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Variations in Cancer Survival and Patterns of Care Across Europe: Roles of Wealth and Health-Care Organization

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Cancer survival varies markedly across Europe. We analyzed variations in all-cancer 5-year relative survival in relation to macroeconomic and health-care indicators, and 5-year relative survival for three major cancers (colorectal, prostate, breast) in relation to application of standard treatments, to serve as baseline for monitoring the efficacy of new European initiatives to improve cancer survival. Five-year relative survival data were from the European cancer registry–based study of cancer patients' survival and care (EUROCARE-4). Macroeconomic and health system data were from the Organisation for Economic Co-operation and Development, and European Observatory on Health Care Systems. Information on treatments given was from EUROCARE studies. Total national health spending varied widely across Europe and correlated linearly with survival ($R = 0.8$). Countries with high spending had high numbers of diagnostic and radiotherapy units, and 5-year relative survival was good (>50%). The treatments given for major cancers also varied; advanced stage at diagnosis was associated with poor 5-year relative survival and low odds of receiving standard treatment for breast and colorectal cancer.

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Cancer is the second most important cause of death in Europe. According to GLOBOCAN, 2.5 million new cancer cases and 1.3 million cancer deaths occurred in 2008 in the 27 member states of the European Union (population is 497 455 033) (1). Nevertheless, cancer incidence and mortality vary by a factor of two across the continent. Survival also varies markedly: As documented by the European cancer registry–based study of cancer patients' survival and care (EUROCARE-4) (2), survival is generally low in low-income Eastern Europe and high in the high-income countries of Northern and Western Europe (2).

This large variation in cancer burden suggests that much can be done to lessen it by bringing national health-care systems up to or close to the level of the best. Several studies have found correlations between cancer survival and macroeconomic variables such as countries' overall wealth and spending on health (3–6). Health spending depends ultimately on a country's wealth, but also varies widely in relation to social factors and the varying organizational structures of national health systems (7). In some countries, the health service is mainly public; in others, the private sector plays an important role. Methods of financing also vary: In some countries, costs are met almost entirely out of general taxation (national health systems); in others, insurance plays a major role (social insurance systems) and may be mutual (organized by trade or professional associations or government and essentially nonprofit) or private.

The aim of the present study was: 1) to analyze variations in all-cancer survival across European countries in relation to macroeconomic and health-care system indicators; 2) to analyze survival for three major cancers (colorectal, prostate, and breast) in relation to adherence to accepted treatment guidelines.

Materials and Methods

Sources of Information

Relative Survival for All Cancers Combined. Survival data were obtained from EUROCARE-4. The EUROCARE-4 study checked, archived, and analyzed incidence and follow-up information on cancer patients diagnosed from January 1, 1978, to December 31, 2002, collected by European cancer registries (CRs). Here we made use of 2000–2002 period estimates of 5-year relative survival for all cancers combined produced by Verdecchia et al. (2) and based on cases registered in 1996–2002 by 47 of the CRs participating in EUROCARE-4. There were 12 national CRs (100% national coverage) covering 9 countries (Austria, Finland, Iceland, Ireland, Malta, Norway, Slovenia, Sweden, and the United Kingdom) and 36 regional CRs representing 10 countries (Belgium, Czech Republic, France, Germany, Italy, the Netherlands, Poland, Slovakia, Spain, and Switzerland) with national coverage ranging from 1% for Germany and France to 58% for Belgium (2).

Macroeconomic and Health-Care System Indicators. The main macroeconomic indicator we used was total national expenditure on health (TNEH) obtained from the Organisation for Economic Co-operation and Development (OECD) (7,8). TNEH measures current health expenditure (total consumption of health-care goods and services) plus capital investment in health-care infrastructure (7) and includes public and private spending on medical services and goods, public health and prevention programs, and administration. It excludes health-related expenditures such as training, research, and environmental health. To compare the overall consumption of health goods and services across countries at a given point, total health expenditure per capita was converted into

US dollars and adjusted to take account of the varying purchasing power of national currencies (parity purchasing power, US$PPP). Information used to estimate TNEH was obtained from national health accounts (NHAs). NHAs obtain estimates based on expenditure information collected within an internationally recognized framework. The estimates vary in their reliability depending on the availability and quality of national information; however, estimates are sent to the respective Ministries of Health each year for validation. The figures presented in this paper refer to 2002.

We also used information on availability of medical devices or equipment, extracted from the OECD (7). Specifically, we extracted information on computed tomography (CT), magnetic resonance imaging (MRI), and radiotherapy (RT) equipment, including linear accelerators, cobalt-60 units, cesium-137 units, and low orthovoltage X-ray units (brachytherapy units normally excluded). For CT, MRI, and RT devices, numbers per million of population in 2002 are reported. For most countries, the numbers include equipment installed in hospitals and outpatient units. However, coverage is only partial for some countries. In particular, the data for the United Kingdom refer only to devices in the public sector, and in Spain the data refer only to devices in hospitals; thus, for these countries the total numbers of devices are underestimated. Information on RT equipment was also obtained from the Quantification of Radiation Therapy Infrastructure and Staffing Needs (QUARTS) project, which provided estimates of RT infrastructure needs in relation to estimates of actual numbers available in EU countries, based on the best available evidence (9).

We obtained information on European health-care systems from the European Observatory on Health Care Systems and Policies, which classifies such systems into two basic types based on mode of funding: either funded by compulsory health insurance (social insurance systems) or paid for out of general taxation (national health systems) (10,11). The Austrian, Belgian, Czech, Dutch, French, German, Polish, Slovak, Slovenian, and Swiss health systems are funded by insurance, whereas the Finnish, Icelandic, Irish, Italian, Norwegian, Spanish, Swedish, and UK systems are tax-based.

Survival and Standard Care. High-resolution studies make it possible to interpret survival differences between countries by relating those differences to detailed information on stage at diagnosis, staging procedures, and treatments. The latter information was collected for representative samples of cases selected from population-based CR archives. Here we used results from published EUROCARE high-resolution studies on breast, colorectal, and prostate cancer (12–14). Cases to the breast cancer study were contributed by 26 CRs from 12 countries (Denmark, Estonia, Finland, France, Iceland, Italy, Poland, Slovakia, Slovenia, Spain, Sweden, and the Netherlands) (12); 11 CRs from 8 countries (Estonia, Finland, France, Italy, Poland, Slovenia, Slovakia, and Spain) contributed cases to the colorectal cancer study (13); and 12 CRs from 6 countries (France, Italy, Poland, Slovakia, Spain, and the Netherlands) to the prostate cancer study (14).

The range of cancer survival in these studies reflected that documented across the Europe as a whole. Each CR was asked to provide detailed information on diagnostic and treatment procedures, obtained by consulting individual clinical records and abstracted onto a standard form. The studies analyzed 13 485 breast, 6871 colorectal, and 3486 prostate cancer cases diagnosed in 1994–1999, the large majority in 1996–1998.

From these studies, indicators of adherence to "standard care" for the treatment of these cancers were also estimated and related to 5-year relative survival (15). The following indicators of standard care were used:

- **Breast cancer:** 1) Proportion of early-stage cancers receiving breast-conserving surgery plus RT (BCS + RT); 2) proportion of lymph node–positive (N+) patients receiving chemotherapy (12)
- **Colorectal cancer:** 1) Proportion resected with curative intent; 2) proportion of stage III colon cancer cases receiving adjuvant chemotherapy; 3) proportion of stage I–III rectal cancer cases receiving neoadjuvant/adjuvant RT (13)
- **Prostate cancer:** 1) Proportion of patients treated radically (prostatectomy or RT); 2) use of radical therapies in relation to the cancer risk class (high vs low) proposed by Miller et al. (14,16)

The odds of being treated according to the above modalities by country and adjusted by age and sex were estimated by logistic regression (12–14). The CRs providing data for these studies were grouped by country and the countries grouped into regions: Northern Europe (Iceland, Denmark, Sweden, and Finland), Central Europe (France and the Netherlands), Eastern Europe (Estonia, Slovakia, and Poland), and Southern Europe (Italy, Slovenia, and Spain).

Results

Relation of TNEH and Health-Care System Organization to All-Cancer Survival

Figure 1 shows the relationship between TNEH and the age-adjusted 5-year relative survival for all cancers combined. Each dot represents a country, and its color (black or white) identifies the type of health-care system (national health vs social insurance). Countries were grouped into four TNEH classes (<999 US$PPP, 1000–1999 US$PPP, 2000–2999 US$PPP, and >3000 US$PPP). In general, countries with high TNEH had good survival. Sweden and Finland had survival similar to or better than countries with higher TNEH. Ireland and the United Kingdom had lower survival than countries with similar TNEH. Spain had better survival than expected from its moderate health expenditure. TNEH and survival correlated linearly, with TNEH explaining over 50% of the survival variance (R = 0.8). However, after removing the Eastern European countries of Poland, Czech Republic, Slovakia, and Slovenia, which had the lowest expenditure and lowest survival, the TNEH–survival correlation was much weaker (R = 0.4). Many of the countries with national health systems (specifically Iceland, Sweden, Finland, Norway, Italy, and Spain) had better survival than those with social insurance systems (specifically Austria, France, Switzerland, Germany, the Netherlands, the Czech Republic, Slovakia and Slovenia).

Table 1 shows relative survival by country in relation to numbers of CT, MRI, and RT devices available, with countries ranked by decreasing per capita TNEH. From this table, it is evident that

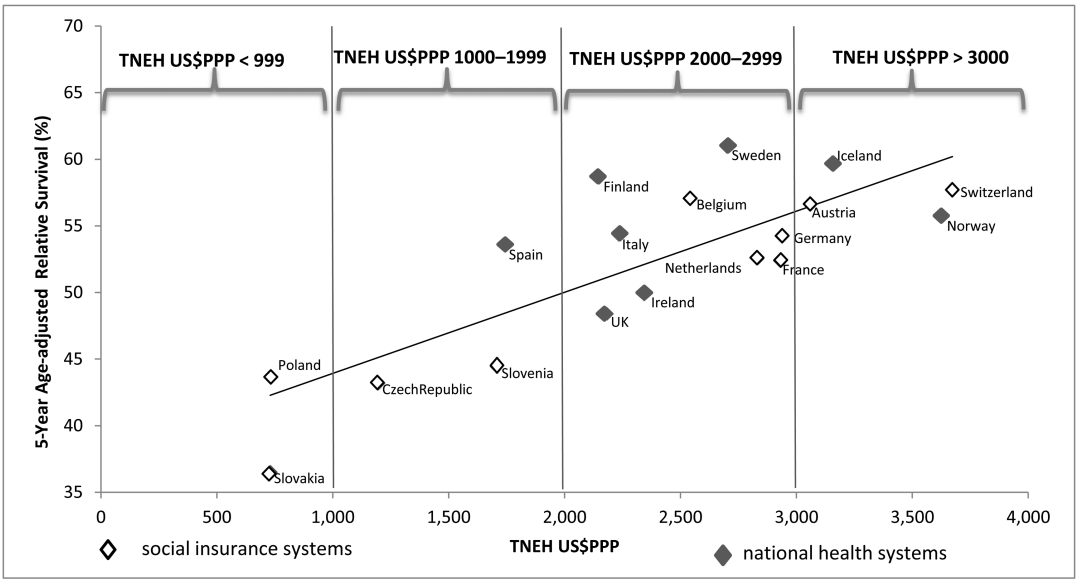

Figure 1. Relationship between total national expenditure on health (TNEH), expressed as US dollar parity purchasing power (US$PPP), and the 5-year age-adjusted relative all-cancer survival (%) by country and national health-care system organization.

Table 1. Medical devices and total national health expenditure (TNEH) expressed as US dollar parity purchasing power (US$PPP) in 2002, in relation to 5-year age-adjusted relative all-cancer survival (period 2000–2002) by country*

	CT per million population	MRI per million population	RT per million population	Actual/ needed RT capacity, %	TNEH, US$PPP	5-year relative survival, %
Switzerland	18	14.1	10.6	NA	3673	58
Norway	NA	NA	NA	NA	3628	56
Iceland	20.9	17.4	13.9	NA	3156	60
Austria	27.2	13.4	4.5	NA	3057	57
Germany	14.2	6	4.6	60–80	2934	54
France	9.7	2.7	6	90	2931	52†
The Netherlands	NA	NA	NA	60–80	2833	53
Sweden	14.2	7.9	NA	90	2702	61
Belgium	28.8	6.6	NA	90	2542	57
Ireland	NA	NA	NA	NA	2344	50
Italy	23.4	10.6	4.3	60–80	2235	54
United Kingdom	5.8‡	5.2‡	3.9‡	50	2184	48
Finland	13.3	12.5	8.8	NA	2150	59
Spain	12.9§	6.2§	3.7§	NA	1745	54
Slovenia	NA	NA	NA	<40	1706	44
Czech Republic	12.1	2.2	6.7	50	1195	43
Poland	5.8	0.9	NA	<40	733	44
Slovakia	8.7	2‖	7.1‖	NA	730	37†
Malta	NA	NA	NA	NA	NA	49

* Countries ranked by TNEH. CT = computed tomography; MRI = magnetic resonance imaging; NA = not available; RT = radiotherapy. Data on CT, MRI, RT, and TNEH from Organisation for Economic Co-operation and Development (7,8). Data on actual/needed RT capacity (%) from Bentzen, et al. (9). Survival data from EUROCARE-4 (2), for France and Slovakia from http://www.eurocare.it.

† Relative survival estimated by cohort approach for diagnostic period 1995–1999.

‡ UK data refer to devices in public sector only.

§ Spanish data pertain only to devices available in hospitals.

‖ MRI and RT data for 2001.

countries with high TNEH (>3000 US$PPP) had the highest numbers of CT, MRI, and RT devices. Countries with TNEH between 2000 and 3000 US$PPP still had relatively high numbers of CT units, ranging from 28 (per million) in Sweden to 14 in Finland, but fewer of the more expensive MRI units. Countries with low TNEH had considerably more CT than MRI units. The correlation between TNEH and MRI was 0.65 and between TNEH and CT was 0.54. Table 1 also shows that all-cancer relative survival

was better in countries with high numbers of CT and MRI units. Relative survival correlated more strongly with availability of diagnostic equipment (particularly MRI; $R = 0.7$) than availability of therapeutic irradiation equipment ($R = 0.3$); however, RT data were missing for many countries. Table 1 also shows QUARTS (9) estimates of the availability of RT equipment as a percentage of that required—estimated from the observed incidence of cancers requiring RT treatment. Slovenia and Poland followed by the Czech Republic and the United Kingdom—all countries with relatively low survival—had the largest gaps between actual and required CT equipment.

At the other end of the range, Sweden, France, and Belgium were the only countries where the availability of megavoltage RT units (in 2003) equaled or exceeded 90% of the QUARTS-estimated need. Sweden and Belgium had high survival. Germany and Italy had relatively good survival in relation to the limited number of RT devices available, even though the actual numbers of RT devices available amounted to 60–80% of requirements.

Survival and Standard Care

Breast Cancer. Overall 55% of the early-stage (T1N0M0) breast cancer patients received BCR + RT (considered standard care) (Figure 2). However, there was marked variation: from 9% in Estonia to 78% in France, and from 20% in Eastern Europe through 47% in Northern Europe, 57% in Southern Europe, to 72% in Central Europe (data not shown). When the data were adjusted by age and tumor size, the odds of receiving BCR + RT (France as reference) were again lowest in Eastern Europe (Estonia, Slovakia, and Poland).

Overall 63% of node-positive breast cancer patients and most (91%) node-positive premenopausal patients received adjuvant chemotherapy (Table 2). Although between-country variation in treatment with adjuvant chemotherapy was marked, especially for the oldest age category, variation was less than for treatment with BCT + RT and showed a different regional pattern: 74% received adjuvant chemotherapy in Eastern Europe, 39% in Northern Europe, 51% in Central Europe, and 70% in Southern Europe. Five-year survival was, as expected, related to stage at diagnosis, in that countries with the lowest survival also had the highest proportion of women with advanced stage at diagnosis (Table 2).

Colorectal Cancer. Overall 71% of colorectal cancer patients were surgically treated with curative intent, ranging from 54% (Poland) to 83% (Italy) (Table 3). Overall 30% of patients had advanced disease at diagnosis. The Eastern European countries had high proportions (>30%) of advanced-stage cases and also lowest proportions of surgically treated cases. High proportions of advanced-stage cases correlated with poorer 5-year survival (Table 3).

Table 4 shows the proportions of stage III colon cancer cases treated with curative intent that also received adjuvant chemotherapy. Overall 46% received adjuvant chemotherapy, with wide variation by country. Adjusting for age, sex, and registry in a multivariable analysis, in four countries (France, Italy, Spain, and Slovakia) stage III cases were significantly more likely to receive adjuvant chemotherapy than Slovenia (reference), and only Polish stage III cases were significantly less likely to receive adjuvant chemotherapy than reference. Adjuvant chemotherapy was less frequently (16%) given to older (>75 years) rather than younger patients (65–74 years, 50%; <65 years, 69%) (Table 4).

Overall only 12% of stage I–III rectal cancers treated with curative intent received neoadjuvant/adjuvant RT (Figure 3). The between-country variation in proportion receiving this standard treatment (1.3% in Slovakia to 51% in France) was greater than the variation in colon cancer cases receiving adjuvant chemotherapy. Multivariable analysis showed that rectal cancer patients in Spain (Navarra), France (Côte-d'Or), Estonia, and Finland (Tampere) had significantly greater odds of receiving RT than those in Slovenia (reference).

Prostate Cancer. About one in three patients received radical treatment (radical prostatectomy or RT), with prostatectomy

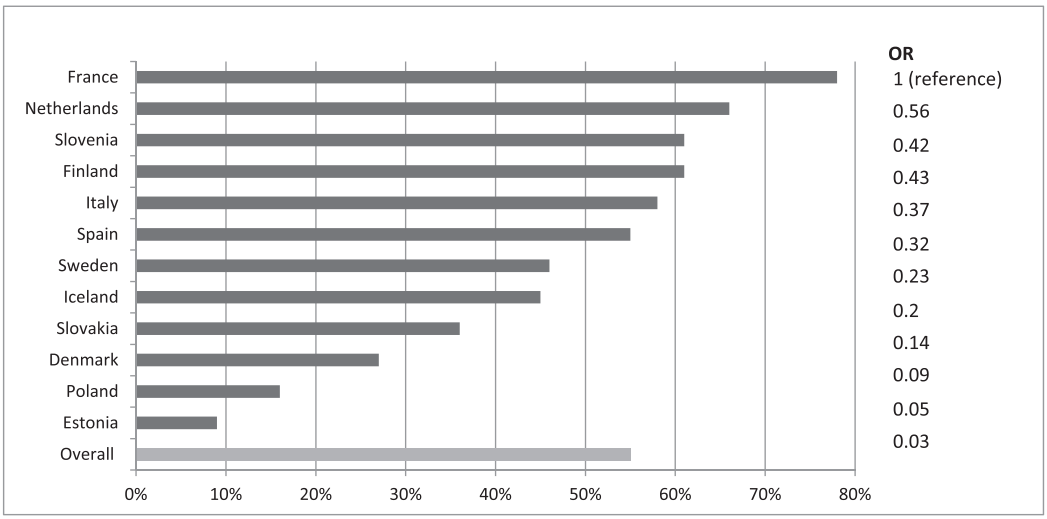

Figure 2. High-resolution study on breast cancer: proportions of T1N0M0 cases that received breast-conserving surgery plus radiotherapy with odds ratios (ORs) by country. Data from EUROCARE high-resolution study (12).

Table 2. High-resolution study on breast cancer: proportions of lymph node–positive (N+) patients who received adjuvant chemotherapy by age, and proportions with advanced stage at diagnosis and 5-year relative survival (cohort 1995–1999) by country and European region*

Country/region	Percentage of N+ breast cancer patients receiving adjuvant chemotherapy by age			Proportion of breast cancer patients with advanced stage, %	5-yr relative survival, %
	All ages	Age 15–49	Age 55–99		
Denmark	21	53	16	54	77.5
Estonia	46	98	77	57	NA
Finland	52	82	23	34	83.5
France	54	90	51	34	77.5
Iceland	56	90	40	40	87.5
Italy	47	84	61	44	82.7
Poland	76	89	46	52	73.9
Slovakia	72	96	73	58	61.6
Slovenia	85	99	67	50	71.9
Spain	71	97	69	42	80.3
Sweden	74	81	16	43	84.7
The Netherlands	66	93	15	34	81.4
Northern Europe	39	83	24	42	80.4
Central Europe	51	85	34	34	79.8
Eastern Europe	74	96	59	55	67.1
Southern Europe	70	92	65	44	81.6
All cases	63	91	52	43	80.5

* Northern Europe includes Iceland, Denmark, Sweden, and Finland; Central Europe includes France and The Netherlands; Eastern Europe includes Estonia, Slovakia, and Poland; Southern Europe includes Italy, Slovenia, and Spain. Data from EUROCARE high-resolution (12) and EUROCARE-4 studies (15), for Slovakia from http://www.eurocare.it. NA = not available (country not included in EUROCARE-4).

Table 3. High-resolution study on colorectal cancer: numbers of cases studied and proportions undergoing surgery with curative intent, with odds (odds ratio [OR], 95% confidence interval [CI]) of receiving curative intent resection, and proportions of advanced cases, by country and European region*

Country/region	N cases	Resected with curative intent, %	OR for resection with 95% CI			Advanced cases, %	5-yr relative survival based on total incident cases, %	Total incident cases, N
Estonia	560	56	0.5	0.4	0.7	33	NA	NA
Finland	523	74	1.3	1.0	1.7	26	58	8737
France	561	77	1.6	1.2	2.0	25	57	1371
Italy	1100	83	2.3	1.9	2.8	26	55	6586
Poland	786	54	0.5	0.4	0.6	36	35	3071
Slovakia	581	63	0.7	0.6	0.9	34	39	10286
Slovenia	940	70	1.0			30	44	4290
Spain	1820	76	1.6	1.4	1.9	31	51	4419
"Western" Europe	4944	76	1.6	1.5	1.8	29	53	25403
Eastern Europe	1927	57	0.6	0.5	0.6	35	38	13357
All cases	6871	71	1.3	1.3	1.4	30	48	38760

* Northern, Central, and Southern Europe comprise "Western Europe," or Finland, France, Italy, Slovenia, and Spain; Eastern Europe includes Estonia, Slovakia, and Poland. Data from EUROCARE high-resolution (13) and EUROCARE-4 studies (15), for Slovakia from http://www.eurocare.it. NA = not available (country not included in the EUROCARE-4).

performed more often than RT (22% vs 14%) (Table 5). Less than 30% of prostate cancer cases were treated radically in Slovakia, Poland, and Spain; 40% or slightly more were radically treated in the Netherlands (55%) and France (40%). Overall, radical treatments were given to 61% of high-risk and to 34% of low-risk cases (Table 5). For all countries, except Slovakia, proportionately more high-risk patients received radical treatment.

Five-year prostate cancer survival was slightly above 80% in the Netherlands, Italy, and France, and the proportion of M+ cases was lowest (<18%) in the same countries. The Polish registry of Krakow with 32% M+ at diagnosis had the lowest (46%) 5-year survival. In fact, overall the proportion of M+ cases was inversely related to the proportion radically treated.

Discussion

This paper has analyzed population-based data. The main outcome considered was 5-year relative survival, estimated using the EUROCARE methodology (2,15). The economic and health indicators used were those estimated by the OECD and are, therefore, authoritative (7,8). The main limitation is that data were not always collected according to uniform criteria. Thus, data on diagnostic

Table 4. High-resolution study: numbers and proportions of stage III colon cancer cases treated by curative intent surgery and adjuvant chemotherapy with odds of receiving that treatment (odds ratio [OR]) with 95% confidence interval (CI), by country and by age*

Country/age	N cases	Resected stage III cases given adjuvant chemotherapy, %	OR	95% CI	
Estonia	37	46	1.2	0.5	2.8
Finland	45	42	1.7	0.8	3.8
France	62	52	2.9	1.4	5.9
Italy	153	40	2.6	1.5	4.4
Poland	46	26	0.4	0.2	0.8
Slovakia	33	73	5.2	1.9	13.8
Slovenia	115	45	1.0		
Spain	228	50	2.5	1.6	3.7
<65 years	240	69	1.0		
65–74 years	261	50	0.4	0.2	0.6
≥75 years	218	16	0.1	0.0	0.1
All cases	719	46			

* Data from EUROCARE high-resolution study (13).

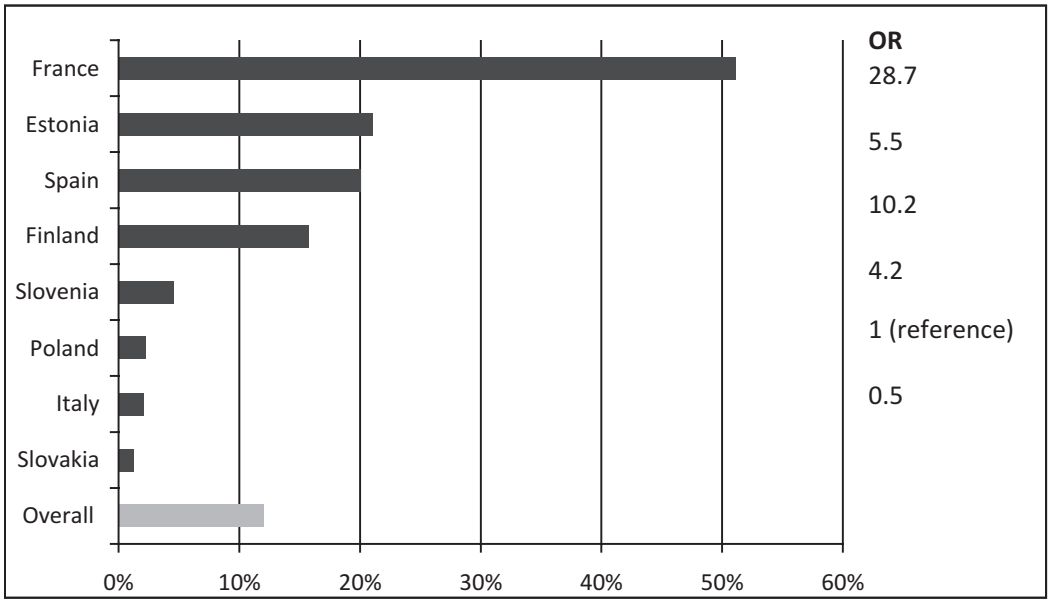

Figure 3. High-resolution study on colorectal cancer: proportions of stage I–III rectal cancer cases treated with curative intent surgery that also received adjuvant radiotherapy by country, with odds ratios (ORs). Data from EUROCARE high-resolution study (13).

or therapeutic device availability were collected in different ways in different countries; survival data were provided by CRs covering entire countries in some cases, but only parts of countries in other cases; adherence to standard treatment was estimated from representative samples of cases provided by CRs participating in high-resolution studies and may not be representative of the case-mix at the national level. However, the survival rates for prostate, breast, and colorectal cancer in the areas covered by CRs included in the high-resolution studies were similar to the national survival estimates. This supports the idea that CRs and the cases reviewed provide a good description of the case population.

We found that both 5-year relative survival for all cancers combined and adherence to standard treatment for major cancers varied markedly between countries. These variations were larger than regional variations documented across the United States, Australia, and Canada (17,18).

Relation of TNEH and Health-Care Organization to All-Cancer Survival

In the last decade, health expenditures grew in real terms by around 3% per year, on average, across OECD countries (including European countries), with similar growth patterns in the European Union and the United States (7). However, considerable variations across countries were observed in health spending growth over time (7). Focusing on 1992–2003, several countries (e.g., Czech Republic, Ireland, and Poland) with lower income and lower health expenditures per capita in the early 1990s experienced exceptionally high growth in health expenditure. By contrast,

Table 5. High-resolution study on prostate cancer: proportions of patients receiving radical treatment by type of treatment and risk group (high risk and low risk), and proportions of metastatic cases (M+) and age-adjusted survival by country and region*

Country/region	N	Radical treatment					M+, %	5-year relative survival, %
		Type			According to risk			
		RP, %	RRT, %	RP + RRT, %	High, %	Low, %		
France	991	21	19	40	67	33	17	80.3
Italy	1166	30	8	38	60	31	11	81.0
Poland	261	13	14	27	44	34	32	46.1
Slovakia	435	19	4	23	29	36	43	47.2
Spain	326	11	12	23	58	22	22	75.0
The Netherlands	307	19	36	55	75	56	12	82.9
Central Europe	1298	21	23	44	69	39	16	81.0
Eastern Europe	696	17	8	25	34	35	39	47.0
Southern Europe	1492	26	9	35	60	29	13	81.0
All cases	3486	22	14	36	61	34	19	72.5

* Central Europe includes France and the Netherlands; Eastern Europe includes Slovakia and Poland; Southern Europe includes Italy and Spain. Data from EUROCARE high-resolution (14) and EUROCARE-4 studies (15), for Slovakia from http://www.eurocare.it. RP = radical prostatectomy, RRT = radical radiotherapy.

some countries (e.g., Finland, Germany, and Italy) experienced slow growth, both in total and public expenditure on health, following the introduction of cost containment measures in the early 1990s (7). Mean European 5-year relative survival for all cancers combined increased significantly from 44% in 1988 to 50% in 1999. The increase was almost linear up to 1994–1996, and then it slowed. Countries with poor relative survival at the beginning (e.g., Poland, Czech Republic, and Slovenia) had larger increases in survival for all cancers combined (6–10%) than countries with high levels (northern European countries and Switzerland). This caused some reduction in between-country survival variation from 1988–1990 to 1997–1999 (19). In 2002, Norway and Switzerland had the highest per capita spending, with almost 4000 US$PPP. At the other end of the scale, Poland and the Czech Republic spent about 1000 US$PPP on health in 2002. A previous study (3) found that, in general, cancer survival increased as health spending increased. This trend was repeated in the present analysis although Sweden and Finland had better survival than Germany, Norway, and the Netherlands—with similar or higher TNEH, whereas Ireland and the United Kingdom had lower survival than several other countries with similar TNEH. Thus, health spending is not the only factor influencing cancer survival differences.

All EU countries have adopted the policy that their citizens should have access to health care (20,21). However, the organization of health-care provision varies markedly between EU countries (22). National health systems are inspired by egalitarian principles and financed through general taxation, and in general, health-care services are publicly owned and managed (23). Social insurance systems are financed mainly through obligatory salary or wage deductions, with rights of access to health services often limited (24) and health-care providers typically a mix of public and private (10).

Visual inspection of Figure 1 tends to support the idea that health-care organization has an effect on all-cancer survival differences across Europe. Many countries with national health systems (specifically Iceland, Sweden, Finland, Italy, and Spain) had better survival than countries with social insurance systems (specifically France, Switzerland, Germany, the Netherlands, the Czech Republic, Slovakia, and Slovenia), although there were notable exceptions: The United Kingdom and Ireland, with national health systems, had worse survival than all countries of comparable TNEH (2000–2999 US$PPP), whereas Belgium with a social insurance system had better survival than many countries of comparable TNEH. Focusing on countries with TNEH of 2000 US$PPP and greater (Figure 1), it is evident that all-cancer survival was similar irrespective of health system organization: 55.2% for countries with national health systems and 55.6% for countries with social insurance systems; however, TNEH was higher for the latter (2518 vs 3008 US$PPP). Previous studies support greater efficiency of national health systems, which tend to have more direct control over expenditures (25,26), more equitable distribution of resources and greater allocative efficiency (27), lower out-of-pocket expenses, and lower administrative costs (28), compared with social insurance systems.

Because cancer survival depends on early diagnosis and effective treatment (3), we also sought to characterize EU countries according to the availability of diagnostic and treatment equipment. The data presented in Table 1 show that countries with TNEH greater than 2000 US$PPP had more CT and MRI scanners per capita than those with TNEH less than 2000 US$PPP. Such scanners are important for the early diagnosis and staging and hence provide vital information for deciding appropriate treatment. MRI scanners are expensive, and it is not surprising that the number per capita was closely related to TNEH. We also found that relative survival correlated directly with MRI units per capita, consistent with the known importance of early and accurate diagnosis in cancer survival. Note, however, that our data indicate the availability of scanners but do not provide information on their actual use (7–9).

The relationship between number of RT devices and relative survival was less clear, probably because information on these devices was unavailable for many countries. The QUARTS project (9) reported that the availability of RT devices varied markedly between EU countries and even regions within EU countries. Governments in several EU countries have recognized, and are trying to rectify, the problem of inadequate RT device availability (9).

Survival and Standard Care

The high-resolution studies reported in this paper show marked differences across Europe in terms of the treatments given for major cancers. By the middle of the 1980s, large multicenter clinical studies had established that, for early breast cancer, conservative surgery reduces side-effects and improves aesthetic outcomes, compared with mastectomy, without adversely affecting survival (29–36). Somewhat later, it was also shown that adjuvant chemotherapy improves prognosis in node-positive breast cancer (37). For stage III colon cancer, trials published in 1989 (38) and 1990 (39) concluded that adjuvant chemotherapy improves prognosis. Neoadjuvant or adjuvant RT also reduces local recurrence rates in rectal cancer (40). It is striking, therefore, that only 55% of European early breast cancer patients received breast-conserving treatment and only 46% of stage III colon cancer patients were given chemotherapy (Table 4) over the study period (late 1990s).

It seems that limited availability of treatment guidelines for breast cancer and colorectal cancer in Europe was the major reason for lack of adherence to what are now standard treatments for these diseases. The first meta-analysis on systemic treatment for early breast cancer was published in 1992 (37), and only in 1998 was a comprehensive series of meta-analyses published (41) after which it became evident that guidelines for breast cancer management were desirable (www.eusoma.org). Adjuvant chemotherapy use for colorectal cancer increased markedly the United States (40,42) following the publication of trial data (38,39), but in Europe, additional chemotherapy trials were conducted (43–45). Furthermore, during the study period, European guidelines for treating colorectal cancer were not available, although some national protocols had been produced (12).

The high-resolution studies also showed that advanced stage at diagnosis was associated with poor 5-year relative survival and low odds of receiving surgical treatment for colorectal cancer and radical treatment for prostate cancer. Although over 70% of colorectal cancers were treated by radical resection (the only treatment that offers a chance of cure), in the eastern European countries of Poland, Slovakia, and Estonia, over one-third of cases presented at advanced stage and much less than 70% received surgery with curative intent (Table 3). For breast cancer, countries with screening programs during the study period (the Netherlands, Finland, and Sweden) had high proportions of T1N0M0 cases and low proportions of M1 cases (46). Conservative surgery is only applicable to relatively early-stage breast cancer.

Thus, stage at diagnosis is a major determinant of whether effective treatments can be applied and long-term disease control achieved; however, it is also important that the facilities to deliver effective treatment are available. Access to RT for treatable rectal cancer and early breast cancer seems to be limited by the availability of RT equipment (9) and is likely to be an additional reason for the low rates of conservative surgery in breast cancer and application of RT in rectal cancers. Thus, countries with highest numbers of RT devices were those with the highest proportions of early-stage breast cancers receiving conservative surgery and RT (12). By contrast, adjuvant chemotherapy appeared to be the foundation of breast cancer treatment in Eastern Europe and was also common for colon cancer (Table 4 and Figure 2), probably because chemotherapy costs less than RT (12).

With regard to prostate cancer, about one in three European patients received radical treatment at the end of the 1990s, with prostatectomy given more often than RT. For high-risk cancers, the odds of receiving radical treatment were about twice as high in the Netherlands, Italy, and France, as in Slovakia (Table 5). The same countries had the lowest proportion of M+ cases (<20%). The odds of receiving radical treatment for prostate cancer also correlated with the incidence rate (14). High incidence is likely to be related to extensive PSA testing, resulting in higher proportions of incident cases being eligible for radical treatment. We also found that a considerable proportion (up to 34%) of patients with apparently low-risk disease was treated radically within a year of diagnosis. This proportion was lower than that estimated in the United States in 2000 (16), although some European regions approached US levels (14). Because prostate cancer incidence is likely to remain high in the foreseeable future due to PSA testing, the proportion of indolent and low-risk cancers diagnosed is not expected to decrease. Expectant management (active surveillance and delayed treatment) should become the main approach to low-risk disease (47). Monitoring the extent of application of expectant management would be a useful way of assessing the appropriateness of treatment for prostate cancer.

We conclude by noting, as this survey illustrates, that the information on which to base policies to increase cancer survival overall and reduce survival differences in Europe is available. In fact, the European Union has been seeking to harmonize public health policies across member states since the beginning of the new millennium. Under the Slovenian presidency of the European Union in 2008 (48), cancer control was prioritized and further actions initiated to improve cancer control. As a result, the European Partnership for Action Against Cancer (EPAAC) was launched in 2009 (49), with the aims of integrating cancer policies across EU member states particularly in the areas of primary prevention, treatment guidelines, and cancer research; a European cancer information system is also being set up. It will be important to monitor the impact of these initiatives on cancer survival in Europe as a whole and individual member states.

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