Leading cancers—changes in five-year relative survival

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Abstract

Objectives

Changes in five-year relative survival ratios for prostate, breast, colorectal and lung cancer cases are examined. Ratios for cases diagnosed in the 1985-1987 period are compared with those for 1992-1994. Incidence and mortality rates between 1985 and 1999 are compared with changes in relative survival.

Data sources

Data are from the Canadian Cancer Registry, the National Cancer Incidence Reporting System, the Canadian Mortality Data Base, and life tables.

Analytical techniques

Analysis was conducted using the maximum likelihood method of Estève. Age-standardized ratios for a given cancer were calculated by weighting age-specific ratios to the age distribution of patients diagnosed with that cancer. Statistical tests were used to compare corresponding age-specific and age-standardized ratios across the two periods. National estimates exclude Québec and New Brunswick.

Main results

Between the 1985-1987 period and the 1992-1994 period, increases in five-year age-standardized relative survival ratios were dramatic for prostate cancer, large for breast cancer, and somewhat smaller for colorectal cancer. There was little absolute change in the ratios for lung cancer.

Key words

survival analysis, survival rate/ratios

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Over the last several decades, there have been some major changes in the early detection, diagnosis and treatment of cancer.[1] A cancer patient's prognosis is influenced by several factors. Some are inherent personal characteristics that cannot be modified, such as age, sex and ethnicity. Others relate to early diagnosis and treatment, which can affect the course of the disease.

Cancer control programs attempt to reduce the burden of the disease. At the population level, this means reducing the number of new cases and deaths; short-term measures include improving survival and the quality of life of individual patients.[2] Because population-based survival estimates are based on the experiences of a highly heterogeneous group of people, they are useful "average" outcome indicators of the efficiency of efforts related to early diagnosis and treatment of cancer, and they can be used for comparisons between populations or over time.[3]

Methods

Data sources

Cancer case data were obtained from two different sources: the Canadian Cancer Registry (CCR), a dynamic, person-oriented database containing cases diagnosed from 1992 onward, and its predecessor, the National Cancer Incidence Reporting System (NCIRS), a fixed, tumour-oriented database containing cases as far back as 1969. These databases are maintained by Statistics Canada and contain information based on reports from every provincial/territorial cancer registry. Mortality data are from the Canadian Mortality Data Base (also maintained by Statistics Canada), which is based on information provided by the vital statistics registrars in each province and territory. Canadian and provincial life tables from Statistics Canada were also used.

Analytical techniques

Two separate files were created. The first included all invasive cancer cases diagnosed between 1992 and 1994 and reported to the CCR as of September 2002; the second, all invasive cancer cases diagnosed between 1985 and 1987 and reported to the NCIRS. Three-year periods were chosen to ensure more stable and hence more comparable survival estimates than would have resulted from single-year estimates (for example, 1985 and 1994). Invasive cancer cases were defined using the *International Classification of Diseases, Ninth Edition* codes 140 to 208 (excluding code 173, non-melanoma skin cancer).[4] Historically, coding practices for cases coded to 233.7, in situ bladder, were inconsistent; therefore, such cases were considered to be potentially invasive and were also included.

Vital status during the first five years was determined through record linkage to the Canadian Mortality Data Base, or from information reported by provincial/territorial cancer registries. For deaths reported by a provincial registry but not confirmed by record linkage, it was assumed that the individual died on the date submitted by the reporting province. Such cases represented 0.6% (302 of 53,298) and 0.6% (369 of 61,597) of the total number of deaths to eligible subjects diagnosed between 1985 and 1987, and between 1992 and 1994, respectively. Although computerized record linkage for follow-up precludes a definitive answer about the completeness of mortality tracing, computerized record linkage has been shown to be comparable with, or even superior to, active follow-up.[5]

If a patient had been diagnosed with more than one invasive tumour in either of the files, only the record with the earliest date of diagnosis was retained for analysis. Records for individuals who had been diagnosed with a primary invasive cancer before 1985 or before 1992 were excluded from the 1985-1987 and 1992-1994 analyses, respectively. Historical information (1969 to 1991) for cases diagnosed in 1992-1994 was obtained by linking the CCR data with the NCIRS database. For Ontario, the provincial tumour sequence number was used to determine if an individual had been diagnosed with a primary invasive tumour before 1992. Historic information (1969 to 1984) for cases diagnosed between 1985 and 1987, including those from Ontario, was obtained in a similar manner to that used for the 1992-1994 data.

The analyses were restricted to prostate (ICD-9 code 185), female breast (174), colorectal (153 and 154) and lung cancer (162) cases. Records were excluded when: the year of birth or death was unknown; individuals were younger than 15 or older than 99 when diagnosed; cancer registration was established either through autopsy or death certificate only (DCO); the date of cancer registration was after the date of death (a negative survival time). In both analyses, most exclusions were autopsy or DCO cases (Appendix Tables A through D). When information on day/month of diagnosis and/or day/month of death was missing, survival time was estimated.[6] The percentage of such records was greater in the earlier period (5.0% in 1985-1987 versus 3.4% in 1992-1994).

Both analyses were conducted in STATA 6.0 using the strel module,[2] a user-written module that follows Estève's maximum likelihood method.[7] Cases with the same date of diagnosis and death (not including those previously excluded because they were diagnosed through autopsy or DCO) were assigned one day of survival,[6] as the program automatically excludes cases with zero days of survival. Deaths were grouped into intervals following the actuarial method for survival analysis as follows: 3-month intervals for the first year of follow-up, then 6-month intervals for the remaining 4 years, for a total of 12 intervals. More intervals were used in the first year of follow-up because the actuarial method assumes an approximately even distribution of deaths within each interval, and mortality is often highest during the first year.

To estimate relative survival, observed and expected survival proportions must be compared. The expected survival proportions used to calculate national and provincial relative survival ratios were derived, by single-year-of-age, from sex-specific provincial life tables published by Statistics Canada.[8-10] As only the 1995-1997 life tables were developed up to age 99, the 1985-1987 and 1990-1992 sets of life tables were extended from age 85 to 99 using a method suggested by Dickman et al.[11] The life table deployed was dependent on the year of diagnosis; for example, the survival of cases diagnosed in 1994 was compared with the 1995-1997 life table.

Age-standardized relative survival ratios for a given cancer were calculated by weighting age-specific ratios to the age distribution of patients diagnosed with that cancer. The standard population used by Ellison and Gibbons[6] was selected as the basis to calculate age-standardized estimates. The age-standardized prostate cancer estimate for Prince Edward Island for the 1985-1987 period was calculated as the weighted average of the relative survival ratios of the oldest four age groups, as there were no eligible prostate cancer cases in the youngest age group in this province during this period. Confidence intervals for age-standardized estimates were based on the log (-log) transformation. Non-standardized provincial ratios for each of the four major cancer sites were also calculated (Appendix Table E).

Five-year age-standardized relative survival ratios derived from cases diagnosed in the 1985-1987 period were compared with corresponding ratios derived from cases diagnosed in 1992-1994 using a statistical test,[12] which was conducted on the log (-log) scale. This test considers that the difference of the two survival ratios divided by the square root of the sum of their variances follows an approximately normal distribution.

Trends in cancer survival rates provide information on the extent to which changes in early diagnosis and treatment have improved patients' survival and may reflect the extent to which these services have become available to the population.[2] Comparison of survival estimates can also help identify priorities and indicate measures to improve patients' survival.[13]

Several studies of European populations have examined cancer survival rates over time to assess the impact of changes in diagnosis and treatment.[2,11,14] A recent Canadian report examined five-year relative survival among individuals diagnosed with prostate, breast, colorectal and lung cancer.[6] While this paper provided the first Canadian estimates of five-year relative survival, assessing the changes in diagnosis and treatment over time is better studied by comparing cancer survival to a historical baseline.

This analysis compares the five-year relative survival experience of prostate, breast, colorectal and lung cancer cases that were diagnosed in the 1985-1987 period with those diagnosed in 1992-1994. At the time of analysis, these periods were the most recent for which comparable five-year national survival estimates could be calculated (see *Methods* and *Limitations*). The cancer sites chosen for analysis are the four most commonly diagnosed in Canada. Comparisons are presented for age-specific national (excluding Québec and New Brunswick) and age-standardized provincial estimates. Incidence and mortality rates from 1980 to 1999 are also examined to assess the nature of the changes in relative survival over time.

Rise in prostate cancer survival—all provinces, all age groups

The age-standardized five-year relative survival ratio for prostate cancer increased dramatically, rising from 73% for men diagnosed in 1985-1987 to 89% for those who were diagnosed in 1992-1994 (Table 1). Increases were seen in all provinces, and in all age groups.

Table 1
Five-year relative survival ratios for prostate cancer cases diagnosed in 1985-1987 and in 1992-1994, by province† (age-standardized‡) and by age group

	Prostate cancer diagnosed in:								
	1985-1987				1992-1994				
	Relative survival ratio	95% confidence interval	Number of cases	Number of deaths§	Relative survival ratio	95% confidence interval	Number of cases	Number of deaths§	Comparison of relative survival ratios
	%				%				p-value
Canada†‡	73	72, 74	17,588	8,371	89*	88, 89	34,933	10,995	0.000
Newfoundland	62	54, 69	296	166	81*	74, 86	517	196	0.000
Prince Edward Island	58	46, 68	113	66	79*	71, 85	304	105	0.001
Nova Scotia	70	65, 74	805	407	87*	83, 90	1,580	543	0.000
Ontario	72	70, 73	8,368	4,135	88*	87, 89	16,898	5,413	0.000
Manitoba	70	66, 74	1,227	620	91*	88, 94	2,569	788	0.000
Saskatchewan	68	64, 71	1,177	604	87*	84, 90	2,065	689	0.000
Alberta	75	72, 78	1,912	864	83*	81, 85	3,592	1,255	0.000
British Columbia	79	77, 81	3,687	1,507	92*	90, 93	7,379	1,998	0.000
Age group									
15-99	74	73, 75	17,588	8,371	90	90, 91	34,933	10,995	
15-54	70	64, 75	322	105	86*	83, 88	956	161	0.000
55-64	76	74, 77	2,822	885	91*	90, 92	6,545	1,045	0.000
65-74	76	74, 77	7,001	2,767	93*	92, 94	15,382	3,625	0.000
75-84	71	69, 73	5,847	3,332	86*	85, 88	9,925	4,566	0.000
85-99	59	53, 65	1,596	1,282	70*	64, 74	2,125	1,598	0.003

Data sources: National Cancer Incidence Reporting System (1985 to 1987); Canadian Cancer Registry (1992 to 1994); Canadian Vital Statistics Database
† Excluding Québec and New Brunswick. Results for the Yukon and Northwest Territories are not shown because of an insufficient number of cases, but cases from these areas are included in the analysis for Canada.
‡ Age-standardized to 1992 Canadian case distribution for prostate cancer (Reference 6)
§ Within first five years of follow-up
** Significantly different from 1985-1987 ratio ($p \leq 0.05$)*

Limitations

A national (excluding Québec) internal record linkage is regularly performed on the Canadian Cancer Registry (CCR) data to identify and delete duplicate records. This process could only be done on a regional basis for the National Cancer Incidence Reporting System (NCIRS) data; therefore, it is possible that duplicate records may exist in two different regions. However, no evidence suggests that such cases would overrepresent either higher or lower survival cases and hence skew the survival distribution. It is also unlikely that the additional cases resulted in tighter confidence intervals of survival estimates, because the percentage of duplicates found within regions was quite small and would likely be considerably smaller across regions. It is possible that a person identified as having cancer in one region could previously have been diagnosed with a primary cancer in another region, but was not identified as such and was therefore included in the analysis. But CCR data indicate that subjects diagnosed with an invasive cancer in more than one province are rare, even among those with more than one invasive cancer.

Differences in completeness and availability of linkage variables precluded an identical record linkage of cases to deaths for both the NCIRS and CCR data. However, every effort was made to conduct the processes in a similar manner. For example, linkage thresholds were set so that the probabilities of false positive linkages of cases to deaths and missed linkages to deaths were similar for both time periods.

While the NCIRS contains information on cancer incidence from as far back as 1969, data quality issues before 1985 precluded an earlier national, or near-national, survival analysis comparable to that conducted using CCR data. Therefore, the 1985-1987 period was chosen as the baseline.

New Brunswick was excluded from comparisons of survival ratios. Missing values for key record linkage variables among cases diagnosed in that province between 1985 and 1987 did not permit an accurate linkage to the national mortality database, thus preventing a worthwhile survival analysis. Québec data were not analyzed because of problems with record linkage and because the province's method of ascertaining the date of diagnosis differs considerably from that of other provincial cancer registries.

Results for the territories are not shown because of an insufficient number of cases for analysis; cases are, however, included in the national estimates. Expected survival ratios for Prince Edward Island, the Yukon and Northwest Territories in both periods were derived from the Canadian life tables, as stable estimates for single ages could not be produced because of small populations. This substitution should not introduce bias in national estimates, as these three areas combined accounted for 0.9% and 0.8% of all eligible cases in the 1992-1994 and 1985-1987 periods, respectively.

A previously established convention to retrospectively identify death certificate only (DCO) cases in the NCIRS, based on the original method of diagnosis, the source of registration, and the reporting province, was followed. This was necessary because the NCIRS did not include DCO as an option for method of diagnosis. While the convention is considered fairly rigorous, some misclassification of DCO and non-DCO cases is possible. DCO cases were excluded from relative survival analyses because the date of diagnosis, and hence survival time, was unknown. The "true" survival of cases registered by DCO is generally less favourable than that of those in the registry population.[14] The need to exclude DCO cases may have led to increases in relative survival ratios, particularly in provinces with relatively more DCO cases. The magnitude of such increases, however, is generally minor.[14]

In the context of cancer, relative survival is defined as the ratio of the observed survival for a group of cancer patients to the survival that would have been expected for members of the general population assumed to be practically free of that cancer, who have the same main characteristics associated with survival (for example, sex, age, area of residence) as the cancer patients.[15] Ideally, lung cancer patients would also be matched by smoking status to members of the general population, because most lung cancer patients are smokers or ex-smokers and smoking is known to reduce life expectancy. However, life tables by smoking status were not available. While lung cancer relative survival ratios would likely have been higher if life tables by smoking status were available, a previous study found that adjusting the expected survival for the excess mortality related to smoking increased estimates of relative survival by 1% or less.[15]

Stage of disease at diagnosis is not available in the CCR; therefore, the effectiveness and use of early cancer detection from stage-specific survival estimates cannot be investigated. Until staging information is available at a national level, inferences can only be made about the possible effects of diagnosis and treatment together.

The statistical comparisons of age-standardized five-year relative survival ratios, both provincially and nationally across two time periods, were not adjusted for multiple comparisons.

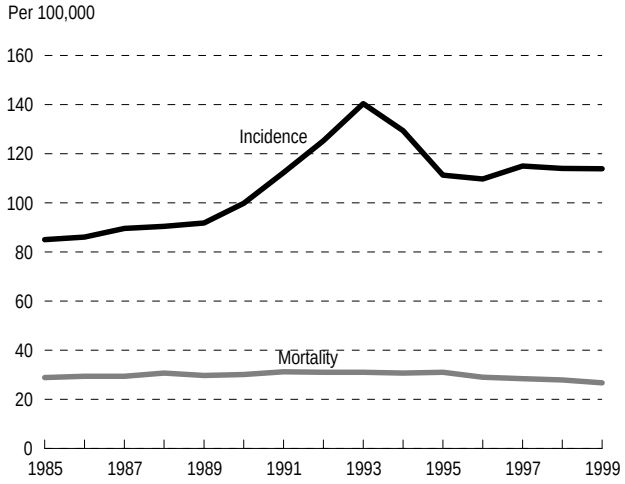
Relative survival for prostate cancer continued to be lower among older and younger men. In both periods, relative survival was lower among 15-to-54-year-olds than among men in the next two older age groups. Other studies have indicated that younger men with this cancer have poorer survival,[16,17] perhaps because of the type of tumours that present in younger men.[17] The smallest absolute increase in relative survival, 11%, was seen in the 85-99 age group.

Provincial increases in relative survival, all of which were statistically significant, ranged from absolute increases of 8% in Alberta to 21% in both Manitoba and Prince Edward Island. Compared with the rest of Canada, use of the prostate-specific antigen (PSA) test was less common in Alberta,[18] which may account for this province's relatively small increase in relative survival. Before the advent of PSA, the use of transurethral resection of the prostate (TURP) to treat symptoms of benign prostatic hypertrophy led to an increase in the diagnosis of prostate cancer in Canada and the United States.[19,20] Provincial variations in prostate cancer survival for men diagnosed in the 1985-1987 period may be due to differential use of the TURP procedure during that time. Similarly, differing rates of PSA screening may be the reason for provincial variations in relative survival ratios for prostate cancers diagnosed in the 1992-1994 period.

Use of the PSA test for the diagnosis of prostate cancer became more widespread in Canada around 1990. At the same time, prostate cancer incidence rates began to rise dramatically (Chart 1). It is thought that this increase in new cases could be attributable to the wider use of PSA testing, which increased the likelihood of diagnosis among the large pool of asymptomatic men with latent prostate cancers.[21-23] Increases in prostate cancer relative survival between 1985-1987 and 1992-1994 may also be attributed to PSA screening. Because such screening results in detection of prostate cancer earlier in the disease progression, time from diagnosis to death is extended, leading to increases in relative survival ratios over time.[24-25]

Mortality rates for prostate cancer have decreased somewhat since 1995 (Chart 1). While some of this decline may be explained by earlier diagnosis of patients with aggressive prostate cancer,[26] it is likely that the primary reason behind the decline was improved treatment of later stage disease.[27] Because mortality began to decrease only after 1995, the observed increase in relative survival is probably not due to improvements in treatment, but to lead-time bias created by the diagnosis of large numbers of clinically indolent prostate cancers between 1992 and 1994.

Chart 1
Age-standardized† prostate cancer incidence and mortality rates, Canada, 1985 to 1999



Data sources: National Cancer Incidence Reporting System (1985 to 1991); Canadian Cancer Registry (1992 to 1999); Canadian Vital Statistics Database
† Age-standardized to 1991 Canadian population

Relative survival for breast cancer higher

The age-standardized five-year relative survival ratio for women diagnosed with breast cancer in the 1992-1994 period was 83%, an absolute percentage increase of 7% from the corresponding ratio for 1985-1987 (Table 2). Increases ranged from 5% among women diagnosed between the ages of 40 and 49 to 9% among those diagnosed between the ages of 50 and 59. The primary target of breast screening programs has been women aged 50 to 69. The observed increase in relative survival in this age range is greater than in any other age group, suggesting a screening effect. However, as survival increased for all age groups, improvements in treatment may have also been partly responsible.

Table 2
Five-year relative survival ratios for breast cancer cases diagnosed in 1985-1987 and in 1992-1994, by province† (age-standardized‡) and by age group

	Breast cancer diagnosed in:								
	1985-1987				1992-1994				
	Relative survival ratio	95% confidence interval	Number of cases	Number of deaths§	Relative survival ratio	95% confidence interval	Number of cases	Number of deaths§	Comparison of relative survival ratios
	%				%				p-value
Canada†‡	76	75, 77	23,888	7,664	83*	83, 84	31,802	8,029	0.000
Newfoundland	71	65, 76	439	158	79*	75, 83	645	182	0.013
Prince Edward Island	72	63, 80	140	48	76	68, 83	188	55	0.491
Nova Scotia	70	67, 73	1,105	427	80*	77, 82	1,428	413	0.000
Ontario	75	74, 76	12,781	4,243	83*	82, 84	16,888	4,295	0.000
Manitoba	76	74, 79	1,453	465	81*	79, 84	1,780	504	0.007
Saskatchewan	80	77, 83	1,200	375	84*	82, 87	1,602	400	0.019
Alberta	78	76, 80	2,601	774	83*	82, 85	3,482	836	0.000
British Columbia	80	78, 82	4,152	1,170	86*	84, 87	5,739	1,333	0.000
Age group									
15-99	76	75, 77	23,888	7,664	83	83, 84	31,802	8,029	
15-39	69	67, 71	1,905	599	75*	73, 77	2,058	515	0.000
40-49	78	77, 80	3,872	871	83*	82, 84	5,729	1,005	0.000
50-59	75	74, 76	4,921	1,344	84*	83, 85	6,296	1,155	0.000
60-69	77	76, 79	5,982	1,664	85*	84, 86	7,547	1,578	0.000
70-79	77	75, 79	4,720	1,706	85*	84, 86	6,713	1,913	0.000
80-99	74	70, 77	2,488	1,480	80*	77, 82	3,459	1,863	0.006

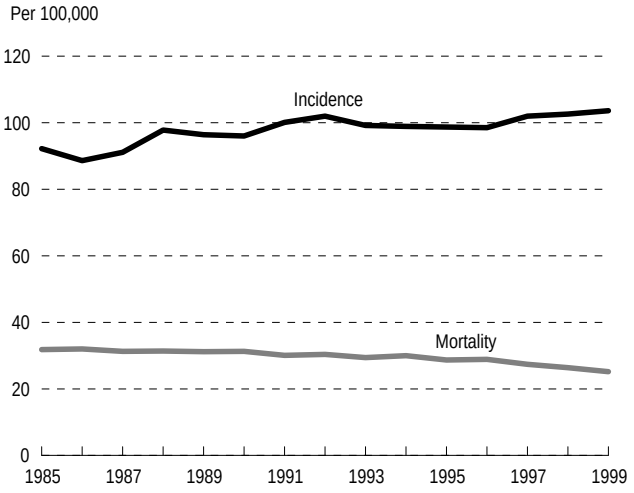
Data sources: National Cancer Incidence Reporting System (1985 to 1987); Canadian Cancer Registry (1992 to 1994); Canadian Vital Statistics Database
† Excluding Québec and New Brunswick. Results for the Yukon and Northwest Territories are not shown because of an insufficient number of cases, but cases from these areas are included in the analysis for Canada.
‡ Age-standardized to 1992 Canadian case distribution for breast cancer (Reference 6)
§ Within first five years of follow-up
** Significantly different from 1985-1987 ratio ($p \leq 0.05$)*

In both periods, five-year relative survival from breast cancer was lowest among women aged 15 to 39, an indication of the more aggressive nature of breast cancer tumours in pre-menopausal women.[28,29]

Increases in relative survival for breast cancer occurred in all provinces between 1985-1987 and 1992-1994, although the increase in Prince Edward Island was not statistically significant. This may have been due to the very small numbers of women diagnosed with breast cancer in that province during that period. Increases in age-standardized provincial survival ratios ranged from 4% in Saskatchewan and Prince Edward Island to 10% in Nova Scotia. Relative survival tended to increase on an east-west gradient in both periods.

Breast cancer incidence rates in Canada rose between 1985 and 1999 (Chart 2). This is likely due

Chart 2
Age-standardized† breast cancer incidence and mortality rates, Canada, 1985 to 1999



Data sources: National Cancer Incidence Reporting System (1985 to 1991); Canadian Cancer Registry (1992 to 1999); Canadian Vital Statistics Database
† Age-standardized to 1991 Canadian population

to a combination of changing reproductive patterns and greater use of mammography screening.[1] At the same time, mortality rates fell, mirroring the increases in relative survival. Earlier diagnosis made possible by mammography screening, as well as advances in treatment, are likely behind these trends.

Increases in survival for colorectal cancer

Statistically significant increases in age-standardized five-year relative survival ratios for colorectal cancer were observed for both sexes. For cases diagnosed in 1985-1987, relative survival was 54% for men and

Table 3
Five-year relative survival ratios for colorectal cancer cases diagnosed in 1985-1987 and in 1992-1994, by province† (age-standardized‡), and by sex and age group

	Colorectal cancer diagnosed in:								
	1985-1987				1992-1994				
	Relative survival ratio	95% confidence interval	Number of cases	Number of deaths§	Relative survival ratio	95% confidence interval	Number of cases	Number of deaths§	Comparison of relative survival ratios
	%				%				p-value
Canada,†‡ men	54	53, 55	13,454	7,737	57*	56, 58	15,526	8,413	0.000
Newfoundland	49	42, 55	356	207	63*	56, 69	462	221	0.004
Prince Edward Island	45	34, 57	118	73	54	42, 65	109	57	0.311
Nova Scotia	54	49, 59	745	430	56	50, 60	720	405	0.747
Ontario	52	51, 54	7,246	4,218	56*	54, 57	8,500	4,635	0.002
Manitoba	51	47, 56	863	521	59*	54, 63	909	484	0.024
Saskatchewan	55	50, 59	738	418	55	51, 60	782	438	0.826
Alberta	53	49, 56	1,217	694	53	50, 56	1,457	830	0.939
British Columbia	58	55, 61	2,167	1,172	58	56, 61	2,563	1,333	0.973
Canada,†‡ women	56	55, 57	12,453	6,703	59*	58, 60	13,335	6,799	0.000
Newfoundland	55	48, 62	341	176	56	50, 62	384	198	0.190
Prince Edward Island	60	48, 70	86	42	60	49, 69	134	65	0.965
Nova Scotia	55	50, 59	686	376	57	52, 61	725	389	0.629
Ontario	55	54, 57	6,932	3,774	59*	58, 60	7,346	3,754	0.000
Manitoba	54	50, 58	814	448	62*	57, 65	793	391	0.007
Saskatchewan	53	49, 58	617	342	60*	55, 64	633	323	0.045
Alberta	56	52, 59	1,099	572	59	55, 62	1,200	614	0.273
British Columbia	58	55, 60	1,876	973	58	56, 61	2,101	1,057	0.698
Age group, men									
15-99	53	52, 54	13,454	7,737	57	56, 58	5,526	8,413	
15-49	54	50, 57	963	456	59*	56, 61	1,205	509	0.020
50-59	54	51, 56	2,218	1,099	59*	57, 61	2,335	1,025	0.001
60-69	54	52, 56	4,247	2,254	58*	56, 60	4,806	2,336	0.001
70-79	55	53, 57	4,164	2,526	57	55, 59	4,853	2,787	0.073
80-99	52	48, 56	1,862	1,402	51	47, 55	2,327	1,756	0.786
Age group, women									
15-99	55	54, 56	12,453	6,703	59	58, 60	13,335	6,799	
15-49	60	56, 63	924	379	63	60, 66	1,083	406	0.115
50-59	58	55, 60	1,633	717	63*	60, 65	1,631	638	0.008
60-69	57	55, 59	3,328	1,574	60*	58, 62	3,154	1,377	0.007
70-79	56	54, 58	3,846	2,071	59*	58, 61	4,223	2,125	0.015
80-99	50	47, 53	2,722	1,962	52	49, 54	3,244	2,253	0.370

Data sources: National Cancer Incidence Reporting System (1985 to 1987); Canadian Cancer Registry (1992 to 1994); Canadian Vital Statistics Database
† Excluding Québec and New Brunswick. Results for the Yukon and Northwest Territories are not shown because of an insufficient number of cases, but cases from these areas are included in the analysis for Canada.
‡ Age-standardized to 1992 Canadian case distribution for colorectal cancer (Reference 6)
§ Within first five years of follow-up
** Significantly different from 1985-1987 ratio ($p \leq 0.05$)*

56% for women (Table 3). By 1992-1994, these ratios had increased to 57% and 59%, respectively. Regardless of time period or sex, relative survival ratios for colorectal cancer tended to be similar for the four age groups between 15 to 49 and 70 to 79, and lowest for those aged 80 to 99 at diagnosis.

Relative survival ratios either increased or remained constant in all provinces across the two periods. Among men, increases were statistically significant in Newfoundland, Ontario and Manitoba. The largest absolute percentage increases were in Newfoundland (14%), Prince Edward Island (9%) and Manitoba (8%), while ratios remained constant in British Columbia, Alberta and Saskatchewan. For women, statistically significant increases occurred in Ontario, Manitoba and Saskatchewan. The largest absolute percentage increases were in Manitoba (8%) and Saskatchewan (7%), while ratios remained constant in British Columbia and Prince Edward Island.

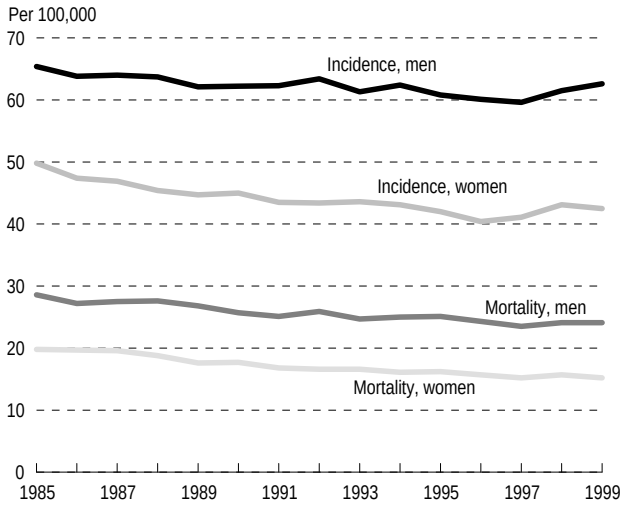
From 1985 to 1997, there was a fairly consistent decline in colorectal cancer incidence and mortality (Chart 3). This likely resulted from changes in exposure to some of the risk factors; for example, use of anti-inflammatory drugs and decreased consumption of dietary fat.[30-32] It is difficult to ascertain whether increases in relative survival reflect changes in diagnosis or treatment.

Lung cancer—little change

There was little absolute change at the national level in five-year relative survival ratios for lung cancer cases diagnosed in 1985-1987 and in 1992-1994. Though small, the slight rise from 13% to 14% for men was statistically significant (Table 4). The lack of statistical significance for the seemingly similar increase among women can be attributed to two factors: the actual increase was smaller (women, 0.6%; men, 1.0%), and because there were approximately half as many cases among women as among men, there was less statistical power to detect a difference. For both sexes, absolute percentage increases in age-specific relative survival ratios between the two periods generally ranged from 1% to 2%. The exceptions were men aged 15 to 49 (+3%) and women aged 70 to 79 (-1%).

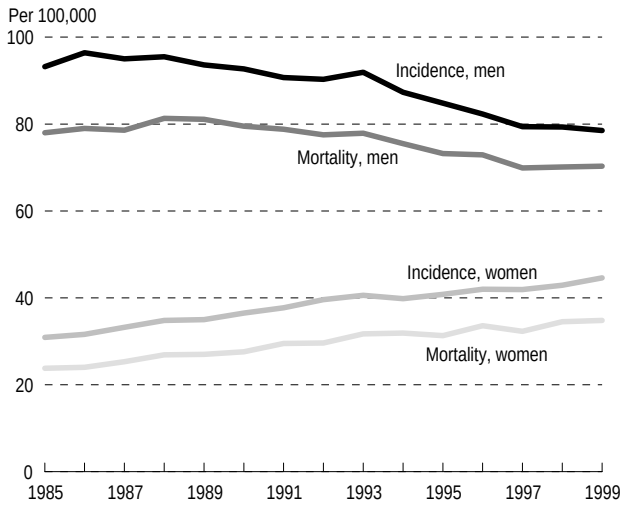
In general, there was little change in provincial five-year relative survival ratios between the two periods. Slight increases among both men and women in Ontario, however, were statistically

Chart 3
Age-standardized† colorectal cancer incidence and mortality rates, by sex, Canada, 1985 to 1999



Data sources: National Cancer Incidence Reporting System (1985 to 1991); Canadian Cancer Registry (1992 to 1999); Canadian Vital Statistics Database
† Age-standardized to 1991 Canadian population

Chart 4
Age-standardized† lung cancer incidence and mortality rates, Canada, by sex, 1985 to 1999



Data sources: National Cancer Incidence Reporting System (1985 to 1991); Canadian Cancer Registry (1992 to 1999); Canadian Vital Statistics Database
† Age-standardized to 1991 Canadian population

Table 4
Five-year relative survival ratios for lung cancer cases diagnosed in 1985-1987 and in 1992-1994, by province[†] (age-standardized[‡]) and by sex and age group

	Lung cancer diagnosed in:								
	1985-1987				1992-1994				
	Relative survival ratio	95% confidence interval	Number of cases	Number of deaths[§]	Relative survival ratio	95% confidence interval	Number of cases	Number of deaths[§]	Comparison of relative survival ratios
	%				%				p-value
Canada,[†‡] men	13	12, 13	17,851	15,932	14*	13, 14	19,759	17,521	0.018
Newfoundland	12	9, 15	465	416	15	11, 18	417	359	0.219
Prince Edward Island	18	11, 26	140	118	8*	5, 11	153	143	0.010
Nova Scotia	14	11, 16	967	854	12	10, 14	1,095	982	0.374
Ontario	12	12, 13	10,042	8,974	14*	14, 15	11,094	9,758	0.000
Manitoba	14	12, 16	1,173	1,036	15	13, 18	1,141	1,001	0.461
Saskatchewan	9	7, 12	889	820	10	8, 12	932	855	0.833
Alberta	11	10, 13	1,513	1,364	11	10, 13	1,906	1,726	0.813
British Columbia	13	12, 15	2,639	2,331	13	12, 14	2,963	2,643	0.503
Canada,[†‡] women	16	15, 17	8,108	6,891	17	16, 17	11,609	9,840	0.241
Newfoundland	15	8, 23	90	76	15	10, 21	132	108	0.974
Prince Edward Island	6	2, 12	35	34	14	8, 21	85	73	0.068
Nova Scotia	12	9, 16	380	335	16	13, 19	560	478	0.198
Ontario	15	14, 17	4,557	3,898	17*	16, 18	6,292	5,306	0.035
Manitoba	20	16, 23	564	460	19	16, 22	672	558	0.642
Saskatchewan	18	14, 22	382	315	16	12, 19	502	429	0.436
Alberta	13	11, 16	707	597	15	13, 18	1,173	997	0.205
British Columbia	16	14, 18	1,373	1,157	15	13, 16	2,153	1,856	0.297
Age group, men									
15-99	13	12, 14	17,851	15,932	14	13, 14	19,759	17,521	
15-49	16	13, 18	941	796	19*	17, 22	1,118	904	0.029
50-59	15	14, 16	3,405	2,922	16	15, 17	2,894	2,452	0.307
60-69	14	13, 15	6,457	5,666	14	13, 15	6,983	6,106	0.889
70-79	11	10, 12	5,359	4,917	13*	12, 14	6,513	5,892	0.048
80-99	7	5, 9	1,689	1,631	7	6, 9	2,251	2,167	0.824
Age group, women									
15-99	17	16, 17	8,108	6,891	17	16, 18	11,609	9,840	
15-49	22	20, 25	799	621	24*	22, 27	1,044	792	0.028
50-59	19	17, 21	1,752	1,428	21*	19, 22	2,005	1,599	0.008
60-69	17	15, 18	2,750	2,319	18*	17, 19	3,738	3,101	0.007
70-79	13	12, 15	2,110	1,872	12	11, 14	3,493	3,118	0.792
80-99	11	8, 14	697	651	12	10, 14	1,329	1,230	0.175

Data sources: National Cancer Incidence Reporting System (1985 to 1987); Canadian Cancer Registry (1992 to 1994); Canadian Vital Statistics Database
† Excluding Québec and New Brunswick. Results for the Yukon and Northwest Territories are not shown because of an insufficient number of cases, but cases from these areas are included in the analysis for Canada.
‡ Age-standardized to 1992 Canadian case distribution for lung cancer (Reference 6)
§ Within first five years of follow-up
** Significantly different from 1985-1987 ratio ($p \leq 0.05$)*

significant. As well, Prince Edward Island had a large increase among women (from 6% to 14%) and a significant decrease for men (from 18% to 8%). The contradictory results in Prince Edward Island may be related to the relatively small number of cases in the province, even over three-year periods, which creates instability in the point estimates.

Since 1985, lung cancer incidence and mortality rates have fallen among men, but have risen among women (Chart 4). These findings are directly attributable to trends in smoking rates, which have been declining among men for several decades, but have only recently begun to drop among women.[1] Changes in exposure to the primary risk factor do

not seem to have affected relative survival ratios for lung cancer between 1985-1987 and 1992-1994.

Concluding remarks

Five-year relative survival ratios for prostate and breast cancer—both among the most commonly diagnosed cancers in Canada—rose substantially between 1985-1987 and 1992-1994. For prostate cancer, five-year relative survival rose from 73% to 89%. The five-year relative survival for breast cancer increased from 76% to 83%. The large numbers of clinically indolent prostate cancers known to exist in the population that were detected through PSA screening have, in particular, contributed to the large survival increase for prostate cancer. Breast cancer survival has likely increased because of a combination of improved treatment and mammography screening.

Relative survival for lung cancer changed little over the period, despite clear advances in the primary prevention of this disease. There were statistically significant increases in five-year relative survival ratios for both men and women with colorectal cancer, but it is difficult to attribute this to any specific factors.

Over the last several decades, there have been major changes in the early detection, diagnosis and treatment of cancer.[1] Studying cancer survival rates over time can provide information on the extent to which these changes have improved the survival experience of cancer patients and may reflect the extent to which these services have become available to the population.[2] ●

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Appendix

Table A
Records remaining after exclusions,† prostate, breast, colorectal and lung cancer cases diagnosed in 1985-1987, by province

Restricted to ...	Canada‡	Nfld	PEI	NS	Ont	Man	Sask	Alta	BC
Prostate									
First tumour only	18,074	308	115	843	8,468	1,258	1,221	1,970	3,885
Year of birth and/or death available	18,064	308	115	843	8,458	1,258	1,221	1,970	3,885
Age at diagnosis ≥ 15 and ≤ 99	18,046	308	115	843	8,451	1,258	1,220	1,968	3,877
Cancer not diagnosed by autopsy or by DCO§	17,589	297	113	805	8,368	1,227	1,177	1,912	3,687
Breast									
First tumour only	24,189	446	144	1,144	12,886	1,471	1,215	2,635	4,231
Year of birth and/or death available	24,177	446	144	1,144	12,875	1,471	1,215	2,634	4,231
Age at diagnosis ≥ 15 and ≤ 99	24,155	446	144	1,142	12,866	1,470	1,214	2,628	4,228
Cancer not diagnosed by autopsy or by DCO§	23,890	439	140	1,105	12,781	1,453	1,202	2,601	4,152
Colorectal									
First tumour only	26,729	710	212	1,534	14,422	1,713	1,417	2,390	4,321
Year of birth and/or death available	26,703	710	212	1,533	14,397	1,713	1,417	2,390	4,321
Age at diagnosis ≥ 15 and ≤ 99	26,678	710	211	1,531	14,386	1,710	1,416	2,388	4,316
Cancer not diagnosed by autopsy or by DCO§	25,907	697	204	1,431	14,178	1,677	1,355	2,316	4,043
Lung									
First tumour only	27,877	576	196	1,554	15,122	1,798	1,412	2,469	4,694
Year of birth and/or death available	27,863	576	196	1,554	15,109	1,798	1,412	2,469	4,693
Age at diagnosis ≥ 15 and ≤ 99	27,856	576	196	1,554	15,107	1,798	1,411	2,468	4,690
Cancer not diagnosed by autopsy or by DCO§	25,963	555	175	1,347	14,599	1,738	1,271	2,221	4,012

Data source: National Cancer Incidence Reporting System
Note: Yukon and Northwest Territories not displayed because of small numbers
† Four lung cancer (2 NWT, 1 Alta, 1 Man), two breast cancer (2 Sask), and one prostate cancer case (Nfld) were also excluded owing to negative survival values.
‡ Excluding Québec and New Brunswick
§ Death certificate only

Table B
Records remaining after exclusions,† prostate, breast, colorectal and lung cancer cases diagnosed in 1992-1994, by province

Restricted to ...	Canada‡	Nfld	PEI	NS	Ont	Man	Sask	Alta	BC
Prostate									
First tumour only	35,324	524	307	1,637	17,028	2,593	2,102	3,605	7,498
Year of birth and/or death available	35,295	517	307	1,637	17,006	2,593	2,102	3,605	7,498
Age at diagnosis ≥ 15 and ≤ 99	35,279	517	307	1,636	16,997	2,593	2,101	3,602	7,496
Cancer not diagnosed by autopsy or by DCO§	34,933	517	304	1,580	16,898	2,569	2,065	3,592	7,379
Breast									
First tumour only	32,077	647	189	1,467	17,039	1,794	1,611	3,483	5,797
Year of birth and/or death available	32,065	645	189	1,465	17,031	1,794	1,611	3,483	5,797
Age at diagnosis ≥ 15 and ≤ 99	32,053	645	189	1,464	17,024	1,793	1,611	3,482	5,795
Cancer not diagnosed by autopsy or by DCO§	31,802	645	188	1,428	16,888	1,780	1,602	3,482	5,739
Colorectal									
First tumour only	29,432	860	248	1,525	16,057	1,741	1,453	2,672	4,833
Year of birth and/or death available	29,414	852	248	1,523	16,049	1,741	1,453	2,672	4,833
Age at diagnosis ≥ 15 and ≤ 99	29,392	850	247	1,516	16,041	1,741	1,452	2,671	4,831
Cancer not diagnosed by autopsy or by DCO§	28,861	846	243	1,445	15,846	1,702	1,415	2,657	4,664
Lung									
First tumour only	32,909	567	249	1,881	17,902	1,894	1,556	3,113	5,648
Year of birth and/or death available	32,892	557	249	1,880	17,897	1,894	1,555	3,113	5,648
Age at diagnosis ≥ 15 and ≤ 99	32,876	556	249	1,879	17,889	1,894	1,555	3,111	5,644
Cancer not diagnosed by autopsy or by DCO§	31,368	549	238	1,655	17,386	1,813	1,434	3,079	5,116

Data source: Canadian Cancer Registry
Note: Yukon and Northwest Territories not displayed because of small numbers
† There were no exclusions resulting from date of diagnosis after date of death.
‡ Excluding Québec and New Brunswick
§ Death certificate only

Table C
Percentage of death certificate only (DCO) cases,† prostate, breast, colorectal and lung cancer diagnosed in 1985-1987, by province

Restricted to ...	Canada‡	Nfld	PEI	NS	Ont	Man	Sask	Alta	BC
Prostate cancer									
Eligible cases + DCOs	17,885	300	115	841	8,412	1,243	1,191	1,956	3,821
DCOs	296	3	2	36	44	16	14	44	134
% of otherwise eligible cases	1.7	1.0	1.7	4.3	0.5	1.3	1.2	2.2	3.5
Breast cancer									
Eligible cases + DCOs	24,136	444	144	1,142	12,862	1,467	1,210	2,627	4,223
DCOs	246	5	4	37	81	14	8	26	71
% of otherwise eligible cases	1.0	1.1	2.8	3.2	0.6	1.0	0.7	1.0	1.7
Colorectal cancer									
Eligible cases + DCOs	26,518	705	209	1,525	14,354	1,699	1,387	2,375	4,254
DCOs	611	8	5	94	176	22	32	59	211
% of otherwise eligible cases	2.3	1.1	2.4	6.2	1.2	1.3	2.3	2.5	5.0
Lung cancer									
Eligible cases + DCOs	27,388	558	193	1,540	14,999	1,764	1,341	2,426	4,514
DCOs	1,425	3	18	193	400	26	70	205	502
% of otherwise eligible cases	5.2	0.5	9.3	12.5	2.7	1.5	5.2	8.5	11.1

Data source: National Cancer Incidence Reporting System
Note: Yukon and Northwest Territories not displayed because of small numbers
*† Calculated as DCO cases * 100 / (eligible cases + DCOs)*
‡ Excluding Québec and New Brunswick

Table D
Percentage of death certificate only (DCO) cases,† prostate, breast, colorectal and lung cancer diagnosed in 1992-1994, by province

Restricted to ...	Canada‡	Nfld§	PEI	NS	Ont	Man	Sask	Alta	BC
Prostate cancer									
Eligible cases + DCOs	35,208	517	305	1,632	16,988	2,591	2,079	3,594	7,472
DCOs	275	...	1	52	90	22	14	2	93
% of otherwise eligible cases	0.8	...	0.3	3.2	0.5	0.8	0.7	0.1	1.2
Breast cancer									
Eligible cases + DCOs	32,045	645	189	1,463	17,026	1,793	1,606	3,482	5,791
DCOs	243	...	1	35	138	13	4	0	52
% of otherwise eligible cases	0.8	...	0.5	2.4	0.8	0.7	0.2	0.0	0.9
Colorectal cancer									
Eligible cases + DCOs	29,302	846	245	1,505	16,025	1,738	1,439	2,660	4,801
DCOs	441	...	2	60	179	36	24	3	137
% of otherwise eligible cases	1.5	...	0.8	4.0	1.1	2.1	1.7	0.1	2.9
Lung cancer									
Eligible cases + DCOs	32,597	549	240	1,855	17,853	1,878	1,514	3,083	5,526
DCOs	1,229	...	2	200	467	65	80	4	410
% of otherwise eligible cases	3.8	...	0.8	10.8	2.6	3.5	5.3	0.1	7.4

Data source: Canadian Cancer Registry
Note: Yukon and Northwest Territories not displayed because of small numbers
*†Calculated as DCO cases * 100 / (eligible cases + DCOs)*
‡ Excluding Québec and New Brunswick
§ Could not have DCO cases, because province did not use information from vital statistics registry to update data.
··· Not applicable

Table E
Non-standardized five-year relative survival ratios for prostate, breast, colorectal and lung cancer cases diagnosed in 1985-1987 and in 1992-1994, ages 15 to 99, by sex and province

	Cancer diagnosed in:							
	1985-1987				1992-1994			
	Relative survival ratios	95% confidence interval	Number of cases	Number of deaths	Relative survival ratios	95% confidence interval	Number of cases	Number of deaths
	%				%			
				Prostate				
Newfoundland	62	54, 70	296	166	86	80, 91	517	196
Prince Edward Island	63	48, 74	113	66	89	80, 94	304	105
Nova Scotia	71	66, 75	805	407	90	87, 93	1,580	543
Ontario	72	71, 74	8,368	4,135	90	89, 91	16,898	5,413
Manitoba	72	68, 75	1,227	620	93	91, 95	2,569	788
Saskatchewan	69	65, 72	1,177	604	88	85, 90	2,065	689
Alberta	76	73, 79	1,912	864	86	84, 88	3,592	1,255
British Columbia	80	78, 82	3,687	1,507	94	93, 95	7,379	1,998
				Breast				
Newfoundland	72	67, 76	439	158	79	75, 82	645	182
Prince Edward Island	77	67, 84	140	48	79	71, 85	188	55
Nova Scotia	70	66, 73	1,105	427	81	78, 83	1,428	413
Ontario	75	74, 76	12,781	4,243	83	82, 83	16,888	4,295
Manitoba	76	74, 79	1,453	465	82	79, 84	1,780	504
Saskatchewan	77	75, 80	1,200	375	85	82, 87	1,602	400
Alberta	77	75, 78	2,601	774	83	81, 84	3,482	836
British Columbia	80	78, 81	4,152	1,170	85	84, 86	5,739	1,333
				Colorectal, men				
Newfoundland	51	45, 57	356	207	64	59, 69	462	221
Prince Edward Island	48	37, 59	118	73	58	46, 69	109	57
Nova Scotia	54	49, 58	745	430	56	52, 60	720	405
Ontario	52	51, 54	7,246	4,218	56	55, 58	8,500	4,635
Manitoba	50	46, 54	863	521	59	55, 63	909	484
Saskatchewan	55	51, 59	738	418	56	52, 60	782	438
Alberta	53	50, 56	1,217	694	54	50, 57	1,457	830
British Columbia	57	55, 60	2,167	1,172	59	57, 61	2,563	1,333
				Colorectal, women				
Newfoundland	56	50, 62	341	176	57	51, 63	384	198
Prince Edward Island	64	49, 76	86	42	62	51, 70	134	65
Nova Scotia	54	50, 59	686	376	57	53, 62	725	389
Ontario	55	54, 56	6,932	3,774	58	57, 59	7,346	3,754
Manitoba	53	49, 57	814	448	61	57, 65	793	391
Saskatchewan	53	48, 58	617	342	59	54, 63	633	323
Alberta	56	53, 59	1,099	572	59	55, 62	1,200	614
British Columbia	57	54, 60	1,876	973	59	57, 62	2,101	1,057
				Lung, men				
Newfoundland	13	9, 16	465	416	17	13, 21	417	359
Prince Edward Island	18	12, 25	140	118	8	4, 13	153	143
Nova Scotia	14	12, 17	967	854	13	11, 15	1,095	982
Ontario	13	12, 14	10,042	8,974	14	14, 15	11,094	9,758
Manitoba	14	12, 17	1,173	1,036	15	13, 18	1,141	1,001
Saskatchewan	9	7, 12	889	820	10	8, 12	932	855
Alberta	12	10, 14	1,513	1,364	11	10, 13	1,906	1,726
British Columbia	14	13, 15	2,639	2,331	13	12, 14	2,963	2,643
				Lung, women				
Newfoundland	16	9, 25	90	76	19	13, 26	132	108
Prince Edward Island	3	0, 14	35	34	15	8, 24	85	73
Nova Scotia	13	10, 17	380	335	16	13, 20	560	478
Ontario	16	15, 17	4,557	3,898	17	16, 18	6,292	5,306
Manitoba	21	17, 25	564	460	19	16, 22	672	558
Saskatchewan	19	15, 23	382	315	16	13, 20	502	429
Alberta	17	14, 20	707	597	17	14, 19	1,173	997
British Columbia	17	15, 19	1,373	1,157	15	14, 17	2,153	1,856

Data sources: National Cancer Incidence Reporting System (1985 to 1987); Canadian Cancer Registry (1992 to 1994)