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by Larry F. Ellison

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# Are “immortals” an issue for survival estimates derived from Canadian Cancer Registry data?

by *Larry F. Ellison*

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## ABSTRACT

### Background

The validity of survival estimates from cancer registry data depends, in part, on the identification of the deaths of deceased cancer patients. People whose deaths are missed seemingly live on forever and are informally referred to as “immortals.” Their presence in registry data can result in inflated survival estimates. This study assesses the issue of immortals in the Canadian Cancer Registry (CCR) using a recently proposed method that compares the survival of long-term survivors of cancers for which “statistical” cure has been reported with that of similar people from the general population.

### Data and methods

Data are from the population-based CCR record linked to the Canadian Vital Statistics – Death Database and tax data. Yearly interval-specific relative survival (IRS) estimates were derived up to 15 years after diagnosis for colon cancer cases, and for colon, rectal and melanoma cancer cases combined, diagnosed from 1992 to 2002.

### Results

With increasing follow-up time since diagnosis, national colon cancer IRS estimates levelled off at 1.00, or slightly less, for each age group studied, indicating that survival did not exceed that of the general population. Similar results were obtained among males and females, and for colon, rectal and melanoma cancer cases combined. Provincial IRS point estimates for the three cancers combined also levelled off around 1.00, though with more variation in the estimates than at the national level.

### Interpretation

Based on the results of this study, immortals do not appear to be an issue at either the national or the provincial level for survival estimates derived from CCR data.

### Keywords

malignant neoplasms, population surveillance, registries, survival analysis

## AUTHORS

Larry F. Ellison is with the Centre for Population Health Data at Statistics Canada, Ottawa, Ontario.

### ***What is already known on this subject?***

- The Canadian Cancer Registry (CCR) is periodically record linked to multiple sources of death information not typically available to provincial cancer registries. The resulting file, referred to as the CCR death-linked file, is primarily used by Statistics Canada to derive national- and provincial-level survival estimates. The goal has been to update this file biennially.
- In survival analyses of cancer registry data, people whose deaths are missed seemingly live on forever and are informally referred to as “immortals.” Their presence in the data can result in inflated survival estimates. This will likely be more profound in instances where a poorer prognosis is expected.
- A method to explore the issue of immortals in cancer registry data has been proposed. This method has been employed to examine data from an international study, including cases obtained directly from most Canadian provinces. However, data from the CCR have not yet been examined for immortals in this way.

### ***What does this study add?***

- Based on a comparison of the survival of long-term survivors with that of similar people from the general population using cancers for which “statistical” cure has been reported, immortals do not appear to be an issue at either the national or the provincial level for survival estimates derived from the CCR death-linked file.
- The rationale for increased concern regarding immortals in provincial registry data in more recent diagnosis years does not apply to the CCR death-linked file created and used by Statistics Canada.

Population-based cancer survival estimates form one pillar of a comprehensive cancer surveillance program with which progress in cancer control may be monitored.<sup>1</sup> The derivation of these estimates requires survival time information, which is often obtained through “passive” follow-up. This typically involves the record linkage of cancer registry cases to one or more sources of death information to ascertain the vital status of patients at various follow-up times. Cases not linked to a death are presumed to be alive. To the extent that the linkage process fails to match cancer cases to corresponding deaths, survival estimates may be overestimated. Such non-matched cases seemingly live on forever and are informally referred to as “immortals.”

Andersson et al.<sup>2</sup> recently proposed a method to explore the issue of immortals in cancer registry data. The method involves comparing the survival of long-term survivors—up to 15 years—with that of similar people from the general population. The comparison is made using a cancer site or sites for which it has been reported that there is little to no excess mortality relative to the general population—“statistical” cure—after a period since diagnosis. Examples cited by Andersson et al.<sup>2</sup> were colon and rectal cancer, and melanoma.<sup>3-5</sup> If the survival for these cancer sites in a registry exceeds that of the corresponding general population, this could indicate the presence of immortals.

Andersson et al.<sup>2</sup> applied the method to colon cancer cases diagnosed from 1995 to 1999 in seven countries, including Canada, participating in the International Cancer Benchmarking Partnership (ICBP) SURVMARK-2 study. The Canadian data

used in this analysis were obtained directly by the partnership from eight provinces (excepting Quebec and Newfoundland and Labrador). The study found “indications of a problem in Canada in the last few years” of follow-up, with the authors conjecturing that the problem with immortals might be larger for cases diagnosed in more recent years than for those covered by their study period (i.e., after 1999). The speculation was driven by the apparent increase in difficulty experienced by some provinces in linking cases diagnosed in their jurisdiction to national vital statistics because of legislative changes.

The Canadian Cancer Registry (CCR) is a population-based database composed of cases submitted annually by provincial and territorial cancer registries (PTCRs) to Statistics Canada, where the CCR is maintained.<sup>6</sup> To the extent of PTCRs’ respective abilities, submissions include information regarding the vital status of current and previously submitted cases. To verify and improve upon such information, the CCR has periodically been linked to the Canadian Vital Statistics – Death Database (CVSD)<sup>7</sup> and the T1 personal master file (as reported on tax returns). The resulting file, referred to as the CCR death-linked file, is primarily used by Statistics Canada to derive national- and provincial-level survival estimates.<sup>8-11</sup>

The purpose of this study was twofold: first, to assess the potential issue of immortals in the CCR death-linked file using the above-described method by Andersson et al.,<sup>2</sup> and second, to extend this assessment to the provincial level. Analyses were conducted by sex and by age group at the national level, and by age group at the provincial level.

**Table 1**  
Interval-specific relative survival with 95% confidence intervals at 1, 5, 10 and 15 years after diagnosis by sex and age group, colon, rectal and melanoma cancer, Canada, cases diagnosed from 1992 to 2002

Cancer(s) / sex Age group (years)	1 year after diagnosis				5 years after diagnosis				10 years after diagnosis				15 years after diagnosis			
	Cases	IRS	95% confidence interval		Cases	IRS	95% confidence interval		Cases	IRS	95% confidence interval		Cases	IRS	95% confidence interval	
			from	to			from	to			from	to			from	to
<b>Colon</b>																
<b>Both sexes</b>																
15 to 44	4,080	0.82	0.81	0.83	2,516	0.97	0.96	0.98	2,248	0.99	0.99	1.00	2,143	0.99	0.99	1.00
45 to 54	10,053	0.82	0.81	0.83	6,078	0.96	0.96	0.97	5,309	0.99	0.99	0.99	4,947	1.00	0.99	1.00
55 to 64	21,486	0.80	0.80	0.81	12,561	0.96	0.95	0.96	10,366	0.99	0.99	0.99	9,002	0.99	0.99	1.00
65 to 74	37,184	0.77	0.76	0.77	19,989	0.96	0.96	0.97	14,621	0.99	0.98	0.99	10,494	0.99	0.98	1.00
75 to 99	47,829	0.66	0.65	0.66	18,510	0.97	0.97	0.98	9,717	0.99	0.98	1.00	4,223	0.98	0.97	1.00
<b>Males</b>																
15 to 44	1,991	0.81	0.80	0.83	1,251	0.97	0.96	0.98	1,114	0.99	0.98	1.00	1,056	0.99	0.98	1.00
45 to 54	5,252	0.81	0.80	0.82	3,156	0.96	0.95	0.97	2,709	0.99	0.98	0.99	2,499	1.00	0.99	1.00
55 to 64	12,100	0.80	0.79	0.80	6,862	0.96	0.95	0.96	5,506	0.99	0.98	0.99	4,666	0.99	0.99	1.00
65 to 74	20,213	0.76	0.76	0.77	10,459	0.96	0.95	0.96	7,218	0.99	0.98	1.00	4,926	0.99	0.98	1.00
75 to 99	20,738	0.66	0.66	0.67	7,614	0.97	0.96	0.98	3,619	1.00	0.98	1.01	1,422	0.99	0.97	1.02
<b>Females</b>																
15 to 44	2,089	0.83	0.81	0.84	1,265	0.96	0.95	0.98	1,134	0.99	0.99	1.00	1,087	1.00	0.99	1.00
45 to 54	4,801	0.83	0.82	0.84	2,922	0.97	0.96	0.97	2,600	0.99	0.99	1.00	2,448	0.99	0.99	1.00
55 to 64	9,386	0.81	0.80	0.82	5,699	0.96	0.96	0.97	4,860	0.99	0.99	1.00	4,336	1.00	0.99	1.00
65 to 74	16,971	0.77	0.76	0.78	9,530	0.97	0.96	0.97	7,403	0.99	0.98	0.99	5,568	0.99	0.98	1.00
75 to 99	27,091	0.65	0.65	0.66	10,896	0.98	0.97	0.98	6,098	0.99	0.98	1.00	2,801	0.98	0.96	1.00
<b>Colon, rectum, and melanoma</b>																
<b>Both sexes</b>																
15 to 44	15,723	0.92	0.92	0.93	12,599	0.98	0.98	0.98	11,689	0.99	0.99	1.00	11,295	1.00	1.00	1.00
45 to 54	23,340	0.88	0.88	0.88	16,279	0.97	0.96	0.97	14,308	0.99	0.99	0.99	13,405	0.99	0.99	1.00
55 to 64	39,952	0.84	0.84	0.85	25,314	0.96	0.96	0.96	20,916	0.99	0.99	0.99	18,195	1.00	0.99	1.00
65 to 74	61,556	0.80	0.80	0.81	34,841	0.96	0.96	0.96	25,391	0.99	0.98	0.99	18,284	0.99	0.98	0.99
75 to 99	70,598	0.69	0.69	0.70	28,108	0.97	0.96	0.97	14,638	0.99	0.98	1.00	6,427	0.99	0.97	1.00
<b>Males</b>																
15 to 44	7,149	0.91	0.90	0.91	5,451	0.98	0.97	0.98	4,997	0.99	0.99	0.99	4,783	1.00	0.99	1.00
45 to 54	12,520	0.87	0.87	0.88	8,510	0.96	0.95	0.96	7,276	0.99	0.98	0.99	6,730	1.00	0.99	1.00
55 to 64	23,805	0.84	0.83	0.84	14,595	0.96	0.95	0.96	11,734	0.99	0.99	0.99	9,987	0.99	0.99	1.00
65 to 74	35,703	0.80	0.80	0.81	19,461	0.96	0.95	0.96	13,435	0.98	0.98	0.99	9,180	0.99	0.98	0.99
75 to 99	32,754	0.70	0.70	0.71	12,346	0.96	0.95	0.97	5,857	0.99	0.98	1.00	2,330	0.99	0.97	1.01
<b>Females</b>																
15 to 44	8,574	0.94	0.93	0.94	7,148	0.98	0.98	0.99	6,692	1.00	0.99	1.00	6,512	1.00	1.00	1.00
45 to 54	10,820	0.89	0.88	0.89	7,769	0.97	0.97	0.98	7,032	0.99	0.99	0.99	6,675	0.99	0.99	1.00
55 to 64	16,147	0.85	0.85	0.86	10,719	0.96	0.96	0.97	9,182	0.99	0.99	0.99	8,208	1.00	0.99	1.00
65 to 74	25,853	0.81	0.80	0.81	15,380	0.96	0.96	0.97	11,956	0.99	0.98	0.99	9,104	0.99	0.98	0.99
75 to 99	37,844	0.69	0.68	0.69	15,762	0.97	0.97	0.98	8,781	0.99	0.98	1.00	4,097	0.99	0.97	1.00

Notes: IRS stands for interval-specific relative survival. No IRS estimates are statistically significantly different from 1.00. Follow-up of cases is to the end of 2017.

Sources: Statistics Canada, Canadian Cancer Registry death-linked file (1992 to 2017) and life tables.

## Data and methods

### Data sources and definitions

#### Canadian Cancer Registry death-linked analytic file

The data source was a pre-existing analytic file created by linking CCR cases diagnosed from 1992 to 2017 to mortality information complete through December 31, 2017, via Statistics Canada’s Social Data Linkage Environment.<sup>12</sup> The mortality information was obtained from the CCR, the CVSD,<sup>7</sup> and the T1 personal master file (as reported on tax returns). The use of death information on tax returns permitted the identification of death events of cancer patients that may not have been included in the CVSD, such as out-of-country deaths. The analytic file followed the multiple primary coding rules of the International Agency for Research on Cancer.<sup>13</sup> Cancer cases were defined based on the International Classification of Diseases for

Oncology, Third Edition,<sup>14</sup> and classified using Surveillance, Epidemiology, and End Results Program grouping definitions.<sup>15</sup>

Expected survival probabilities, necessary for the calculation of relative survival, were mostly obtained from sex-specific complete annual provincial life tables, for which data are available until the age of 109.<sup>16</sup> The construction of complete life tables for Prince Edward Island and the three territories has been described elsewhere.<sup>17</sup>

#### Inclusions and exclusions

All colon, rectum and rectosigmoid junction (rectum), and melanoma of the skin (melanoma) cancer cases diagnosed from 1992 to 2002 were initially included. Andersson et al.<sup>2</sup> suggested colon cancer as the primary option for analysis given that statistical cure has been reported to be reached within eight years of follow-up.<sup>3</sup> They also noted that the additional inclusion of rectal cancer and melanoma cases could be considered to improve statistical power when necessary.<sup>2</sup> The inaugural year of the CCR is 1992, while the most recent year

for which a 15-year follow-up was available is 2002. For analyses specific to colon cancer, only the first primary colon cancer case in an individual was included.<sup>18-21</sup> For analyses that combined colon, rectum and melanoma cancer, only the first primary case of any of these three cancer types per individual was considered. Cases diagnosed solely through a death certificate, or an autopsy, were excluded as the survival time of such cases is undefined. Analyses were restricted to individuals aged 15 to 99 at diagnosis.

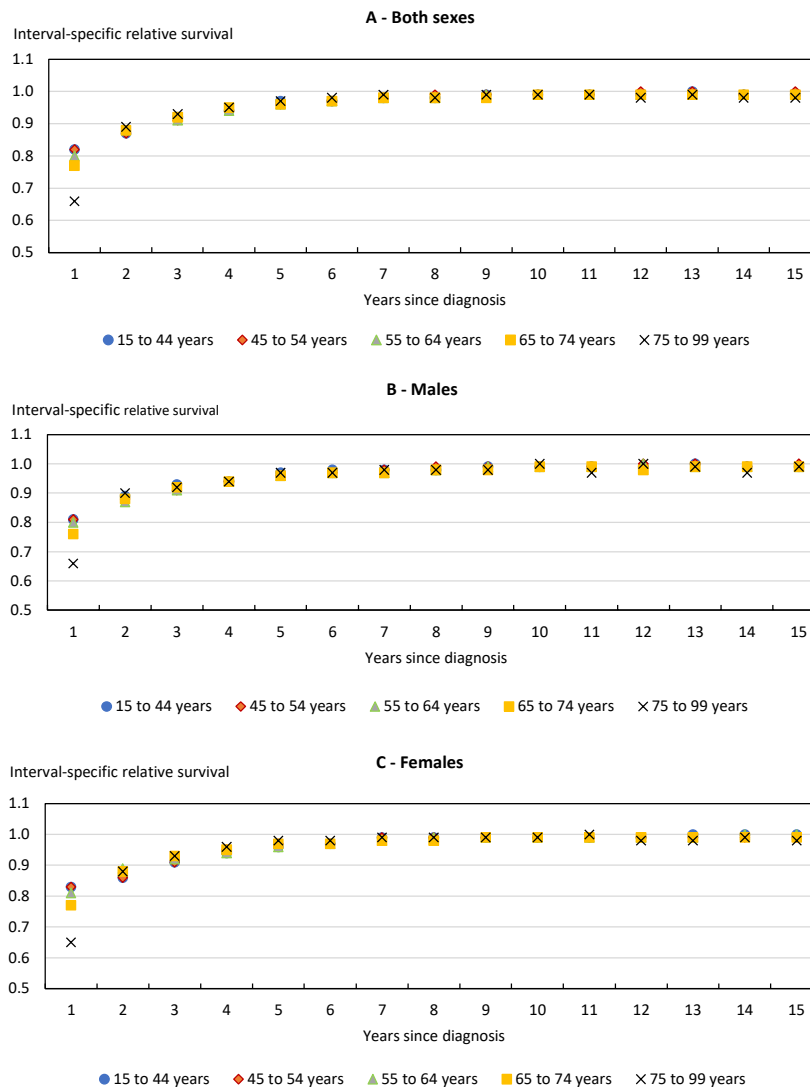
**Statistical analysis**

Based on an approach proposed by Andersson et al.,<sup>2</sup> yearly interval-specific relative survival (IRS) estimates were derived up to 15 years after diagnosis. The first year corresponds to one-

year relative survival. The IRS for subsequent years corresponds to the conditional relative survival of living to the given year, assuming survival to the previous year has already been achieved. Analyses were performed using an algorithm<sup>22</sup> that was adapted for the SAS programming language by Ron Dewar of the Nova Scotia Health Cancer Care Program<sup>23</sup> using the hazard transformation approach. The Ederer II method<sup>24</sup> of calculating expected survival, necessary for relative survival, was employed. Confidence intervals of IRS estimates were calculated on the cumulative excess hazard scale.

The analysis in this study was conducted using cancers that have been reported to achieve statistical cure. National analyses were performed using colon cancer cases, and the combination of colon, rectal and melanoma cancer cases diagnosed from 1992

**Figure 1**  
Interval-specific relative survival for colon cancer by sex, age group and years since diagnosis, Canada, cases diagnosed from 1992 to 2002



**Note:** An interval-specific relative survival of 1.0 indicates that the cancer patient group survival matches the expected survival derived from similar people in the general population.

**Sources:** Statistics Canada, Canadian Cancer Registry death-linked file (1992 to 2017) and life tables.

to 2002. A supplemental national analysis based on colon cancer cases diagnosed from 1995 to 1999 in eight provinces (excepting Quebec and Newfoundland and Labrador) was also performed to compare results with those published elsewhere.<sup>2</sup> Provincial analyses were generated solely using the three cancers combined to aid the statistical power associated with

estimates from less populous provinces. Although estimates from the three territories are not presented because of an insufficient number of cases, data from these jurisdictions are included in the national estimates. The following age groups were used: 15 to 44 years, 45 to 54 years, 55 to 64 years, 65 to 74 years and 75 to 99 years.

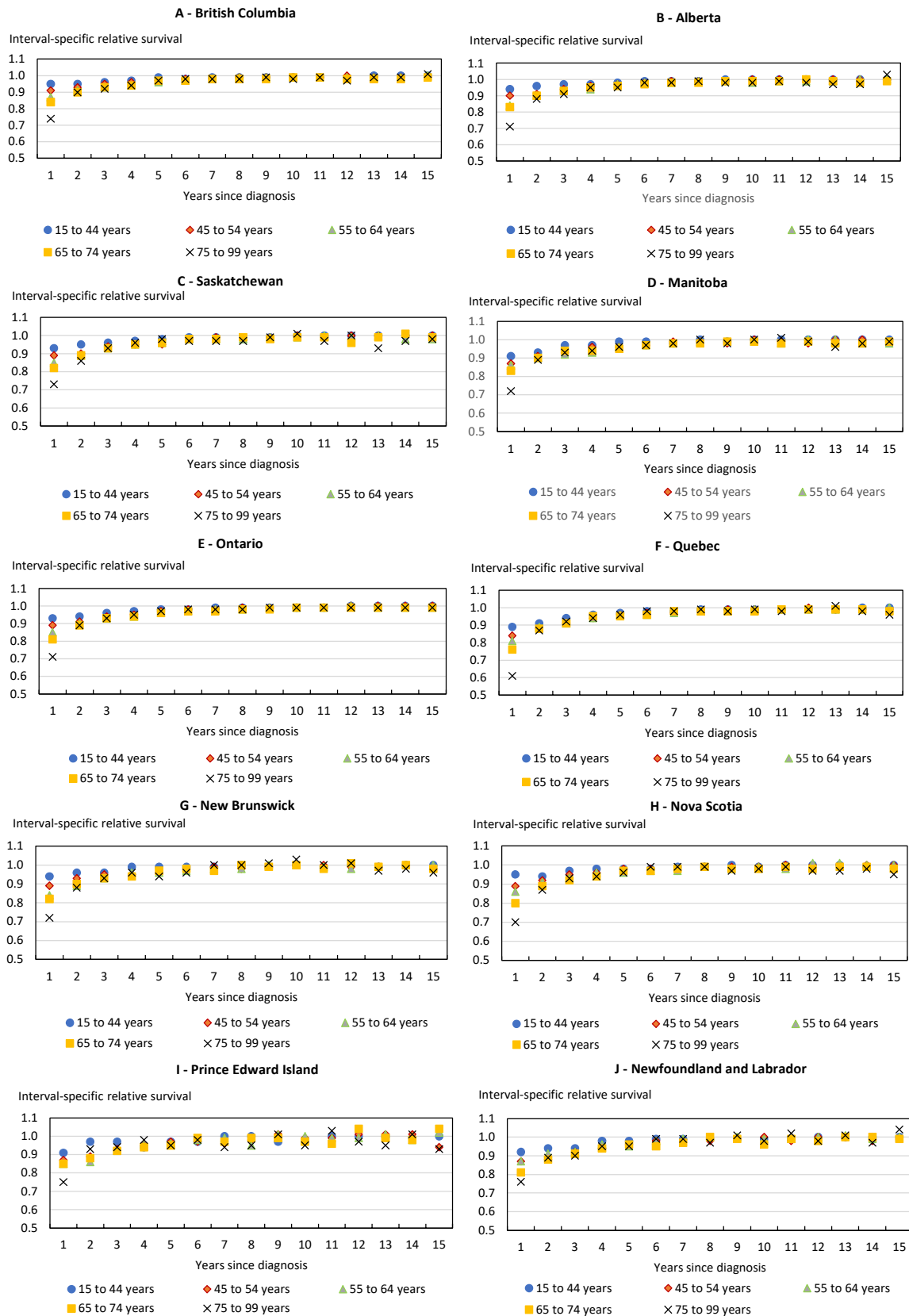
**Table 2**  
Interval-specific relative survival with 95% confidence intervals at 1, 5, 10 and 15 years after diagnosis by jurisdiction and age group, colon, rectal and melanoma cancer, Canada, cases diagnosed from 1992 to 2002

Geography Age group (years)	1 year after diagnosis				5 years after diagnosis				10 years after diagnosis				15 years after diagnosis			
	Cases	95% confidence interval			Cases	95% confidence interval			Cases	95% confidence interval			Cases	95% confidence interval		
		IRS	from	to		IRS	from	to		IRS	from	to		IRS	from	to
<b>British Columbia</b>																
15 to 44	2,277	0.95	0.94	0.96	1,903	0.99	0.98	0.99	1,790	0.99	0.99	1.00	1,724	1.00	0.99	1.00
45 to 54	3,048	0.91	0.90	0.92	2,302	0.97	0.96	0.98	2,029	0.99	0.99	1.00	1,909	0.99	0.99	1.00
55 to 64	4,833	0.87	0.86	0.88	3,233	0.96	0.96	0.97	2,725	0.99	0.99	1.00	2,373	1.00	0.99	1.01
65 to 74	7,670	0.84	0.83	0.85	4,611	0.97	0.96	0.97	3,444	0.99	0.98	1.00	2,499	0.99	0.98	1.00
75 to 99	9,335	0.74	0.73	0.75	4,017	0.97	0.96	0.98	2,138	0.98	0.97	1.00	935	1.01	0.99	1.04
<b>Alberta</b>																
15 to 44	1,710	0.94	0.93	0.95	1,442	0.98	0.98	0.99	1,358	1.00	0.99	1.00	1,333	1.00	1.00	1.00
45 to 54	1,983	0.90	0.88	0.91	1,442	0.97	0.96	0.98	1,281	1.00	0.99	1.00	1,221	1.00	0.99	1.00
55 to 64	3,101	0.84	0.83	0.86	1,995	0.97	0.96	0.97	1,688	0.98	0.97	0.99	1,450	1.00	1.00	1.01
65 to 74	4,361	0.83	0.81	0.84	2,594	0.96	0.95	0.97	1,925	0.99	0.98	1.00	1,402	0.99	0.98	1.01
75 to 99	5,174	0.71	0.69	0.72	2,061	0.95	0.94	0.97	1,075	0.98	0.95	1.00	446	1.03	1.00	1.07
<b>Saskatchewan</b>																
15 to 44	513	0.93	0.90	0.95	417	0.98	0.97	0.99	385	1.00	0.99	1.00	375	1.00	1.00	1.01
45 to 54	711	0.89	0.86	0.91	503	0.95	0.93	0.97	445	1.00	0.99	1.01	422	1.00	0.99	1.01
55 to 64	1,197	0.85	0.83	0.88	772	0.96	0.94	0.97	638	0.99	0.98	1.00	548	0.98	0.97	1.00
65 to 74	2,033	0.82	0.80	0.84	1,179	0.96	0.95	0.98	874	0.99	0.98	1.01	618	0.99	0.97	1.01
75 to 99	2,850	0.73	0.71	0.75	1,169	0.98	0.96	1.00	583	1.01	0.98	1.04	237	0.98	0.92	1.04
<b>Manitoba</b>																
15 to 44	622	0.91	0.89	0.93	494	0.99	0.99	1.00	464	1.00	0.99	1.00	455	1.00	0.99	1.00
45 to 54	824	0.87	0.85	0.90	575	0.96	0.94	0.98	500	1.00	0.99	1.01	461	0.99	0.98	1.00
55 to 64	1,503	0.86	0.84	0.88	954	0.96	0.94	0.97	791	0.99	0.97	1.00	674	0.98	0.97	1.00
65 to 74	2,480	0.83	0.81	0.84	1,463	0.95	0.94	0.97	1,059	0.99	0.97	1.00	738	0.99	0.97	1.02
75 to 99	3,333	0.72	0.70	0.74	1,347	0.96	0.94	0.98	685	1.00	0.97	1.02	297	0.99	0.94	1.04
<b>Ontario</b>																
15 to 44	6,272	0.93	0.92	0.93	5,057	0.98	0.97	0.98	4,689	0.99	0.99	1.00	4,534	1.00	0.99	1.00
45 to 54	8,923	0.89	0.88	0.90	6,365	0.97	0.97	0.97	5,648	0.99	0.98	0.99	5,290	1.00	0.99	1.00
55 to 64	15,587	0.85	0.85	0.86	10,012	0.96	0.96	0.96	8,304	0.99	0.99	1.00	7,288	0.99	0.99	1.00
65 to 74	24,095	0.81	0.81	0.82	13,826	0.96	0.96	0.97	10,087	0.99	0.98	0.99	7,345	0.99	0.98	0.99
75 to 99	25,889	0.71	0.71	0.72	10,714	0.97	0.96	0.98	5,655	0.99	0.98	1.00	2,546	0.99	0.97	1.00
<b>Quebec</b>																
15 to 44	2,847	0.89	0.87	0.90	2,061	0.97	0.97	0.98	1,860	0.99	0.99	1.00	1,768	1.00	0.99	1.00
45 to 54	5,474	0.84	0.83	0.85	3,411	0.96	0.95	0.96	2,920	0.99	0.98	0.99	2,714	0.99	0.99	1.00
55 to 64	9,954	0.81	0.80	0.82	5,869	0.96	0.95	0.96	4,718	0.99	0.98	0.99	4,078	1.00	0.99	1.00
65 to 74	15,408	0.76	0.75	0.77	8,102	0.95	0.94	0.96	5,778	0.98	0.97	0.99	4,120	0.98	0.98	0.99
75 to 99	17,248	0.61	0.61	0.62	6,096	0.96	0.95	0.97	3,149	0.99	0.98	1.01	1,401	0.96	0.94	0.99
<b>New Brunswick</b>																
15 to 44	440	0.94	0.91	0.96	373	0.99	0.98	1.00	353	1.00	0.99	1.00	343	1.00	0.99	1.01
45 to 54	638	0.89	0.87	0.91	468	0.96	0.94	0.98	412	1.00	0.99	1.01	386	0.98	0.97	1.00
55 to 64	1,167	0.84	0.82	0.87	753	0.96	0.95	0.98	630	1.00	0.99	1.01	545	1.00	0.98	1.01
65 to 74	1,617	0.82	0.80	0.84	943	0.97	0.96	0.99	702	1.00	0.98	1.02	517	0.98	0.96	1.01
75 to 99	2,082	0.72	0.70	0.74	843	0.94	0.92	0.97	432	1.03	1.00	1.06	193	0.96	0.89	1.03
<b>Nova Scotia</b>																
15 to 44	607	0.95	0.94	0.97	513	0.98	0.97	0.99	477	0.99	0.99	1.00	460	1.00	0.99	1.01
45 to 54	951	0.89	0.87	0.91	694	0.98	0.97	1.00	621	0.99	0.98	1.00	587	1.00	0.99	1.01
55 to 64	1,443	0.86	0.85	0.88	969	0.96	0.94	0.97	788	0.99	0.97	1.00	688	1.00	0.99	1.02
65 to 74	2,273	0.80	0.78	0.81	1,238	0.97	0.96	0.98	905	0.98	0.97	1.00	628	0.98	0.96	1.01
75 to 99	3,009	0.70	0.68	0.72	1,152	0.96	0.94	0.99	579	0.98	0.95	1.01	233	0.95	0.89	1.02
<b>Prince Edward Island</b>																
15 to 44	81	0.91	0.86	0.98	66	0.97	0.93	1.01	60	0.97	0.92	1.02	57	1.00	1.00	1.00
45 to 54	132	0.87	0.82	0.93	90	0.97	0.94	1.01	78	0.99	0.97	1.02	76	0.94	0.89	1.00
55 to 64	212	0.85	0.81	0.90	130	0.96	0.92	1.00	108	1.00	0.97	1.03	95	1.02	0.99	1.04
65 to 74	339	0.85	0.81	0.89	195	0.95	0.91	0.99	141	0.97	0.92	1.02	96	1.04	1.00	1.08
75 to 99	476	0.75	0.70	0.79	216	0.95	0.90	1.00	99	0.95	0.87	1.04	41	0.93	0.79	1.09
<b>Newfoundland and Labrador</b>																
15 to 44	301	0.92	0.89	0.95	239	0.98	0.96	1.00	223	0.99	0.97	1.00	217	1.00	1.00	1.00
45 to 54	578	0.87	0.84	0.89	379	0.96	0.94	0.98	328	1.00	0.98	1.01	301	0.99	0.98	1.01
55 to 64	883	0.87	0.84	0.89	587	0.95	0.93	0.97	493	0.99	0.98	1.01	428	1.00	0.98	1.02
65 to 74	1,191	0.81	0.79	0.84	647	0.96	0.94	0.98	451	0.96	0.94	0.99	305	0.99	0.95	1.02
75 to 99	1,139	0.76	0.73	0.79	465	0.95	0.91	0.99	232	0.98	0.92	1.03	94	1.04	0.95	1.14

Notes: IRS stands for interval-specific relative survival. No IRS estimates are statistically significantly different from 1.00. Follow-up of cases is to the end of 2017.

Sources: Statistics Canada, Canadian Cancer Registry death-linked file (1992 to 2017) and life tables.

**Figure 2**  
Interval-specific relative survival by age group, province and years since diagnosis, colon, rectal and melanoma cancer, Canada, cases diagnosed from 1992 to 2002



**Note:** An interval-specific relative survival of 1.0 indicates that the cancer patient group survival matches the expected survival derived from similar people in the general population.

**Sources:** Statistics Canada, Canadian Cancer Registry death-linked file (1992 to 2017) and life tables.



## Results

Figure 1A depicts national colon cancer IRS estimates by yearly follow-up duration for each age group. First-year IRS, equivalent to one-year relative survival, differs by age group, with estimates decreasing with advancing age. With time since diagnosis, the age-specific differences fade and IRS estimates levelled off at 1.00, or slightly less, for each age group, indicating that survival did not exceed that of the general population. Similar results were observed among males (Figure 1B) and females (Figure 1C). For selected times since diagnosis, Table 1 presents additional information regarding the number of people at risk at the start of each yearly interval, and IRS 95% confidence intervals. Table 1 also includes results for colon, rectal and melanoma cancer cases combined, which also show a levelling off of IRS estimates at 1.00. Similar results to those reported for Figure 1A were observed when the analysis was restricted to cases diagnosed in eight provinces (excepting Quebec and Newfoundland and Labrador) from 1995 to 1999 (Figure A.1).

Provincial IRS point estimates for colon, rectal and melanoma cancer cases combined also levelled off around 1.00, though there was more variation in the provincial estimates compared with the national ones (Figure 2A to 2J, Table 2). This increased variation was particularly evident in less populous provinces, such as Prince Edward Island and Newfoundland and Labrador, because of the reduced number of cases available for analysis. Only eight point estimates exceeded 1.01—four in Prince Edward Island, two in Newfoundland and Labrador, and one each in New Brunswick and Alberta. Of these, the lone statistically significant result was observed in the 12th year of follow-up for those aged 65 to 74 diagnosed in Prince Edward Island (IRS = 1.04; 95% confidence interval: 1.01 to 1.07).

## Discussion

Using an approach suggested by Andersson et al.,<sup>2</sup> this study found no evidence of the presence of a subset of immortal cases in the CCR death-linked file. This finding held at the national and the provincial levels.

Previously published work, based on data directly submitted from eight provinces to the ICBP SURVMARK-2 study, had indicated that there was a problem with immortals in Canada.<sup>2</sup> While the CCR also receives data directly from the PTCRs, Statistics Canada additionally performs a national linkage of CCR records to the CVSD and to tax files through its Social Data Linkage Environment. This process, meant to occur biennially, provides a means of potentially identifying not only deaths missed by provinces and territories in their jurisdiction, but also deaths occurring in other jurisdictions inside and outside Canada. The additional effort to match cases to deaths using CCR data likely explains the discrepancy in findings between the two studies in terms of immortals in Canada.

Andersson et al.<sup>2</sup> suggest that the issue with immortals they observed in the Canadian data they collected may be “partly due

to changes in legislation that has led to difficulty in linking to the national vital statistics.” The first CCR death-linked file was created in 2018 and covered the period from 1992 to 2014.<sup>25</sup> In 2020, an update was performed to extend the coverage to 2017. A subsequent update to 2020 is planned. There is no legislative impairment to this operation, though Yukon had not submitted deaths for the 2017 data year to the CVSD at the time the current death-linked file was created. What can be an issue from a PTCR perspective, however, is sharing information concerning a death in one jurisdiction with another jurisdiction (e.g., place of residence of the cancer patient at the time of diagnosis). This is impermissible without proper signed legal agreement. There may also be challenges between vital statistics registrars and cancer registries within the same jurisdiction, and this could result in an incomplete death clearance.

Provincial analyses in this study were performed using colon, rectal and melanoma cancer cases combined to facilitate reporting on all provinces. Nevertheless, there was considerably more variation in survival estimates from the least populous provinces—Prince Edward Island, and Newfoundland and Labrador, specifically. As such, the evidence against the existence of immortals in these provinces is not as strong as the evidence for the more populous provinces, such as Ontario. While the colon cancer analysis was sufficient for the study goal at the national level, survival estimates for the three cancers combined were included for potential comparison with the provincial results.

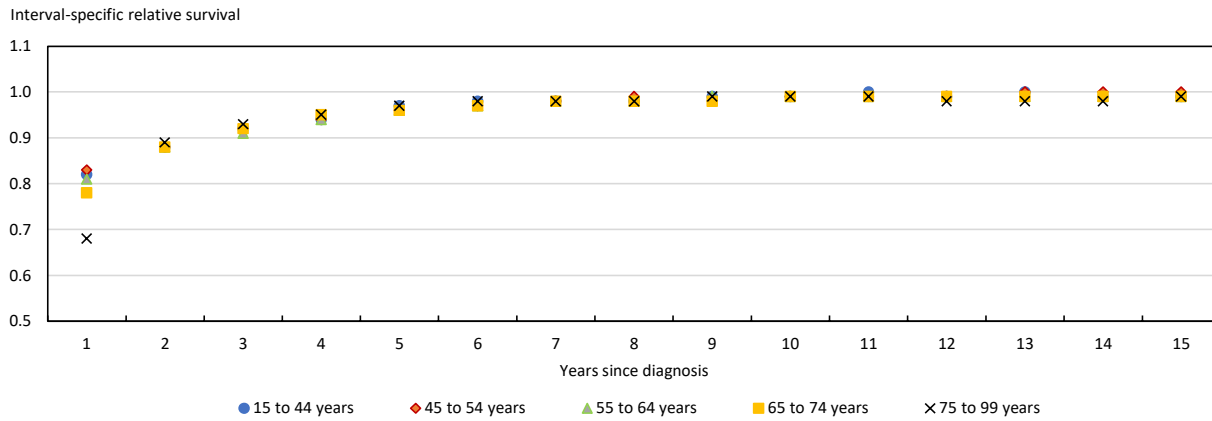
The analysis in this study was conducted using a limited number of cancers that have been reported to achieve statistical cure. Based on the assumption that the process and likelihood of identifying deaths of cases are consistent across various cancer diagnoses, there is no need to repeat the analysis for additional cancers. However, where immortals are an issue, the impact on five-year survival estimates will likely be more profound in instances where a poorer prognosis is expected (e.g., lung cancer).<sup>26</sup> This is the main reason age group-specific analyses were included in the present study, as the impact of immortals is likely to differ by age group, with the greatest effect observed in the older age groups.<sup>27</sup>

While the results of this study are reassuring, it should be noted that the method cannot definitively disprove the existence of immortals. Similarly, for registries where there may appear to be an issue, alternative explanations are possible, including those involving the accuracy of expected survival probabilities.<sup>2</sup> Nonetheless, this method provides cancer registry personnel with a practical way in which to explore the existence of immortals in their cancer registries.

## Conclusion

This study found no evidence of the presence of a subset of immortal cases in the CCR death-linked file at either the national or the provincial level.

**Appendix Figure A.1**  
**Interval-specific relative survival for colon cancer by sex, age group and years since diagnosis, selected provinces, cases diagnosed from 1995 to 1999**



**Note:** An interval-specific relative survival of 1.0 indicates that the cancer patient group survival matches the expected survival derived from similar people in the general population. All 10 provinces are included except Newfoundland and Labrador and Quebec.  
**Sources:** Statistics Canada, Canadian Cancer Registry death-linked file (1992 to 2017) and life tables.

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