shown in Table 2 for cancers of the lung or brain, because there was little change in survival, or for testicular cancer, because age-standardisation was not possible for some countries.

Five-year survival from stomach cancer rose by 7.5% in Western Europe, to 24.2% for patients diagnosed in 1987–1989, but by only 1.8% in Northern Europe (to 19.0%). The largest increase in survival for bowel cancer also occurred in Western Europe (12.0% increase to 49.8%), but a consistent increase was also seen in Northern Europe (6.3% increase to 52.1%). For melanoma, survival increased most in Eastern Europe (by 12.3%), but the 5-year survival rate of 61.5% for patients diagnosed in 1987–1989 was still 10–20% lower than in the other European regions. Five-year survival from breast cancer increased by a remarkable 24.8% in Eastern Europe (from 31.0 to 55.8%), but survival for

Table 1

Changes in cancer survival^a up to 1994 among adults in Europe, by broad age group at diagnosis: number of patients, 5-year relative survival (%) and standard error (S.E.)

Tumour	Patients diagnosed 1978–1980				Patients diagnosed 1987–1989				Difference 1987–1989 versus 1978–1980		
	No. of patients	All ages % (S.E.)	Age 15–54 years % (S.E.)	Age 65–99 years % (S.E.)	No. of patients	All ages % (S.E.)	Age 15–54 years % (S.E.)	Age 65–99 years % (S.E.)	All ages	Age 15–54 years	Age 65–99 years
Stomach	29086	15.0 (0.7)	28.6 (2.3)	12.4 (1.0)	26095	21.0 (0.8)	31.0 (2.8)	18.4 (1.3)	6.0	2.4	6.1
Large bowel	56150	36.6 (0.9)	45.6 (2.3)	34.4 (1.5)	66737	47.0 (0.9)	54.6 (2.5)	45.0 (1.6)	10.3	9.1	10.5
Lung	74120	7.1 (0.3)	12.9 (0.9)	5.1 (0.5)	78271	8.7 (0.3)	14.4 (1.0)	6.6 (0.6)	1.6	1.4	1.5
Melanoma of skin	6768	68.5 (1.8)	72.0 (2.5)	63.9 (5.6)	11890	77.1 (1.3)	81.5 (1.9)	71.5 (5.0)	8.6	9.5	7.6
Breast (women)	52959	64.6 (0.6)	68.8 (1.1)	60.5 (1.6)	67918	73.5 (0.6)	75.6 (1.1)	70.9 (1.5)	8.9	6.7	10.3
Cervix uteri	9996	59.8 (1.2)	68.7 (2.2)	42.8 (3.4)	10575	61.4 (1.3)	71.7 (2.2)	47.8 (3.8)	1.6	3.0	4.5
Ovary	10994	28.2 (1.3)	42.7 (2.7)	19.1 (2.8)	12889	31.7 (1.1)	52.2 (3.0)	18.9 (2.3)	3.5	9.5	–0.2
Prostate	22933	53.1 (1.6)	58.4 (2.4)	50.5 (3.7)	32721	58.3 (1.2)	59.7 (2.0)	55.4 (2.7)	5.2	1.3	5.0
Testis ^b	2514	79.9 (1.9)	82.1 (2.1)	58.0 (11.7)	3521	91.9 (1.4)	92.5 (1.5)	86.6 (8.8)	12.0	10.4	28.7
Kidney	8107	40.9 (2.0)	50.5 (3.4)	36.4 (4.1)	11292	47.5 (1.5)	59.2 (3.4)	40.3 (3.1)	6.6	8.7	3.9
Brain	5960	16.3 (1.2)	29.4 (2.9)	5.6 (3.0)	7575	17.9 (1.3)	34.6 (3.5)	5.7 (3.0)	1.6	5.2	0.1
Hodgkin's disease	3244	61.9 (1.8)	76.2 (2.6)	25.0 (6.8)	3280	69.4 (2.4)	80.9 (2.8)	38.8 (8.8)	7.5	4.8	13.8
Non-Hodgkin's lymphoma	9127	41.4 (1.7)	54.7 (3.2)	34.4 (3.8)	14975	48.6 (1.3)	63.7 (2.9)	37.4 (2.7)	7.2	9.0	2.9

^a Five-year relative survival (%) among adults aged 15–99 years at diagnosis: European average, weighted by the number of cases in each country. All-ages survival rates are standardised to the age distribution of all cases included in the analysis for a given cancer, using four age groups (15–44 years, 45–54 years, 55–64 years and 65–99 years).

^b Upper age group for testicular cancer was 55–99 years.

women diagnosed in 1987–1989 was still at least 12% lower than in other regions of Europe. More modest increases in breast cancer survival occurred in Western Europe (by 8.6%) and in Northern Europe, Denmark

and the UK (by approximately 5%), but breast cancer survival remains highest in Northern Europe (80.5%). For cancer of the cervix, the only substantial increase occurred in Denmark and the UK (6.1%), but 5-year

Table 2

Regional trends in survival up to 1994 for 10 cancers: 5-year age-standardised relative survival rate (%) and standard error (S.E.)

Cancer	Region ^a	Calendar period of diagnosis				Difference	
		1978–1980	1981–1983	1984–1986	1987–1989	1987–1989 versus 1978–1980	
		Rate (S.E.)	Rate (S.E.)	Rate (S.E.)	Rate (S.E.)	Survival	Mortality ⁱ
Stomach	Northern Europe	17.2 (1.4)	18.8 (1.4)	18.4 (1.4)	19.0 (1.5)	1.8	–38
	Denmark and UK	8.6 (0.3)	10.0 (0.3)	11.2 (0.4)	12.0 (0.4)	3.4	–30
	Western Europe	16.7 (1.3)	20.0 (1.3)	23.0 (1.5)	24.2 (1.8)	7.5	–31
	Eastern Europe	12.4 (1.8)	6.2 (1.3)	10.6 (2.0)	11.9 (1.9)	–0.5	–26 ^e
Large bowel	Northern Europe	45.8 (1.8)	49.0 (1.8)	50.1 (1.8)	52.1 (1.7)	6.3	–5
	Denmark and UK	34.8 (0.5)	37.5 (0.5)	39.4 (0.5)	41.9 (0.5)	7.1	–3
	Western Europe	37.8 (2.1)	41.1 (2.1)	46.7 (2.0)	49.8 (2.2)	12.0	–2
	Eastern Europe	21.3 (3.9)	13.3 (2.5)	19.9 (3.2)	23.0 (3.4)	1.7	12 ^h
Melanoma of the skin	Northern Europe	81.8 (2.2)	81.4 (2.1)	83.9 (1.7)	87.6 (1.6)	5.8	10
	Denmark and UK	70.4 (1.2)	72.5 (1.0)	75.9 (0.9)	79.9 (0.7)	9.5	18
	Western Europe	68.4 (4.8)	69.4 (4.5)	75.4 (3.8)	76.6 (3.7)	8.2	20
	Eastern Europe	49.2 (4.4)	53.5 (4.3)	55.1 (4.6)	61.5 (3.4)	12.3	23 ^g
Breast	Northern Europe	75.4 (1.1)	75.9 (1.1)	77.8 (1.1)	80.5 (1.0)	5.1	2
	Denmark and UK	62.9 (0.4)	64.4 (0.4)	65.0 (0.3)	67.8 (0.3)	4.9	4
	Western Europe	68.0 (1.6)	70.7 (1.5)	74.4 (1.4)	76.6 (1.5)	8.6	9
	Eastern Europe	31.0 (2.7)	51.7 (1.4)	56.2 (1.2)	55.8 (1.3)	24.8	7 ^h
Cervix	Northern Europe	64.2 (2.9)	64.5 (2.8)	66.6 (3.2)	64.6 (3.6)	0.4	–41
	Denmark and UK	55.8 (0.8)	58.3 (0.8)	60.2 (0.7)	61.9 (0.7)	6.1	–15
	Western Europe	64.9 (3.0)	61.7 (3.2)	64.8 (3.1)	65.2 (1.5)	0.3	–28
	Eastern Europe	48.4 (3.2)	55.6 (3.4)	49.6 (3.1)	49.4 (4.2)	1.0	–5 ^e
Ovary	Northern Europe	37.1 (2.3)	42.5 (2.2)	41.8 (2.2)	42.2 (3.6)	5.1	3
	Denmark and UK	25.8 (0.6)	28.9 (0.6)	29.6 (0.6)	30.3 (0.6)	4.5	2
	Western Europe	29.1 (3.2)	31.1 (3.1)	36.1 (3.0)	32.3 (4.2)	3.2	4
	Eastern Europe	23.4 (3.3)	25.8 (4.3)	22.6 (2.9)	26.2 (3.3)	2.8	na
Prostate	Northern Europe	59.1 (1.8)	59.2 (1.7)	61.9 (1.7)	66.1 (1.5)	7.0	–1
	Denmark and UK	43.6 (0.7)	43.4 (0.6)	45.1 (0.6)	43.3 (0.6)	–0.3	23
	Western Europe	56.6 (4.1)	56.3 (3.5)	55.6 (3.2)	63.5 (3.5)	6.8	10
	Eastern Europe ^e	34.7 (6.4)	31.3 (3.4)	32.1 (3.1)	42.6 (4.4)	7.9	14 ^e
Kidney	Northern Europe ^b	43.8 (2.5)	43.9 (2.4)	46.5 (2.4)	48.5 (2.3)	4.7	–4
	Denmark and UK	34.0 (1.1)	35.0 (1.0)	36.2 (0.9)	37.8 (0.9)	3.8	14
	Western Europe ^d	38.4 (3.8)	43.5 (3.7)	53.1 (3.4)	53.8 (3.6)	15.4	19
	Eastern Europe	27.3 (5.1)	21.3 (4.1)	19.6 (3.3)	19.8 (3.0)	–7.5	na
Hodgkin's disease	Northern Europe ^b	68.5 (3.6)	65.0 (4.4)	71.6 (3.3)	71.2 (3.2)	2.7	–705
	Denmark and UK	62.4 (1.2)	66.3 (1.2)	68.8 (1.2)	71.4 (1.2)	9.0	–37
	Western Europe ^c	61.3 (3.8)	61.1 (3.9)	66.4 (3.7)	71.8 (4.3)	10.5	–53
	Eastern Europe ^f	64.5 (8.3)	64.0 (6.8)	65.4 (6.7)	65.6 (6.9)	1.1	–4 ^h
Non-Hodgkin's lymphoma	Northern Europe ^b	36.3 (2.3)	42.1 (2.4)	47.7 (2.3)	47.3 (2.3)	11.0	–8
	Denmark and UK	38.2 (0.9)	40.2 (0.8)	42.4 (0.7)	45.1 (0.7)	6.9	26
	Western Europe ^c	43.0 (4.2)	45.8 (3.4)	47.3 (3.4)	51.4 (3.3)	8.6	43
	Eastern Europe ^e	41.9 (11.4)	44.0 (3.2)	47.8 (2.9)	50.5 (2.8)	8.6	na

na, mortality data for the considered period not available.

^a Northern Europe: Finland, Sweden and Iceland; Western Europe: France, the Netherlands, Germany, Italy and Switzerland; Eastern Europe: Estonia and Poland.

^b Finland and Sweden only.

^c France, Germany, The Netherlands and Italy only.

^d France and Italy only.

^e Estonia only.

^f Crude relative survival, as insufficient cases for age-standardisation.

^g Poland only.

^h Poland only, 1987–1989 versus 1981–1983.

ⁱ [(world standardised mortality rate 1987–1989)–(world standardised mortality rate 1978–1980)]/0.5*(world standardised mortality rate 1987–1989 + world standardised mortality rate 1978–1980).

survival (61.9%) was still slightly lower than in Northern and Western Europe (approximately 65%). The largest increases in survival from ovarian cancer occurred in Northern Europe and in Denmark and the UK, where 5-year survival rates for women diagnosed in 1981–1983 were approximately 3–5% higher than for women diagnosed only 3 years earlier — but survival in Northern Europe remains at least 10% higher than in other regions.

In Northern and Western Europe, prostate cancer survival was approximately 4–8% higher for men diagnosed during 1987–1989 than for those diagnosed only 3 years earlier, and the most recent 5-year survival rates were in the range of approximately 64–66% in both regions. In striking contrast, prostate cancer survival rates have remained unchanged at around 43–45% in Denmark and the UK, and were approximately 20% lower than in Northern and Western Europe. In Eastern Europe, prostate cancer survival also rose by 7.9%, but was still 42.6% for men diagnosed during 1987–1989.

Survival from renal tumours increased sharply to 53.8% in Western Europe, where it is now approximately 5% higher than in Northern Europe and at least 16% higher than in Denmark and the UK and Eastern Europe.

Five-year survival from Hodgkin's disease was much higher in Northern Europe than elsewhere for patients diagnosed in 1978–1980, but rose by approximately 9–11% in Western Europe and Denmark and the UK to reach 71–72% in Western Europe, Northern Europe and in Denmark and the UK in 1987–1989. No increase was seen in Eastern Europe. In contrast, survival for non-Hodgkin's lymphoma was relatively low in Northern Europe for patients diagnosed in 1978–1980, but rose by 11.0%, and the 5-year survival rate in 1987–1989 was closer to that of Western Europe (47.3 and 51.4%, respectively).

The last column of Table 2 shows the percentage differences between world standardised mortality rates in 1987–1989 and 1978–1980, for each region. Survival increased and mortality decreased for tumours of the stomach, large bowel and for Hodgkin's disease. For tumours of the breast and ovary, survival rates increased without much change in mortality. Mortality increased for skin melanoma, prostate and kidney cancer, although survival increased for all these tumours. Mortality from cervical cancer fell, although survival was essentially stable.

4. Discussion

For all 13 cancers examined here, 5-year survival in the 13 European countries was higher for patients diagnosed during 1987–1989 than for those diagnosed dur-

ing 1978–1980, an average lapse of 9 years. For cancers of the lung, brain and cervix, however, the increase was small in all regions, and 5-year survival remained below 10% for lung cancers.

Despite the overall increase, large disparities in survival between regions of Europe persisted up to 1994. The important exceptions concern Western and Northern Europe: gains in survival for large bowel, breast, kidney and stomach cancers, Hodgkin's disease and melanoma of the skin were more marked in Western Europe than Northern Europe, and regional differences in survival, for most of these sites, fell as a result. Within Western Europe, the most marked increases in survival occurred in Italy and France [7]. In the UK and Denmark, survival remained distinctly lower than the European average for most solid tumours. Survival also remained generally lower in Eastern European countries than the other regions, despite some large increases.

For bowel cancer, survival improved about equally for younger and older patients, while for cancers of the stomach, breast, prostate and testis and for Hodgkin's disease, most of the increases occurred among older patients.

Analysis of mortality together with survival may assist in the interpretation of observed survival time trends. It is important to note, however, that mortality statistics for a given year include many patients who were diagnosed and treated years earlier, while survival rates for a given year include only patients diagnosed in that year: in short, they do not represent the same patients. Nevertheless, increases in survival over time, accompanied by decreasing mortality, do suggest that the prognosis has really improved. This pattern occurred for Hodgkin's disease and for cancers of the large bowel and stomach. An increase in survival with stable or increasing mortality suggests that incidence of the tumour has increased, even though therapeutic improvements and downstaging may have occurred. This was the case for cancers of the breast and prostate and for skin melanoma.

The time trends and regional differences in survival documented in this study are larger than the plausible effects of artefact and bias that can affect population-based survival comparisons. However, interpreting these trends is not easy. Potential errors and biases have been discussed previously [2,4] and they are reviewed briefly below.

Better survival may be due to better treatment or to the treatment being more effective because the cancer was diagnosed at an earlier stage. Stage-specific survival was not available in the present study; however, disease stage depends strongly on the diagnostic procedures used, and the continuing development of more sensitive techniques for the detection of metastases can confound comparisons of stage-specific survival over time or between countries [9]. The survival of all cancer patients

combined is not influenced by artefactual shifts between stage categories, however, and it therefore remains a reliable indicator of the overall performance of a national health system in managing cancer, including the extent to which patients are diagnosed at an early stage of disease.

All cancer patients registered in a given country or territory were included. The reliability of diagnosis and the completeness of cancer registration may vary between regions and over time, however. For example, cases notified to the cancer registry by death certificate only (DCO) cannot be included in survival estimates because their date of diagnosis is unknown. A high proportion of DCO cases may therefore lead to some overestimation of survival, since these patients are likely to have been too ill to be hospitalised, with a correspondingly poor prognosis [10]. If anything, this is likely to have reduced the regional differences reported here, because about 5% of cases in the UK and Denmark, Western Europe and Eastern Europe were DCOs, compared with less than 1% in Northern Europe, where survival was generally highest. Patients lost to follow-up can also lead to overestimation of survival, but the percentage was low: from zero to 7% [3]. International differences in the accuracy of death certification are not an issue, since relative survival rates compare the mortality rates of cancer patients with those of the general population, regardless of cause of death [4].

Cancers registered under the same broad rubric in different countries are not necessarily comparable: both morphological type and the precise anatomical location may vary. In Northern Europe, the rapid drop in the incidence of stomach cancer [11] may have left a higher proportion of cancers with more aggressive morphology (e.g. undifferentiated carcinoma) and in parts of the stomach with poorer prognosis (e.g. the cardia) than in Western Europe, where the incidence of stomach cancer has not fallen so quickly. This may explain why survival for stomach cancer in Northern Europe is lower than Western Europe.

Cancer survival in the areas of a country covered by cancer registration might not be representative of the country as a whole, if areas with cancer registries also had better cancer care than the rest of the country. Geographical variation in survival has been reported in Italy [12] and the UK [1], but regional survival rates were generally consistent with the national ranking within Europe. We have aggregated countries into larger regions for this report, and within-country variability was less important.

Survival from large bowel cancer increased steadily in all regions except Eastern Europe. In Northern Europe, where survival was already high for patients diagnosed during 1978–1980, survival also increased steadily, indicating that even with good levels of care there is still room for improvement. Survival increased almost twice

as quickly in Western Europe, where survival was low for patients diagnosed during 1978–1980. Earlier diagnosis from more widespread use of endoscopy is likely to have been responsible for much of this increase.

The overall increase in breast cancer survival was similar to that for colorectal cancer, but more marked for older women. International differences are most marked in the first 6 months after diagnosis [13], strongly suggesting that the influence of stage at diagnosis is a major prognostic factor [14]. This pattern of increase by age was probably due mainly to an earlier stage at diagnosis [15] and for women over age 50 years, at least partly, as a result of mass screening [16]. Increases in survival among women diagnosed over the period 1978–1989 were not associated with a decline in mortality rates during the same period, but more recent data show that in many European countries, breast cancer mortality trends fell during the period 1990–1997, particularly in the UK [8]. As discussed above, the fact that the decline in mortality occurred later than the increase in survival is to be expected, and it reflects the relatively long life expectancy of women dying of breast cancer, who are known to survive on average 7–8 years after diagnosis.

International differences in prostate cancer survival trends are related to trends in incidence [17,18]. Survival rose most quickly in Northern and Western Europe for men diagnosed in 1987–1989 compared with those diagnosed 3 years earlier, at a time when transrectal ultrasonography and prostate-specific antigen (PSA) assay were being widely introduced, and recorded incidence rose quickly. Similar trends have been observed in the USA, where incidence rose by 20% in 1990 [19,20] and survival rates jumped 7% in 2 years, even though no new treatments were introduced. The efficacy of mass screening for prostate cancer has not been established, but a rapid increase in diagnostic activity with more sensitive tests can lead to a rise in recorded incidence from the detection of asymptomatic, preclinical tumours with a good prognosis. This amounts to a shift in the biological spectrum of malignancy. The lack of increase in prostate cancer survival in Denmark has been attributed to a low diagnostic activity [21], and this argument may also apply in other countries where survival has not risen, such as the UK, Poland and Estonia. Survival from prostate cancer rose mainly in men aged 65 years and over. Greater use of transurethral resection to treat benign adenoma or hyperplasia of the prostate in elderly men may also have led to the detection of more asymptomatic carcinomas.

Survival from cervical cancer increased only substantially in the UK and Denmark, where survival rates for women diagnosed in 1978–1980 were very low. In Northern Europe, mass screening has been effective since the 1960s, the incidence of invasive cervical cancers has fallen and survival has remained practically

constant, or even tended to decrease, e.g. in Finland [22]. This trend, together with the mortality decrease, points to the efficacy of screening in preventing less aggressive cervical tumours, while faster-growing cancers of the cervix may develop in the interval between examinations.

The marked overall increase in survival from melanoma of the skin can be partly explained by a greater awareness of skin lesions, encouraged by health campaigns in certain countries. Survival rates were fairly high in the UK and Denmark, in contrast with the low survival rates for many other cancers in these countries. In Eastern Europe, survival from melanoma increased more than in other regions, but remained substantially lower than elsewhere. Melanomas in this region are less often diagnosed when thin or at an early stage (Breslow thickness less than 1.5 mm), and are more often nodular, a type with poor prognosis [23].

The increases in survival for non-Hodgkin's lymphoma, as for ovarian cancer, were much greater for patients under 55 years at diagnosis than for those aged 65 years or more. This may be attributable to the development of more effective adjuvant chemotherapy protocols during the 1980s. These treatments have a high systemic toxicity, and are better tolerated by younger patients. By contrast, survival from testicular cancer increased most for older men, and it may be surmised that effective chemotherapy regimens, available since the 1970s, have been progressively extended to this age group.

Regional differences in survival from the lymphomas have been notably smaller than for the solid tumours, and they have converged over time. Survival for non-Hodgkin's lymphomas rose considerably in Estonia, and 5-year survival rates for patients diagnosed in 1987–1989 approach or exceed those elsewhere in Europe.

Regional differences in survival for the solid tumours were marked. Early diagnosis makes curative surgery, with or without adjuvant therapies, more effective for these tumours. National average survival rates are therefore strongly influenced by the extent of access to adequate diagnosis and treatment services, which is in turn dependent on socio-economic status and the efficiency of the health system. Northern Europe had higher than average survival for most solid tumours, but about average survival for the lymphomas. Similarly, Denmark and the UK had low survival rates for many common and operable tumours, while survival for malignancies treated mainly by chemotherapy (lymphomas, testicular cancer) was similar to the European mean. This suggests that advanced stage at diagnosis is a key factor in the lower survival rates for solid tumours in Denmark [24] and the UK [25]. The poor survival for most solid tumours in Eastern Europe is likely to reflect poorer access to diagnostic and therapeutic facilities than elsewhere in Europe.

Cancer survival and the socio-economic status of individual cancer patients have been directly linked in several studies [1,26–28]. Broader societal measures can also offer insight into international differences in survival. The following measures were all independently and significantly associated with cancer survival in a multiple regression analysis [29] of the European survival patterns reported here: the proportion of gross national product spent on health; the unemployment rate; the number of in-patient beds; the number of computed tomography (CT) scanners per million population and the life expectancy at birth. These variables explain a large part of the variability of cancer survival across Europe, particularly for cancers of the breast, large bowel and prostate. Inequality of access to adequate healthcare facilities is likely to be a major cause of the wide differences in cancer survival in Europe.

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Appendix

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