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Progress in net cancer survival in Canada over 20 years

by Larry F. Ellison

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Progress in net cancer survival in Canada over 20 years

by Larry F. Ellison

Abstract

Background: Monitoring the progress of cancer survival in a population over time is an important part of cancer surveillance.

Data and methods: Data are from the Canadian Cancer Registry with mortality follow-up through record linkage to the Canadian Vital Statistics Death Database and tax files. Net survival (NS) was derived using the Pohar Perme method. Predicted estimates of NS for the period from 2012 to 2014 were calculated using the period method. Age-standardized and age-specific changes in five-year NS between the periods from 1992 to 1994 and 2012 to 2014 were determined for 30 individual cancers.

Results: Predicted five-year NS for 2012 to 2014 ranged from 98% for thyroid cancer to 7% for mesothelioma. Between 1992 to 1994 and 2012 to 2014, improvements in five-year age standardized NS were greatest for chronic myeloid leukemia (23.9 percentage points), though a large majority of the increase occurred in the first decade. Increases exceeding 15.0 percentage points were also observed for non-Hodgkin lymphoma (19.5), cancer of the small intestine (17.4) and multiple myeloma (16.9). In contrast, little to no improvement was observed for cancers of the anus, larynx, soft tissue or uterus, or for mesothelioma. Increases in five-year NS were greatest for chronic myeloid leukemia in each age group with the exception of those aged 75 to 84 years (thyroid).

Interpretation: This study reveals important areas of progress in cancer outcomes in Canada since the early 1990s. It also sheds light on cancers for which there has seemingly been no improvement in five-year net survival over a 20-year period.

Keywords: neoplasms, net survival, population-based, registries, prognosis, survival analysis

Deriving cancer survival estimates on a population basis permits the monitoring of progress in outcomes over time. Net survival (NS) is the preferred method for comparing cancer survival in population-based cancer studies because it adjusts for the fact that different populations may have different levels of background risk of death.¹ This measure of cancer survival may be thought of as the survival probability that would be observed in the hypothetical situation where the cancer of interest is the only possible cause of death.

The recent creation of an analytic file (1992 to 2014), wherein incidence data from the Canadian Cancer Registry (CCR) was linked with death information, has provided an excellent opportunity to reexamine progress in cancer survival in Canada across many types of cancer. In comparison to its predecessor, the new file includes six more years of data and was created using additional sources of death information. Moreover, with the maturation of the CCR, it is now possible to report on changes in five-year survival over a 20-year period.

This report provides predicted estimates of NS for the 2012 to 2014 period. NS estimates for durations of 1, 5 and 10 years are derived for 30 of the most commonly diagnosed cancers in people aged 15 to 99. Five-year age-standardized and age-specific estimates for 2012 to 2014 are compared with corresponding figures for cases diagnosed 20 years previously. NS was estimated using the unbiased and consistent Pohar Perme estimator rather than indirectly through relative survival. Traditional methods of estimation using relative survival have recently been shown to result in biased estimates of net survival under certain circumstances.²

Methods

Data sources

The CCR is a dynamic, person-oriented, population-based database comprised of cases diagnosed among Canadian residents since 1992. Each provincial and territorial cancer registry provides demographic and cancer-specific information to Statistics Canada in a standard format for each case they submit.³ An analytic file was created by linking the November 2017 CCR tabulation file to mortality information complete through December 31, 2014. This information was obtained from the Canadian Vital Statistics Death database⁴ and T1 Personal Master Files (as reported on tax returns). The analytic file follows the multiple primary coding rules of the International Agency for Research on Cancer.⁵ Survival time is measured in days, while variables for age at diagnosis and diagnosis year are available to three decimal places. More information on the linkage process and on the resulting death-linked analytic file is available upon request.⁶

Expected survival probabilities, necessary for the calculation of NS, were mostly obtained from sex-specific annual provincial life tables.⁷ As complete life tables were not available for Prince Edward Island or the territories, expected survival for these jurisdictions were derived, up to age 99, from abridged life tables for Canada and the affected jurisdictions⁸ and from complete Canadian life tables⁷ using a method suggested by Dickman et al.⁹ For ages 100 to 109, where this was not possible for these jurisdictions, complete Canadian life table values were directly used.

Analytical techniques

Cases were defined based on the International Classification of Diseases for Oncology, Third Edition¹⁰ and classified using Surveillance, Epidemiology, and End Results (SEER) Program grouping definitions.¹¹ Analyses were based on all primary cancers.¹²⁻¹⁴ with the exception of second- and higher-order primary cancers of the same site.¹⁵ The relative number of such cases was extremely small but, as expected, increased with the aging of the CCR. Records were also excluded if age at diagnosis was younger than 15 or older than 99; diagnosis had been established through autopsy only or death certificate only; or the year of birth or death was unknown (both extremely rare). Incident cases from the province of Quebec were excluded because cancer incidence data from this province have not been submitted to the CCR since the 2010 data year.

Unstandardized (crude) survival analysis estimates were derived using an algorithm¹⁶ that has been augmented by Ron Dewar of the Nova Scotia Cancer Care Program (Dewar R 2018, email communication, 19th April) to include the Pohar Perme estimator of NS² using the hazard transformation approach. The following assumptions apply to the estimation of net survival. First, it is assumed that the non-cancer mortality rate in the group being examined is adequately estimated by the mortality rates in the general population life tables. Secondly, conditional independence between the probability of death due to the cancer of interest and the probability of death due to other causes is assumed.

To better satisfy the first assumption, expected survival data used in the calculation of NS for prostate and female breast cancer were adjusted for cancer-specific mortality rates in the general population.¹⁷⁻¹⁹ In each case, the proportion of deaths among Canadian residents due to the specific cancer, by sex, five-year age group and year of death, was used for the adjustment. Provincial-specific mortality estimates were used for those aged 55

to 59 and older age groups. Otherwise, national estimates were used. The second assumption, concerning the conditional independence of probabilities of death, noted above, may be considered tenuous when analyzing cases diagnosed among the most elderly. For this reason and several others, including the increased variability inherent in the estimates and the limited potential for useful interpretation, both the age-specific description of results and the related trend analyses excluded the 85 to 99 age group.

Age-standardized NS estimates were calculated using the direct method by weighting age-specific estimates for a given cancer to the age distribution of people aged 15 to 99 diagnosed with that cancer. The incident age-distributions were based on cases diagnosed from 2010 to 2014 included in the November 2017 CCR tabulation file (except Quebec). Standard errors for age-standardized NS estimates were estimated by taking the square root of the sum of the squared, weighted, age-specific NS standard errors. See Appendix Table A for a comparison of five-year NS estimates age-standardized using the Canadian cancer survival standard weights described above and, alternatively, weights developed from data collected for the EURO CARE-2 study.²⁰ Canadian survival standard weights for individual cancers are provided in Appendix Table B. Corresponding weights for specific groups of cancers (e.g., colorectal cancer, leukemias) are available upon request at STATCAN.infostats-infostats@STATCAN@canada.ca.

NS estimates for the 2012-to-2014 period were calculated using the period method;²¹ for 1992 to 1994 and 2002 to 2004, the cohort method was used. NS estimates were suppressed if the corresponding standard error was greater than 0.1; caution was indicated if the standard error was greater than 0.05 but less than or equal to 0.1. The percentage-point increase in five-year NS was used as the measure of improvement in survival. Differences in NS were calculated before rounding to one decimal place. The Z

test was used to determine P values for between-time-period differences; the standard errors of differences were estimated by the square root of the sum of the variances associated with the two point estimates. The P values were provided to aid the general interpretation of the differences—in particular to avoid the over-interpretation of potentially large but fairly imprecise differences—rather than as a means to formal hypothesis testing.

Wide variation in survival by cancer type

NS varied considerably across cancer types (Table 1). Long-term NS was highest for thyroid and testicular cancer and lowest for mesothelioma—a cancer of the thin layer of tissue that covers most of the internal organs—and pancreatic cancer. Five-year NS ranged from 98% for thyroid cancer to 7% for mesothelioma. A similar range (from 97% to 5%) was observed for 10-year survival for these cancers. However, when only the first year after diagnosis was considered the range was considerably smaller (from 99% for thyroid to 28% for pancreas).

In addition to the cancers mentioned previously, five-year NS was also particularly high for cancers of the testis (97%) and prostate (93%). On the other end of the spectrum, five-year survival was also especially low for cancers of the esophagus (15%), lung and bronchus (19%), liver (19%), and brain (21%), as well as for acute myeloid leukemia (21%). With the exception of stomach cancer (28%), five-year NS was 44% or greater for all other cancers studied. Cancer survival is generally higher among females than among males (Appendix, Table A). A more extensive evaluation of sex differences in cancer survival in Canada is available elsewhere.²²

The largest declines in NS for years two through five post-diagnosis were observed for mesothelioma (34 percentage points), multiple myeloma (32), and ovarian cancer (31). From 5 to 10 years, the largest decline (16 percentage

Table 1
Predicted net survival (NS) estimates, by selected cancer type and survival duration, ages 15 to 99 years at diagnosis, Canada excluding Quebec, 2012 to 2014[†]

Cancer	Survival duration								
	1 year			5 years			10 years		
	NS (%)	95% confidence interval		NS (%)	95% confidence interval		NS (%)	95% confidence interval	
from		to	from		to	from		to	
Tongue	83	82	85	63	61	65	55	52	58
Esophagus	42	41	44	15	14	16	12	10	13
Stomach	51	50	52	28	27	29	27	25	29
Small intestine	73	71	75	56	53	59	46	42	50
Colon	81	81	81	65	64	66	61	59	62
Rectum	86	85	86	66	65	67	62	60	63
Anus	87	85	89	64	61	67	56	52	61
Liver	45	44	47	19	18	20	13	12	15
Pancreas	28	27	29	8	7	9	7	6	8
Larynx	84	83	86	62	59	64	49	46	53
Lung and bronchus	44	44	45	19	18	19	13	13	13
Soft tissue (including heart)	80	78	81	61	59	63	57	54	60
Melanomas of the skin	96	95	96	88	87	88	87	85	88
Breast	97	97	97	88	88	89	82	81	83
Cervix uteri	88	87	89	72	70	74	67	65	69
Uterus (body, NOS)	93	93	94	83	83	84	80	79	82
Ovary	76	74	77	45	44	47	36	35	38
Prostate	97	97	98	93	92	93	90	89	90
Testis	98	97	99	97	96	97	96	94	98
Bladder (including in situ) [‡]	89	88	89	75	74	76	66	63	69
Kidney and renal pelvis	84	83	84	71	70	72	63	61	64
Brain	48	46	49	21	19	22	15	14	16
Thyroid	99	98	99	98	97	98	97	96	98
Hodgkin lymphoma	92	91	93	86	84	87	81	78	83
Non-Hodgkin lymphoma	80	80	81	68	67	69	59	56	61
Multiple myeloma	76	75	77	44	43	46	32	30	34
Chronic lymphocytic leukemia	94	93	94	83	81	84	67	65	70
Acute myeloid leukemia	42	40	44	21	19	22	18	17	20
Chronic myeloid leukemia	83	81	85	60	57	63	50	47	54
Mesothelioma	41	38	44	7	6	9	5	4	7

NOS=not otherwise specified

[†] data from Quebec have not been submitted to the Canadian Cancer Registry since the 2010 data year; NS estimates predicted using the period method[‡] the province of Ontario did not submit in situ bladder cancer cases to the Canadian Cancer Registry prior to the 2010 data year

Sources: Canadian Cancer Registry death linked file (1992-2014); life tables.

points) was seen for chronic lymphocytic leukemia (CLL) followed by laryngeal cancer (13) and multiple myeloma (12). The relatively poor outlook for CLL over the subsequent five years among those surviving the first five years has previously been noted.²³ For thyroid and testicular cancer, there was little difference between estimates of NS at 1 year and at 10 years.

Greatest progress for chronic myeloid leukemia

Among the cancers studied herein, the median change in age-standardized five-

year NS over the 20 years between the 1992-to-1994 and the 2012-to-2014 periods was 6.1 percentage points (Table 2). At 23.9 percentage points, progress was greatest among those diagnosed with chronic myeloid leukemia (CML). Substantial progress in CML survival in Canada has previously been observed and has been attributed to improvements in treatment.²⁴ A large majority of the improvement for CML over this time period, and seemingly, the entire increase for prostate cancer, occurred in the first decade. In contrast, more progress was observed in the

most recent decade for both Hodgkin lymphoma and cancer of the lung and bronchus.

Increases of over 15 percentage points were also observed for non-Hodgkin lymphoma (19.6), cancer of the small intestine (17.4) and multiple myeloma (16.8). Progress was similar across the two decades for these cancers. For cancers of the anus, larynx, soft tissue, uterus, and for mesothelioma, predicted five-year NS estimates for 2012 to 2014 were quite similar to corresponding estimates from 20 years earlier.

Decreasing survival with advancing age

NS generally decreases with advancing age. Among the cancers considered in this study, the median decline in five-year NS between the 15-to-44 and 75-to-84 age groups was 24 percentage points (Table 3). The largest declines were observed for both acute myeloid leukemia and brain cancer (59 percentage points), followed by CML (56) and ovarian cancer (54). In general, decreases from one age group to the next tended to be larger between age groups comprised of older individuals.

The pattern in which five-year NS declined from the youngest to the oldest age groups varied considerably between cancers. For the cancers with the largest declines, as well as others like Hodgkin lymphoma, multiple myeloma and cervical cancer, relatively large decreases were observed with almost all progressions from one age group to the next. Another group of cancers had little to modest changes up to the 65-to-74 age group followed by large declines thereafter. This pattern was particularly exemplified by anal and prostate cancer, and to a lesser extent by breast cancer. For cancers of the pancreas and liver, declines were largest between the first and second age groups. Subsequent declines for these cancers were more tempered, in part because NS was already very poor.

Table 2
Predicted changes in age-standardized net survival, by selected cancer type and time period, ages 15 to 99 years at diagnosis, Canada excluding Quebec, 1992-to-1994 to 2012-to-2014 period[†]

Cancer	Time period							
	1992-1994 to 2012-2014				2002-2004 to 2012-2014			
	change (% points)	95% confidence interval		p-value	change (% points)	95% confidence interval		p-value
Tongue	14.4	10.6	18.3	<0.0005	7.9	4.4	11.3	<0.0005
Esophagus	5.0	3.2	6.8	<0.0005	2.4	0.7	4.1	0.007
Stomach	8.7	7.0	10.3	<0.0005	5.2	3.5	6.9	<0.0005
Small intestine	17.4	12.5	22.3	<0.0005	8.7	4.5	12.9	<0.0005
Colon	9.3	8.2	10.4	<0.0005	3.9	2.9	4.9	<0.0005
Rectum	11.4	9.9	12.9	<0.0005	4.2	2.8	5.5	<0.0005
Anus	-0.5	-5.5	4.5	0.848	-0.6	-4.8	3.6	0.785
Liver	10.2	8.1	12.2	<0.0005	3.7	1.7	5.7	<0.0005
Pancreas	3.2	2.3	4.1	<0.0005	2.4	1.5	3.2	<0.0005
Larynx	0.0	-3.6	3.7	0.981	-0.3	-3.9	3.3	0.887
Lung and bronchus	5.4	4.9	6.0	<0.0005	4.5	3.9	5.0	<0.0005
Soft tissue (including heart)	-1.1	-5.3	3.1	0.601	-0.6	-4.1	2.9	0.728
Melanomas of the skin	4.7	2.9	6.5	<0.0005	1.3	-0.1	2.7	0.070
Breast	6.7	6.1	7.4	<0.0005	2.4	1.8	3.0	<0.0005
Cervix uteri	2.4	0.1	4.7	0.040	1.9	-0.4	4.1	0.103
Uterus (body, NOS)	-0.4	-1.8	1.0	0.570	0.2	-1.1	1.4	0.795
Ovary	7.6	5.6	9.6	<0.0005	4.4	2.6	6.3	<0.0005
Prostate	7.2	6.5	7.9	<0.0005	-0.4	-1.0	0.3	0.254
Testis	1.6	0.0	3.2	0.047	0.8	-0.6	2.2	0.258
Bladder (including in situ) [‡]	3.3	1.6	5.0	<0.0005	5.5	4.0	7.0	<0.0005
Kidney and renal pelvis	10.6	8.8	12.4	<0.0005	6.4	4.8	8.0	<0.0005
Brain	2.1	0.6	3.7	0.006	1.0	-0.4	2.4	0.147
Thyroid	4.6	3.3	5.9	<0.0005	1.2	0.4	2.1	0.005
Hodgkin lymphoma	4.8	2.1	7.4	<0.0005	4.4	2.1	6.8	<0.0005
Non-Hodgkin lymphoma	19.6	18.1	21.1	<0.0005	8.4	7.1	9.7	<0.0005
Multiple myeloma	16.8	14.3	19.2	<0.0005	9.6	7.4	11.8	<0.0005
Chronic lymphocytic leukemia	14.0	11.1	16.8	<0.0005	5.6	3.3	8.0	<0.0005
Acute myeloid leukemia	7.6	5.5	9.7	<0.0005	2.7	0.7	4.7	0.008
Chronic myeloid leukemia	23.9	19.3	28.5	<0.0005	3.9	-0.6	8.4	0.880
Mesothelioma	0.2	-3.9	4.2	0.932	2.8	0.3	5.4	0.031

NOS=not otherwise specified;

[†] data from Quebec have not been submitted to the Canadian Cancer Registry since the 2010 data year; net survival estimates for 2012 to 2014 predicted using the period method

[‡] the province of Ontario did not submit in situ bladder cancer cases to the Canadian Cancer Registry prior to the 2010 data year

Sources: Canadian Cancer Registry death linked file (1992-2014); life tables.

Increases in survival across all age groups

Generally speaking, increases in cancer survival were similar across all age groups studied, except for the 75-to-84 age group, where it was somewhat diminished (Table 4). The median increase in age-specific five-year NS between the 1992-to-1994 and the 2012-to-2014 periods ranged from 6.9 (65 to 74) to 8.6 (55 to 64) percentage points among the first four age groups; for the 75-to-84 age group, it was 5.1.

With the exception of those aged 75 to 84, increases in five-year NS over the 20-year period were greatest for CML ranging from 25.6 percentage points (55 to 64) to 44.3 percentage points (45 to 54). In addition to CML, relatively large increases were also noted in all age groups studied for non-Hodgkin lymphoma, multiple myeloma, cancer of the small intestine, and to a lesser degree colon, rectum, liver and prostate cancer. CML, acute myeloid leukemia, non-Hodgkin lymphoma, as well as cancers of the liver, pancreas, and prostate were

all associated with increases of over 20 percentage points in the 15-to-44 age group. Among those 75 to 84, thyroid cancer was associated with the largest increase (26.1) followed by non-Hodgkin lymphoma (20.3).

Decreases in five-year NS were noted in the 75-to-84 age group for both anal and brain cancer. Trends in these particular strata were examined in more detail by deriving estimates for three-year overlapping periods (data not shown). For anal cancer, NS estimates declined sharply between the 1993-to-1995 and the 1996-to-1998 periods, rose back to levels seen in the early 1990s by the mid-2000s, then experienced another period of sharp decline. For brain cancer, the decrease appears restricted to a drop between 1996 to 1998 and 1997 to 1999, which itself seems to be mainly driven by data from the populous province of Ontario.

Conclusion

This study highlights the wide variation in NS across many types of cancer while also revealing important areas of progress in cancer outcomes in Canada since the early 1990s. At the same time, it sheds light on cancers for which there has been seemingly no improvement in five-year net survival over a 20-year period.

NS estimates for the 2012-to-2014 period were based on predictions. This is because survival estimates based on the actual follow-up experience of people diagnosed with cancer during these years, especially long-term estimates, will not be known for some time. Predicted estimates were derived from a commonly used methodology that has been shown empirically to provide more up-to-date estimates of survival than would otherwise be available.²⁵⁻²⁷ Still, to the extent that survival appears to have been increasing in the most recent years for a particular cancer or cancers, these predictions may underestimate the survival which will eventually be revealed.^{25,28}

Proper interpretation of cancer survival trends can be challenging, and it is

Table 3

Age-specific predicted five-year net survival (NS) estimates, by selected cancer type, Canada excluding Quebec, 2012 to 2014[†]

Cancer	Age group at diagnosis (years)																	
	15 to 44			45 to 54			55 to 64			65 to 74			75 to 84			85 to 99		
	95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval			95% confidence interval		
	NS (%)	from	to	NS (%)	from	to	NS (%)	from	to	NS (%)	from	to	NS (%)	from	to	NS (%)	from	to
Tongue	75	68	81	70	66	74	67	63	70	61	56	65	41	35	48	51 ^E	31	68
Esophagus	21	14	31	20	16	23	20	17	22	15	13	17	12	10	15	4	2	7
Stomach	34	29	39	32	28	35	30	28	33	32	30	34	26	23	28	13	10	17
Small intestine	70	60	77	67	62	72	64	59	68	57	52	61	46	39	52	29 ^F	18	41
Colon	73	70	75	69	67	71	68	66	69	67	66	68	63	62	65	55	52	58
Rectum	73	70	76	75	73	76	72	70	73	69	67	70	58	56	60	40	35	44
Anus	72	61	81	71	65	76	72	68	77	69	63	75	46	38	54	26 ^E	14	41
Liver	40	31	49	27	23	30	25	23	28	16	14	19	11	9	13	4	2	9
Pancreas	39	33	45	16	14	19	11	9	12	7	6	8	5	4	6	1	1	2
Larynx	77 ^E	62	87	71	65	76	65	61	69	61	56	65	53	46	59	60 ^F	40	75
Lung and bronchus	35	31	39	24	22	25	22	21	23	21	20	21	15	14	16	9	7	10
Soft tissue (including heart)	71	67	74	69	64	73	66	61	70	60	55	65	50	43	56	40 ^E	28	51
Melanomas of the skin	92	91	93	91	90	92	89	88	90	87	85	88	83	80	85	80	72	86
Breast	88	87	89	91	90	91	90	90	91	91	90	92	83	82	85	75	71	78
Cervix uteri	86	84	87	72	69	75	64	60	68	53	47	59	44	36	52	38 ^E	21	55
Uterus (body, NOS)	90	87	92	88	87	90	88	87	89	82	80	83	73	70	76	58	49	65
Ovary	77	73	80	64	61	67	52	49	55	35	32	38	23	20	26	10	6	14
Prostate	95	90	98	97	96	97	97	97	97	97	96	97	87	85	88	57	53	61
Testis	97	96	98	97	93	99	93	84	97	96 ^E	30	100	F	F	F	F	F	F
Bladder (including in situ) [‡]	89	85	92	87	84	89	82	80	83	79	77	80	70	68	72	57	53	62
Kidney and renal pelvis	88	86	90	82	80	84	77	76	79	70	68	72	59	56	62	33	28	39
Brain	61	58	64	27	24	30	12	11	14	7	5	9	2	1	3	2	0	5
Thyroid	100	99	100	99	98	99	97	96	98	95	93	97	91	85	95	F	F	F
Hodgkin lymphoma	96	95	97	92	88	95	80	74	86	61	53	68	48 ^E	37	59	F	F	F
Non-Hodgkin lymphoma	84	82	86	81	79	83	77	76	79	70	68	71	57	55	59	40	35	44
Multiple myeloma	77	68	83	62	57	66	57	54	60	47	44	50	35	31	38	16	12	21
Chronic lymphocytic leukemia	93	85	97	96	93	97	92	90	94	86	84	89	75	71	78	61	52	69
Acute myeloid leukemia	62	57	67	44	39	50	24	21	28	10	8	13	3	2	6	3	1	8
Chronic myeloid leukemia	93	89	96	90	84	94	73	67	78	57	50	63	37	30	44	12 ^E	5	24
Mesothelioma	F	F	F	8	2	18	12	7	19	7	5	10	7	4	10	1	0	10

NOS=not otherwise specified

^E use with caution^F too unreliable to be published (i.e., standard error greater than 0.1)[†] data from Quebec have not been submitted to the Canadian Cancer Registry since the 2010 data year; NS estimates predicted using the period method[‡] the province of Ontario did not submit in situ bladder cancer cases to the Canadian Cancer Registry prior to the 2010 data year**Sources:** Canadian Cancer Registry death linked file (1992-2014); life tables.

best approached on an individual cancer basis, taking many potential factors into consideration.^{29,30} While such a task is beyond this study's scope, this article does provide a general overview of changes in net survival over time in Canada and serves as a starting point for such investigations. Factors that may

influence trends in survival include, but are not limited to: improvements in the completeness of case registration; more effective treatments, new screening programs and whether they effect real improvement or simply result in a lead-time bias; changes in the proportion of histologic subtypes where survival differs

between the subtypes; completeness of follow-up in addition to methodological factors relating to the length of operation of the cancer registry.²⁹⁻³¹ Finally, a complete interpretation is best undertaken in conjunction with corresponding cancer incidence and mortality trends.²⁹ ■

Table 4
Age-specific changes in five-year net survival, by selected cancer type, ages 15 to 84 years, Canada excluding Quebec, 1992-to-1994 to 2012-to-2014 period[†]

Cancer	Age group at diagnosis (years)																			
	15 to 44				45 to 54				55 to 64				65 to 74				75 to 84			
	95% confidence interval		p-value		95% confidence interval		p-value		95% confidence interval		p-value		95% confidence interval		p-value		95% confidence interval		p-value	
change	point	change			point	change			point	change			point	change			point	change			point	change	point
Tongue	7.9	-2.7	18.5	0.146	13.9	5.9	21.9	0.001	19.6	12.9	26.3	<0.0005	15.3	7.8	22.8	<0.0005	3.3	-8.6	15.2	0.587
Esophagus	-3.5	-16.9	9.8	0.605	9.9	4.5	15.2	<0.0005	8.5	4.9	12.1	<0.0005	3.4	0.3	6.6	0.035	3.8	0.1	7.6	0.045
Stomach	4.5	-2.8	11.7	0.225	7.7	2.8	12.7	0.002	9.7	6.3	13.2	<0.0005	12.2	9.1	15.3	<0.0005	9.5	6.3	12.8	<0.0005
Small intestine	14.9	0.6	29.2	0.041	20.0	7.7	32.2	0.001	23.3	13.8	32.7	<0.0005	24.1	15.8	32.4	<0.0005	14.2	3.2	25.1	0.011
Colon	14.7	10.3	19.0	<0.0005	9.6	6.7	12.5	<0.0005	11.0	8.9	13.0	<0.0005	10.1	8.3	11.8	<0.0005	9.4	7.2	11.6	<0.0005
Rectum	10.1	4.4	15.8	0.001	15.7	12.1	19.4	<0.0005	15.4	12.8	18.1	<0.0005	12.7	10.2	15.3	<0.0005	8.1	4.6	11.7	<0.0005
Anus	-5.8	-19.0	7.5	0.394	-0.8	-11.0	9.4	0.876	8.6	-0.8	17.9	0.074	5.6	-4.3	15.4	0.268	-13.5	-27.1	0.1	0.052
Liver	24.2	13.4	35.0	<0.0005	12.3	5.6	19.0	<0.0005	13.2	8.9	17.5	<0.0005	8.8	5.3	12.4	<0.0005	7.5	3.9	11.1	<0.0005
Pancreas	21.6	13.1	30.1	<0.0005	7.6	4.0	11.2	<0.0005	5.6	3.6	7.6	<0.0005	2.5	1.0	3.9	0.001	2.1	0.6	3.6	0.006
Larynx	-2.8	-17.5	11.9	0.707	0.3	-7.5	8.2	0.931	1.6	-3.8	7.1	0.561	-3.2	-9.2	2.7	0.289	0.0	-9.8	9.8	1.000
Lung and bronchus	11.8	7.1	16.5	<0.0005	5.0	3.1	7.0	<0.0005	6.4	5.2	7.5	<0.0005	6.6	5.7	7.5	<0.0005	5.0	3.9	6.1	<0.0005
Soft tissue (including heart)	1.7	-4.5	7.8	0.594	-2.3	-10.4	5.8	0.579	5.1	-3.1	13.3	0.226	2.6	-5.6	10.8	0.538	-5.3	-16.7	6.1	0.365
Melanomas of the skin	1.9	0.2	3.7	0.028	4.0	1.7	6.3	0.001	3.3	0.7	5.9	0.012	6.2	3.0	9.5	<0.0005	6.0	0.4	11.6	0.037
Breast	9.9	8.4	11.4	<0.0005	6.8	5.7	7.9	<0.0005	7.7	6.6	8.8	<0.0005	7.6	6.4	8.8	<0.0005	3.2	1.0	5.3	0.004
Cervix uteri	2.2	-0.4	4.8	0.101	4.4	-0.8	9.6	0.095	2.4	-3.9	8.8	0.457	-3.1	-10.9	4.8	0.446	1.7	-9.7	13.1	0.771
Uterus (body, NOS)	1.2	-2.7	5.1	0.537	-1.7	-4.2	0.7	0.166	-3.0	1.0	0.330	0.178	1.8	-0.8	4.5	0.178	-1.7	-6.5	3.1	0.485
Ovary	5.2	0.2	10.2	0.043	16.2	11.5	21.0	<0.0005	13.9	9.6	18.3	<0.0005	6.3	2.3	10.3	0.002	2.3	-2.5	7.0	0.346
Prostate	20.8	7.9	33.8	0.002	11.1	8.6	13.7	<0.0005	7.3	6.3	8.3	<0.0005	7.1	6.2	8.1	<0.0005	8.4	6.5	10.2	<0.0005
Testis	1.6	0.2	3.1	0.028	2.2	-2.7	7.1	0.381	-1.1	-11.9	9.7	0.842	15.9	-5.9	37.7	0.154	..	..	..	..
Bladder (including in situ) [‡]	-5.6	-9.8	-1.3	0.010	2.0	-1.5	5.4	0.261	0.7	-1.8	3.2	0.588	3.6	1.2	5.9	0.003	5.1	1.9	8.4	0.002
Kidney and renal pelvis	9.1	4.9	13.4	<0.0005	14.5	10.9	18.1	<0.0005	16.1	12.9	19.2	<0.0005	10.4	7.1	13.6	<0.0005	5.7	0.5	11.0	0.030
Brain	7.6	3.1	12.1	0.001	3.1	-1.9	8.0	0.222	3.3	0.5	6.1	0.022	2.2	-0.1	4.4	0.057	-3.9	-6.8	-1.1	0.007
Thyroid	0.0	-0.5	0.5	0.882	1.6	-0.2	3.4	0.083	6.3	2.9	9.8	<0.0005	8.8	3.3	14.4	0.002	26.1	15.2	37.1	<0.0005
Hodgkin lymphoma	3.5	1.5	5.4	<0.0005	5.1	-1.8	12.1	0.148	8.9	-0.9	18.7	0.074	6.7	-5.1	18.6	0.281	11.8	-5.8	29.4	0.190
Non-Hodgkin lymphoma	22.5	19.5	25.5	<0.0005	17.6	14.4	20.8	<0.0005	22.0	19.1	24.8	<0.0005	20.9	18.1	23.6	<0.0005	20.3	16.8	23.8	<0.0005
Multiple myeloma	17.5	5.1	29.8	0.005	22.8	15.5	30.1	<0.0005	24.3	19.2	29.4	<0.0005	23.5	19.4	27.6	<0.0005	9.3	4.5	14.1	<0.0005
Chronic lymphocytic leukemia	6.5	-3.4	16.4	0.196	7.6	2.6	12.5	0.003	10.6	6.4	14.8	<0.0005	13.9	9.5	18.4	<0.0005	16.2	9.7	22.7	<0.0005
Acute myeloid leukemia	22.4	15.0	29.9	<0.0005	22.7	14.5	30.9	<0.0005	10.2	4.5	15.9	<0.0005	5.5	2.2	8.9	0.001	-1.3	-4.7	2.1	0.444
Chronic myeloid leukemia	26.9	18.9	34.8	<0.0005	44.3	33.4	55.1	<0.0005	25.6	14.8	36.4	<0.0005	32.3	23.2	41.3	<0.0005	15.4	4.7	26.1	0.005
Mesothelioma	..	..	..	..	-4.0	-15.2	7.2	0.483	3.1	-4.7	10.9	0.438	2.2	-2.4	6.8	0.349	1.2	-5.4	7.8	0.722

NOS=not otherwise specified

.. not available for a specific reference period

[†] data from Quebec have not been submitted to the Canadian Cancer Registry since the 2010 data year; net survival estimates for 2012-2014 predicted using the period method

[‡] the province of Ontario did not submit in situ bladder cancer cases to the Canadian Cancer Registry prior to the 2010 data year

Sources: Canadian Cancer Registry death linked file (1992-2014); life tables.

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Appendix

The use of Canadian weights, rather than ones from an external source, results in a higher degree of interpretability of age-standardized NS estimates—particularly for estimates corresponding to more recently diag-

nosed cases—and differences in such estimates over time. However, for international comparison purposes Table A provides estimates derived using both Canadian and international standards. The largest differences were observed for

cancers of the cervix uteri and brain—six percentage points lower and higher, respectively, when the international standard weights were used.

Table A
Predicted, sex-specific, five-year age-standardized net survival (NS) estimates by standard weight source used,[†] selected cancer type, ages 15 to 99 years at diagnosis, Canada excluding Quebec, 2012 to 2014[‡]

Cancer	Canadian cancer survival standard weights						International Cancer Survival Standard weights											
	Both sexes			Male		Female	Both sexes			Male		Female						
	95% confidence interval			95% confidence interval		95% confidence interval	95% confidence interval			95% confidence interval		95% confidence interval						
	NS (%)	from	to	NS (%)	from	to	NS (%)	from	to	NS (%)	from	to	NS (%)	from	to			
Tongue	63	61	65	62	59	64	65	61	68	59	57	62	59	55	62	61	57	65
Esophagus	15	14	16	14	13	16	18	16	21	15	14	17	15	13	16	19	16	22
Stomach	28	27	29	27	25	28	30	28	32	29	28	30	28	26	29	31	29	33
Small intestine	56	54	59	56	52	59	56	53	60	56	53	58	56	52	59	56	52	60
Colon	65	64	65	65	64	66	65	64	66	66	65	67	66	65	67	66	65	67
Rectum	66	65	67	65	64	66	67	66	69	66	65	67	65	64	66	67	66	69
Anus	64	61	67	61	56	65	66	63	70	62	58	65	59	53	64	64	60	67
Liver	19	18	20	18	17	19	23	20	26	19	18	21	18	17	20	23	20	26
Pancreas	8	7	9	7	6	8	9	8	10	10	9	11	9	8	10	12	11	13
Larynx	62	59	64	62	60	65	57	52	62	62	59	65	63	60	66	58	52	63
Lung and bronchus	19	18	19	15	15	16	22	21	22	20	20	21	17	17	18	23	23	24
Soft tissue (including heart)	61	59	63	60	57	63	62	58	65	64	62	66	63	60	65	65	62	68
Melanomas of the skin	88	87	88	85	83	86	91	90	92	89	88	89	86	85	87	92	91	93
Breast	88	88	89	82	76	87	88	88	89	88	87	88	81	75	86	88	87	88
Cervix uteri	...	...	...	...	...	...	72	70	73	...	...	...	...	...	...	66	64	68
Uterus (body, NOS)	...	...	...	...	...	...	83	83	84	...	...	...	...	...	...	81	80	82
Ovary	...	...	...	...	...	...	45	44	46	...	...	...	...	...	...	41	39	42
Prostate	...	...	...	93	92	93	...	...	...	...	...	...	92	92	92	...	...	...
Testis	...	...	...	97	96	97	...	...	...	...	...	...	93	88	96	...	...	...
Bladder (including in situ) [§]	75	74	75	75	74	76	73	72	75	77	77	78	78	77	79	76	75	78
Kidney and renal pelvis	71	70	72	70	68	71	73	71	74	69	68	70	69	67	70	71	69	73
Brain	20	19	21	19	18	21	22	20	23	26	25	27	25	23	26	28	26	29
Thyroid	98	97	98	95	93	96	99	98	99	96	96	97	93	91	94	98	97	99
Hodgkin lymphoma	86	84	87	85	82	87	87	85	89	85	84	87	85	82	87	87	84	89
Non-Hodgkin lymphoma	68	67	69	66	65	67	71	69	72	69	68	69	66	65	68	71	70	72
Multiple myeloma	44	42	45	43	41	45	45	43	48	48	46	49	47	45	49	50	47	52
Chronic lymphocytic leukemia	83	81	84	80	78	82	87	84	89	85	83	86	82	80	84	88	86	90
Acute myeloid leukemia	20	18	21	19	17	21	20	18	23	19	18	21	19	17	21	20	18	22
Chronic myeloid leukemia	59	56	62	58	54	62	61	57	65	59	56	62	58	54	62	61	57	65
Mesothelioma	8	6	10	7	5	9	15	9	22	11	8	13	11	8	14	17	11	23

... not applicable; NOS—not otherwise specified

[†] Canadian weights derived on a cancer-specific basis using Canadian Cancer Registry incidence data from 2010 to 2014 (see Analytical techniques). International weights were previously developed from incidence data collected for the EURO-CARE-2 study (i.e., European patients diagnosed in the 1985-to-1989 period).²⁰

[‡] data from Quebec have not been submitted to the Canadian Cancer Registry since the 2010 data year; NS estimates predicted using the period method

[§] the province of Ontario did not submit in situ bladder cancer cases to the Canadian Cancer Registry prior to the 2010 data year

Sources: Canadian Cancer Registry death linked file (1992-2014); life tables.

Table B
Canadian cancer survival standard weights[†] used in the age-standardization of net survival estimates

Cancer	Age group (years)					
	15 to 44	45 to 54	55 to 64	65 to 74	75 to 99	15 to 99
Lip	0.041	0.096	0.184	0.255	0.424	1.000
Tongue	0.065	0.188	0.339	0.244	0.164	1.000
Salivary gland	0.150	0.122	0.200	0.199	0.329	1.000
Floor of mouth	0.021	0.164	0.361	0.283	0.171	1.000
Gum and other mouth	0.061	0.136	0.246	0.240	0.317	1.000
Nasopharynx	0.184	0.284	0.254	0.158	0.120	1.000
Oropharynx	0.027	0.170	0.363	0.264	0.176	1.000
Hypopharynx	0.010	0.137	0.270	0.309	0.274	1.000
Other oral cavity and pharynx	0.044	0.248	0.374	0.223	0.111	1.000
Esophagus	0.019	0.104	0.269	0.285	0.323	1.000
Stomach	0.044	0.105	0.197	0.263	0.391	1.000
Small intestine	0.061	0.145	0.239	0.265	0.290	1.000
Colon excluding rectum	0.036	0.084	0.191	0.271	0.418	1.000
Rectum and rectosigmoid	0.049	0.135	0.251	0.272	0.293	1.000
Anus, anal canal and anorectum	0.051	0.209	0.303	0.221	0.216	1.000
Liver	0.029	0.105	0.317	0.265	0.284	1.000
Gall bladder	0.020	0.064	0.177	0.299	0.440	1.000
Pancreas	0.024	0.086	0.205	0.279	0.406	1.000
Other digestive system	0.038	0.088	0.198	0.282	0.394	1.000
Larynx	0.019	0.116	0.286	0.309	0.270	1.000
Lung and bronchus	0.010	0.067	0.212	0.331	0.380	1.000
Other respiratory system	0.138	0.144	0.225	0.218	0.275	1.000
Soft tissue (including heart)	0.192	0.154	0.198	0.193	0.263	1.000
Melanoma of the skin	0.138	0.165	0.227	0.218	0.252	1.000
Other non-epithelial skin	0.134	0.113	0.145	0.184	0.424	1.000
Breast	0.098	0.211	0.253	0.235	0.203	1.000
Cervix uteri	0.418	0.225	0.169	0.100	0.088	1.000
Corpus uteri	0.049	0.169	0.356	0.262	0.164	1.000
Uterus, not otherwise specified	0.077	0.154	0.214	0.200	0.355	1.000
Ovary	0.104	0.185	0.237	0.230	0.244	1.000
Other female genital organs	0.075	0.138	0.214	0.215	0.358	1.000
Testis	0.795	0.133	0.045	0.017	0.010	1.000
Penis	0.043	0.098	0.173	0.289	0.397	1.000
Other male genital organs	0.076	0.126	0.184	0.260	0.354	1.000
Urinary bladder (including in situ)	0.019	0.065	0.184	0.296	0.436	1.000
Kidney and renal pelvis	0.067	0.160	0.263	0.270	0.240	1.000
Other urinary organs	0.010	0.059	0.176	0.289	0.466	1.000
Eye and orbit	0.110	0.156	0.248	0.235	0.251	1.000
Brain	0.186	0.151	0.236	0.215	0.212	1.000
Cranial nerves and other nervous system	0.332	0.169	0.183	0.169	0.147	1.000
Thyroid	0.351	0.256	0.204	0.127	0.062	1.000
Other endocrine including thymus	0.202	0.171	0.229	0.236	0.162	1.000
Hodgkin lymphoma	0.575	0.123	0.111	0.102	0.089	1.000
Non-Hodgkin lymphoma	0.089	0.122	0.212	0.252	0.325	1.000
Myeloma	0.024	0.088	0.199	0.292	0.397	1.000
Acute lymphocytic leukemia	0.433	0.164	0.155	0.114	0.134	1.000
Chronic lymphocytic leukemia	0.018	0.092	0.234	0.287	0.369	1.000
Acute myeloid leukemia	0.117	0.107	0.167	0.238	0.371	1.000
Chronic myeloid leukemia	0.143	0.117	0.169	0.228	0.343	1.000
Other leukemia	0.091	0.115	0.169	0.204	0.421	1.000
Other, ill-defined and unknown sites	0.044	0.074	0.149	0.229	0.504	1.000
Mesothelioma	0.018	0.045	0.149	0.311	0.477	1.000
Kaposi sarcoma	0.268	0.168	0.123	0.174	0.267	1.000
	20 to 44	45 to 54	55 to 64	65 to 74	75 to 99	20 to 99
Bones and joints	0.291	0.169	0.185	0.180	0.175	1.000
	15 to 54	55 to 64	65 to 74	75 to 84	85 to 99	15 to 99
Prostate	0.079	0.299	0.373	0.195	0.054	1.000
Ureter	0.037	0.171	0.288	0.344	0.160	1.000

[†] For each primary cancer, the standard weight was based on the age-specific proportion of cases diagnosed in Canada (excluding Quebec) from 2010 to 2014.

Source: Statistics Canada's November 2017 Canadian Cancer Registry tabulation file (1992-to-2015), International Agency for Research on Cancer multiple primary rules version.