Cancer survival in five continents: a worldwide population-based study (CONCORD)

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Summary

Background **Cancer survival varies widely between countries. The CONCORD study provides survival estimates for 1·9 million adults (aged 15–99 years) diagnosed with a first, primary, invasive cancer of the breast (women), colon, rectum, or prostate during 1990–94 and followed up to 1999, by use of individual tumour records from 101 population-based cancer registries in 31 countries on five continents. This is, to our knowledge, the first worldwide analysis of cancer survival, with standard quality-control procedures and identical analytic methods for all datasets.**

Methods **To compensate for wide international differences in general population (background) mortality by age, sex, country, region, calendar period, and (in the USA) ethnic origin, we estimated relative survival, the ratio of survival noted in the patients with cancer, and the survival that would have been expected had they been subject only to the background mortality rates. 2800 life tables were constructed. Survival estimates were also adjusted for differences in the age structure of populations of patients with cancer.**

Findings **Global variation in cancer survival was very wide. 5-year relative survival for breast, colorectal, and prostate cancer was generally higher in North America, Australia, Japan, and northern, western, and southern Europe, and lower in Algeria, Brazil, and eastern Europe. CONCORD has provided the first opportunity to estimate cancer survival in 11 states in USA covered by the National Program of Cancer Registries (NPCR), and the study covers 42% of the US population, four-fold more than previously available. Cancer survival in black men and women was systematically and substantially lower than in white men and women in all 16 states and six metropolitan areas included. Relative survival for all ethnicities combined was 2–4% lower in states covered by NPCR than in areas covered by the Surveillance Epidemiology and End Results (SEER) Program. Age-standardised relative survival by use of the appropriate race-specific and state-specific life tables was up to 2% lower for breast cancer and up to 5% lower for prostate cancer than with the census-derived national life tables used by the SEER Program. These differences in population coverage and analytical method have both contributed to the survival deficit noted between Europe and the USA, from which only SEER data have been available until now.**

Interpretation **Until now, direct comparisons of cancer survival between high-income and low-income countries have not generally been available. The information provided here might therefore be a useful stimulus for change. The findings should eventually facilitate joint assessment of international trends in incidence, survival, and mortality as indicators of cancer control.**

Funding **Centers for Disease Control and Prevention (Atlanta, GA, USA), Department of Health (London, UK), Cancer Research UK (London, UK).**

Introduction

International comparisons of population-based cancer survival have been rare,[1–5] but large and unexplained differences in survival have been reported for many cancers from individual studies and cancer registries in Europe and North America.[6] For example, 5-year relative survival for women diagnosed with breast cancer during 1985–89 was 73% in Europe (weighted mean for 17 countries)[7] and 84% in the USA.[8] The CONCORD study provides a systematic comparison of survival between Europe and North America,[9–16] extended to countries in all other continents.

The first international comparison of cancer survival, published in 1964,[17] was a study of patients diagnosed with one of 15 common cancers in Denmark, England, Finland, France, Norway, Sweden, and the USA, mainly during 1945–54. It was the first study in which relative survival techniques, first described in the 1950s,[18–20] were used to correct the survival estimates for differences in background mortality between participant countries. The findings are mainly of historical interest, but survival in the USA (represented by Connecticut) was generally higher than in the European countries.

Cancer survival is known to vary between the regions of the USA covered by the US National Cancer Institute's (NCI) Surveillance, Epidemiology and End Results (SEER) Program,[21] but the range of survival in Europe is much wider. Furthermore, survival from breast cancer during 1985–94 was higher in each of the nine SEER areas than in any of the 22 countries participating in the European study of cancer survival (EUROCARE).[7,22] The differences were

Published Online July 17, 2008 DOI:10.1016/S1470-2045(08)70179-7

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often more marked in elderly patients:[9] for several cancers, 5-year survival for patients diagnosed aged 75 years or older during the 1990s was nearly 20% higher in the USA than in Europe.[23]

The CONCORD study began in 1999 as an extension of the EUROCARE-3 study, then just starting. EUROCARE has published systematic comparisons of survival for most adult and childhood cancers in Europe since 1995.[24] The first EUROCARE study involved patients diagnosed in 1978–84 in 12 countries;[25] EUROCARE-2 covered patients diagnosed during 1985–89 in 17 countries,[26] and EUROCARE-3 involved 22 countries, with patients diagnosed in 1990–94 and followed up to 1999.[27,28] More recently, EUROCARE-4 has included patients diagnosed in 23 countries during all or part of 1995–2002 and followed up to 2003.[29,30]

CONCORD was originally designed to assess the survival of adults (aged 15–99 years) diagnosed with cancer of the breast (women), colorectum, or prostate during 1990–94 in Europe and the USA, using population-based data and standardised quality control, and with identical analysis for all datasets, adjusted for differences in general population (background) mortality by country, region, race, and calendar period, and also for differences in the age structure of patient populations. CONCORD also enables comparison of cancer survival between five states and four metropolitan areas in the USA covered by the SEER Program (SEER-9) and 11 states covered by the Centers for Disease Control and Prevention's (CDC) National Program of Cancer Registries (NPCR). It also provides a wider comparison of cancer survival between black and white patients in the USA than has previously been possible.

See Online for webfigure 1

CONCORD includes data from one or more countries on all five continents. To our knowledge, it is the first attempt at a global comparison of cancer survival.

Methods

Cancer registries

In 1999, we identified at international cancer meetings in Atlanta (USA) and Lisbon (Portugal), and from published studies, population-based cancer registries that had published survival data and were operational during 1990–99. Registries that had met the quality criteria for inclusion in *Cancer Incidence in Five Continents* (volume VII, 1988–92)[31] were eligible. We obtained data from 19 other registries. Most had met comparable criteria, such as those in the EUROCARE-3 study (patients diagnosed during 1990–94 with follow-up to 1999).[28] North American registries were eligible if they had met the standards required for Cancer Incidence in North America, 1991–95,[32] and could provide complete follow-up to the end of 1999. In total, we identified 112 registries, but 11 were withdrawn or excluded: no response (one); withdrawal for legal reasons (one); incomplete registration before 1995 (four); follow-up activity stopped before 1999 (two); data not supplied by the September, 2005 deadline (three).

A pilot study of 50 registries in 2000 obtained a 100% response. All registries were able to provide data for patients diagnosed during all or part of the period 1990–94, and had access to various data sources to obtain follow-up information for all patients for at least 5 years or to the end of 1999. After further recruitment, a detailed questionnaire was obtained for 100 of the 101 registries finally included in the analyses, covering data definitions and methods of operation, including data collection, coding of tumour site, morphology, behaviour, and stage at diagnosis, tracing of registered patients to ascertain their vital status, and linkage between data on the incident tumour and data on subsequent death or loss to follow-up. The procedures and definitions used, the stated quality and completeness of data on the registration of incident cancers, and of the follow-up of those patients over the next 5 years, were deemed adequate to attempt cancer-survival analysis, subject to central quality control of the data. The pilot study confirmed the feasibility of the CONCORD protocol[33] and the active support of cancer registries for wider international comparisons of cancer survival. The questionnaire and detailed findings are available online.[34]

Data sources

Anonymised individual tumour records were obtained from population-based cancer registries in all five continents, as defined on UN guidelines:[35] Africa, America (Central and South, including the Caribbean), America (North), Asia, Europe, and Oceania (table 1 and webfigure 1). We retained Hawaii (USA) with North America rather than Oceania.

Africa was represented by a single cancer registry, for the wilaya (département, or state) of Sétif (Algeria).

Central and South America, including the Caribbean, were represented by the national cancer registry of Cuba and two regional registries in Brazil: the Goiânia (Goiás state) registry is one of 20 registries in state capitals, whereas the Campinas (São Paulo state) registry is the only one in Brazil that is not in a state capital.

Data from North America include five of the seven largest provinces in Canada (British Columbia, Manitoba, Nova Scotia, Ontario, and Saskatchewan). Data for the USA came from 22 registries covering 16 states (California, Colorado, Connecticut, Florida, Hawaii, Idaho, Iowa, Louisiana, Michigan, Nebraska, New Jersey, New Mexico, New York State, Rhode Island, Utah, and Wyoming) and six metropolitan areas (Atlanta, GA, Los Angeles, CA, San Francisco, CA, Detroit, MI, New York City, NY, and Seattle, WA).

Population-based cancer registries in the USA receive support from either or both of the two federal cancer-surveillance programmes, the NCI's SEER Program and the CDC's NPCR.[36] As of 1990, the SEER Program included nine population-based cancer registries covering some 10% of the US population (SEER-9): the states of Connecticut, Hawaii, Iowa, New Mexico, and Utah, and the metropolitan areas of Atlanta, GA, Detroit, MI, San Francisco, CA, and Seattle, WA. The Los Angeles cancer registry became a SEER registry in 1992, but we opted to retain it with the NPCR data, so that the SEER grouping

we used was identical with that for which SEER data had been published in the past (SEER-9). The NPCR at the CDC began more recently, and this is the first cancer-survival analysis for 11 states: California, Colorado, Florida, Idaho, Louisiana, Michigan, Nebraska, New Jersey, New York, Rhode Island, and Wyoming.

	Population covered by registry	% of national population	Breast	Colon		Rectum		Colorectum		Prostate	Total
			Women	Men	Women	Men	Women	Men	Women		
Africa											
Algeria (Sétif)	1104561	4·2	180	10	14	30	30	40	44	36	300
America (Central and South)											
Brazilian registries	1795387	1·2	806	130	194	50	69	180	263	474	1723
Campinas	870380	0·6	175	61	82	..	..	..	..	149	467
Goiânia	925007	0·6	631	69	112	50	69	119	181	325	1256
Cuba	10754868	100·0	6461	1083	1516	674	734	1757	2250	4341	14809
South American registries	12550255	..	7267	1213	1710	724	803	1937	2513	4815	16532
America (North)											
Canadian registries	16474543	58·1	44620	13989	13819	6272	4220	20261	18039	45999	128919
British Columbia	3131700	11·0	9141	2223	2178	625	412	2848	2590	11496	26075
Manitoba	1109998	3·9	2932	954	957	556	343	1510	1300	3761	9503
Nova Scotia	918000	3·2	2316	771	829	..	..	..	..	2243	6159
Ontario	10298801	36·3	27389	9214	9069	4613	3154	13827	12223	25310	78749
Saskatchewan	1016044	3·6	2842	827	786	478	311	1305	1097	3189	8433
US registries	108775729	42·4	324551	89673	96186	40149	32774	129822	128960	356881	940214
Atlanta,† GA	2315961	0·9	5747	1215	1473	474	496	1689	1969	6406	15811
California	30974659	12·1	85143	21384	22351	9999	8172	31383	30523	95707	242756
Los Angeles, CA	9055424	..	22587	5741	6136	2659	2233	8400	8369	25789	65145
San Francisco, CA	3805588	..	12321	3165	3375	1463	1194	4628	4569	12733	34251
Colorado	3495939	1·4	9117	2084	2183	944	751	3028	2934	11433	26512
Connecticut	3300712	1·3	11335	3112	3299	1458	1128	4570	4427	11357	31689
Florida	13650553	5·3	46065	14845	15007	6007	4790	20852	19797	64256	150970
Hawaii	1158613	0·5	2857	986	808	508	279	1494	1087	3482	8920
Idaho	1071685	0·4	2689	676	681	331	239	1007	920	3899	8515
Iowa	2818401	1·1	9133	2776	3532	1267	989	4043	4521	10743	28440
Louisiana	4293003	1·7	11204	3302	3780	1374	1186	4676	4966	13059	33905
Michigan	9479065	3·7	31183	8821	9323	3791	3162	12612	12485	23705	79985
Detroit, MI	3969304	..	12247	3223	3534	1499	1213	4722	4747	17162	38878
Nebraska	1611687	0·6	5242	1625	1801	776	544	2401	2345	6828	16816
New Jersey	7880508	3·1	27125	8110	8670	3694	3091	11804	11761	29877	80567
New Mexico	1595442	0·6	3796	901	892	436	323	1337	1215	5393	11741
New York State	18246653	7·1	55404	15191	17426	6936	5889	22127	23315	47096	147942
New York City	7322564	..	21644	5821	7048	2335	2253	8156	9301	16770	55871
Rhode Island	1012581	0·4	3466	1113	1280	477	440	1590	1720	3449	10225
Seattle,† WA	3567217	1·4	10451	2415	2577	1168	893	3583	3470	12818	30322
Utah	1836799	0·7	3506	866	805	393	293	1259	1098	5779	11642
Wyoming	466251	0·2	1088	251	298	116	109	367	407	1594	3456
North American registries	125250272	44·0	369171	103662	110005	46421	36994	150083	146999	402880	1069133
Asia											
Japanese registries	10819997	8·7	7179	5469	4588	3510	2248	8979	6836	1691	24685
Fukui	827000	0·7	840	738	709	477	310	1215	1019	325	3399
Osaka	8734516	7·0	5112	3337	2593	2075	1283	5412	3876	920	15320
Yamagata	1258481	1·0	1227	1394	1286	958	655	2352	1941	446	5966

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	Population covered by registry	% of national population	Breast	Colon		Rectum		Colorectum		Prostate	Total
			Women	Men	Women	Men	Women	Men	Women		
(Continued from previous page)											
Europe											
Austria (Tirol)	624 939	8·0	1559	416	483	261	237	677	720	1432	4388
Czech Republic (West Bohemia)	861 000	8·3	1543	672	601	681	416	1353	1017	693	4606
Denmark	5 145 160	100·0	14 686	3954	4822	3308	2495	7262	7317	6503	35 768
Estonia	1 562 468	100·0	2205	598	845	479	553	1077	1398	1143	5823
Finland	5 070 000	100·0	12 214	1907	2639	1687	1561	3594	4200	7544	27 552
French registries	3 098 526	5·6	6359	1675	1544	1164	876	2839	2420	2909	14 527
Bas-Rhin	954 710	1·8	2591	848	730	522	379	1370	1109	1626	6696
Calvados	618 353	1·1	1640	440	448	345	309	785	757	1283	4465
Côte d'Or	507 147	0·9	791	387	366	297	188	684	554	..	2029
Isère	1 018 316	1·8	1337	..	..	..	..	..	..	..	1337
Germany (Saarland)	1 067 027	1·3	2957	1035	1237	712	656	1747	1893	1610	8207
Iceland	254 960	100·0	504	125	128	37	47	162	175	493	1334
Ireland	3 609 000	100·0	1513	587	534	382	224	969	758	1062	4302
Italian registries	8 944 772	15·3	26 403	8713	8672	4743	3887	13 456	12 559	10 671	63 089
Ferrara	355 479	0·6	1321	488	486	200	158	688	644	438	3091
Genoa	695 981	1·3	2571	892	894	442	380	1334	1274	1122	6301
Latina	468 865	0·8	657	199	182	135	84	334	266	197	1454
Macerata	281 537	0·5	629	296	283	168	119	464	402	435	1930
Modena	602 570	0·5	1887	641	654	361	275	1002	929	810	4628
Parma	391 237	0·7	1318	480	410	256	204	736	614	456	3124
Ragusa	140 537	0·5	513	159	171	123	82	282	253	227	1275
Romagna	604 488	0·8	1347	498	549	226	226	724	775	740	3586
Sassari	469 570	0·8	591	143	128	126	62	269	190	198	1248
Turin	996 443	1·8	3009	868	904	500	457	1368	1361	1030	6768
Tuscany	1 167 687	2·1	3807	1420	1446	854	702	2274	2148	1797	10 026
Varese	793 378	1·4	2400	691	710	410	344	1101	1054	803	5358
Veneto	1 977 000	3·5	6 353	1938	1855	942	794	2880	2649	2418	14 300
Malta	365 000	100·0	359	76	73	53	31	129	104	111	703
Netherlands registries	5 158 472	34·3	15 862	2418	2791	1471	1271	3889	4062	5353	29 166
Amsterdam	2 620 000	17·4	7509	1764	2117	1020	946	2784	3063	4171	17 527
Netherlands (North)	1 602 661	10·6	5999	..	..	..	..	..	..	..	5999
Netherlands (South)	935 811	6·3	2354	654	674	451	325	1105	999	1182	5640
Norway	4 245 180	100·0	9193	3590	4136	2536	2048	6126	6184	9841	31 344
Polish registries	2 373 190	6·1	4220	1080	1152	827	773	1907	1925	1159	9211
Cracow	747 985	1·9	1205	240	243	203	168	443	411	253	2312
Warsaw	1 625 205	4·2	3015	840	909	624	605	1464	1514	906	6899
Portugal (South)	1 145 000	11·4	1219	364	355	327	236	691	591	344	2845
Slovakia	5 297 774	100·0	6079	2572	2126	2646	1815	5218	3941	2821	18 059
Slovenia	2 072 000	100·0	3327	914	898	1025	851	1939	1749	160	8175
Spanish registries	5 566 140	14·4	9744	3439	2934	2502	1613	5941	4547	4273	24 505
Basque Country	2 097 000	5·4	3816	1321	1027	1057	589	2378	1616	1721	9531
Granada	787 898	2·0	879	299	255	219	152	518	407	..	1804
Mallorca	582 655	1·5	1143	447	394	296	213	743	607	617	3110
Murcia	1 036 966	2·8	1485	505	512	397	330	902	842	643	3872
Navarra	520 300	1·3	1229	404	304	249	167	653	471	688	3041
Tarragona	541 321	1·4	1192	463	442	284	162	747	604	604	3147

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Survival estimates reported from the SEER Program have until now been the only population-based cancer survival data from the USA.[21,37] We wanted to compare survival between the areas covered by registries in the NPCR and the SEER Program during 1990–94. We received separate datasets from Detroit, MI, San Francisco, CA (SEER registries), and Los Angeles, CA (NPCR), and these were included in the respective totals for SEER and NPCR. However, the data from these metropolitan areas could not be separately identified in the state-wide datasets we received from California and Michigan, therefore, the non-metropolitan data for those states could not be included with the other NPCR data. Data from all nine SEER registries were available.[38]

Survival in the SEER-9 areas was therefore compared with survival in nine states and one metropolitan area covered by

	Population covered by registry	% of national population	Breast	Colon		Rectum		Colorectum		Prostate	Total
			Women	Men	Women	Men	Women	Men	Women		
(Continued from previous page)											
Sweden	8 826 939	100·0	24 170	6112	6685	4401	3578	10 513	10 263	24 041	68 987
Swiss registries	1 758 249	25·8	4847	..	..	..	..	..	..	..	4847
Basel	429 104	6·3	1365	..	..	..	..	..	..	..	1365
Geneva	381 492	5·6	1275	..	..	..	..	..	..	..	1275
Graubunden-Glarus	210 485	3·1	544	..	..	..	..	..	..	..	544
St Gallen-Appenzell	483 801	7·1	1027	..	..	..	..	..	..	..	1027
Valais	253 367	3·7	636	..	..	..	..	..	..	..	636
UK	58 984 046	..	154 867	41 499	45 729	30 600	22 556	72 099	68 285	78 608	373 859
England (national)	49 310 000	100·0	129 703	33 983	37 334	25 618	18 780	59 601	56 114	66 181	311 599
East Anglia	2 089 000	4·2	6330	1820	2060	1245	954	3065	3014	3897	16 306
Mersey	2 412 000	4·9	6561	1932	2080	1425	1069	3357	3149	3242	16 309
Oxford	2 582 000	5·2	7458	1737	1934	1193	929	2930	2863	3612	16 863
South Thames	6 756 000	13·7	17 002	3880	4689	2824	2328	6704	7017	8232	38 955
South West	3 320 000	6·7	19 203	5630	6215	3869	2917	9499	9132	11 766	49 600
Trent	4 745 000	9·6	13 360	3523	3793	3045	2087	6568	5880	6774	32 582
West Midlands	5 278 000	10·7	13 561	4397	4482	3272	2066	7669	6548	7315	35 093
Yorkshire	3 698 000	7·5	9 473	2599	2910	2121	1574	4720	4484	5165	23 842
English registries	30 880 000	62·5	92 948	25 518	28 163	18 994	13 924	44 512	42 087	50 003	229 550
Northern Ireland	1 648 960	100·0	1527	562	576	328	224	890	800	888	4105
Scotland	5 100 086	100·0	14 254	4441	5089	2671	2124	7112	7213	6855	35 434
Wales	2 925 000	100·0	9383	2513	2730	1983	1428	4496	4158	4684	22 721
European registries	126 029 842	..	303 830	81 746	88 384	59 842	45 724	141 588	134 108	161 771	741 297
Oceania											
Australia	18 071 422	100·0	41 090	15 200	15 098	9911	6904	25 111	22 002	42 890	131 093
Australian Capital Territory	304 371	1·7	548	180	160	99	78	279	238	414	1479
New South Wales	6 133 913	33·9	14 382	5358	5066	3478	2354	8836	7420	15 507	46 145
Northern Territory	178 062	1·0	165	46	41	41	20	87	61	78	391
Queensland	3 252 245	18·0	7052	2783	2743	1619	998	4402	3741	7468	22 663
Southern Australia	1 473 966	8·2	3688	1323	1335	937	734	2260	2069	4228	12 245
Tasmania	472 971	2·6	1081	474	453	242	171	716	624	1321	3742
Victoria	4 521 392	25·0	10 583	3865	4103	2683	1978	6548	6081	9826	33 038
Western Australia	1 734 502	9·6	3591	1171	1197	812	571	1983	1768	4048	11 390
CONCORD											
CONCORD total	293 826 349	..	728 717	207 300	219 799	120 438	92 703	327 738	312 502	614 083	1 983 040

*Some registries provided data for shorter periods, ie, 4 years: Campinas, Macerata, Granada (1991–94); 3 years: Isère (1990–92), Portugal (1991–93), Sétif, Sassari (1992–94); 2 years: Malta, Northern Ireland (1993–94); 1 year: Ireland (1994). †No state-wide data available for this city. Where a registry did not provide data for a given cancer, cell entries for numbers of patients and survival estimates are left blank. National percentages are derived from the raw data and can differ from the sum of regional percentages because of rounding. Row totals avoid double counting of colon and rectal tumours, also shown in the table as colon and rectum combined.

Table 1: **Population coverage and number of adults (aged 15–99 years) diagnosed with cancer of the breast, colon, rectum, or prostate during 1990–94* and included in the analyses: continent, country, and region**

NPCR: Colorado, Florida, Idaho, Los Angeles, CA, Louisiana, Nebraska, New Jersey, New York, Rhode Island, and Wyoming. For this comparison, data from the non-metropolitan areas of California and Michigan were excluded to ensure that the two sets of data were mutually exclusive.

In Asia, Japan was represented by three of the prefectural (state) registries: Fukui, Osaka, and Yamagata.

In Europe, the 53 cancer registries that contributed data to EUROCARE-3[28] on cancers of the breast, colon, rectum, or prostate all participated in the CONCORD study. Six other registries also provided data: two national registries (Northern Ireland and Ireland) and four regional registries from the Netherlands (North) and Switzerland (Graubunden-Glarus, St Gallen-Appenzell, Valais). As in the EUROCARE study, the UK is considered as its four constituent countries (England, Scotland, Wales, Northern Ireland), each of which has a national registry. In England, both the national cancer registry and eight of the regional cancer registries submitted datasets.

Oceania was represented by the national cancer registry of Australia, with data from each of the eight population-based state or territorial registries.

Quality control

Procedures used in the EUROCARE-3 study were applied to all datasets. Tumour records were supplied with the anatomical site coded to the ninth revision of the International Classification of Diseases (ICD-9[39]) for four index tumours: cancers of the breast (women) (ICD-9 174.0–174.9), colon (153.0–153.9), rectum (including the anus, 154.0–154.9), and prostate (185). Tumour morphology and behaviour were coded to the first or second revision of ICD-Oncology (ICD-O,[40] ICD-O-2[41]). Only invasive malignant tumours (behaviour code 3) were included. Patients with an index tumour had sometimes been registered with another malignancy, either before or after the index tumour. Data on those other cancers in index patients were also submitted. Only the first, primary, invasive, malignant tumour diagnosed in each patient was retained for analysis. Patients registered with a malignant neoplasm before the index tumour were excluded, although non-melanoma skin cancer was not counted as a previous tumour for this purpose. Bilateral breast cancers and multiple colon cancers were included as a single tumour if synchronous; otherwise, only the earliest tumour was considered. The duration of survival was taken from the date of diagnosis of the index tumour until death from any cause, or until the patient was censored from the analysis as alive, either at loss to follow-up or after Dec 31, 1999, whichever came first; any subsequent tumour occurring in the same patient during that period was ignored.

Standard quality-control routines, based on those developed by the International Agency for Research on Cancer,[42] were applied to each tumour record. Records with invalid codes, impossible sequences of dates, or improbable combinations of tumour site and morphology were returned to the registry for checking. Usually, the registry provided a correction or an explanation. Corrected tumour records were checked again: those which still had missing, invalid or inconsistent values for sex, site, morphology, or dates were flagged as major errors and excluded from analysis. Records for which an unlikely combination of age, site and morphology had nonetheless been confirmed as correct were flagged as minor errors, and included in the analyses. Details of the approach have been published elsewhere.[43] Detailed quality-control findings are available online.[34]

Follow-up

All registries used more than one mechanism of follow-up to ascertain the vital status (alive, dead, emigrated, lost to follow-up) and the date of the last vital status for each registered patient. The mechanisms varied between countries, usually linkage between the registry's database and a variety of other data sources, especially the national index of deaths. Secure linkage of a tumour record and a record of death, based on a set of identifiers such as name, sex, date of birth, and personal identity number, enabled the registry to update the tumour record accordingly. Direct contact with the patient or their family to establish vital status was unusual, although home visits by registry staff were done in Algeria. Enquiries to the patient's primary care physician or hospital consultant were frequently used. A wide variety of administrative databases was also used, such as social insurance, health insurance, motor vehicle records, drivers' licences, hospital discharge records, national primary-care databases, electoral registers (those eligible to vote), and voter registration records (those who voted in the last election). The presence of a person's record in such administrative databases on a given date is taken as evidence that the person was alive on that date. This is subject to administrative error (failure to remove in timely fashion the record of a person known to be dead) and fraud (by someone seeking to retain access to benefits received by the deceased), but in most instances the risks are small. If coverage of the databases was known to be high, and especially if a person was present in more than one such database, the risk of error decreased further.

In the USA, a match to an administrative database might show that an event occurred during a certain quarter of a year (eg, an insurance claim paid, a licence renewed), but the exact date might not be known; the date of last vital status was then set to the first day of the quarter, ie, Jan 1, April 1, July 1, Sept 1. This approach can give rise to irregular distributions of the day of last known vital status, but it is a conservative approach to establishing when patients were last known to be alive, because patients are censored from survival analysis on the latest of any such dates in the record.

The proportion of patients not known to be dead and for whom the registry could not be certain that the date of last vital status was at least 5 years after diagnosis was less than 1% overall. The proportion was often zero (follow-up for at least 5 years was established for every patient not known to be dead), the highest proportion was 4%, and only in a

 Published online July 17, 2008 DOI:10.1016/S1470-2045(08)70179-7

	Breast	Colon		Rectum		Colorectum		Prostate
	Women RS (%) (95% CI)	Men RS (%) (95% CI)	Women RS (%) (95% CI)	Men RS (%) (95% CI)	Women RS (%) (95% CI)	Men RS (%) (95% CI)	Women RS (%) (95% CI)	RS (%) (95% CI)
Africa								
Algeria (Sétif)	38·8 (31·4–46·2) R	11·4 (0·7–40·9) R	30·6 (9·5–56·1) R	25·9 (11·4–43·7) R	18·2 (6·6–34·6) R	22·5 (10·6–37·7) R	22·6 (11·2–36·7) R	21·4 (8·7–38·9) R
America (Central and South)								
Brazilian registries	58·4 (52·7–64·6)	33·1 (24·2–45·3)	32·7 (26·1–40·8)	49·3 (34·8–69·8)	38·4 (27·3–53·9)	47·3 (37·5–59·6)	43·5 (35·7–53·1)	49·3 (43·6–55·8)
Campinas	36·6 (27·8–48·3)	23·8 (13·1–36·8) R	21·4 (12·6–31·9) R	..	..	..	..	34·4 (25·2–47·0)
Goiânia	65·4 (58·3–73·2)	48·1 (36·7–63·1)	44·8 (35·2–56·9)	49·3 (34·8–69·8)	38·4 (27·3–53·9)	47·3 (37·5–59·6)	43·5 (35·7–53·1)	55·7 (49·0–63·3)
Cuba	84·0 (82·9–85·2)	59·3 (55·8–63·1)	61·4 (58·3–64·5)	59·2 (55·1–63·7)	62·8 (58·6–67·4)	59·5 (56·8–62·5)	62·0 (59·5–64·6)	69·7 (67·1–72·3)
America (North)								
North American registries	83·7 (83·5–83·9)	59·5 (59·1–59·9)	59·9 (59·5–60·3)	56·4 (55·8–56·9)	59·7 (59·1–60·3)	58·6 (58·3–58·9)	60·0 (59·7–60·3)	91·1 (90·9–91·3)
Canadian registries	82·5 (81·9–83·0)	56·1 (55·1–57·2)	58·7 (57·7–59·7)	53·1 (51·5–54·6)	58·7 (57·0–60·4)	55·3 (54·4–56·2)	58·9 (58·0–59·8)	85·1 (84·4–85·7)
British Columbia	85·4 (84·2–86·5)	57·0 (54·5–59·6)	59·2 (56·8–61·7)	64·6 (59·9–69·7)	62·8 (57·5–68·6)	58·7 (56·4–61·0)	59·9 (57·7–62·2)	89·3 (88·1–90·5)
Manitoba	82·9 (80·9–85·0)	57·4 (53·4–61·6)	59·8 (56·1–63·8)	54·6 (49·6–60·1)	58·1 (52·3–64·6)	56·4 (53·3–59·7)	59·5 (56·4–62·8)	87·5 (85·5–89·6)
Nova Scotia	79·3 (77·0–81·8)	54·3 (50·0–58·9)	58·2 (54·3–62·4)	..	..	..	..	84·7 (81·8–87·6)
Ontario	81·6 (80·9–82·3)	56·0 (54·8–57·3)	58·5 (57·3–59·7)	51·1 (49·3–52·9)	57·8 (55·8–59·8)	54·5 (53·5–55·6)	58·6 (57·5–59·6)	83·4 (82·5–84·3)
Saskatchewan	82·8 (80·8–84·8)	55·4 (51·3–59·7)	58·0 (53·9–62·4)	54·8 (49·6–60·6)	61·1 (55·1–67·7)	55·2 (52·0–58·6)	59·1 (55·6–62·7)	77·5 (74·4–80·8)
US registries	83·9 (83·7–84·1)	60·1 (59·6–60·5)	60·1 (59·7–60·5)	56·9 (56·3–57·5)	59·8 (59·2–60·4)	59·1 (58·8–59·5)	60·2 (59·8–60·5)	91·9 (91·7–92·1)
Atlanta,† GA	85·7 (84·0–87·4)	63·9 (60·2–67·7)	60·7 (57·8–63·7)	56·5 (50·9–62·7)	64·3 (59·4–69·7)	62·3 (59·3–65·6)	62·0 (59·4–64·7)	93·4 (91·8–94·9)
California	84·6 (84·3–85·0)	60·4 (59·5–61·2)	59·5 (58·7–60·3)	57·2 (56·0–58·5)	60·1 (58·8–61·4)	59·4 (58·7–60·1)	59·9 (59·2–60·5)	90·4 (90·0–90·8)
Los Angeles, CA	83·4 (82·6–84·2)	61·2 (59·6–62·9)	58·4 (56·9–60·0)	55·7 (53·3–58·1)	58·5 (56·1–61·0)	59·5 (58·1–60·8)	58·5 (57·2–59·8)	90·7 (89·9–91·5)
San Francisco, CA	86·2 (85·2–87·2)	59·2 (57·1–61·4)	59·9 (57·9–62·0)	56·5 (53·4–59·8)	60·3 (57·1–63·7)	58·4 (56·6–60·2)	60·2 (58·4–62·0)	89·5 (88·4–90·6)
Colorado	87·0 (85·8–88·2)	61·6 (59·0–64·4)	62·0 (59·5–64·6)	55·6 (51·7–59·8)	59·8 (55·9–64·0)	59·7 (57·5–62·0)	61·7 (59·6–63·8)	92·8 (91·6–93·9)
Connecticut	85·7 (84·7–86·7)	62·3 (60·1–64·7)	63·4 (61·3–65·6)	61·3 (58·1–64·6)	62·4 (59·1–65·8)	62·0 (60·2–63·9)	63·4 (61·6–65·2)	91·7 (90·5–93·0)
Florida	84·0 (83·5–84·5)	60·2 (59·2–61·3)	61·0 (60·0–62·0)	57·1 (55·5–58·7)	61·0 (59·4–62·6)	59·4 (58·5–60·2)	61·2 (60·3–62·1)	89·0 (88·4–89·5)
Hawaii	89·3 (87·3–91·4)	67·9 (64·2–71·8)	66·5 (62·6–70·6)	59·3 (54·2–64·8)	61·0 (54·7–68·0)	65·0 (61·9–68·1)	65·5 (62·2–69·0)	90·9 (88·7–93·2)
Idaho	86·3 (84·2–88·5)	61·4 (56·9–66·3)	63·4 (59·1–68·0)	66·9 (60·8–73·6)	60·0 (53·3–67·6)	63·6 (59·9–67·6)	62·8 (59·2–66·7)	91·7 (89·8–93·7)
Iowa	86·6 (85·5–87·7)	60·8 (58·4–63·3)	64·8 (62·7–67·0)	59·0 (55·6–62·6)	63·8 (60·2–67·6)	60·3 (58·3–62·3)	64·7 (62·9–66·6)	92·6 (91·4–93·8)
Louisiana	81·0 (79·9–82·2)	59·8 (57·5–62·1)	58·8 (56·8–60·7)	57·3 (53·9–60·9)	58·7 (55·5–62·1)	59·1 (57·3–61·1)	58·9 (57·2–60·6)	88·4 (87·2–89·6)
Michigan‡	82·3 (81·7–83·0)	58·7 (57·4–60·1)	59·3 (58·0–60·5)	55·2 (53·2–57·2)	59·2 (57·2–61·3)	57·8 (56·7–58·9)	59·4 (58·4–60·5)	100·0 (99·8–100)
Detroit, MI	83·0 (82·0–84·1)	60·5 (58·3–62·8)	58·0 (56·0–60·1)	55·8 (52·6–59·1)	57·5 (54·2–60·9)	59·1 (57·3–61·0)	57·9 (56·2–59·6)	93·4 (92·4–94·4)
Nebraska	85·4 (84·0–86·9)	60·4 (57·3–63·7)	64·2 (61·4–67·2)	58·3 (54·0–63·0)	60·6 (56·0–65·7)	59·8 (57·3–62·5)	63·6 (61·1–66·1)	92·8 (91·3–94·4)
New Jersey	83·3 (82·6–84·0)	61·3 (59·9–62·7)	61·1 (59·8–62·5)	56·1 (54·0–58·2)	58·4 (56·3–60·5)	59·6 (58·4–60·8)	60·5 (59·4–61·6)	90·8 (90·1–91·6)
New Mexico	84·6 (82·7–86·4)	62·0 (58·1–66·2)	61·6 (57·8–65·7)	52·6 (47·2–58·7)	59·1 (53·0–65·8)	59·0 (55·7–62·4)	61·0 (57·8–64·4)	92·4 (90·7–94·1)
New York State	81·0 (80·5–81·5)	56·6 (55·6–57·7)	56·4 (55·5–57·4)	54·9 (53·4–56·4)	56·7 (55·2–58·2)	56·1 (55·3–57·0)	56·6 (55·8–57·4)	85·6 (85·0–86·2)
New York City	77·4 (76·6–78·2)	54·2 (52·6–55·9)	53·6 (52·1–55·1)	50·6 (48·2–53·2)	52·4 (50·0–54·9)	53·2 (51·8–54·5)	53·3 (52·1–54·6)	81·6 (80·5–82·7)
Rhode Island	84·6 (82·8–86·4)	64·7 (60·9–68·7)	63·5 (60·0–67·2)	60·1 (54·5–66·3)	59·9 (54·5–65·8)	63·3 (60·2–66·7)	62·8 (59·8–65·8)	90·8 (88·4–93·2)
Seattle,† WA	88·6 (87·5–89·7)	63·7 (61·3–66·2)	64·1 (61·9–66·5)	60·7 (57·2–64·4)	65·4 (61·9–69·2)	63·0 (60·9–65·1)	64·8 (62·9–66·8)	95·0 (94·0–96·0)
Utah	85·8 (84·0–87·7)	60·8 (56·8–65·1)	58·6 (54·5–63·0)	59·9 (54·2–66·2)	61·3 (55·0–68·2)	61·1 (57·8–64·6)	59·6 (56·2–63·3)	93·7 (92·2–95·2)
Wyoming	84·3 (80·9–87·8)	59·5 (52·5–67·4)	58·5 (52·2–65·6)	46·5 (37·3–57·9)	52·3 (42·7–64·0)	56·0 (50·1–62·5)	57·8 (52·4–63·7)	92·2 (89·3–95·3)
Asia								
Japanese registries	81·6 (79·7–83·5)	63·0 (61·3–64·8)	57·1 (55·5–58·8)	58·2 (55·9–60·5)	57·6 (55·2–60·1)	61·1 (59·7–62·5)	57·3 (55·9–58·6)	50·4 (46·3–54·9)
Fukui	83·1 (78·3–88·2)	68·5 (64·2–73·0)	62·8 (58·8–67·0)	59·6 (54·1–65·7)	61·6 (56·0–67·8)	65·3 (61·8–68·9)	62·4 (59·1–65·9)	54·1(46·6–61·6)R
Osaka	79·4 (77·1–81·9)	59·6 (57·3–62·0)	52·5 (50·4–54·7)	54·4 (51·3–57·7)	55·2 (51·9–58·7)	57·6 (55·7–59·5)	53·3 (51·5–55·2)	51·1 (46·1–56·6)
Yamagata	87·3 (83·4–91·4)	67·5 (64·3–70·8)	63·7 (60·7–66·8)	63·7 (59·8–67·9)	61·8 (57·6–66·3)	66·0 (63·5–68·5)	63·0 (60·5–65·5)	49·4(43·2–55·6)R
Europe								
European registries	73·1 (72·9–73·4)	46·8 (46·3–47·2)	48·4 (48·0–48·8)	43·2 (42·7–43·7)	47·4 (46·9–48·0)	45·3 (45·0–45·6)	48·1 (47·7–48·4)	57·1 (56·7–57·6)
Austria (Tirol)	74·9 (71·9–78·1)	57·0 (51·5–63·0)	59·3 (54·3–64·7)	45·8 (39·1–53·8)	45·2 (37·6–52·8) R	52·7 (48·2–57·6)	55·1 (50·8–59·7)	86·1 (82·9–89·4)
Czech Republic (West Bohemia)	62·9 (58·9–67·1)	37·7 (33·0–43·0)	37·6 (33·3–42·5)	29·3 (25·2–34·1)	39·1 (33·8–45·2)	33·8 (30·5–37·6)	38·3 (34·9–42·0)	50·7 (44·4–58·0)
Denmark	73·6 (72·5–74·7)	44·7 (42·7–46·7)	48·6 (46·8–50·4)	43·4 (41·2–45·6)	45·9 (43·6–48·3)	44·2 (42·7–45·7)	47·7 (46·3–49·2)	38·4 (36·3–40·6)
Estonia	61·3 (57·9–64·8)	38·5 (33·7–44·1)	39·1 (35·3–43·2)	33·6 (28·4–39·7)	30·2 (26·0–35·1)	36·4 (32·8–40·4)	35·5 (32·6–38·6)	56·5 (52·3–60·9)

(Continues on next page)

	Breast	Colon		Rectum		Colorectum		Prostate
	Women RS (%) (95% CI)	Men RS (%) (95% CI)	Women RS (%) (95% CI)	Men RS (%) (95% CI)	Women RS (%) (95% CI)	Men RS (%) (95% CI)	Women RS (%) (95% CI)	RS (%) (95% CI)
(Continued from previous page)								
Finland	80·2 (79·0–81·4)	54·6 (51·6–57·8)	54·7 (52·5–57·1)	49·8 (46·8–53·0)	52·6 (49·7–55·6)	52·5 (50·4–54·7)	54·0 (52·2–55·8)	62·9 (60·6–65·2)
French registries	79·8 (78·2–81·4)	57·4 (54·4–60·7)	60·1 (57·2–63·2)	52·8 (49·3–56·7)	63·9 (60·1–67·8)	55·6 (53·3–58·1)	61·5 (59·2–64·0)	73·7 (70·5–77·1)
Bas-Rhin	82·2 (79·7–84·7)	57·8 (53·5–62·5)	62·7 (58·8–66·9)	57·9 (52·6–63·7)	61·7 (56·0–67·9)	57·8 (54·4–61·4)	63·0 (59·6–66·6)	73·8 (69·4–78·4)
Calvados	75·6 (72·5–78·8)	62·0 (56·0–68·5)	61·3 (56·0–67·1)	52·2 (45·6–59·8)	67·9 (62·0–74·5)	57·6 (53·1–62·5)	64·2 (60·1–68·5)	73·1 (68·4–78·2)
Côte d'Or	78·1 (74·1–82·3)	50·6 (44·6–57·5)	52·6 (46·7–59·4)	45·3 (38·8–53·0)	61·3 (53·3–70·5)	48·7 (44·1–53·7)	55·3 (50·5–60·6)	..
Isère	81·9 (78·6–85·2)	..	..	..	..	..	..	..
Germany (Saarland)	75·5 (73·3–77·8)	52·0 (48·2–56·0)	56·2 (52·9–59·7)	47·8 (43·0–53·1)	52·5 (48·1–57·3)	50·1 (47·2–53·2)	55·0 (52·3–57·9)	76·4 (72·7–80·4)
Iceland	79·0 (73·5–85·0)	48·1 (39·0–59·3)	54·9 (45·2–66·6)	52·1 (31·9–71·4) R	48·4 (31·7–64·6) R	49·5 (41·0–59·9)	54·0 (45·9–63·6)	69·7 (62·2–78·1)
Ireland	69·6 (66·1–73·3)	49·1 (44·0–54·8)	48·5 (43·7–53·8)	41·1 (35·0–48·2)	52·5 (44·6–60·3) R	46·0 (42·0–50·4)	50·0 (45·9–54·5)	62·8 (58·0–68·0)
Italian registries	79·5 (78·8–80·3)	52·4 (51·1–53·8)	53·8 (52·6–55·0)	47·4 (45·7–49·2)	50·4 (48·6–52·3)	50·7 (49·7–51·8)	52·7 (51·7–53·8)	65·4 (63·7–67·2)
Ferrara	78·8 (75·6–82·2)	48·5 (43·2–54·5)	54·9 (49·8–60·5)	44·6 (37·1–53·6)	48·0 (40·5–57·0)	47·3 (42·8–52·2)	53·6 (49·2–58·4)	69·8(63·2–76·0)R
Genoa	80·6 (78·3–83·0)	49·9 (45·9–54·2)	51·2 (47·5–55·3)	40·5 (35·2–46·6)	45·4 (40·0–51·5)	46·8 (43·5–50·3)	49·5 (46·3–52·9)	66·2 (61·0–71·9)
Latina	81·8 (76·4–87·5)	52·7 (45·3–61·3)	57·4 (49·9–65·9)	46·3 (36·3–56·2) R	45·1 (34·7–58·5)	51·2 (45·0–58·2)	53·3 (47·1–60·3)	61·0 (53·9–69·1)
Macerata	77·5 (73·0–82·4)	48·9 (42·8–55·9)	57·9 (51·7–65·0)	42·0 (34·1–51·8)	52·1 (41·2–62·6) R	46·7 (41·6–52·3)	56·8 (51·4–62·7)	69·7(63·1–76·0)R
Modena	83·1 (80·4–85·8)	55·0 (50·5–59·9)	52·0 (47·7–56·5)	48·4 (42·5–55·1)	45·3 (39·0–52·5)	52·8 (49·2–56·7)	49·8 (46·2–53·7)	68·7 (61·7–76·6)
Parma	81·2 (78·1–84·4)	50·7 (45·6–56·4)	53·7 (48·3–59·7)	47·4 (39·9–54·9) R	41·6 (34·7–49·7)	49·8 (45·6–54·5)	49·3 (44·9–54·2)	56·1 (48·0–65·6)
Ragusa	68·9 (63·2–75·1)	39·5 (32·0–48·8)	44·0 (36·8–52·6)	50·3 (40·8–61·9)	37·8 (26·0–50·3) R	44·9 (38·7–52·1)	41·9 (35·9–48·9)	49·9(41·0–58·9)R
Romagna	87·4 (84·4–90·4)	51·4 (46·2–57·1)	58·7 (54·0–63·8)	51·0 (42·9–59·0) R	57·9 (50·8–65·9)	50·9 (46·6–55·5)	58·4 (54·4–62·7)	73·3 (67·9–79·2)
Sassari	76·4 (71·3–81·9)	39·9 (31·2–51·0)	41·5 (32·0–51·0) R	44·5 (34·2–54·8) R	42·8 (31·5–58·0)	42·3 (35·8–50·1)	43·5 (36·5–51·8)	52·2(42·8–61·5)R
Turin	79·4 (77·1–81·7)	50·1 (46·1–54·5)	51·4 (47·8–55·4)	43·7 (39·0–49·0)	54·0 (48·8–59·6)	47·8 (44·7–51·2)	52·4 (49·3–55·6)	63·2 (58·1–68·8)
Tuscany	80·8 (78·9–82·7)	55·6 (52·5–58·9)	54·4 (51·4–57·5)	50·8 (46·9–55·0)	48·7 (44·6–53·2)	53·8 (51·4–56·4)	52·5 (50·1–55·1)	66·4 (62·4–70·7)
Varese	77·6 (75·2–80·0)	55·3 (51·0–59·9)	55·1 (51·1–59·5)	52·4 (46·5–59·0)	53·4 (47·8–59·6)	54·5 (51·1–58·2)	54·5 (51·1–58·1)	72·2 (66·7–78·2)
Veneto	77·6 (76·2–79·1)	53·7 (50·9–56·7)	54·6 (52·0–57·3)	48·4 (44·6–52·5)	55·7 (51·7–60·0)	52·0 (49·8–54·4)	55·0 (52·8–57·2)	61·8 (58·5–65·3)
Malta	73·5 (66·7–81·1)	38·0 (25·9–50·7) R	58·0 (46·5–72·4)	34·7 (20·8–49·9) R	52·5 (31·9–71·4) R	35·7 (27·0–47·1)	55·5 (46·1–66·8)	44·3(32·3–56·9)R
Netherlands registries	77·6 (76·6–78·6)	52·7 (50·1–55·4)	55·4 (53·2–57·7)	55·0 (51·6–58·6)	54·5 (51·3–57·9)	53·6 (51·5–55·7)	55·1 (53·3–57·0)	69·5 (67·2–71·9)
Amsterdam	78·0 (76·5–79·4)	52·1 (49·1–55·2)	54·1 (51·6–56·7)	51·5 (47·6–55·7)	56·4 (52·7–60·3)	51·9 (49·5–54·3)	54·8 (52·7–57·0)	68·1 (65·4–70·8)
Netherlands (North)	77·8 (76·2–79·4)	..	..	..	..	..	..	..
Netherlands (South)	75·7 (72·9–78·5)	54·2 (49·2–59·8)	59·4 (54·9–64·2)	62·1 (56·6–68·1)	49·2 (43·1–56·1)	58·0 (54·2–62·2)	56·1 (52·5–60·0)	74·9 (70·3–79·8)
Norway	76·3 (75·1–77·6)	50·8 (48·7–53·0)	54·4 (52·5–56·3)	51·3 (48·9–53·9)	56·9 (54·3–59·6)	51·1 (49·5–52·8)	55·3 (53·8–56·9)	63·0 (60·9–65·1)
Polish registries	62·9 (60·6–65·3)	28·5 (25·3–32·1)	30·9 (28·0–34·2)	28·4 (24·7–32·7)	30·2 (26·7–34·1)	28·6 (26·1–31·3)	30·6 (28·3–33·0)	37·1 (33·0–41·6)
Cracow	54·7 (50·6–59·1)	24·6 (18·8–32·1)	23·4 (17·9–30·7)	25·0 (18·9–33·3)	22·9 (16·8–31·1)	25·7 (21·5–30·8)	22·5 (18·3–27·6)	21·3 (15·2–29·9)
Warsaw	66·1 (63·4–68·9)	29·7 (26·1–33·9)	33·6 (30·3–37·4)	29·2 (24·9–34·2)	32·6 (28·6–37·3)	29·6 (26·8–32·7)	33·0 (30·3–35·8)	41·4 (36·5–46·8)
Portugal (South)	72·2 (68·2–76·5)	48·6 (42·6–55·4)	44·8 (39·1–51·3)	42·3 (35·5–50·4)	44·5 (37·8–52·4)	46·5 (41·8–51·8)	44·7 (40·2–49·7)	47·7(40·7–54·8)R
Slovakia	57·9 (55·9–59·9)	40·1 (37·7–42·7)	44·1 (41·7–46·7)	27·6 (25·5–29·8)	32·3 (29·9–34·8)	34·0 (32·3–35·8)	38·7 (37·0–40·5)	45·7 (42·7–49·0)
Slovenia	66·3 (63·8–68·9)	37·3 (33·5–41·5)	39·8 (36·3–43·6)	34·0 (30·5–38·0)	35·6 (32·1–39·5)	35·7 (33·1–38·5)	37·7 (35·3–40·4)	43·7 (39·4–48·4)
Spanish registries	77·7 (76·4–79·0)	54·2 (52·2–56·3)	56·3 (54·2–58·4)	50·0 (47·7–52·4)	51·8 (49·1–54·6)	52·5 (51·0–54·1)	54·7 (53·1–56·4)	60·5 (57·6–63·6)
Basque Country	79·5 (77·6–81·5)	59·0 (55·8–62·3)	58·3 (55·0–61·8)	53·3 (49·6–57·3)	52·2 (47·8–56·9)	56·5 (54·1–59·0)	56·2 (53·5–58·9)	63·0 (58·8–67·4)
Granada	71·8 (67·0–77·0)	50·6 (44·3–57·8)	50·9 (44·5–58·2)	45·7 (38·1–54·8)	51·1 (43·0–60·8)	48·2 (43·3–53·7)	51·1 (46·0–56·8)	..
Mallorca	80·1 (77·2–83·2)	51·4 (46·4–57·1)	57·4 (52·2–63·0)	48·9 (42·5–56·2)	51·7 (44·5–59·9)	50·9 (46·9–55·3)	56·1 (51·8–60·7)	68·2 (60·7–76·6)
Murcia	72·8 (69·1–76·8)	49·7 (44·4–55·7)	54·8 (50·2–59·9)	49·2 (43·4–55·8)	47·8 (42·0–54·4)	49·7 (45·5–54·3)	52·3 (48·7–56·3)	52·0 (45·4–59·4)
Navarra	78·3 (74·9–81·8)	50·6 (45·1–56·8)	53·3 (46·8–60·8)	42·7 (36·4–50·1)	58·1 (49·1–66·5) R	47·7 (43·4–52·4)	55·6 (50·4–61·3)	54·6 (47·2–63·0)
Tarragona	76·4 (73·0–80·0)	49·2 (43·9–55·1)	52·8 (47·8–58·3)	50·1 (43·2–58·0)	49·8 (40·9–58·4) R	49·6 (45·4–54·3)	51·7 (47·4–56·4)	54·6 (46·3–64·3)
Sweden	82·0 (81·2–82·7)	52·5 (50·9–54·2)	54·8 (53·3–56·3)	53·0 (51·2–55·0)	58·2 (56·3–60·2)	52·8 (51·6–54·1)	56·2 (55·0–57·4)	66·0 (64·7–67·3)
Swiss registries	76·0 (74·3–77·7)	..	..	..	..	..	..	..
Basel	78·2 (75·1–81·4)	..	..	..	..	..	..	..
Geneva	79·1 (76·0–82·4)	..	..	..	..	..	..	..

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 Published online July 17, 2008 DOI:10.1016/S1470-2045(08)70179-7

very few registries was it greater than 1% (available online[34]). Such patients are described as censored from the analysis.

Statistical analysis

We estimated relative survival up to 5 years after diagnosis from the individual tumour data, using the Hakulinen approach[44] embedded in the US National Cancer Institute's publicly accessible SEER*Stat software.[45] SEER*Stat is the standard tool used for cancer-survival estimation by the SEER Program cancer registries, and we used it to ensure that survival estimates for US registries would be seen as comparable with those already published by the SEER Program. Survival estimates were also derived by race for the USA (black and white).

Relative survival is the ratio of the survival noted in the patients with cancer and the survival that would have been expected had they been subject only to the mortality rates of the general population (background mortality). It is a measure of the excess mortality in patients with cancer over and above the background mortality, and can be interpreted as survival from the cancer after correction for other causes of death. This approach is crucial for international comparisons of cancer survival, because the background risks of death from all causes in adults often differ very widely. Background mortality was taken from life tables developed specially for the CONCORD study, specific for sex, calendar year, region, and race.[46]

The probability of survival in successive years after diagnosis was estimated in survivors to the start of each year. We report the cumulative relative survival at 5 years. Survival was not estimated if fewer than five patients with a given cancer were available for analysis in any category defined by age, sex, and race. Relative survival was adjusted

	Breast	Colon		Rectum		Colorectum		Prostate
	Women RS (%) (95% CI)	Men RS (%) (95% CI)	Women RS (%) (95% CI)	Men RS (%) (95% CI)	Women RS (%) (95% CI)	Men RS (%) (95% CI)	Women RS (%) (95% CI)	RS (%) (95% CI)
(Continued from previous page)								
Graubunden-Glarus	71·7 (66·8–77·0)	..	..	..	..	..	..	..
St Gallen-Appenzell	71·7 (68·1–75·5)	..	..	..	..	..	..	..
Valais	75·3 (70·4–80·6)	..	..	..	..	..	..	..
UK	69·7 (69·4–70·1)	43·5 (42·9–44·1)	44·4 (43·8–45·0)	40·6 (39·9–41·3)	45·3 (44·5–46·1)	42·3 (41·8–42·8)	44·7 (44·3–45·2)	51·1 (50·4–51·8)
England (national)	69·8 (69·5–70·2)	43·4 (42·8–44·1)	44·3 (43·7–45·0)	40·4 (39·6–41·2)	45·4 (44·6–46·3)	42·2 (41·7–42·7)	44·7 (44·2–45·3)	50·9 (50·1–51·7)
East Anglia	70·8 (69·2–72·4)	43·6 (40·8–46·7)	42·9 (40·2–45·8)	46·0 (42·4–49·8)	49·8 (46·1–53·9)	44·6 (42·4–47·0)	45·2 (43·0–47·6)	51·9 (48·4–55·7)
Mersey	69·4 (67·8–71·1)	43·8 (41·0–46·9)	43·6 (41·0–46·4)	41·2 (38·1–44·5)	44·5 (41·0–48·2)	43·0 (40·9–45·1)	44·0 (41·8–46·2)	52·6 (49·3–56·1)
Oxford	71·1 (69·6–72·6)	44·8 (42·1–47·8)	45·0 (42·4–47·8)	43·1 (39·8–46·6)	45·6 (41·8–49·7)	44·3 (42·1–46·6)	45·3 (43·2–47·6)	50·4 (47·4–53·6)
South Thames	73·9 (73·0–74·9)	45·5 (43·6–47·6)	48·3 (46·5–50·2)	45·3 (43·0–47·8)	51·1 (48·6–53·6)	45·5 (44·0–47·1)	49·3 (47·9–50·8)	56·1 (54·0–58·2)
South West	73·4 (72·5–74·2)	51·5 (49·8–53·1)	51·6 (50·1–53·2)	48·6 (46·7–50·6)	52·0 (49·8–54·2)	50·3 (49·0–51·5)	51·8 (50·5–53·1)	55·8 (53·9–57·9)
Trent	68·2 (67·2–69·3)	40·3 (38·3–42·5)	42·2 (40·2–44·2)	39·3 (37·1–41·6)	43·8 (41·3–46·5)	39·8 (38·3–41·4)	42·9 (41·3–44·5)	47·0 (44·8–49·4)
West Midlands	75·4 (74·2–76·5)	48·0 (46·2–49·9)	48·4 (46·6–50·2)	44·4 (42·2–46·7)	46·9 (44·3–49·6)	46·6 (45·2–48·1)	48·0 (46·5–49·5)	55·4 (53·2–57·7)
Yorkshire	71·4 (70·1–72·8)	45·5 (43·1–48·1)	45·4 (43·1–47·8)	43·8 (41·1–46·7)	49·8 (46·8–53·0)	44·7 (42·9–46·6)	47·0 (45·1–48·9)	53·3 (50·5–56·4)
Northern Ireland	72·0 (68·9–75·3)	47·3 (42·1–53·0)	49·0 (44·3–54·3)	48·2 (41·6–55·8)	43·8 (37·0–51·9)	47·8 (43·7–52·3)	47·8 (43·8–52·2)	54·0 (48·7–59·9)
Scotland	70·6 (69·5–71·8)	45·9 (44·0–47·9)	47·8 (46·1–49·6)	42·3 (39·9–44·9)	46·9 (44·4–49·6)	44·6 (43·1–46·2)	47·7 (46·2–49·2)	54·2 (52·0–56·5)
Wales	67·1 (65·8–68·4)	39·9 (37·5–42·6)	38·0 (35·7–40·4)	39·5 (36·8–42·3)	41·9 (38·8–45·2)	39·8 (38·0–41·8)	39·3 (37·5–41·3)	47·9 (44·9–51·1)
Oceania								
Australia (national)	80·7 (80·1–81·3)	57·8 (56·8–58·8)	57·7 (56·7–58·6)	54·8 (53·6–56·1)	59·2 (57·8–60·6)	56·7 (55·9–57·5)	58·2 (57·4–58·9)	77·4 (76·6–78·2)
Australian Capital Territory	80·4 (74·3–87·0)	62·0 (53·8–71·5)	59·1 (51·2–68·2)	57·2 (45·5–68·1) R	61·3 (49·8–75·5)	56·5 (49·1–65·1)	59·8 (53·0–67·5)	78·7 (72·5–85·5)
New South Wales	80·4 (79·4–81·5)	60·8 (59·1–62·6)	58·2 (56·6–59·9)	56·9 (54·7–59·1)	59·6 (57·3–61·9)	59·3 (57·9–60·7)	58·7 (57·4–60·0)	78·3 (77·0–79·6)
Northern Territory	71·9 (58·7–88·0)	53·5 (36·3–69·4) R	51·7 (34·2–67·5) R	46·3 (28·9–63·4) R	66·5 (39·6–86·0) R	52·1 (38·6–70·5)	53·2 (39·9–70·9)	63·7(49·0–77·0)R
Queensland	80·5 (79·0–82·0)	59·8 (57·5–62·3)	60·6 (58·6–62·8)	53·7 (50·7–56·9)	61·2 (57·7–64·8)	57·7 (55·8–59·6)	60·7 (58·9–62·5)	75·7 (73·9–77·6)
Southern Australia	80·0 (78·0–82·0)	56·3 (53·0–59·8)	58·6 (55·5–61·8)	55·2 (51·3–59·4)	59·2 (55·1–63·6)	55·8 (53·3–58·4)	58·6 (56·1–61·2)	77·1 (74·3–80·1)
Tasmania	77·1 (73·4–81·1)	52·4 (46·8–58·6)	50·0 (44·9–55·6)	44·9 (37·5–53·6)	55·0 (46·8–64·6)	50·2 (45·7–55·1)	51·8 (47·4–56·6)	70·2 (65·8–74·8)
Victoria	81·5 (80·4–82·7)	54·7 (52·7–56·7)	56·1 (54·3–57·9)	54·9 (52·5–57·4)	59·0 (56·5–61·6)	54·8 (53·3–56·4)	57·2 (55·7–58·6)	76·8 (75·2–78·4)
Western Australia	81·4 (79·3–83·5)	53·2 (49·7–56·9)	54·5 (51·4–57·8)	50·9 (46·8–55·3)	54·8 (50·3–59·7)	52·5 (49·8–55·3)	54·8 (52·1–57·5)	80·0 (77·7–82·3)

RS=relative survival. R=raw (not age-standardised) survival estimate: too few cases in one or more age groups. *International Cancer Survival Standard (see text). †No state-wide data available for this city. ‡Survival truncated if greater than 1·0 (100%). 95% CIs were calculated by use of a logarithmic transformation (see text).

***Table 2*: 5-year relative survival (%), age-standardised to ICSS weights* with 95% CIs for adults (aged 15–99 years) diagnosed with cancer of the breast (women), colon, rectum, or prostate during 1990–94 and followed up to Dec 31, 1999: continent, country, and region**

for heterogeneity in the withdrawal of patients from follow-up and consequent changes in the age-sex-race distribution of patients with cancer in successive calendar years, by use of the exact method.[44]

Expected survival was derived from complete life tables that contained the probabilities of death or the central death rates for the general population of the registry's territory, by single year of age, sex and (where possible) race, and single calendar year between 1990 and 1999. Many registries provided complete life tables. For some registries, complete life tables were constructed from raw data obtained from published sources on the numbers of deaths by age, sex, and race in the relevant year(s) or period, and the corresponding populations. For the remaining registries, abridged (5-year or 10-year age groups) life tables from published sources were smoothed to produce complete life tables. In some registries, life tables were interpolated, as required, to provide life tables by single calendar year throughout the decade 1990–99. Details are provided in an accompanying paper.[46]

Cancer survival is known to vary with race,[47–55] and we assessed racial differences in survival where possible. Individual tumour records were coded by race only in the data from the USA (black, white, other). Race-specific estimates of relative survival were produced with separate life tables for each race, constructed from the raw data on populations and the number of deaths.[46]

In the USA, race-specific mortality in the general population also varies between states.[36] We developed separate sets of complete life tables for each state and metropolitan area and for each sex. This approach was designed to enable the closest possible adjustment of relative survival estimates in the USA for geographic variation in background mortality in both blacks and whites, by age, sex, and calendar period. Race-specific life tables for both blacks and whites were developed for 11 of the 16 states and all six metropolitan areas. Where race-specific life tables were available, they were used in the estimation of relative survival for patients of that race. For other patients, the all-races life table for that population was used. For five less populous states (Hawaii, Idaho, New Mexico, Utah, and Wyoming: 6% of the 109 million population covered by participating registries; webtable), only the life tables for whites were sufficiently robust, and relative survival estimates for blacks are not separately presented.

See Online for webtable

Relative survival measures the extent to which patients with cancer have a higher death rate than the general population of the country or region in which they live.[56] Occasionally, despite use of the most appropriate life table, this excess death rate can be negative in a given time interval since diagnosis, implying that the death rate of cancer survivors during that interval is actually lower than that of the general population. This situation can arise from random variation in the death rate when the number of deaths in the interval is small,[57] either because the interval is very short, or because survival is poor and most patients have already died before the start of the interval, or because survival is high and there are very few deaths. In such situations, we present by default the estimate derived by use of the SEER*Stat option to constrain the excess mortality rate to zero, which imposes a plateau in the relative survival curve. The unconstrained estimate was also obtained for comparison.

Even though relative survival is already adjusted for age-specific differences in background mortality, robust international comparison of relative survival requires age-standardisation,[23] because the age distribution of patients with cancer varies between countries, and because relative survival also varies widely by age, at least in Europe.[27] Conventional age-specific weights used to standardise incidence or mortality rates (eg, the national population or the hypothetical world standard population[58]) are unsuitable because patients with cancer have a very different age profile from that of the general population.

A cancer-survival comparison of such wide scope has not been done before and the choice of weights for age-standardisation was not straightforward. International standard cancer-patient populations have been proposed, with different sets of weights in 5-year or 10-year age bands for each of 20 common cancers, derived from their world-wide distribution.[59] The weights used for the EUROCARE-3 study were derived from the age distribution of all patients included in that study for each cancer, and were thus cancer-specific.[43] The disadvantage of these standards is either that a unique set of weights is required for each cancer (cancer-specific), or else that the standards are arbitrary (study-specific), vitiating comparison between studies.

We chose the recently developed International Cancer Survival Standard (ICSS) weights.[60] These comprise just three sets of age weights, derived from discriminant analysis to find the smallest number of sets of standard age weights that enable adequate standardisation of survival. Each standard is applicable to a range of different cancers, and provides age-standardised survival estimates that are not too different from the unstandardised estimates. The first ICSS standard applies to cancers for which incidence rises rapidly with age, and we used this in all analyses. For cancers of the breast, colon, and rectum, we used five age groups: 15–44, 45–54, 55–64, 65–74, and 75–99 years. For prostate cancer, which occurs mainly in older men, we used four age groups: 15–54, 55–64, 65–74, and 75–99 years. Where data were too sparse for standardisation, the raw (unstandardised) survival estimate is presented, flagged with "R".

The same age weights were used for men and women, and for each race, enabling direct comparison of age-standardised relative survival between patient groups defined by sex and race. Because identical weights were used for breast, colon, and rectal cancer, the age-standardised estimates of survival for these cancers can also be directly compared. This would not be possible if cancer-specific weights were used.

 Published online July 17, 2008 DOI:10.1016/S1470-2045(08)70179-7

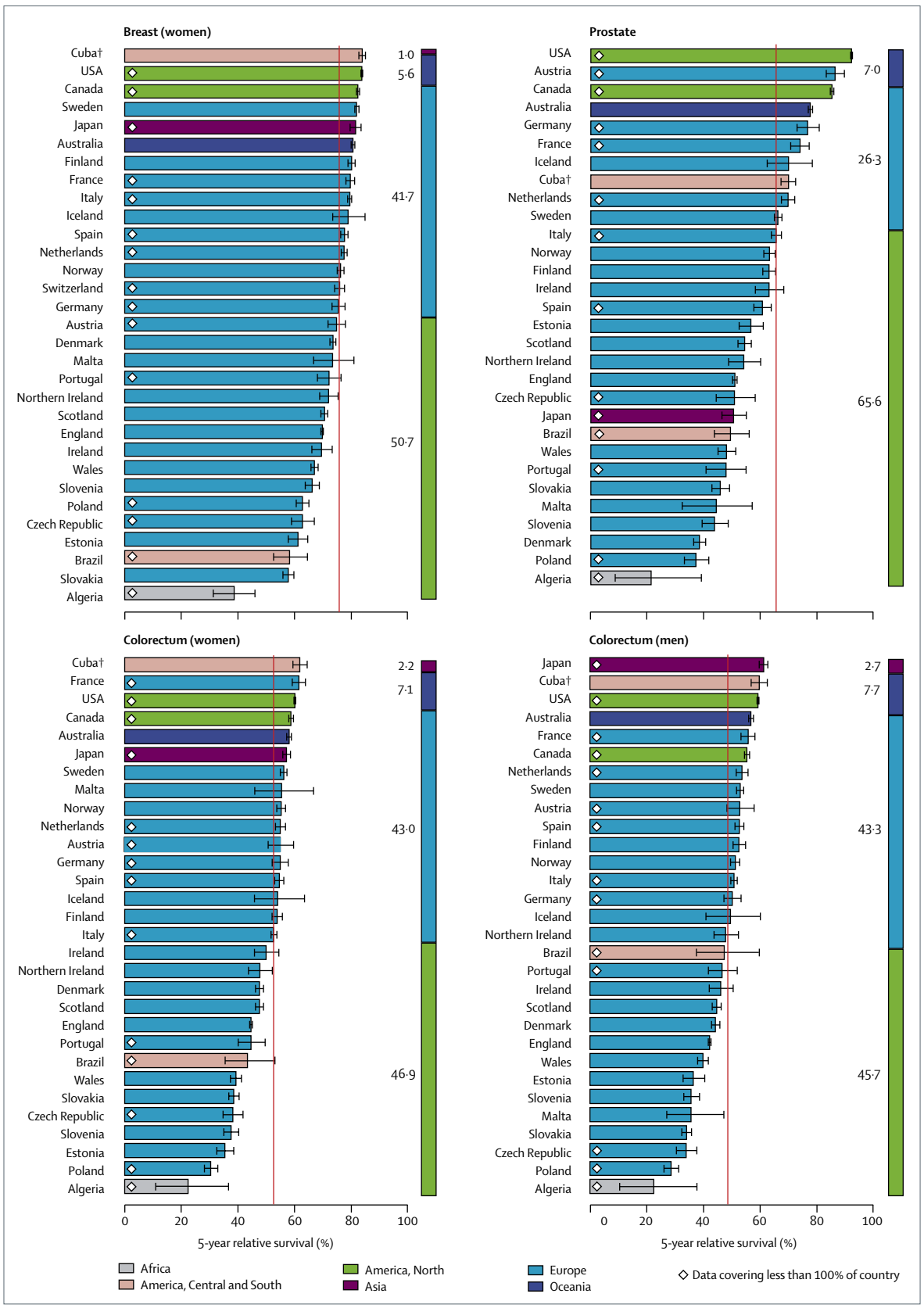

***Figure 1*: 5-year relative survival (%), age-standardised to the ICSS weights* with 95% CIs for adults (aged 15–99 years) diagnosed with cancer of the breast (women), colorectum, or prostate during 1990–94 and followed up to Dec 31, 1999: country**

Vertical bar on the right of each graphic shows the contribution (%) of each continent to the total number of cases analysed (contributions under 1% are not labelled). Red vertical line represents mean survival for the 22 European countries that participated in EUROCARE-3, age-standardised to ICSS weights. Switzerland only provided data for breast cancer. *Age-standardised to ICSS weights, except for Sétif, Algeria (all cancers), Malta (prostate), and Portugal (prostate), which were unstandardised values (see text). †Problems with data quality might have led to over-estimation (see text).

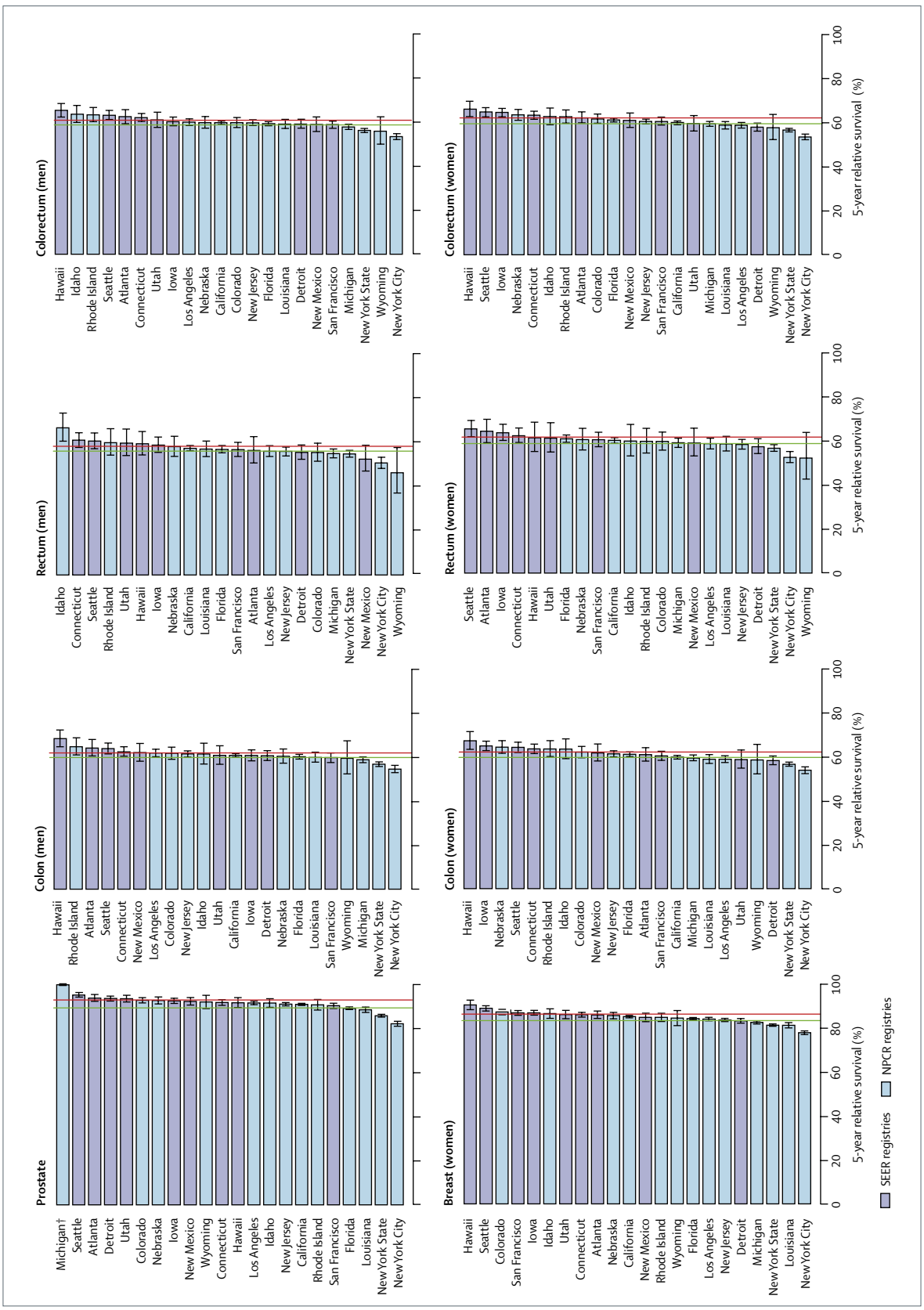

***Figure 2*: 5-year relative survival (%), using state-specific and race-specific life tables and age-standardised to the ICSS weights* for adults (aged 15–99 years) diagnosed with cancer of the breast (women), colon, rectum, colon and rectum combined, or prostate during 1990–94 and followed up to Dec 31, 1999: 16 US States and six metropolitan areas**

Vertical lines represent mean survival for SEER (red) and NPCR (green) registries, age-standardised to ICSS weights (see text). *Age-standardised to ICSS weights (see text). †Problems with data quality might have led to over-estimation (see text).

www.thelancet.com/oncology **Published online July 17, 2008 DOI:10.1016/S1470-2045(08)70179-7**

For countries represented by more than one regional cancer registry, we provide a survival estimate derived from the pooled data for all contributing registries, age-standardised in the same way. This is an overall estimate of survival in the combined territories providing data from that country, not a weighted mean of the various regional estimates. The combined estimate should not be considered as necessarily representative of survival in the country as a whole, except where the regional registries cover the entire country.

	Breast	Colon		Rectum		Colorectum		Prostate
	Women RS (%) (95% CI)	Men RS (%) (95% CI)	Women RS (%) (95% CI)	Men RS (%) (95% CI)	Women RS (%) (95% CI)	Men RS (%) (95% CI)	Women RS (%) (95% CI)	RS (%) (95% CI) See Online for webpanel
Atlanta, GA (all races), S	85·7 (84·0–87·4)	64·1 (60·5–68·0)	60·9 (58·0–63·9)	56·6 (51·0–62·8)	64·5 (59·5–69·8)	62·5 (59·4–65·8)	62·2 (59·6–64·9)	94·0 (92·4–95·6)
Black	71·1 (67·1–75·4)	59·9 (52·3–68·5)	52·6 (47·2–58·6)	45·5 (35·3–58·6)	52·1 (42·5–63·7)	56·8 (50·3–64·2)	52·9 (48·1–58·2)	86·5 (83·3–89·8)
White	89·6 (87·8–91·5)	65·4 (61·3–69·8)	63·9 (60·5–67·6)	59·4 (52·9–66·7)	67·9 (62·3–74·1)	64·1 (60·6–67·8)	65·4 (62·4–68·4)	96·1 (94·4–97·9)
California (all races), N	84·9 (84·5–85·3)	60·8 (59·9–61·6)	59·8 (59·0–60·6)	57·5 (56·3–58·8)	60·3 (59·0–61·6)	59·8 (59·1–60·5)	60·1 (59·4–60·8)	91·1 (90·6–91·5)
Black	73·4 (71·4–75·6)	54·8 (51·4–58·4)	51·1 (48·3–54·2)	50·3 (44·9–56·4)	50·9 (45·9–56·4)	53·6 (50·7–56·7)	51·2 (48·7–53·8)	84·5 (82·9–86·1)
White	85·3 (84·9–85·7)	60·7 (59·8–61·6)	60·1 (59·2–61·0)	57·4 (56·1–58·7)	60·4 (59·0–61·8)	59·7 (58·9–60·4)	60·3 (59·6–61·0)	90·8 (90·3–91·2)
Los Angeles, CA (all races), N	83·8 (83·0–84·6)	61·9 (60·2–63·6)	58·8 (57·3–60·3)	56·2 (53·8–58·6)	58·8 (56·4–61·3)	60·0 (58·7–61·4)	58·8 (57·6–60·2)	91·7 (90·9–92·6)
Black	72·5 (69·6–75·6)	58·9 (54·5–63·8)	52·1 (48·2–56·3)	49·8 (42·3–58·7)	50·1 (43·4–57·9)	57·0 (53·2–61·2)	51·7 (48·2–55·3)	84·8 (82·5–87·3)
White	84·7 (83·9–85·5)	61·5 (59·7–63·4)	59·4 (57·6–61·2)	55·4 (52·8–58·2)	58·5 (55·7–61·4)	59·6 (58·0–61·1)	59·2 (57·7–60·7)	92·3 (91·4–93·2)
San Francisco, CA (all races), S	86·6 (85·6–87·6)	59·8 (57·6–62·0)	60·3 (58·2–62·5)	57·0 (53·8–60·3)	60·6 (57·4–64·0)	58·9 (57·2–60·8)	60·5 (58·8–62·3)	90·5 (89·4–91·6)
Black	77·2 (73·2–81·4)	47·4 (41·0–54·7)	50·0 (44·4–56·4)	54·7 (43·7–68·5)	52·3 (41·5–66·0)	49·7 (44·2–56·0)	50·6 (45·6–56·2)	83·7 (80·4–87·1)
White	87·5 (86·5–88·6)	60·3 (57·9–62·9)	61·1 (58·7–63·6)	56·8 (53·2–60·5)	61·5 (57·9–65·4)	59·3 (57·3–61·4)	61·4 (59·4–63·5)	90·2 (88·9–91·4)
Colorado (all races), N	87·0 (85·8–88·2)	61·7 (59·1–64·5)	62·0 (59·6–64·6)	55·6 (51·7–59·9)	59·8 (55·9–64·0)	59·8 (57·6–62·1)	61·7 (59·6–63·9)	92·9 (91·8–94·1)
Black	81·6 (74·1–89·9)	45·0 (34·3–58·8)	48·0 (36·9–62·5)	76·8 (44·8–97·7) R	39·6 (16·2–64·9) R	49·7 (39·3–63·0)	46·7 (36·2–60·2)	80·7 (74·6–87·4)
White	87·0 (85·8–88·2)	62·1 (59·4–65·0)	62·3 (59·8–65·0)	54·9 (50·9–59·2)	60·6 (56·6–64·9)	59·8 (57·6–62·2)	62·1 (60·0–64·4)	92·8 (91·6–94·0)
Connecticut (all races), S	85·7 (84·7–86·8)	62·4 (60·2–64·7)	63·5 (61·4–65·7)	61·3 (58·1–64·6)	62·4 (59·1–65·9)	62·1 (60·3–64·0)	63·4 (61·6–65·2)	91·9 (90·7–93·2)
Black	75·2 (69·3–81·6)	51·1 (41·9–62·3)	52·7 (44·8–61·9)	63·5 (47·5–85·0)	73·3 (56·8–86·2) R	54·4 (46·0–64·3)	56·5 (49·4–64·6)	82·3 (77·6–87·2)
White	86·3 (85·3–87·3)	62·9 (60·6–65·3)	64·1 (61·9–66·4)	61·3 (58·1–64·7)	61·9 (58·5–65·5)	62·4 (60·5–64·3)	63·7 (61·9–65·6)	92·3 (91·0–93·6)
Florida (all races), N	84·0 (83·5–84·5)	60·2 (59·2–61·2)	61·0 (60·0–62·1)	57·0 (55·5–58·6)	61·0 (59·4–62·7)	59·4 (58·5–60·2)	61·2 (60·4–62·1)	89·2 (88·7–89·8)
Black	72·7 (70·1–75·3)	54·4 (50·0–59·1)	54·3 (50·9–57·9)	44·8 (37·7–53·1)	54·5 (48·4–61·3)	51·6 (47·8–55·6)	54·8 (51·9–58·0)	84·7 (82·7–86·7)
White	84·7 (84·2–85·2)	60·5 (59·4–61·6)	61·6 (60·5–62·7)	57·8 (56·2–59·5)	61·3 (59·6–63·1)	59·8 (59·0–60·8)	61·7 (60·8–62·6)	89·7 (89·1–90·3)
Hawaii (all races), S	90·2 (88·1–92·3)	68·4 (64·7–72·3)	67·2 (63·3–71·3)	59·6 (54·5–65·2)	61·5 (55·1–68·6)	65·4 (62·4–68·6)	66·2 (62·8–69·7)	91·8 (89·6–94·1)
White	90·2 (86·5–94·1)	67·9 (61·2–75·2)	61·6 (54·1–70·1)	54·0 (44·3–65·8)	66·0 (50·8–79·0) R	64·6 (58·6–71·1)	62·9 (56·2–70·3)	92·4 (89·0–96·0)
Idaho (all races), N	86·3 (84·2–88·5)	61·4 (56·9–66·3)	63·4 (59·1–68·0)	66·9 (60·8–73·6)	60·0 (53·3–67·6)	63·6 (59·9–67·6)	62·8 (59·1–66·7)	91·7 (89·8–93·7)
White	86·3 (84·2–88·5)	61·4 (56·8–66·4)	63·4 (59·1–68·1)	66·7 (60·5–73·4)	59·9 (53·1–67·5)	63·6 (59·8–67·5)	62·8 (59·1–66·8)	91·5 (89·5–93·5)
Iowa (all races), S	86·6 (85·5–87·7)	60·8 (58·4–63·3)	64·8 (62·7–67·0)	59·0 (55·6–62·6)	63·8 (60·2–67·6)	60·3 (58·3–62·3)	64·7 (62·9–66·6)	92·7 (91·5–93·9)
Black	60·1 (46·6–77·5)	66·8 (39·0–89·6) R	75·2 (51·7–94·1) R	56·5 (17·3–91·4) R	40·7 (12·5–71·8) R	66·9 (43·7–86·2) R	65·9 (46·5–82·8) R	85·8 (72·3–97·6) R
White	86·8 (85·7–87·8)	60·8 (58·4–63·3)	64·6 (62·5–66·8)	58·7 (55·3–62·4)	63·8 (60·2–67·7)	60·2 (58·2–62·2)	64·6 (62·7–66·5)	92·6 (91·4–93·8)
Louisiana (all races), N	81·0 (79·8–82·1)	59·9 (57·6–62·2)	58·8 (56·9–60·8)	57·2 (53·8–60·9)	58·7 (55·5–62·1)	59·2 (57·3–61·1)	58·9 (57·2–60·6)	88·6 (87·4–89·9)
Black	69·9 (67·2–72·7)	54·2 (49·6–59·3)	53·1 (49·6–56·9)	48·0 (40·8–56·4)	48·2 (41·9–55·4)	53·1 (49·2–57·2)	52·4 (49·2–55·8)	80·6 (78·1–83·2)
White	84·0 (82·8–85·3)	61·6 (59·1–64·3)	60·6 (58·4–63·0)	58·4 (54·6–62·4)	61·4 (57·8–65·3)	60·7 (58·6–62·9)	61·1 (59·2–63·1)	91·0 (89·6–92·4)
Michigan (all races)‡, N	82·3 (81·6–82·9)	58·8 (57·5–60·2)	59·3 (58·1–60·6)	55·2 (53·2–57·2)	59·2 (57·2–61·3)	57·8 (56·7–59·0)	59·5 (58·4–60·6)	100 (99·8–100)
Black‡	69·6 (67·2–72·1)	47·9 (44·2–51·9)	51·8 (48·5–55·4)	45·1 (39·1–51·9)	45·1 (39·3–51·8)	47·1 (43·9–50·6)	50·5 (47·6–53·6)	100 (99·3–100)
White‡	83·3 (82·6–84·0)	59·7 (58·3–61·2)	60·2 (58·9–61·6)	55·9 (53·8–58·1)	60·2 (58·1–62·4)	58·7 (57·5–59·9)	60·4 (59·3–61·6)	100 (99·8–100)
Detroit, MI (all races), S	83·0 (81·9–84·0)	60·6 (58·4–62·9)	58·2 (56·2–60·3)	55·7 (52·5–59·0)	57·4 (54·2–60·9)	59·2 (57·3–61·0)	58·0 (56·3–59·8)	93·8 (92·8–94·8)
Black	71·7 (68·9–74·6)	50·6 (45·9–55·8)	51·3 (47·6–55·4)	48·4 (40·9–57·2)	44·5 (37·4–53·0)	49·8 (45·7–54·2)	50·5 (47·1–54·3)	88·7 (86·4–91·1)
White	85·4 (84·3–86·5)	62·7 (60·2–65·3)	60·7 (58·3–63·2)	57·4 (53·9–61·0)	59·6 (55·9–63·4)	61·1 (59·1–63·2)	60·3 (58·3–62·4)	95·3 (94·2–96·4)
Nebraska (all races), N	85·4 (84·0–86·8)	60·4 (57·3–63·7)	64·3 (61·4–67·2)	58·3 (53·9–63·0)	60·6 (55·9–65·7)	59·8 (57·3–62·5)	63·6 (61·1–66·1)	92·9 (91·3–94·4)
Black‡	83·1 (72·7–94·9)	69·6 (46·5–88·2) R	48·2 (29·9–66·4) R	60·0 (24·9–90·5) R	77·4 (22·6–100) R	66·9 (47·5–83·5) R	52·6 (34·9–69·7) R	78·7 (68·4–90·6)
White	85·4 (83·9–86·8)	59·9 (56·7–63·2)	64·9 (62·1–67·9)	57·8 (53·4–62·6)	60·5 (55·7–65·7)	59·3 (56·7–62·0)	64·0 (61·5–66·6)	93·1 (91·6–94·7)
New Jersey (all races), N	83·4 (82·7–84·1)	61·5 (60·1–62·9)	61·2 (59·9–62·6)	56·1 (54·1–58·3)	58·4 (56·4–60·6)	59·7 (58·6–60·9)	60·6 (59·5–61·7)	91·2 (90·4–91·9)
Black	73·1 (70·2–76·1)	51·6 (46·4–57·4)	51·5 (47·7–55·6)	46·4 (38·3–56·2)	45·1 (38·5–53·0)	50·3 (45·8–55·2)	50·3 (46·9–53·9)	81·0 (78·5–83·5)
White	83·8 (83·1–84·6)	61·4 (60·0–62·9)	61·8 (60·4–63·2)	56·0 (53·9–58·3)	58·9 (56·7–61·1)	59·6 (58·4–60·9)	61·1 (59·9–62·3)	90·8 (90·0–91·7)

(Continues on next page)

The proportion of survivors is constrained in the range zero to one (or 0 to 100%), but confidence intervals (CIs) for relative survival derived in the usual way, from the Normal approximation, can produce implausible values (<0 or >1). SEER*Stat provided the standard error of the cumulative relative survival based on the Greenwood formula,[61] but did not provide CIs. We used these standard errors to estimate CIs on the logarithmic scale (webpanel).

For the USA, we constructed funnel plots of relative survival for each cancer and sex, to obtain further insight into the variability of survival by race and state, and to avoid spurious ranking of the survival estimates.[62] The plots show how much a particular survival estimate deviates from the pooled US value, given the precision of each estimate. The precision depends on the number of deaths included in the analysis, which depends in turn on the size of the population and the frequency and lethality of the cancer in that population. 5-year relative survival estimates for each population, age-standardised and adjusted for race-specific and state-specific background mortality, were plotted against the precision of the estimates, taken as the inverse square of their standard errors (webpanel). The horizontal line in each plot, the target, was estimated as the pooled 5-year relative survival for all participating US populations, age-standardised to the same weights. Raw survival estimates were not plotted. The 99·8% control limits superimposed on each plot represent about three standard deviations from the pooled US survival at each level of precision.

	Breast	Colon		Rectum		Colorectum		Prostate
	Women RS (%) (95% CI)	Men RS (%) (95% CI)	Women RS (%) (95% CI)	Men RS (%) (95% CI)	Women RS (%) (95% CI)	Men RS (%) (95% CI)	Women RS (%) (95% CI)	RS (%) (95% CI)
(Continued from previous page)								
New Mexico (all races), S	84·6 (82·8–86·4)	62·1 (58·1–66·3)	61·7 (57·9–65·7)	52·6 (47·2–58·7)	59·1 (53·0–65·8)	59·0 (55·8–62·4)	61·0 (57·8–64·4)	92·4 (90·7–94·2)
White	84·7 (82·8–86·6)	61·7 (57·7–66·0)	61·4 (57·5–65·6)	52·7 (47·1–58·9)	59·0 (52·8–65·9)	58·9 (55·6–62·4)	60·9 (57·6–64·4)	92·7 (91·0–94·4)
New York State (all races), N	81·0 (80·5–81·5)	56·8 (55·8–57·8)	56·5 (55·6–57·5)	55·0 (53·5–56·5)	56·7 (55·2–58·3)	56·3 (55·4–57·1)	56·7 (55·9–57·5)	85·9 (85·3–86·5)
Black	67·2 (65·4–69·1)	45·9 (42·8–49·2)	46·0 (43·5–48·6)	42·8 (37·6–48·7)	46·8 (42·2–51·9)	45·1 (42·4–47·9)	46·2 (44·0–48·5)	75·9 (74·2–77·7)
White	82·1 (81·5–82·6)	57·3 (56·2–58·4)	57·2 (56·2–58·2)	55·8 (54·2–57·4)	57·4 (55·8–59·1)	56·9 (56·0–57·8)	57·4 (56·5–58·2)	86·5 (85·8–87·2)
New York City, NY (all races), N	77·6 (76·8–78·4)	54·5 (52·9–56·2)	53·8 (52·3–55·3)	50·9 (48·4–53·5)	52·6 (50·2–55·1)	53·5 (52·1–54·9)	53·5 (52·3–54·8)	82·3 (81·2–83·4)
Black	65·8 (63·7–67·9)	45·2 (41·7–49·1)	45·0 (42·2–48·0)	44·4 (38·3–51·4)	46·5 (41·3–52·3)	45·0 (41·9–48·3)	45·3 (42·8–48·0)	74·0 (71·9–76·1)
White	79·6 (78·7–80·6)	55·6 (53·7–57·6)	54·9 (53·1–56·7)	51·9 (49·1–54·9)	53·3 (50·5–56·3)	54·5 (52·9–56·2)	54·5 (53·0–56·1)	83·3 (81·8–84·7)
Rhode Island (all races), N	84·6 (82·7–86·4)	64·7 (60·9–68·7)	63·4 (60·0–67·1)	60·1 (54·5–66·3)	59·9 (54·5–65·7)	63·4 (60·2–66·7)	62·7 (59·8–65·8)	90·9 (88·5–93·3)
Black‡§	82·9 (65·8–100)	58·6 (28·5–85·9) R	45·0 (16·5–71·8) R	NA	79·6 (28·8–100) R	65·5 (35·6–90·7) R	57·5 (31·4–78·5) R	75·5 (59·5–89·0) R
White	84·9 (83·1–86·8)	64·9 (61·1–69·0)	63·7 (60·2–67·4)	60·2 (54·5–66·4)	59·3 (53·9–65·3)	63·6 (60·4–66·9)	62·8 (59·8–65·9)	91·4 (89·0–93·9)
Seattle, WA (all races), S	88·7 (87·6–89·8)	63·9 (61·5–66·4)	64·2 (61·9–66·6)	60·8 (57·4–64·5)	65·5 (61·9–69·3)	63·2 (61·1–65·3)	64·9 (62·9–66·9)	95·3 (94·3–96·4)
Black	64·7 (55·5–75·3)	54·9 (42·5–71·0)	63·9 (45·4–80·2) R	46·9 (26·6–67·1) R	48·7 (20·1–75·1) R	51·9 (41·0–65·6)	54·9 (42·1–71·8)	89·6 (84·0–95·4)
White	89·3 (88·2–90·4)	64·4 (61·9–67·0)	64·1 (61·7–66·5)	61·7 (58·1–65·6)	65·7 (61·9–69·6)	63·8 (61·7–66·0)	64·8 (62·8–66·9)	95·4 (94·3–96·4)
Utah (all races), S	85·8 (84·0–87·7)	60·8 (56·8–65·1)	58·6 (54·5–63·0)	59·9 (54·2–66·2)	61·3 (55·0–68·2)	61·1 (57·8–64·6)	59·6 (56·2–63·3)	93·7 (92·1–95·2)
White	85·9 (84·0–87·9)	60·7 (56·6–65·1)	58·7 (54·6–63·2)	59·7 (53·8–66·2)	62·6 (56·3–69·8)	61·0 (57·6–64·6)	60·2 (56·6–63·9)	93·5 (91·9–95·1)
Wyoming (all races), N	84·2 (80·8–87·7)	59·5 (52·5–67·4)	58·5 (52·1–65·6)	46·4 (37·2–57·9)	52·2 (42·7–63·9)	55·9 (50·1–62·4)	57·7 (52·2–63·8)	92·2 (89·2–95·2)
White	84·3 (80·9–87·8)	60·5 (53·5–68·4)	58·1 (51·7–65·3)	46·2 (37·0–57·9)	52·5 (42·7–64·4)	56·5 (50·6–63·0)	57·5 (52·0–63·7)	92·1 (89·2–95·1)
NPCR (all races)	83·1 (82·8–83·4)	59·8 (59·3–60·4)	59·6 (59·1–60·1)	56·3 (55·5–57·1)	58·8 (58·0–59·7)	58·8 (58·3–59·2)	59·6 (59·1–60·0)	89·5 (89·2–89·8)
Black	70·7 (69·6–71·8)	52·1 (50·2–54·1)	50·5 (49·0–52·0)	46·9 (43·7–50·2)	49·1 (46·4–51·9)	50·7 (49·1–52·5)	50·3 (49·0–51·6)	81·1 (80·2–82·1)
White	84·0 (83·7–84·3)	60·1 (59·6–60·7)	60·4 (59·8–60·9)	56·7 (55·8–57·5)	59·4 (58·5–60·3)	59·1 (58·6–59·6)	60·2 (59·8–60·7)	90·0 (89·7–90·3)
SEER (all races)	86·1 (85·6–86·5)	61·9 (61·0–62·8)	62·1 (61·2–62·9)	58·5 (57·1–59·8)	61·8 (60·4–63·2)	60·9 (60·2–61·7)	62·2 (61·5–62·9)	93·1 (92·7–93·5)
Black	72·6 (70·8–74·5)	52·1 (48·9–55·5)	52·8 (50·2–55·5)	51·1 (45·8–56·9)	50·0 (45·1–55·6)	51·9 (49·2–54·9)	52·5 (50·2–55·0)	87·2 (85·7–88·7)
White	87·0 (86·6–87·5)	62·3 (61·3–63·3)	62·8 (61·9–63·8)	58·9 (57·5–60·4)	62·7 (61·2–64·2)	61·3 (60·5–62·2)	63·0 (62·2–63·8)	93·5 (93·0–93·9)
US registries (all races)	84·0 (83·8–84·2)	60·2 (59·8–60·6)	60·2 (59·8–60·6)	57·0 (56·4–57·6)	59·9 (59·2–60·5)	59·3 (58·9–59·6)	60·3 (60·0–60·6)	92·3 (92·1–92·5)
Black	70·9 (70·0–71·8)	51·5 (50·0–53·1)	51·0 (49·8–52·3)	47·4 (44·7–50·1)	49·4 (47·1–51·7)	50·5 (49·1–51·8)	50·8 (49·7–51·9)	85·8 (85·0–86·6)
White	84·7 (84·5–84·9)	60·5 (60·0–60·9)	60·8 (60·4–61·2)	57·3 (56·6–57·9)	60·4 (59·7–61·1)	59·6 (59·2–59·9)	60·8 (60·5–61·2)	92·4 (92·2–92·7)

RS=relative survival. S=Surveillance, Epidemiology and End Results (SEER) registry. N=National Program of Cancer Registries (NPCR) registry. See text for attribution of registries to NPCR and SEER. R=raw (not age-standardised) survival estimate: too few cases in one or more age groups. *International Cancer Survival Standard (see text). †95% CIs were calculated by use of a logarithmic transformation (see text). ‡Survival truncated if greater than 1·0 (100%). §Survival estimates based on fewer than five patients are not shown (NA=not applicable). Black populations are not shown separately for Hawaii, Idaho, New Mexico, Utah, or Wyoming, because it was not possible to estimate relative survival for blacks in these states with race-specific life tables (see text).

***Table 3*: 5-year relative survival (%) by use of state-specific and race-specific life tables and age-standardised to ICSS weights* with 95% CIs† for adults (aged 15–99 years) diagnosed with cancer of the breast (women), colon, rectum, or prostate during 1990–94 and followed up to Dec 31, 1999, by race: US populations**

Differences between survival estimates are presented as the absolute value, eg, 15% is given as 5% (not 50%) higher than 10%.

We analysed individual data for almost 2 million adults who were diagnosed with a first, primary, malignant, invasive neoplasm of the breast (women), colon, rectum, or prostate during the period 1990–94 and who had been followed up to ascertain their vital status for at least 5 years after diagnosis until the end of 1999 or later. Data were contributed by 101 population-based cancer registries covering a combined population of almost 300 million persons living in 31 countries (table 1 and webfigure 1). Canada and the USA contributed 1·07 million patients (54% of the total) from a population base of 125 million. The 24 European countries contributed 740 000 patients (37%) from a population base of 126 million, indicating lower mean incidence of cancer than in North America.

The smallest dataset came from Sétif (Algeria), covering a population of 1·1 million, some 4% of the national population. The registry could only provide data for the period 1992–94, the population is young, and cancer risks are currently low on the global scale.[63] The dataset was therefore small, a total of 300 patients. This decreases the statistical precision of survival estimates, but no patient was detected solely at death certification or autopsy, and the vital status of every patient was ascertained at a home visit by registry staff, something no other registry could deliver. Some of the datasets for black patients in US states were of similar size (webtable). California provided the largest single dataset of 240 000 patients diagnosed during 1990–94 in a population of 31 million (12% of the US population), with a very high cancer risk on the global scale (table 1).

For 16 of the 31 countries, the data covered 100% of the national population (table 1). The proportion of the national population covered by the data for the other 15 countries ranged from less than 10% (Algeria, Brazil, Japan, Austria, Czech Republic, France, Germany, Poland) to 10–29% (Italy, Portugal, Spain, Switzerland) and 30% or more (Canada, USA, the Netherlands).

Most registries provided data on patients diagnosed during the entire 5-year period 1990–94, but ten registries provided data for shorter periods (table 1).

Data for all four index cancers were provided by 89 of the 101 registries. Two specialised registries in Côte-d'Or (France) only collect data on cancers of the breast or colorectum, respectively, whereas ten general registries that collect data for all cancers only contributed data for selected cancers: breast (Isère, France; northern Netherlands; all five Swiss registries); breast, colon, and prostate (Campinas, Brazil; Nova Scotia, Canada), or breast, colon, and rectum (Granada, Spain; table 1).

Ethical approval for the CONCORD study[33] was obtained from the Istituto Superiore di Sanità, Rome, Italy (CE-ISS 02/03, May 20, 2002) and from the Institutional Review Board of the CDC, Atlanta, GA, USA (IRB #3551, July 24, 2002). SEER data were obtained from the public-use dataset.[38] For other registries, anonymised data were transmitted to the CONCORD Data Analysis Centre at the Istituto Superiore di Sanità by use of special courier delivery of encrypted and password-protected CD-ROMs with separate email transmission of the password, or pre-planned deposition of password-protected files on a specially created File Transfer Protocol (FTP) site from which the data were immediately removed in Rome. Each tumour record included a serial number for the purposes of quality control with the originating cancer registry.

Role of the funding source

The pilot study (January, 2000 to March, 2000) was funded by the UK Department of Health (£75 000). The CDC funded data collection and the costs of linkage to the National Death Index for the phase I study in participating registries in the National Program of Cancer Registries (US$3 million). The Cancer Survival Group (including BR, MQ) in the London School of Hygiene and Tropical Medicine, London, UK, has been funded by Cancer Research UK (grant C1336/A5735) since April, 2005. Funding applications were open and competitive. None of the funding sources had any role in design, data collection, analysis, interpretation of the data, or writing of this article. MPC, MQ, RdA, RC, SF, MSantaquilani, and AV had access to the raw data. The corresponding author had full access to all of the data and the final responsibility to submit for publication.

Results

The background risk of death in the general population varied widely between the participating countries and regions. The mean life expectancy at birth during the decade 1990–99 ranged from 63·7 to 77·6 years in men and from 70·9 to 83·7 years in women.[46] In the USA, the range of life expectancies in white and black populations did not overlap at all in the states and metropolitan areas for which life tables could be constructed for both groups. The ranges for men were 64·0–70·1 years in blacks and 71·1–75·9 years in whites, whereas the ranges in women were 73·3–76·5 years in blacks and 78·8–80·9 years in whites.

The cumulative risk of death from all causes over the age range 15–59 years in the general population of the participating countries and regions ranged widely, from 9% to 34% in men and from 5% to 17% in women. Over the age range 60–84 years, the cumulative risk of death ranged from 60% to 86% in men and from 40% to 75% in women.[46]

Of 785 255 records of breast cancer submitted for analysis, 45 020 (6%) related to women registered with a previous primary cancer, and were excluded (available online[34]) Of the 740 235 eligible first primary invasive breast cancers, 9215 records were excluded as death-certificate-only (DCO) registrations (1%), 239 as autopsy-detected tumours (<1%) and 2064 with major errors (<1%), leaving 728 717 patients for analysis (98% of those eligible), of whom 370 000 (51%) were resident in North America and 304 000 (42%) in Europe (table 1). Almost all (97%) of the

tumours included in the analyses were microscopically verified, less than 1% of patients were censored from the analysis within 5 years of diagnosis, and 2·3% died within 1 month of diagnosis.

Relative survival at 5 years, age-standardised to the International Cancer Survival Standard weights, ranged from 80% or over in North America, Sweden, Japan, Finland, and Australia to less than 60% in Brazil and Slovakia, and below 40% in Algeria (table 2 and figure 1). Survival in the 24 European countries that contributed to CONCORD was mostly in the range 70–79%.

The survival estimate of 38·8% (95% CI 31·4–46·2) for Sétif (Algeria) is based on 180 patients, and it is not age-standardised because there were too few patients for analysis in some age groups, but age-standardisation for breast cancer in other datasets rarely altered the raw estimate by more than 5% in either direction (data not shown), and survival from breast cancer was undoubtedly much lower in Algeria than in all the other countries.

The pooled estimate of 5-year survival for the two Brazilian registries was 58·4%, but the estimate for Goiânia (65·4%) is more reliable than the very low figure for Campinas (36·6%), where high proportions of patients were excluded as DCO or with major errors (available online[34]). The proportion of metastatic tumours was higher in Campinas, however. The 5-year survival estimate for Cuba was 84·0%, but this was likely to be an over-estimate: some 28% of records were excluded because they were registered solely from a death certificate.

The pooled estimate of 5-year survival for Canada was 82·5%, with a narrow range from 79·3% in Nova Scotia to 85·4% in British Columbia (table 2 and figure 1). In the USA, 5-year relative survival for all races combined ranged from 78–81% in New York City, New York State, and Louisiana to 89–90% in Hawaii and Seattle, WA (table 2), but most of the estimates were within a fairly narrow range, from 82% to 87% (figure 2). Survival in metropolitan areas covered by SEER registries was similar to that in the respective states: Detroit, MI 83·0% and Michigan State 82·3%; San Francisco, CA 86·2% and California State 84·6%. 5-year survival was 77·4% for residents of New York City, NY (with 40% of the state population), slightly lower than for New York State as a whole, 81·0%.

Survival was lower for blacks than for whites in all 17 populations in the USA for which this could be assessed with race-specific life tables (webfigure 2). The age-adjusted pooled estimate of 5-year survival was 84·7% for whites (range 80–90%) and 70·9% for blacks (table 3). The range in survival was wider for blacks (60–83%), but the values at both extremes of the range were based on relatively few patients and have wider CIs. Within a given US population, the absolute difference in age-adjusted relative survival between blacks and whites ranged from 2% (Rhode Island, Nebraska) to 25–27% (Iowa and Seattle, WA; table 3 and webfigure 2). Even in areas where blacks comprise 25% or more of the population, survival for black women was 8–14% below the lowest estimate for white women (79·6%) in any of the participating areas: Atlanta, GA (71·1%), Detroit, MI (71·7%), New York City, NY (65·8%), and Louisiana (69·9%). The pooled estimate of 5-year survival for the USA was 84·0%, with 86·1% in areas covered by SEER and 83·1% in areas covered by NPCR (table 3).

See Online for webfigures 2 and 3

Survival in black women was always lower than the mean survival for all US populations included, and often more than three standard deviations below it (below the 99·8% control limits), after controlling for the precision of the estimates. Survival in white women is generally within or above the upper control limits, especially in territories covered by the SEER Program. A notable exception is for white women in New York State, including New York City, where the survival estimates are precise, but well below the lower control limits (webfigure 3).

The pooled estimate of 5-year survival for breast cancer in Japan was 81·6%. Survival in Osaka (79·4%) was lower than in Fukui (83·1%) and Yamagata (87·3%; table 2 and figure 1).

5-year relative survival for breast cancer in Europe, age-standardised to the ICSS weights, ranged from 57·9% in Slovakia to 82·0% in Sweden (table 2 and figure 1), whereas the pooled estimate derived from the data of 58 registries in the 24 participating European countries was 73·1%. Survival estimates for most of these countries have been reported.[27] The CONCORD study includes additional data from four countries: 5-year survival was 69·6% in Ireland and 72·0% in Northern Ireland, similar to the UK mean value of 69·7% (table 2). In Switzerland, 5-year survival in the cantons of St Gallen-Appenzell, Graubunden-Glarus, and Valais was 72–75%, about 4–7% lower than in Geneva or Basel. 5-year survival was 77·8% in northern Netherlands, similar to that in Amsterdam and southern Netherlands (76–78%).

The national estimate of 5-year survival for breast cancer in Australia was 80·7%. Survival was virtually identical in the six largest states (96% of the national population), in the range 80–82%, but notably lower in the two smallest regions: 71·9% in Northern Territory (1·0% of the population) and 77·1% in Tasmania (2·6%).

Of 488 741 colon cancer records submitted for analysis, 45 862 records (9%) were excluded for a previous cancer, leaving 442 879 first, primary, invasive colon cancers eligible for analysis (available online[34]). A further 13 102 (3%) were excluded as DCO registrations, 1534 (<1%) as autopsy-detected tumours, and 1144 (<1%) as major errors, leaving 427 099 patients for inclusion in the analyses (96% of those eligible). Of these, 214 000 (50%) were resident in North America, 170 000 (40%) in Europe, and 30 300 (7%) in Australia. Cancers of the colon comprised 67% of all colorectal tumours (table 1). Microscopic verification was high (94%), and less than 1% of patients were censored from the analysis within 5 years of diagnosis. Almost 11% of patients died within the first month after diagnosis.

Relative survival at 5 years, age-standardised to the ICSS weights, ranged from about 60% in North America, Japan, Australia, and some western European countries down to

 Published online July 17, 2008 DOI:10.1016/S1470-2045(08)70179-7

40% or less in Algeria, Brazil, Czech Republic, Estonia, Poland, Slovenia, and Wales (table 2 and figure 3).

The survival estimates of 11·4% (95% CI 0·7–40·9) for men and 30·6% (9·5–56·1) for women in Sétif (Algeria) were based on fewer than 20 patients, and are not age-standardised, but survival was clearly lower in Algeria than in all the other countries.

The estimate of 5-year relative survival for Goiânia (48·1% in men, 44·8% in women) was more plausible for Brazil than the low estimates for Campinas, where 26% of patients had to be excluded with errors.[34] 5-year survival in Cuba was about 60% in both sexes, although more than half the patients were excluded from analysis as DCOs.[34]

In Canada, the pooled estimate of 5-year survival was 56·1% for men and 58·7% for women. Variation between provinces was small, from 54–57% in men and 58–60% in women (table 2 and figure 3). In the USA, 5-year relative survival for all races combined was 60·1% in both sexes, with a range from 53·6% for women in New York City to 67·9% for men in Hawaii (table 2 and figure 2). Again, most of the estimates were within a narrow range, 59–64%.

5-year survival for colon cancer among blacks in the USA was lower than among whites. In 34 paired observations of this difference in survival (men and women in 17 populations), only three exceptions were noted, in men and women in Iowa and men in Nebraska. The estimates for blacks in those three areas were based on fewer than 50 patients, have wide confidence intervals and were not age-standardised (table 3 and webfigure 4). The pooled estimate of age-adjusted 5-year relative survival for the USA was 61% for white men and women, and 51–52% for black men and women. Within a given population, the absolute difference between blacks and whites ranged from 2·6% in men and 7·3% in women in Los Angeles, CA to 14·3–17·2% in Colorado. The geographical range in black–white differences in survival is affected by small populations to some extent, but even in areas where blacks comprise 25% or more of the population (Atlanta, GA, Detroit, MI, New York City, NY, Louisiana), 5-year survival from colon cancer in blacks was 6–12% lower than for whites in the same population (table 3). The pooled estimate of 5-year survival in areas covered by NPCR was 59·8% for men and 59·6% for women, and 61·9% for men and 62·1% for women in SEER areas.

Age-standardised survival in whites ranged from 54·9% to 67·9% (table 3 and webfigure 4). The range of age-standardised survival for blacks was 45·0% to 59·9%. Survival in blacks was generally lower than the mean value for all included US populations and often more than three standard deviations below the mean, after controlling for precision of the survival estimates. Survival in whites was generally within the control limits. The main exception was for white women in New York State, including New York City, NY, where survival estimates were precise, but more than three standard deviations below the lower control limits around the pooled US estimate (webfigure 3).

In Japan, the pooled survival estimate was 63·0% in men and 57·1% in women, although survival was about 10% lower in Osaka prefecture than in Fukui or Yamagata (table 2 and figure 3).

In Europe, 5-year relative survival for colon cancer in men ranged from 28·5% in Poland to 54–57% in Spain, Finland, Austria, and France. In women, the lowest estimate was also for Poland (30·9%), while survival was in the range 55–60% in nine countries (table 2 and figure 3). The pooled estimates for the 51 contributing registries in 23 European countries were 46·8% in men and 48·4% in women. Data on colon cancer were not available for the five Swiss registries, Isère (France), or northern Netherlands. Survival estimates for most of these countries have been published elsewhere.[27] This study included additional data from two countries. 5-year survival in Ireland was 49·1% in men and 48·5% in women. The estimates for Northern Ireland were 47·3% in men and 49·0% in women, slightly higher than the pooled estimate for the UK, 43·5% in men and 44·4% in women (table 2).

The national estimate of 5-year survival for colon cancer in Australia was 57·8% in men and 57·7% in women. Survival ranged from 50–62% in the eight states and territories: it was highest in New South Wales, the Australian Capital Territory, and Queensland, and lowest in Tasmania, Northern Territory, and Western Australia (9·6% of the population; table 1).

Of 233 176 rectal-cancer records submitted for analysis, 15 731 records (7%) were excluded for a previous cancer, leaving 217 445 first, primary, invasive rectal cancers eligible for analysis (available online[34]). A further 3213 (1%) were excluded as DCO registrations, 517 (<1%) as autopsy-detected tumours and 574 (<1%) as major errors, leaving 213 141 patients for inclusion in the analyses (98% of those eligible). Of these, 83 000 (39%) were resident in North America, 106 000 (50%) in Europe, and 16 800 (8%) in Australia. Cancers of the rectum comprised 33% of all colorectal tumours (table 1). Microscopic verification was high (96%). Less than 1% of patients were censored from the analysis within 5 years of diagnosis. Almost 8% died within the first month after diagnosis.

See Online for webfigure 4

5-year relative survival from rectal cancer, age-standardised to the ICSS weights, ranged from about 60% to around 20% in both sexes, with Japan, Canada, the USA, France, the Netherlands, Sweden, and Australia at the upper end of the range, and Algeria, Estonia, Poland, and Slovakia at the lower end (table 2 and figure 3).

The 5-year survival estimates of 25·9% (95% CI 11·4–43·7) for men and 18·2% (6·6–34·6) for women in Sétif (Algeria) were each based on 30 patients, and were not age-standardised because data were too sparse in some age groups.

5-year relative survival in Goiânia, Brazil, was 49·3% in men and 38·4% in women. No data were available for Campinas. 5-year survival in Cuba was 59·2% in men and 62·8% in women, based on analysis of about 700 patients

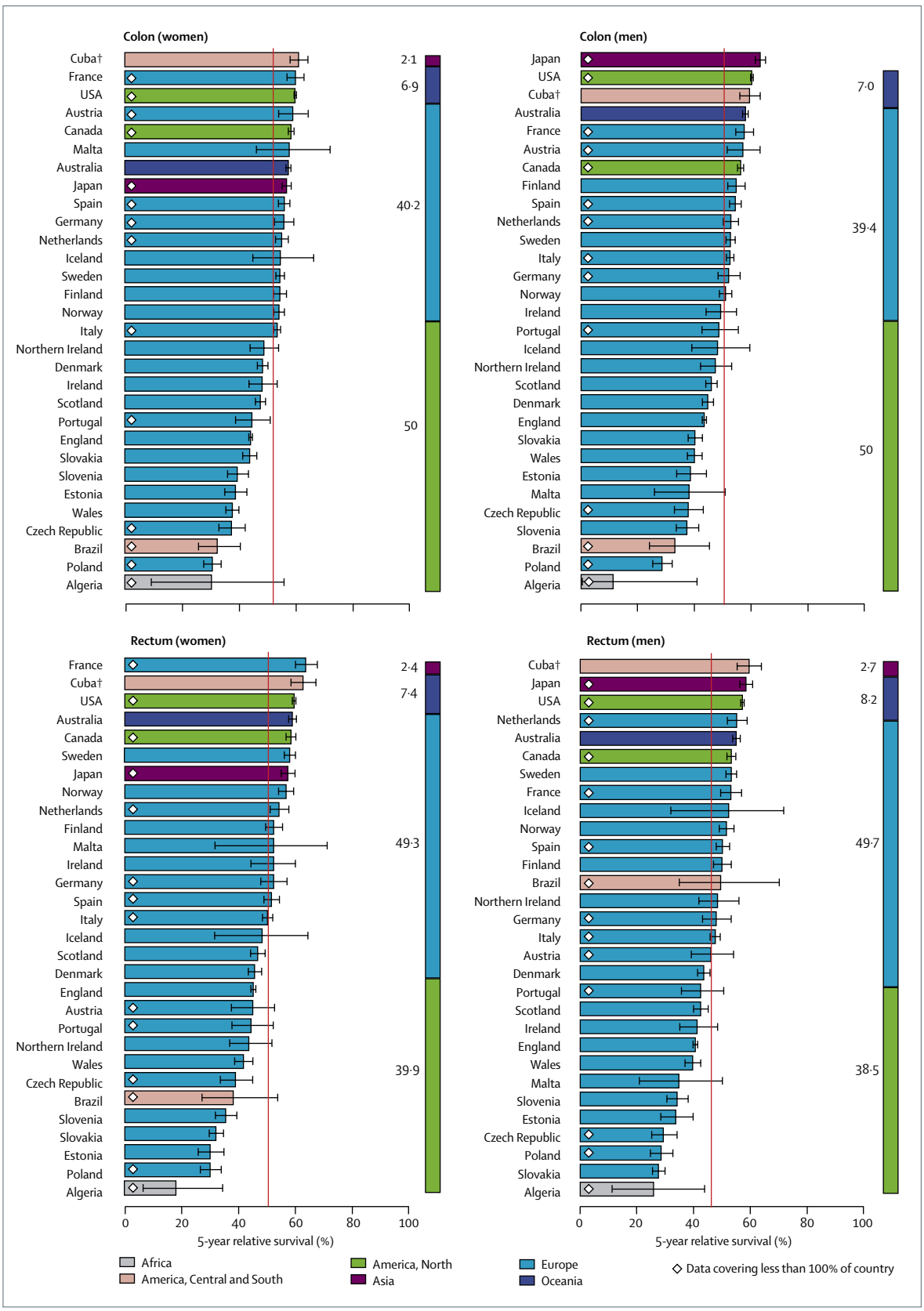

***Figure 3*: 5-year relative survival (%), age-standardised to the ICSS weights* with 95% CIs for adults (aged 15–99 years) diagnosed with cancer of the colon or rectum during 1990–94 and followed up to Dec 31, 1999: country**

Vertical bar on the right of each graphic shows the contribution (%) of each continent to the total number of cases analysed (contributions under 1% are not labelled). Red vertical line represents mean survival for the 22 European countries that participated in EUROCARE-3, age-standardised to the ICSS weights. *Age-standardised to ICSS weights, except for Sétif, Algeria (all cancers), Austria (rectum [women]), Iceland (rectum [men and women]), Ireland (rectum [women]), Malta (colon [men] and rectum [men and women]), which were unstandardised values (see text). †Problems with data quality might have led to over-estimation (see text).

www.thelancet.com/oncology **Published online July 17, 2008 DOI:10.1016/S1470-2045(08)70179-7**

in each sex, although 782 (36%) patients had been excluded as DCO (available online[34]).

In Canada, the pooled estimate of 5-year survival was 58·7% for women and 53·1% for men, slightly lower in the global range than for cancers of the breast, colon, or prostate in Canada. Survival in men ranged from 51·1% (Ontario) to 64·6% (British Columbia), and from 57·8% to 62·8% in women. In the USA, 5-year relative survival for all races combined was 56·9% in men and 59·8% in women, with a range from 46–67% in men and 52–66% in women (table 2 and figure 2). Again, most of the estimates were within a narrow range, from 55–60% in men and 57–62% in women. By contrast with colon cancer, survival from rectal cancer was slightly higher in women than in men.

5-year survival for rectal cancer in the USA was generally lower for blacks than for whites, in both sexes (webfigure 4). The overall estimate of 5-year survival in men was 47·4% for blacks and 57·3% for whites; for women, the estimates were 49·4% for blacks and 60·4% for whites (table 3). When survival for blacks was above 60%, or higher than for whites in the same population (Colorado, Connecticut, Nebraska, Rhode Island), the estimates for blacks were based on around 50 or fewer patients, with wide CIs, and were usually not age-standardised (table 3 and webfigure 4). Even where blacks comprised 25% or more of the population (Atlanta, GA, Detroit, MI, New York City, NY, Louisiana), 5-year survival was 6–16% lower than for whites in the same area. The pooled estimate of 5-year survival in areas covered by NPCR was 56·3% for men and 58·8% for women, some 2–3% lower than for SEER areas (58·5% men, 61·8% women; table 3 and figure 2).

5-year survival ranged from 46·2% to 67·9% in whites; in blacks, the range of age-standardised survival was from 42·8% to 63·5% (table 3 and webfigure 4). Survival in blacks was generally lower than the mean value for all included US populations, although more often within the control limits. Survival for whites was also generally within the control limits, with the exception of New York City, NY, where survival was below the control limits (webfigure 3).

In Japan, the pooled survival estimate for colon cancer was 58·2% for men and 57·6% for women, although survival was lower in Osaka (54–55%) than in Fukui or Yamagata (60–64%; table 2 and figure 3).

In Europe, the geographical pattern for age-standardised 5-year survival was similar to that for colon cancer. For men, the range was from 28–30% in Poland, West Bohemia (Czech Republic), and Slovakia to 53–55% in France, Sweden, and the Netherlands; whereas for women, the range was from 30–32% in Poland, Estonia, and Slovakia up to 63·9% in France, where three of the four contributing registries ranked the highest in Europe (table 2 and figure 3). The pooled estimates for the 51 contributing registries in 23 European countries were 43·2% in men and 47·4% in women. Data on rectal cancer were not available for Isère (France), northern Netherlands, or the five Swiss registries. 5-year survival in Ireland was 41·1% in men and 52·5% in women. The estimate for women is not age-standardised, but it is based on over 200 patients (table 1), and similarity between the raw and standardised estimates for cancers of the colon and colon and rectum combined (less than 1%, data not shown) suggests that an age-standardised estimate for rectal cancer would not have been very different. In Northern Ireland, the estimates were 48·2% in men and 43·8% in women (pooled UK estimates were 40·6% in men and 45·3% in women; table 2).

The national estimate of age-standardised 5-year survival for rectal cancer in Australia was 54·8% in men and 59·2% in women. Survival ranged from 45–57% in men and from 55–61% in women.

Of 663 621 men with prostate cancer, 35 934 (5%) were excluded for a previous cancer, leaving 627 687 eligible first, primary, invasive cancers of the prostate (available online[34]). After 11 163 (2%) exclusions for DCO, 1640 (<1%) for autopsy-detection and 801 (<1%) for major error, 614 083 men were included in the analyses (98% of those eligible). Of these, 403 000 (66%) were resident in North America, 162 000 (26%) in Europe, and 43 000 (7%) in Australia (table 1). Microscopic verification was available for 96% of the tumours. Less than 1% of men were censored from the analysis within 5 years of diagnosis, but 3·2% died within 1 month of diagnosis.

5-year relative survival, age-standardised to the ICSS weights, ranged from 80% or higher in the USA (92%), Canada and Austria to less than 40% in Denmark, Poland, and Algeria (table 2 and figure 1).

The 5-year survival estimate of 21·4% (95% CI 8·7–38·9) in Sétif (Algeria) was based on 36 patients, and was not age-standardised.

In Brazil, 5-year survival was 34·4% in Campinas and 55·7% in Goiânia. Some 30% of tumour records in Campinas were excluded with major errors. Notably, 20 (13·4%) men in Campinas and 71 (21·8%) men in Goiânia died within 1 month of diagnosis, which are the highest proportions of any of the participating registries (available online[34]). 5-year survival in Cuba was 69·7% (table 3). This estimate was based on 4300 patients, but 54% of the original data set of 9500 patients had been excluded as DCO (table 1 and data available online[34]).

The pooled estimate of 5-year survival for prostate cancer in Canada was 85·1%, ranging from 77·5% in Saskatchewan to 89·3% in British Columbia (table 2 and figure 1). In the USA, 5-year relative survival from prostate cancer was 91·9% for all races combined, with a range from 81·6% in New York City, NY up to 95·0% in Seattle, WA (table 2 and figure 2), but most of the estimates were within a fairly narrow range, from 88·6% (Louisiana) to 94·0% (Atlanta, GA). The relative survival estimate for the state of Michigan was 100%, although in the city of Detroit, MI, with 42% of the state population (webtable), survival from prostate cancer in the same period was 93·8%.

Age-standardised 5-year relative survival for prostate cancer in blacks was lower than for whites in all

populations for which this could be separately assessed with race-specific life tables (webfigure 2). The overall estimate of 5-year survival was 85·8% for blacks and 92·4% for whites, with an overall difference of 6·6% (table 3). The difference in survival between blacks and whites ranged from 5·0% (Florida) to 14–16% (Nebraska, Rhode Island), and although the largest differences arise where the black populations are smallest, each survival estimate was based on at least 70 patients (webtable). Survival in whites ranged from 83·3% (New York City, NY) to 96·1% (Atlanta, GA), and in blacks from 74·0% (New York City, NY) to 89·6% (Seattle, WA). The pooled estimate of 5-year survival was 89·5% in areas covered by NPCR, and 93·1% in SEER areas (table 3).

Survival in blacks was usually lower than the pooled US estimate, and often more than three standard deviations below it, after controlling for precision (webfigure 3). Survival in whites was generally within the control limits. 5-year survival for whites was above the upper 99·8% control limit in three SEER populations (Atlanta, GA, Seattle, WA, and Detroit, MI). Survival in whites was below the lower control limit in four NPCR populations, but for California and Florida the difference was small (2–3%). In New York State, including New York City, NY, survival estimates are precise, but 6–9% below the pooled US estimate of 92·3% and well below the lower control limit (webfigure 3).

The 5-year relative survival estimates for Michigan State (100% in both blacks and whites) were too high, and they are not shown in webfigure 3, although the data were included in the pooled estimate. Information about the death had not been linked to the tumour record for some of the apparent 5-year survivors from prostate cancer in Michigan State, leading to an inflated estimate. This error did not affect the survival estimates for prostate cancer in Detroit, MI or those for other cancers in Michigan State.

The pooled estimate of 5-year survival in Japan was 50·4%, much lower on the global scale than for cancers of the breast, colon, or rectum in Japan. Survival estimates were similar in all three prefectures (table 2 and figure 1).

The range of 5-year survival in Europe was especially wide for prostate cancer, from less than 40% in Poland and Denmark to more than 80% in Austria (table 2 and figure 1). The pooled estimate for the 49 contributing registries in 23 European countries was 57·1%. Data were not available for nine registries: Switzerland (five registries), Isère and Côte d'Or (France), Granada (Spain), and northern Netherlands. 5-year survival in the Ireland was 62·8%. In Northern Ireland, the estimate was 54·0%, slightly higher than the pooled estimate of 51·1% for the UK (table 2).

The national estimate of age-standardised 5-year survival for prostate cancer in Australia was 77·4%. Survival was closely similar in the six largest states, in the range 76–80%, but notably lower in the two smallest regions: 63·7% in Northern Territory (based on 78 patients, estimate not age-standardised) and 70·2% in Tasmania (1321 patients).

Discussion

To our knowledge, the CONCORD study is the first attempt to provide directly comparable data on cancer survival from many countries around the world by use of central quality-control procedures, standard analytic methods, and a single, centralised analysis of individual tumour records from population-based cancer registries. The findings should eventually complement the international data series on cancer incidence[63,64] and mortality[65–67] that have been available for several decades. Cancer-mortality statistics have often been used for international comparisons of progress against cancer,[68–72] but they are also affected by well-known problems of comparability, both between countries and between successive revisions of the ICD.[72–75] The findings presented here should help joint consideration of trends in incidence, survival, and mortality as indicators of cancer control. None of these indicators is perfect, but none is adequate on its own.[76–78]

Around 2800 life tables were created to enable the estimation of relative survival by age, sex, country, and race.[46] The life tables are available on the CONCORD website.[34]

5-year relative survival for breast, colorectal, and prostate cancers was generally higher in North America, Australia, Japan, and northern, western, and southern Europe, and lower in Algeria, Brazil, and eastern Europe.

Exclusions for a previous cancer (5–9%) were not unexpected. Population-based cancer survival analyses are usually restricted to patients with a first, primary invasive cancer, therefore, to the extent that patients with a previous cancer have been completely excluded in this study, this improves the comparability of the findings with other studies. Participating registries began operation between 1950 and 1990. The data from newer registries are more likely to include unrecognised second and subsequent cancers, because any previous cancer(s) in a given patient might have been diagnosed before the registry began operation.

The main indices of data quality for cancer survival are the proportions of registered patients known to the registry by DCO, or lost to follow-up, and histologically verified. Data quality varied between registries (available online[34]), but was high overall: very few records were excluded with a major error. Exclusions for major errors were high in Campinas, Brazil (26–47%). The overall proportion of patients who died within 1 month of diagnosis was low for breast cancer (2·3%) and prostate cancer (3·2%), but higher for colon (10·9%) and rectal cancers (7·8%). These values varied between registries, but the overall pattern is plausible; up to a third of colorectal cancers present as an emergency with bowel obstruction. Fewer than 1% of patients were censored from the analysis within 5 years of diagnosis.

Three registries were excluded after quality control, because of high losses to follow-up or inefficient regional or national linkage of information on the deaths of patients with cancer. The data for three other registries, Cuba, Campinas (Brazil) and, for prostate cancer, Michigan State

 Published online July 17, 2008 DOI:10.1016/S1470-2045(08)70179-7

(USA), are less reliable than those from other registries, although for different reasons, discussed below. As with the first global compilation of cancer incidence data, in the 1960s, retention of the two registries from Central and South America was partly prompted by the paucity of information on cancer survival from that region: "in this situation, even incomplete data have value".[64]

Overall, the exclusion of DCO registrations accounted for only 1% (9215) of the eligible records for breast cancer, 3% (13 102) for colon cancer, 1% (3213) for rectal cancer, and 2% (11 163) for prostate cancer (available online[34]). The percentage was less than 1% in Algeria, USA, Canada, and Australia, and in the range 0–5% in most European countries and in Brazil, but higher in Osaka (Japan; 5–22%),[79] south Thames (UK); 10–16%), and Cuba (28–60%).[80]

The proportion of DCOs is not particularly useful as a comparative index of data quality,[81] but a high proportion of DCO records does suggest that routine data-collection systems might not be complete. The relevance of this index also varies with the system of data collection. Sweden does not use DCOs because the registration of patients with cancer at the time of diagnosis is close to 100%; by contrast, hospitals in Cuba are not allowed to retain the clinical records of deceased persons for more than 5 years.[80]

The different proportions of DCO records are unlikely to explain the differences in survival between Europe and North America, however. The survival of patients whose tumour is registered as a DCO is generally lower than the mean for all registered cancer patients,[82] so if they could have been included, the transatlantic differences in survival would have been slightly greater. Furthermore, most DCO records in the European data are for patients aged 75 years or over,[43] where the survival differences are in any case more marked.[9] By contrast, if a high proportion of DCO records is taken to suggest under-registration of long-term survivors, this might produce lower survival estimates. Adjustment for both DCOs and incompleteness of registration in Thames (UK) and Finland had surprisingly little effect on survival, however, even when 10–20% of registrations were DCOs, because the two corrections tended to off-set one another.[83] Under-reporting of incident tumours by up to 5% has been shown not to affect international comparisons of survival greatly.[84]

A plateau was imposed on the relative survival curve at some point during the first 5 years after diagnosis in about 7% of the 6500 age-specific survival estimates by registry, cancer, sex, and race (data not shown). The effect on the age-standardised survival estimates at national level was almost always less than 1%.

Diagnostic variability between pathologists might contribute to international differences in cancer survival. Thus, survival from colorectal cancer in Japan is among the highest reported here, especially for men. In western countries, invasive colorectal carcinoma is diagnosed when neoplastic tissue invades beyond the submucosa of the bowel. Severe cytological or architectural changes confined to the mucosa (in situ or intramucosal carcinoma) have no metastatic potential, and are often labelled high-grade dysplastic adenoma. Japanese pathologists rely more on cytological features, however, and do not consider evidence of invasion into the submucosal layer as a mandatory requirement for the diagnosis of colorectal carcinoma.[85] Pathological practice on this issue might vary substantially between western pathologists. Islands of dysplastic tissue might also be displaced or herniated beyond the muscularis mucosae without implying invasive potential (pseudo-invasion), and differential diagnosis can be very difficult.[86,87]

Assessment of the extent to which international survival differences might be attributable to differences in the pathological definition of disease would need blinded review of pathological diagnoses of a sample of patients by an international panel of expert pathologists. Such reviews are invaluable, but rare.[88]

Survival in Sétif (Algeria) was the lowest of all the populations in the CONCORD study for each cancer. Even though the dataset was small, and covers only 4% of the national population, there is little doubt that survival in Algeria is very low. The age distribution of patients was younger than in most populations (available online[34]) and it cannot explain the low overall survival. Survival in Sétif was similar to or even lower than survival in blacks diagnosed during 1993–97 in Harare, the Zimbabwean capital, where the very low survival was attributed to inadequate access to facilities for early diagnosis, clinical investigation, and treatment.[89]

Survival in the two Brazilian registries was generally low, although rectal-cancer survival in Goiânia was close to the European mean. Data quality issues prevented the inclusion of data from three of the 20 population-based registries in state capitals: these registries should be used to provide a broader picture of cancer survival in Brazil. Relative survival reported here for patients with cancer diagnosed in Cuba during 1990–94 was about 20% higher than estimates for those diagnosed during 1988–89, just a few years earlier.[80] Cancer survival for children diagnosed in Cuba during 1988–89 was lower than in more developed countries.[90] The high proportion of DCOs in the 1988–89 data was considered less likely to be biased with respect to survival than in other registries, because of the way data were collected,[80] but the survival estimates for Cuba reported here are still likely to be considerably inflated, and should be interpreted accordingly.

National estimates of survival for patients with cancer diagnosed in Japan during 1993–96 were slightly higher than the estimates for 1990–94 reported here.[79] They were based on data from seven prefectures, including the three reported here (Yamagata, Fukui, and Osaka). As in the CONCORD data, survival in Osaka was generally lower than the mean survival for Japan.

Variation in survival between the provinces of Canada and the states and territories of Australia was generally small, and overall survival was high: this suggests health care of a high standard in most areas. Variation between the countries of Europe was much wider.

The substantial differences in survival between Australia and the UK have been noted before.[91] They are unlikely to be because of differences in data quality. For breast cancer, survival from both localised and regional disease was higher in Australia, but survival from metastatic disease was similar. Elderly women in England had especially poor survival. More effective treatment in Australia is a plausible explanation.[92]

Comparisons of cancer survival between Europe and the USA since 2000 have identified wide differences, with survival usually higher in the USA.[9] Closer assessment of these differences with more detailed data, not routinely collected by all registries, has enabled the explanatory effect of clinical variables such as stage at diagnosis, investigative approach, anatomical site, and morphology to be quantified for colorectal cancer[12,93] and breast cancer,[10] and for a range of cancers in children.[11] In those studies, the USA has always been represented by data from the SEER Program registries, representing some 10% of the US population at that time, because no other data have been available. The availability of data from a large number of state-wide population-based cancer registries that began operation around 1990, and meet data quality standards comparable with those of the SEER registries, now enables a larger proportion of the US population to be included in national and international comparisons of cancer survival. The CONCORD study provided the first opportunity for the cancer registries of 11 US states in the NPCR to follow up all their patients for vital status and to undertake analyses of cancer survival, and 42% of the US population is included in these analyses.

The survival differences between US and European patients with cancer, especially in the oldest patients, seem unlikely to be attributable to artefacts of cancer registration. The CONCORD study has nonetheless identified two methodological issues that probably do explain some of the well-known differences in survival between Europe and the USA, from which only SEER data have been available until now.

First, relative survival was about 2–4% higher in SEER-9 areas than in participating NPCR areas of the USA. Consequently, cancer survival in the 42% of the US population covered by the CONCORD study was 1–3% lower than survival in the SEER areas alone (10% of the US population). Direct estimation of cancer survival for other areas of the USA would be desirable.

Second, census-derived US national life tables give higher estimates of all-cause mortality than are noted in the SEER areas, especially with the gradual decline of mortality in the decade after a census.[46] Use of census-derived national life tables to estimate relative survival (the SEER approach) therefore produces estimates that are almost always higher than those obtained with state-specific life tables for each calendar year in the decade (CONCORD approach), which we believe to be more appropriate because it provides tighter control for changes over time in background mortality. With the CONCORD approach, age-standardised 5-year survival in the 22 participating areas of the USA was up to 3% lower than with the SEER approach for breast cancer in women, up to 4% lower for colorectal cancer, and up to 5% lower for prostate cancer (available online[34]).

The differences in cancer survival between blacks and whites of both sexes in the USA are large, and remarkably consistent in 16 states and six metropolitan areas—more populations than it has been possible to study in the past.[94] The differences were adjusted for age and for differences in background mortality between blacks and whites within each state or metropolitan area. It would be interesting to know if the differences were attributable to artefact, or differences between blacks and whites in tumour biology, in stage at diagnosis, in access to health care, or in compliance with treatment. The survival differences seen in this study are consistent with those in other studies.[47–53] Data-collection systems were identical for all races. The black–white differences in relative survival that we report would have been even larger if we had used race-specific national life tables instead of race–state life tables, because background mortality is higher (and expected survival lower) in blacks than in whites in all the populations studied.[23,95]

Survival from cancers of the breast, colorectum, and prostate varied with the type of health insurance in a population-based study:[96] survival was highest in patients who had private insurance, intermediate with federal insurance, and lowest with no insurance. Another study[97] suggested that prostate cancer is not more biologically aggressive in blacks than whites. Late stage,[98] less treatment, and higher mortality seem to be associated with black race, low socioeconomic status, and poor survival in the USA.[99–101] Extensive reviews have led to the conclusion that racial disparities in cancer treatment, which are not explained by clinical factors, lead to worse outcomes in blacks.[102,103] Analysis of SEER data suggested that some racial differences in treatment and cause-specific survival persist after adjustment for poverty.[104] By contrast, the racial difference in survival from colorectal cancer was almost absent in patients managed under the equal-access, integrated health-care Veterans' Affairs system.[105] Finally, overviews of race, socioeconomic status, and cancer outcomes strongly suggest that equal treatment yields equal outcome, irrespective of race.[53,106] The data presented here extend the evidence that cancer survival in the USA is lower in blacks than in whites.

Simple ranking of countries by overall survival can be misleading. Survival is very similar in many European countries, at the centre of the global range, and a small shift in the survival estimate in either direction can entail a large change in the rank. Thus, even the national survival estimates for Iceland and Malta have wide confidence intervals and unstable rankings because they are based on populations of around 250 000 (figures 1 and 3). The detailed data by country and region are tabulated by continent, country, and region, rather than ranked: some

 Published online July 17, 2008 DOI:10.1016/S1470-2045(08)70179-7

estimates, based on sparse data, could not be age-standardised (table 2).

The numbers of patients included in the analysis varied widely, as did the proportion of the national population covered by the data. These proportions affect the extent to which the survival estimates can be deemed representative of the country concerned. For example, in Algeria, Brazil, and Germany, only 1–4% of the national populations were covered by the data. Population coverage of participating registries in Italy was about 15%, but they were concentrated in the wealthier north of the country.[22,30] The same point also applies to the USA, however, because the data presented here confirm suggestions[107] that cancer survival in the SEER Program areas (10% population coverage during the 1990s) was higher than in other parts of the country. By contrast, regional variation in survival in Australia and Canada was much less marked than in the USA. Similarly, survival for 1990–94 in the four French départements reported here (6% national coverage) was high on the European scale for most cancers,[27] and a much larger study for the same period in 14 départements (20% coverage) showed similar patterns of survival.[108,109]

For countries with more than one contributing registry but less than 100% population coverage, we have presented estimates of survival derived from the pooled data, not weighted means of the regional estimates of survival. The question of whether pooled survival estimates derived from regional registries with less than 100% national coverage can properly be considered representative of cancer survival in the whole country has been discussed elsewhere.[22] If population-based estimates of cancer survival are deemed reliable, however, they do suggest a potentially achievable level of survival, irrespective of whether the estimate is for a whole country or only one region in that country. Regional variation in survival within a country tends to prompt efforts to improve survival in regions where it is low. The same argument should apply on an international scale. This has already happened in Europe.[110]

No overall worldwide estimate for cancer survival has been presented. The proportionate contributions from each continent to the CONCORD study are very different from the worldwide distribution of cancers of the breast, colon, rectum, and prostate. The national data for Australia alone represented 63% of the population of Oceania in 1995,[111] and the survival estimates for North America included 44% of the combined populations of USA and Canada around 1992, but for Africa, Asia, and South America, the population coverage of these data was much lower. The survival data for Europe were based on 25% of the continental population of 512 million in 1992,[112] but the EUROCARE study (ongoing since 1989) is the largest and most widely cited international study of cancer survival, and all 57 cancer registries in that study, and six others, contributed to CONCORD. To provide an international summary measure of cancer survival for visual comparison, we therefore used the overall estimates for 23 countries in EUROCARE-3, but age-standardised to the ICSS weights used in CONCORD, instead of the weights used in EUROCARE-3.[113] We have presented pooled estimates of survival for Europe and North America (table 3), but not for other continents.

The size of the population covered by the data affects the statistical precision of the survival estimates. This is shown by 95% CIs, but ranked graphics do not provide visual appreciation of the extent to which the survival estimate for a given country or region falls outside the distribution of survival estimates that might be expected, under the hypothesis that survival should be the same in all areas. In that situation, regional variation in relative survival should arise only from random variation around some underlying average. We used funnel plots[62] to provide that visual effect for geographical and racial variation in survival in the USA, with the target value as the pooled estimate for the USA, age-standardised to the ICSS weights.[60] These plots display striking geographical and racial variation in survival.

Clinical practice has continued to evolve in the 15 years or so since the patients included in this study were diagnosed. Changes in diagnosis, screening, and treatment have undoubtedly improved the prognosis for cancer patients, at least in wealthier countries.

Survival has increased substantially for cancers of the breast (women), colon, rectum, and prostate in the 17 areas of the USA covered by the SEER Program during 1996–2003,[114] and in Canada (1996–98)[115] and Australia (1994–2004).[116,117] Smaller increases have been reported in 11 of the 47 Japanese prefectures.[118] These estimates of relative survival, published for national purposes, cannot be compared with the data reported here, however, because of differences in the quality control of incidence data or completeness of follow-up, and in methods of analysis. Some estimates were not age-standardised for international comparison, whereas others were standardised to country-specific age weights, rather than the ICSS age weights that we used.

The only recent international study of cancer survival is EUROCARE-4, which included patients diagnosed in 23 countries during all or part of 1995–2002 and followed up to 2003.[29,30] Survival increased substantially in eastern European countries, where it was much lower than in other parts of Europe during 1990–94. This narrowing of the east–west gap suggests substantial improvements in cancer care. The rise in breast cancer survival in several countries was associated with a fall in mortality, possibly because of improved care and screening programmes; the rise in prostate-cancer survival (and incidence) might be a result of more widespread PSA testing. In western Europe, survival in the UK and Denmark was still low for several cancers in the late 1990s.

CONCORD is, by chance, reasonably well-timed to provide a baseline for international comparisons of cancer survival to assess the effect of several major public health initiatives for the control of breast,

colorectal, and prostate cancers. In 1990, mass population screening for breast cancer with mammography was beginning in many (but not all) participant countries. At that time, intense early diagnostic activity with prostate-specific antigen (PSA) had recently become widespread in the USA, but was little used elsewhere. In Denmark, for example, the 50-year increase in prostate cancer incidence is considered real,[119] but the Danish Society for Urology assessed the evidence in 1990[120] and decided not to advocate PSA testing in asymptomatic men, because the therapeutic benefit was very small;[121] only symptomatic patients were offered treatment. Mass screening for colorectal cancer with faecal occult blood (FOB) testing or endoscopy had not begun during 1990–94 in any contributing country as far as we are aware. Opportunistic screening with the FOB test began in Japan in 1992; by 2004, about 20% of people aged 40 years or over had been tested within the previous year.[122] Opportunistic endoscopy had already become widespread in some parts of the US population by 1990.

The CONCORD study was planned in three phases. The study reported here (phase I, low resolution) was designed to quantify international differences in population-based relative survival by age, sex, country, or region for patients diagnosed during 1990–94 with a cancer of the breast, colon, rectum, or prostate. Phase II (high resolution) was designed to help interpret those international differences in survival, by use of a subset of registries that could re-abstract detailed clinical data, including stage at diagnosis and treatment, from the original medical records for large random samples of patients diagnosed with one of the same cancers during 1996–98. Findings will be reported in due course. Phase III was designed as a blinded, expert review of the pathological diagnosis for a subset of patients from the phase II study, to assess the extent to which international survival differences might be attributable to differences in the pathological definition of disease in participating countries.

The range of survival estimates for each cancer is very wide. Population-based cancer registries are increasingly important in the comparative assessment of cancer outcomes,[123] and even allowing for differences in data quality or statistical robustness, there is little doubt that the chances of survival after a cancer diagnosis vary hugely on a global scale.

The comparability of cancer survival estimates between countries is criticised far more often than the comparability of cancer incidence data from the same registries. There is no statistical basis for this distinction. National sensitivities about cancer survival seem to be much greater than sensitivities about cancer incidence. Cancer survival is a measure of the overall effectiveness of cancer treatment services, whereas cancer incidence is a measure of the long-term effect of prevention policies, which are less visible on a day-to-day basis and can, incorrectly, be seen as less important.

Cancer survival is a valuable indicator for international comparison of progress in cancer control,[76,124,125] despite the fact that part of the variation in cancer survival identified in this study could be attributable to differences in the intensity of diagnostic activity (case-finding) in participating populations. Notably, the very same point applies to international comparisons of cancer incidence. If over-diagnosis—which depends on diagnostic intensity—is more marked in one country than another, then it will certainly be harder for researchers to compare incidence, mortality, and survival in those countries. But over-diagnosis has different connotations for health-care systems and patients. In each country, the health-care system will have to be funded, staffed, and equipped to cope with the diagnostic and therapeutic burden of all patients with cancer, however they are diagnosed. The health-care system must make provision accordingly, and monitor the outcome of that provision; cancer survival is one such overall indicator.

Furthermore, a patient with cancer is still a patient with cancer, whether or not they represent over-diagnosis. If it were possible to distinguish the one from the other reliably, it would be done routinely. As it is, a cancer diagnosis represents the best that medicine has to offer in a given country at a given time, and that best is variable. PSA testing for prostate cancer is an example. No matter how a patient with cancer is diagnosed, they have to cope with the consequences, both psychological and physical, and will usually want to be treated. Such patients cannot be excluded from either incidence or survival analyses. We do not know who they are. In this sense, cancer incidence and survival estimates describe as accurately as possible the occurrence and the outcome, respectively, of cancer as it is diagnosed and treated at a given time in a given population.

Most of the wide global range in survival is probably attributable to differences in access to diagnostic and treatment services.[3,82,89,91,126] International variation in survival in Europe has been associated with national levels of economic development, as measured by total national expenditure on health.[29] Survival is positively associated with gross domestic product and the amount of investment in health technology such as CT scanners.[124] Part of the international variation in survival is thus probably attributable to under-investment in health resources.[127,128] The variation in survival might be considered intuitively obvious, given wide global variation in expenditure on health care, whether that is expressed in absolute terms or as a proportion of national resources. A parallel could be drawn with differences in survival between rich and poor patients with cancer in a given country, which have frequently been reported.[129,130]

Until now, however, direct international comparisons of cancer survival between high-income and low-income countries have not generally been available. The information provided here might therefore be a useful stimulus for change.

 Published online July 17, 2008 DOI:10.1016/S1470-2045(08)70179-7

Contributors
All authors were involved in the study design. JML, MPC, GG, and MSant undertook the pilot study. RC, SF, RdA, MSantaquilani, MQ, GG, MSant, FB, JML, TH, SK, and AV were involved in data preparation and quality control. MQ, RdA, BR, FB, PB, TH, JLY, and MPC did the data analyses. MPC, FB, JLY, TH, HW, JML, MQ, BR, RdA, AM, PB, JME, SK, GAS, and HHS contributed to interpretation of findings. MPC, MQ, BR, FB, PB, HW, JLY, JML, TH, AM, GG, MSant, GAS, HHS, and HT drafted the report. All authors revised the report.

Conflicts of interest
The authors declared no conflicts of interest.

Acknowledgments
We are grateful to the many cancer registry staff around the world whose meticulous and sustained efforts at data collection, linkage, and quality control have enabled the survival of patients to be analysed and compared in this study. We thank Dee Bhakta and Adrian Cousins (London School of Hygiene and Tropical Medicine, London, UK) for help in undertaking the pilot study and for producing webfigure 1, respectively. The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the US CDC.

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