
Cancer incidence, mortality and survival trends in Canada, 1970–2007

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This article has been peer reviewed.

Abstract

Introduction: Monitoring cancer trends can help evaluate progress in cancer control while reinforcing prevention activities. This analysis examines long-term trends for selected cancers in Canada using data from national databases.

Methods: Annual changes in trends for age-standardized incidence and mortality rates between 1970 and 2007 were examined by sex for 1) all cancers combined, 2) the four most common cancers (prostate, breast, lung, colorectal) and 3) cancers that demonstrate the most recent notable changes in trend. Five-year relative survival for 1992–2007 was also calculated.

Results: Incidence rates for all primary cancer cases combined increased 0.9% per year in males and 0.8% per year in females over the study period, with varying degrees of increase for melanoma, thyroid, liver, prostate, kidney, colorectal, lung, breast, and bladder cancers and decrease for larynx, oral, stomach and cervical cancers. Mortality rates were characterized by significant declines for all cancers combined and for most cancers examined except for melanoma and female lung cancer. The largest improvements in cancer survival were for prostate, liver, colorectal and kidney cancers. While the overall trends in mortality rates and survival point to notable successes in cancer control, the increasing trend in incidence rates for some cancers emphasize the need for continued efforts in prevention.

Keywords: cancer surveillance, incidence, mortality, survival, risk factors

Introduction

At the beginning of 2007, nearly 750 000 Canadians had a diagnosis of cancer in the previous 10 years.¹ Cancer is the leading cause of death in Canada,² with 82% of all cancer deaths occurring in those aged 60 years and over.¹ By 2036, about 10.9 million Canadians will be aged 65 years or older,³ which will lead to more new cancer cases and create significant demands for cancer care.

An examination of historical cancer trends can help us predict future patterns of this

disease and evaluate progress in cancer control, thus allowing public health professionals to reinforce existing cancer prevention and control activities.

This analysis examines long-term trends for (1) all cancers combined, (2) the four most common cancers in Canada (prostate, female breast, lung, colorectal), and (3) those cancers shown to have the most notable changes in their incidence or mortality trends in the past decade (stomach, liver, thyroid, larynx, melanoma, bladder, kidney, cervix). To our knowledge, this is the most up-to-date and

comprehensive examination of long-term Canadian cancer trends. As such, it can be used to compare with reported trends in other countries. More importantly, trends are discussed in the context of major cancer risk factors and associated health behaviours to provide perspective on the possible determinants of disease.

Methods

Data sources

We took cancer incidence data from 1992 to 2007 from the July 2010 version of the Canadian Cancer Registry, a person-oriented, population-based database.⁴ Data for the earlier period, from 1970 to 1991, are from the National Cancer Incidence and Reporting System, a tumour-oriented database established in 1969.⁵ Mortality data were from the Canadian Vital Statistics Death Database. Population estimates were from Statistics Canada's Demographic Estimates Compendium 2010.⁶

We created a file containing records of invasive cancer cases for all ages and in situ bladder cancer cases (except from the province of Ontario) using the International Agency for Research on Cancer multiple primary coding rules.⁷ Cancer cases were classified based on the *International Classification of Diseases for Oncology, 3rd Edition*.⁸ Cancer group definitions are provided elsewhere.¹ For cancer deaths, the underlying causes of death were selected according to the *International Classification of Diseases* and classified to version 10 (ICD-10).⁹

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Statistical analysis

We calculated age-specific rates for each year and then standardized them to the 1991 Canadian population to obtain the age-standardized incidence rates (ASIR) and mortality rates (ASMR). Trends over the short and long terms were analyzed by calculating the annual percent change (APC) and average annual percent change (AAPC) in rates, respectively, using Joinpoint version 3.5.1 software.¹⁰ Joinpoint uses piecewise regression to model the change in ASIR and ASMR on the log scale. While other approaches, such as a polynomial fit to the data, could be used, Joinpoint characterizes trends more succinctly by transforming the slope of each segment into an average percent change.¹¹ A minimum of 5 years of data before and after a point of change was required to identify a new trend. Models were tested using the Monte Carlo permutation method ($p = .05$ level of significance). Any statistically significant changes in trend are described here as “decreasing” or “declining” or, conversely, “increasing.”

Relative survival analyses were based on a publicly available algorithm¹² which we adapted slightly. The focus of this analysis was on all primary cancer cases aged 15 to 99 years at diagnosis. Mortality follow-up through December 31, 2007, was determined by record linkage of the Canadian Cancer Registry to the Canadian Vital Statistics Death Database and from information reported by provincial/territorial cancer registries. Data from Quebec were excluded because the method of ascertaining the date of diagnosis of cancer cases in this province differed from that of the other provinces^{13,14} and because of issues in correctly ascertaining the vital status of cases diagnosed in Quebec within the Canadian Cancer Registry. We derived 5-year relative survival ratio (RSR) estimates using the cohort method for 1992 to 1994, 1996 to 1998, and 2000 to 2002 and the period method for 2005 to 2007. Because more recent data were unavailable, expected survival data for 2005 to 2007 (used in the derivation of relative survival) were assumed to be the same as in 2000 to 2002. Further information on the survival methodology used is provided elsewhere.¹⁵

Results

In 2007, 85 430 new cancer cases and 36 569 cancer deaths were reported in males, and 78 099 new cases and 33 026 deaths occurred in females. Together, the most frequently diagnosed cancers (prostate, female breast, colorectal and lung) accounted for 55% and 52% of all new cancer diagnoses in males and females, respectively, as well as 50% and 51% of cancer deaths in each sex.

Trends in incidence and mortality

All cancers combined

Table 1 shows the APCs and AAPCs for cancer incidence. The ASIRs for all cancers combined for 1970 and 2007 were higher in males (1970: 330.4 per 100 000; 2007: 463.2 per 100 000) than in females (1970: 272.0 per 100 000; 2007: 362.3 per 100 000). The rate increased at an average of 0.9% per year in males and 0.8% per year in females over the study period.

The APCs and AAPCs for cancer mortality are shown in Table 2. As for incidence, the ASMR for all cancers combined was higher in males (1970: 228.4 per 100 000; 2007: 200.1 per 100 000) than in females (1970: 152.1 per 100 000; 2007: 141.2 per 100 000) but decreased at a rate of 0.3% per year in males and 0.2% per year in females over the study period.

Selected cancers

Between 1970 and 2007, there was an overall upward trend in male incidence rates (Figure 1) for melanoma (AAPC: 3.7%) and for thyroid (3.6%), liver (3.5%), prostate (2.2%), kidney (1.8%), colorectal (0.6%) and bladder cancers (0.4%) but a declining trend for larynx (0.8%), oral (1.4%) and stomach (2.1%) cancers. Incidence rates increased in females for thyroid (AAPC: 4.4%), lung (4.4%), melanoma (2.9%), kidney (2.1%), liver (1.9%), breast (0.5%) and bladder cancers (0.5%) while decreasing AAPCs were observed for cervix (2.5%) and stomach cancers (2.3%).

For most cancers, mortality rates between 1970 and 2007 were characterized by statistically significant decreases (Figure 2) with the exception of female lung cancer

(AAPC: 4.0%) and melanoma (AAPC: 2.3% for males, 0.8% for females), for which increases were observed.

The trends for certain cancers are worth highlighting. For example, the prostate cancer incidence rate peaked twice, in 1993 and 2001 (Table 1 and Figure 1). Following the first peak, the incidence rate decreased (APC: 5.2%) until 1997, after which the rate climbed at 3.9% per year to a second peak in 2001, followed by a period of non-significant decline. We observed only one period of increase in the mortality rate for this cancer, between 1977 and 1993, which preceded a continuous decline that has further accelerated since 2001 (Table 2).

The incidence rate of lung cancer increased by 3.7% per year in males between 1970 and 1983. This was followed by a period of non-significant change until 1990 when the incidence rate started declining (Table 1). In females, the incidence rate has been increasing since 1970 but has slowed from 8.4% per year (1970–1983) to 3.8% per year (1983–1992) and finally to 1.4% per year (1992–2007). Lung cancer mortality in males followed a trajectory similar to incidence: the rate increased (2.7% per year) until 1983, remained stable (0.0% per year) from 1983 to 1992, and then began declining at an annual rate of 2.2% (Table 2). In contrast, the lung cancer mortality rate in females has continued to increase since 1970, from 6.9% per year (1970–1985) to 3.6% per year (1985–1994) and finally 1.0% per year (1994–2007).

Larynx cancer incidence rates increased from 1970 until 1980 in males (APC: 3.6%) and until 1989 in females (3.2% per year). Male incidence rates declined at 1.0% per year from 1980 to 1992, after which the decrease accelerated to 3.4% per year. Female incidence rate declined at an annual rate of 3.1% since 1989. The mortality rate increased from 1970 until 1988 for males (0.8% per year) and until 1991 for females (1.9% per year), followed by significant declines in both sexes.

Bladder cancer incidence rates increased from 1970 to 1981 (males: 3.3% per year; females: 3.5% per year), but the trend

TABLE 1
Annual percent change and average annual percent change in age-standardized incidence rates per 100 000 for selected cancers, Canada^a, 1970–2007

Cancer type	ASIR 1970	ASIR 2007	Trend 1		Trend 2		Trend 3		Trend 4		Trend 5		Trend 6		
			Year	APC (95% CI)	Year	APC (95% CI)	Year	APC (95% CI)	Year	APC (95% CI)	Year	APC (95% CI)	Year	APC (95% CI)	
Males															
All cancers	330.4	463.2	1970–1983	2.6* (2.3, 2.9)	1983–1989	0.0 (–1.0, 1.0)	1989–1993	2.3* (0.3, 4.4)	1993–1997	–2.2* (–4.0, –0.3)	1997–2001	1.1 (–0.7, 3.0)	2001–2007	–0.6* (–1.2, 0.0)	0.9* (0.5, 1.3)
Prostate	53.8	124.7	1970–1989	2.8* (2.6, 3.1)	1989–1993	9.7* (6.4, 13.1)	1993–1997	–5.2* (–7.8, –2.6)	1997–2001	3.9* (1.2, 6.7)	2001–2007	–0.7 (–1.5, 0.1)			2.2* (1.6, 2.7)
Colorectal	47.8	60.4	1970–1984	2.2* (1.9, 2.5)	1984–1996	–0.6* (–1.0, –0.3)	1996–2000	1.4 (–0.9, 3.7)	2000–2007	–0.7* (–1.3, –0.2)					0.6* (0.3, 0.9)
Lung	59.3	67.8	1970–1983	3.7* (3.4, 4.0)	1983–1990	–0.4 (–1.2, 0.4)	1990–2007	–1.9* (–2.0, –1.7)							0.3* (0.1, 0.5)
Bladder	24.5	26.9	1970–1981	3.3* (2.5, 4.0)	1981–2007	–0.7 (–0.9, –0.6)									0.4* (0.2, 0.7)
Thyroid	1.5	5.2	1970–1997	2.4* (1.9, 2.8)	1997–2007	6.9* (5.7, 8.1)									3.6* (3.1, 4.0)
Larynx	6.9	4.8	1970–1980	3.6* (2.5, 4.6)	1980–1992	–1.0* (–1.8, –0.3)	1992–2007	–3.4* (–3.9, –3.0)							–0.8* (–1.2, –0.4)
Liver	2.0	6.2	1970–2007	3.5* (3.3, 3.7)											3.5* (3.3, 3.7)
Melanoma	3.4	13.7	1970–1986	6.2* (5.4, 7.1)	1986–2007	1.9* (1.6, 2.2)									3.7* (3.3, 4.1)
Oral	20.6	12.9	1970–1978	0.2 (–0.8, 1.1)	1978–1992	–1.7* (–2.1, –1.3)	1992–1998	–3.5* (–5.2, –1.8)	1998–2007	–1.0* (–1.7, –0.3)					–1.4* (–1.8, –1.0)
Stomach	23.4	10.4	1970–1983	–1.3* (–1.7, –0.9)	1983–2007	–2.6* (–2.7, –2.4)									–2.1* (–2.3, –2.0)
Kidney	7.8	15.1	1970–1977	1.2 (–0.3, 2.6)	1977–1989	4.0* (3.4, 4.6)	1989–1998	–0.3 (–1.0, 0.4)	1998–2007	1.4* (0.9, 2.0)					1.8* (1.4, 2.2)
Females															
All cancers	272.0	362.3	1970–1981	1.6* (1.2, 1.9)	1981–2007	0.4* (0.4, 0.5)									0.8* (0.7, 0.9)
Breast	77.1	98.4	1970–1998	0.9* (0.8, 1.1)	1998–2007	–0.7* (–1.2, –0.2)									0.5* (0.4, 0.7)
Colorectal	44.5	40.6	1970–1983	1.0* (0.6, 1.4)	1983–1996	–1.5* (–1.8, –1.1)	1996–2000	1.3 (–1.8, 4.4)	2000–2007	–0.8* (–1.6, –0.1)					–0.2 (–0.6, 0.2)
Lung	9.3	47.2	1970–1983	8.4* (7.9, 8.9)	1983–1992	3.8* (3.2, 4.4)	1992–2007	1.4* (1.2, 1.5)							4.4* (4.2, 4.6)
Bladder	6.7	7.9	1970–1981	3.5* (1.9, 5.1)	1981–2007	–0.4* (–0.6, –0.2)									0.5* (0.1, 0.9)
Thyroid	3.9	18.0	1970–1989	1.8* (1.4, 2.2)	1989–1994	6.9* (3.5, 10.4)	1994–1998	1.9 (–2.7, 6.7)	1998–2002	12.5* (8.2, 17.0)	2002–2007	6.9* (5.4, 8.3)			4.3* (3.5, 5.1)
Larynx	0.7	1.0	1970–1989	3.2* (2.3, 4.1)	1989–2007	–3.1* (–3.8, –2.3)									0.1 (–0.5, 0.6)
Liver	0.9	1.7	1970–2007	1.9* (1.6, 2.2)											1.9* (1.6, 2.2)
Melanoma	4.1	11.3	1970–1980	7.4* (5.8, 9.1)	1980–2007	1.3* (1.0, 1.5)									2.9* (2.4, 3.3)
Oral	5.1	5.4	1970–1979	1.4 (0.0, 2.9)	1979–2007	–0.4* (–0.6, –0.2)									0.0 (–0.3, 0.4)
Cervix	19.4	7.8	1970–1988	–3.3* (–3.6, –3.0)	1988–2007	–1.8* (–2.1, –1.5)									–2.5* (–2.7, –2.3)
Stomach	11.2	4.8	1970–1986	–1.9* (–2.3, –1.5)	1986–1991	–4.2* (–7.2, –1.1)	1991–2007	–2.0* (–2.4, –1.7)							–2.3* (–2.7, –1.8)
Kidney	3.7	9.0	1970–1980	1.4* (0.1, 2.7)	1980–1987	6.7* (4.4, 8.9)	1987–1997	–0.1 (–1.0, 0.8)	1997–2007	1.8* (1.2, 2.5)					2.1* (1.5, 2.7)

Abbreviations: APC, average annual percent change; ASIR, age-standardized incidence rates; CI, confidence interval.

^a Excluding Quebec.

* Two-sided $p < .05$.

TABLE 2
Annual percent change and average annual percent change in age-standardized mortality rates per 100 000 for selected cancers in Canada^a, 1970–2007

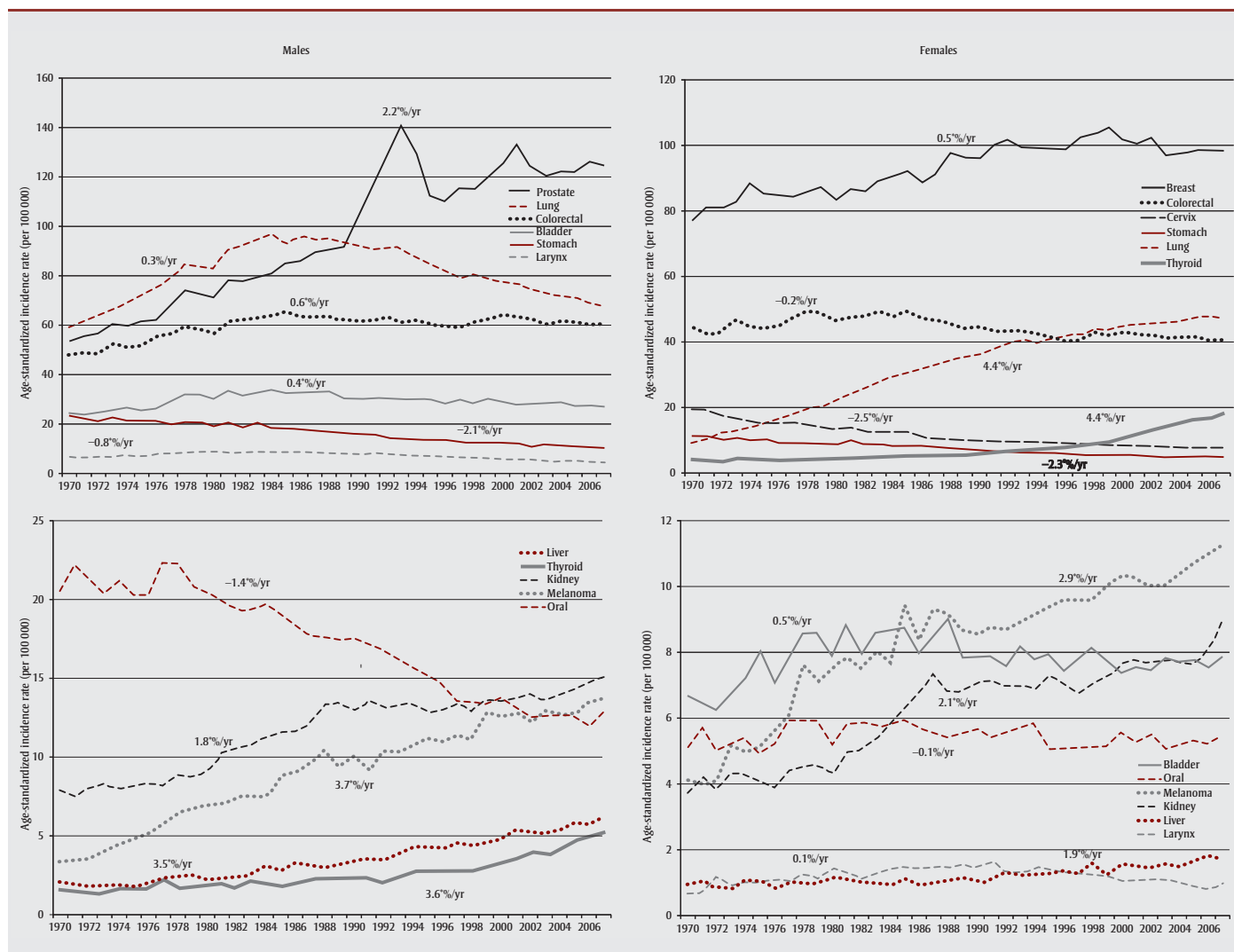
Cancer type	ASMR		Trend 1		Trend 2		Trend 3		Trend 4		AAPC (95% CI) (1970–2007)
	1970	2007	Year	APC (95% CI)	Year	APC (95% CI)	Year	APC (95% CI)	Year	APC (95% CI)	
Males											
All cancers	228.4	200.1	1970–1988	0.7* (0.6, 0.7)	1988–2001	-0.9* (-1.0, -0.8)	2001–2007	-2.0* (-2.3, -1.7)	2001–2007	-4.2* (-5.1, -3.4)	-0.3* (-0.4, -0.3)
Prostate	25.4	20.4	1970–1977	-0.2 (-1.3, 0.8)	1977–1993	1.4* (1.1, 1.7)	1993–2001	-2.3* (-3.0, -1.6)	2001–2007		-0.6* (-0.9, -0.3)
Colorectal	33.9	24.4	1970–1988	0.0 (-0.2, 0.2)	1988–2003	-1.1* (-1.4, -0.8)	2003–2007	-2.5* (-4.1, -0.9)	2003–2007		-0.7* (-0.9, -0.5)
Lung	55.0	57.0	1970–1983	2.7* (2.4, 3.0)	1983–1992	0.0 (-0.5, 0.5)	1992–2007	-2.2* (-2.3, -2.0)	1992–2007		0.0 (-0.1, 0.2)
Bladder	9.0	6.9	1970–2007	-0.7* (-0.8, -0.6)							-0.7* (-0.8, -0.6)
Thyroid	0.6	0.4	Not applicable: small number of deaths								
Larynx	3.1	1.8	1970–1988	0.8* (0.4, 1.3)	1988–2001	-2.3* (-2.9, -1.7)	2001–2007	-6.0* (-7.8, -4.2)	2001–2007		-1.4* (-1.4, -1.0)
Liver	1.8	3.1	1970–1982	0.1 (-1.7, 1.8)	1982–1987	8.6* (0.3, 17.6)	1987–1991	-5.2 (-15.0, 5.7)	1991–2007	2.4* (1.7, 3.2)	1.6 (0.0, 3.3)
Melanoma	1.3	2.8	1970–1985	4.2* (3.0, 5.3)	1985–2007	1.1* (0.6, 1.5)					2.3* (1.8, 2.8)
Oral	6.3	4.1	1970–1991	-0.5* (-0.8, -0.1)	1991–2007	-2.5* (-3.0, -2.0)					-1.5* (-1.6, -1.0)
Stomach	23.3	6.5	1970–2007	-3.3* (-3.4, -3.3)							-3.3* (-3.4, -3.3)
Kidney	4.7	5.0	1970–1992	0.8* (0.5, 1.1)	1992–2007	-0.7* (-1.1, -0.2)					0.2 (-0.1, 0.4)
Females											
All cancers	152.1	141.2	1970–1977	-0.6* (-1.1, -0.1)	1977–1988	0.5* (0.2, 0.8)	1988–2002	-0.3* (-0.4, -0.1)	2002–2007	-1.2* (-1.8, -0.6)	-0.2* (-0.4, -0.1)
Breast	30.7	21.8	1970–1982	-0.4* (-0.7, -0.1)	1982–1986	2.0 (-0.4, 4.4)	1986–1994	-1.0* (-1.6, -0.4)	1994–2007	-2.4* (-2.7, -2.2)	-1.0* (-1.3, -0.7)
Colorectal	28.6	16.3	1970–1986	-1.2* (-1.5, -1.0)	1986–2007	-1.7* (-1.8, -1.5)	1994–2007	1.0* (0.8, 1.3)			-1.5* (-1.6, -1.3)
Lung	8.3	36.1	1970–1985	6.9* (6.5, 7.4)	1985–1994	3.6* (2.9, 4.2)					4.0* (3.8, 4.3)
Bladder	2.8	2.1	1970–1996	-1.2* (-1.5, -0.8)	1996–2007	0.3 (-0.7, 1.3)					-0.7* (-1.1, -0.4)
Thyroid	1.0	0.4	Not applicable: small number of deaths								
Larynx	0.4	0.4	1970–1991	1.9* (0.8, 3.0)	1991–2007	-2.7* (-4.0, -1.4)					-0.1 (-0.9, -0.7)
Liver	0.7	0.8	1970–1989	1.2* (0.3, 2.0)	1989–1994	-6.3 (-13.2, 1.1)	1994–2007	1.9* (0.7, 3.1)			0.4 (-0.8, 1.5)
Melanoma	1.1	1.6	1970–1983	2.0* (0.7, 3.3)	1983–2007	0.2 (-0.2, 0.6)					0.8* (0.3, 1.3)
Oral	1.9	1.5	1970–2007	-0.6* (-0.8, -0.3)							-0.6* (-0.8, -0.3)
Cervix	7.3	1.9	1970–1976	-7.7* (-9.8, -5.6)	1976–2007	-3.1* (-3.3, -2.8)					-3.8* (-4.2, -3.5)
Stomach	11.3	2.9	1970–1977	-5.3* (-6.7, -3.9)	1977–2007	-3.1* (-3.3, -2.9)					-3.5* (-3.8, -3.2)
Kidney	2.2	2.3	1970–1978	-1.1 (-2.8, 0.8)	1978–1988	2.1* (0.8, 3.4)	1988–2007	-0.8* (-1.2, -0.5)			-0.1 (-0.6, 0.4)

Abbreviations: AAPC, average annual percent change; APC, annual percent change; ASMR, age-standardized mortality rates; CI, confidence interval.

^a Excluding Quebec.

* Two-sided $p < .05$.

FIGURE 1
Average annual percent change in age-standardized incidence rates for selected cancers in males and females, Canada, 1970–2007



Note: Joinpoint analyses with up to 5 joinpoints were based on age-adjusted rates (per 100 000 persons).

^a Excluding Quebec.

* Two-sided $p < .05$.

reversed in 1981 when incidence rates began decreasing (males: 0.7% per year; females: 0.4% per year). Mortality rates, on the other hand, have decreased over the entire study period for males (0.7% per year) and from 1970 to 1996 for females (1.2% per year).

The overall incidence rate of kidney cancer in males increased over two periods, 1977 to 1989 and 1998 to 2007. We observed two similar periods of increase in females, from 1980 to 1987 and from 1997 to 2007. In contrast, the male mortality rate increased from 1970 to 1992 but has been decreasing since then,

while the female mortality rate increased from 1978 to 1988 and has since declined.

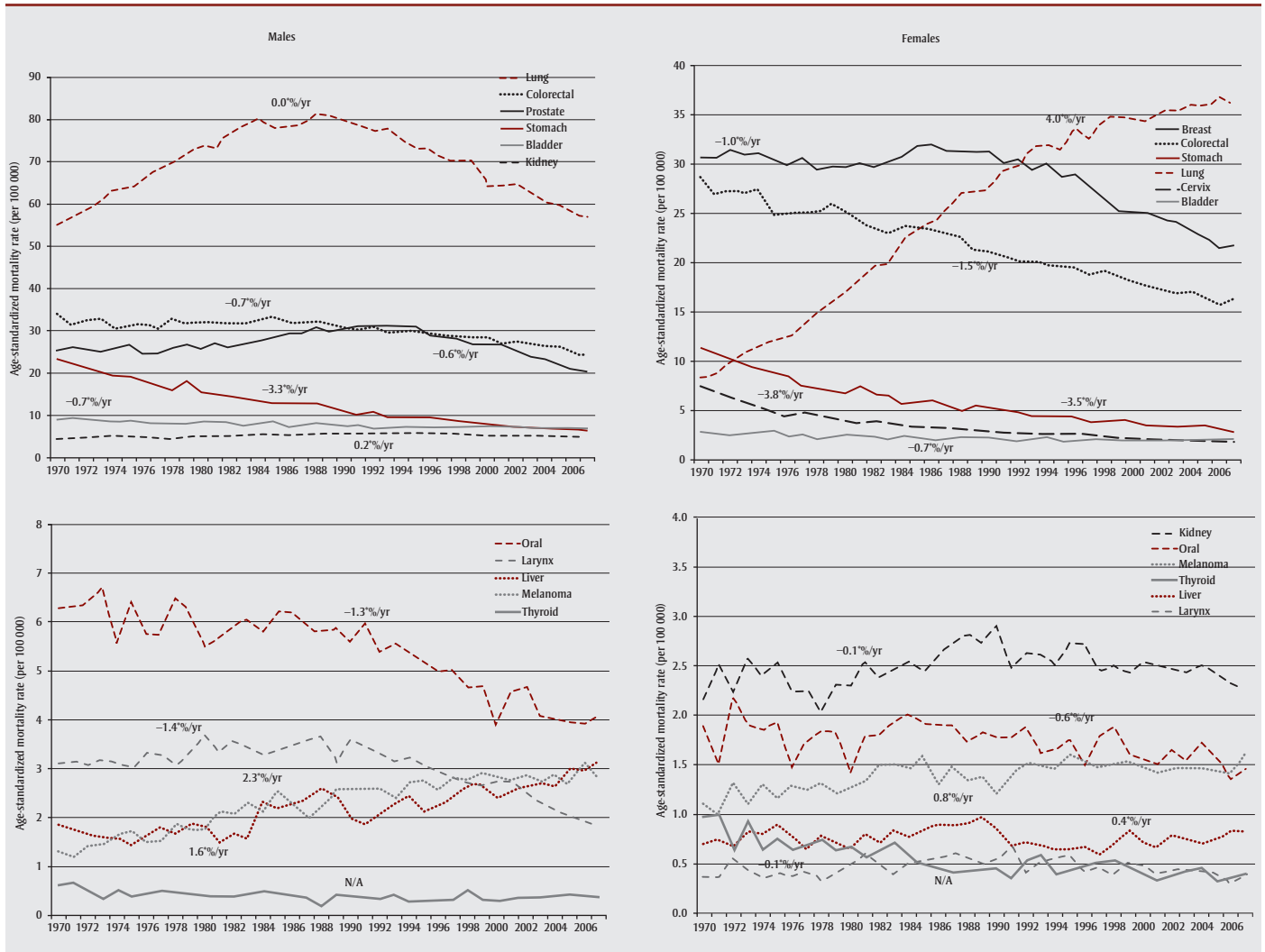
The incidence rate of thyroid cancer has been steadily increasing since 1970 in both sexes. In males, the rate increased at 2.4% per year between 1970 and 1997 and then accelerated to 6.9% per year until 2007. More notably, in females the incidence rate has varied from 1.8% per year between 1970 and 1989, 6.9% per year between 1989 and 1994, 12.5% per year between 1998 and 2002, and more recently (2002–2007), 6.9% per year. Thyroid cancer mortality rates were too low to permit a Joinpoint analysis.

Trends in survival

Between 1992 to 1994 and 2005 to 2007, the 5-year age-standardized RSR for all cancers combined rose by 6.8 percentage points to 62% (Table 3). Larger gains in survival were seen for males than females (8.5 vs. 5.0 percentage points) over this period, resulting in considerable narrowing in the previous gap.

The degree of improvement in the 5-year RSR varied considerably for individual cancers. The largest improvements of approximately 8 to 10 percentage points were for prostate, liver, colorectal and kidney cancers. Small improvements of 2

FIGURE 2
Average annual percent change in age-standardized mortality rates for selected cancers in males and females, Canada^a, 1970–2007



Abbreviation: N/A, not applicable.

Note: Joinpoint analyses with up to 5 joinpoints were based on age-adjusted rates (per 100 000 persons).

^a Excluding Quebec.

* Two-sided $p < .05$.

to 3 percentage points were observed for lung, larynx, cervical and oral cancers. There was no apparent improvement for bladder cancer over the study period. Disparities between the sexes in survival gains favoured females (data not shown) and included oral (3.7% females vs. 1.1% males), larynx (4.1% vs. 1.5%), lung (3.5% vs. 1.3%) and stomach cancers (6.3% vs. 4.5%).

Discussion

Over the nearly 40-year period between 1970 and 2007, incidence rates for all cancers combined increased significantly

in both Canadian males and females. While rates have stabilized in males since 1993, in females the overall incidence rate appears to have started plateauing only recently. These overall trends were driven largely by the three most common cancers in males (i.e. lung, prostate and colorectal) and in females (i.e. breast, lung and colorectal).

Cancer mortality rates in both sexes peaked in 1988 and have since declined largely due to reductions in mortality rates in the four leading causes of cancer death (i.e. lung, colorectal, prostate and breast cancers). The gains in 5-year RSR since the

period 1992 to 1994 for all cancers combined and for selected cancers suggest improvements in treatment and early detection of certain cancers as well as advances in supportive and general medical care.

Trends in leading cancers

Prostate cancer

Little is known about the risk factors for prostate cancer aside from age. Although androgens are critical for prostate cancer growth, it is unclear whether high androgen levels can promote cancer initiation.¹⁶ A link with physical activity has been

TABLE 3
Five-year age-standardized relative survival ratios for selected cancers^a by time period, Canada^b, 1992–2007

Cancer type	RSR ^c , % (95% CI)				Change ^d 1992–1994 to 2005–2007
	1992–1994	1996–1998	2000–2002	2005–2007	
All cancers	56 (55–56)	57 (57–57)	60 (60–61)	62 (62–63)	6.8
Male	54 (54–54)	55 (55–56)	60 (60–60)	62 (62–63)	8.5
Female	57 (56–57)	58 (58–59)	60 (60–60)	62 (62–63)	5.0
Prostate	87 (86–87)	90 (89–90)	94 (94–95)	96 (96–97)	9.8
Female breast	82 (82–83)	85 (85–86)	87 (86–87)	88 (87–88)	5.6
Colorectal	56 (55–56)	58 (57–59)	61 (60–61)	64 (64–65)	8.6
Lung	14 (13–14)	15 (14–15)	15 (15–15)	16 (16–17)	2.6
Bladder	73 (72–74)	71 (70–72)	71 (70–72)	72 (71–73)	–0.3
Thyroid	93 (92–94)	94 (93–95)	96 (96–97)	98 (97–98)	4.9
Larynx	62 (60–64)	63 (61–65)	62 (59–64)	64 (61–66)	1.9
Liver	10 (8–11)	12 (11–14)	17 (15–18)	18 (17–20)	8.7
Melanoma	84 (83–86)	87 (86–87)	89 (88–90)	89 (89–90)	4.9
Oral	60 (59–61)	59 (58–61)	61 (59–62)	62 (61–64)	2.3
Cervix	70 (68–71)	70 (69–72)	73 (71–75)	72 (70–73)	2.2
Stomach	19 (18–21)	22 (20–23)	22 (21–23)	25 (23–26)	5.1
Kidney	60 (58–61)	62 (60–63)	64 (63–65)	67 (66–69)	7.7

Abbreviations: CI, confidence interval; RSR, relative survival ratio.

^a For persons aged 15 to 99 years at diagnosis.

^b Excluding Quebec.

^c Results derived using both the cohort (1992–1994, 1996–1998 and 2000–2002) and period (2005–2007) methods.

^d Absolute difference in percentage points.

suggested¹⁷ but the evidence remains inconclusive.^{18,19} Obesity is only weakly associated with the development of prostate cancer, but there is some suggestion that it could increase the risk of death and metastasis.^{20–22}

Despite uncertainty about the benefits and risks of prostate cancer testing using the prostate-specific antigen (PSA) test, its use is widespread.²³ According to national health surveys, the proportion of males aged 35 plus who had ever had a PSA test was 53.8% in 2008.²⁴ Two recent randomized trials have not confirmed PSA as a viable population-based screening tool for reducing prostate cancer deaths,^{25,26} and it is not currently recommended in Canada as a population-based screening test. Nonetheless, the prostate cancer incidence rate in Canada rose sharply following the introduction of the PSA test in 1988. The incidence rate peaked in 1993 and then again in 2001. This second date could be explained by the publicity that year surrounding the then federal health minister's

disclosure that he had been diagnosed with prostate cancer.

The prostate cancer mortality rate in Canada has declined since 1995, returning to pre-1970 levels in 2007. Early detection of prostate cancer through widespread screening is believed to have contributed to the decreasing mortality trend in the United States,²⁷ and there is some suggestion that a similar phenomenon is responsible for the mortality and survival trends in Canada.²⁸ The nearly 10 percentage point gain in the 5-year RSR since 1992 to 1994 may also, to some degree, be explained by the greater availability of effective hormonal therapy for early and advanced-stage disease in the mid-1980s²⁹ followed by the introduction of watchful waiting and advances in combined radiation and hormonal therapy for prostate cancer which occurred in the 1990s.³⁰

Breast cancer

The female breast cancer incidence rate in Canada rose steadily at 0.9% per year

between 1970 and 1998, after which the rate started to decline at 0.7% per year. Trends in breast cancer incidence likely reflect long-term changes in hormonal factors (e.g. early age at menarche, late age at menopause, breastfeeding, oral contraceptive use, hormone replacement therapy use) and the increasing uptake of mammography screening, especially throughout the 1980s.³¹ The first provincial organized breast cancer screening program was implemented in Canada in 1988, and all 10 Canadian provinces had established programs by 1998.³² While all provincial programs offer mammography screening to women aged 50 to 69 years, some are also open to those in their 40s and those older than 69 years.³²

National health surveys show that the proportion of postmenopausal females aged between 50 and 69 years who self-report having a mammogram within the previous two years has increased from 40.5% in 1990 to 72.5% in 2008.³² The brief decline in the breast cancer incidence rate between 1998 and 2005 could be due to the exhaustion of undiagnosed prevalent cases as a result of screening and/or to a reduction in breast cancer risk as a result of postmenopausal women avoiding hormone replacement therapy following reports from the Women's Health Initiative and earlier investigations that highlighted the associated risks.³³

Although postmenopausal obesity and alcohol consumption can increase breast cancer risk^{34,35} and physical activity can reduce risk,³⁶ the impact of these factors in the Canadian context is not clear.

The breast cancer mortality rate started declining in 1986 at 1.0% per year and accelerated to 2.4% per year after 1994. The lower mortality and improved survival likely resulted from the increasing use of opportunistic mammography testing prior to the establishment of provincial screening programs, the increasing use of hormonal and adjuvant chemotherapy^{37,38} and the shift in clinical practice to breast-conserving surgery and lumpectomy.^{39,40}

Lung cancer

Smoking is a causal factor in the development of lung, oral cavity and larynx

cancers, among others.⁴¹ The effects of smoking tobacco on lung cancer incidence are observed only after a latency period of approximately 25 years.⁴² The prevalence of smoking in Canada has decreased substantially between 1965 and 2007 from 61% to 20% in males and from 38% to 18% in females aged 15 plus years.⁴³ After reaching a peak in 1965, tobacco use dropped in response to the widely publicized negative health effects of cigarette smoking reported by the U.S. Surgeon General.⁴⁴ This resulted in a decline in the male lung cancer incidence rate after this peaked in 1983 and in male mortality rate after this peaked in 1988. By 2007, the male lung cancer incidence rate had fallen to nearly the same level as in 1970.

The lung cancer mortality rate in females, on the other hand, has continued to increase, albeit at a slower pace since the mid-2000s. Smoking rates in females started to decrease about 15 years after those in males, remaining between 37% and 39% until 1979.⁴³ Though there is still an upward trend in lung cancer incidence and mortality rates in Canadian females, encouraging U.S. data show that the female lung cancer death rate in that country is decreasing following a plateau.⁴⁵

Colorectal cancer

Colorectal cancer is associated with several modifiable risks including obesity, physical inactivity, consumption of red and processed meat and smoking.⁴⁶ The prevalence of obesity (i.e. body mass index ≥ 30 kg/m²) in Canadian adults has increased from 13.8% to 23.9% over the 30 years until 2007/2009.^{47,48} Prevalence was higher in females (15.9%) than in males (11.5%) in 1978/1979, but this pattern has now reversed such that slightly more males (24.2%) than females (23.6%) were considered obese in 2007/2009.^{47,48}

The colorectal cancer incidence rate in males has returned to a level seen in the early 1980s, while in females the rate is now lower than that in the 1970s. The decline in the male death rate began in 1988, while in females the rate continued a decline that began before 1970. These differing trends suggest different risk

factors. It has been suggested that increasing use of hormone replacement therapy in women prior to the early 2000s may have contributed to the declining risk of colon cancer in this sex.^{34,49}

The decline in colorectal cancer death rates in both sexes began before the growing uptake of screening through the organized programs largely implemented across Canadian provinces in the past six years. Testing of occult blood in the stools of average-risk individuals aged 50 plus years⁵⁰ and colonoscopy for high-risk individuals have been the predominant approaches for the early detection and removal of pre-cancerous polyps,⁵¹ aimed at lowering colorectal cancer incidence and mortality. Currently, the average participation rate for those aged between 50 and 74 years in provincial organized screening programs is 32.2%.⁵² Greater uptake of screening will likely further reduce colorectal cancer incidence and mortality rates in Canada.

Emerging trends in other cancers

Thyroid cancer

Thyroid cancer has been one of the most rapidly increasing cancers in Canada in recent years.^{1,53} The steep upward trend could be due to the increasing use of diagnostic technologies such as fine-needle aspiration for the detection of subclinical tumours, increased exposure to diagnostic ionizing radiation that could promote the initiation of new tumours, or increased exposure to an as yet unidentified environmental risk factor.^{54,55} Ionizing radiation remains the most established risk factor for thyroid cancer, but mounting evidence points to a possible role of body weight and female reproductive factors, both of which probably operate in carcinogenesis through hormonal pathways. Despite the growing incidence rate, thyroid cancer mortality rates have remained low and the 5-year RSR in both sexes (98%) is the highest of all the major cancers.

Liver cancer

The most common type of primary liver cancer, hepatocellular carcinoma, is associated with low survival and high mortality. Between 1970 and 2007, incidence of

liver cancer in Canada has increased faster in males (3.5% per year) than in females (1.9% per year). Gender differences in incidence may be due to the different distribution of liver cancer risk factors, such as heavy drinking (i.e. above the low-risk drinking guidelines⁵⁶), smoking and hepatitis infection. Population-based estimates show that the heavy drinking rate in Canada has increased between 1989 and 2007 from 18.9% to 25% for males and 7.2% to 9.6% for females.^{57,58}

In developed countries the greatest burden of liver cancer is due to chronic hepatitis C infection rather than hepatitis B virus (HBV) infection, which is more prevalent in other parts of the world.⁵⁹ A link has also been hypothesized between obesity and liver cancer, which is believed to occur through non-alcoholic fatty liver disease.⁶⁰ Such an association places greater importance on the increasing obesity rate in Canada, which has climbed from 14% in the late 1970s to 24% in 2007/2009.^{47,48}

Melanoma

Ultraviolet radiation can cause all forms of skin cancer.⁶¹ Although the increasing incidence of melanoma in Canada could be in part due to better detection,^{62,63} it more likely reflects greater recreational UV exposure from sun and artificial tanning. The prevalence of tanning is about 49% in Canadian women and 28% in Canadian men aged 16 to 24 years according to the 2006 National Sun Survey.⁶⁴

Of all the major cancers, melanoma has had the second greatest increase in mortality rate (after liver cancer in males and lung cancer in females) since 1970. Although the mortality rate in females has remained essentially unchanged since 1983, in males the mortality rate rose by 1.1% per year over a similar time period (1985–2007). The lower 5-year RSR⁶⁵ and the higher proportion of more advanced-stage cases in males⁶⁶ reflects the higher melanoma mortality rate in men compared with women. However, the upward rise in male mortality has been diminishing, possibly due to improved survival through earlier detection and better treatments for melanoma including surgical resection.⁶⁷

Kidney

The reason behind the increasing kidney cancer incidence rate, while not clear, could reflect several changes including the availability of newer diagnostic techniques^{68,69} as well as the increased prevalence of obesity and hypertension, both of which are important risk factors.⁷⁰ In fact, 55% of kidney cancers in Canadian males and 27% in females may be attributable to being overweight or obese.⁷¹

Trends in cancers with decreasing rates

Stomach, cervix, oral, larynx, bladder

Smoking is an important risk factor shared by stomach, oral, larynx, bladder and cervical cancers. The decreasing incidence and mortality trends for these cancers can be largely explained by trends in smoking, which dropped dramatically after 1965 for males and after 1979 for females in Canada.⁴³ Changes in other risk factors have also influenced observed trends. For example, the decline in stomach cancer rates since the 1970s resulted from improvements in diet including higher intakes of fruits and vegetables and lower intake of salt-preserved foods,⁷² and more recently, an increased recognition and treatment of *Helicobacter pylori* bacterium infection, a key stomach cancer risk factor.⁷³

Cervical cancer incidence and mortality rates in Canada continued to decline during the study period due to the widespread use of the Papanicolaou (Pap) test screening introduced in 1949.⁷⁴ As a complement to Pap screening, immunization of females aged 9 to 26 years with a human papillomavirus (HPV) vaccine (approved in Canada in 2008⁷⁵) is expected to further reduce the long-term incidence and mortality rates. With the growing recognition of HPV in the etiology of certain oral cancers, such as those arising in the tonsils and oropharynx,^{76,77} HPV immunization could also help shape future oral cancer trends in Canada.

Limitations

Our analysis had several limitations. First, we attempted to explain observed cancer trends with regard to population-based data on risk factors that are largely

cross-sectional and mostly self-reported. Second, because of data availability, we were able to consider only a subset of modifiable lifestyle factors that influence disease rates. Moreover, we considered only modifiable risk factors that may be etiologically relevant to adult-onset cancers but not those unique to pediatric and adolescent cancers. Third, the data sources, methods for cancer registration, as well as completeness and accuracy of data used for deriving incidence estimates can vary across Canada.¹ Such differences can lead to minor under- and overestimates of disease rates, which are discussed more fully elsewhere.¹ Finally, relative survival estimates for the years 2005 to 2007 may be overestimated due to the necessity of using expected survival data from an earlier time period in their derivation. The effect would likely be greatest for cancers with older case distributions such as prostate cancer.

Conclusion

The downward trends in incidence rates for certain cancers and mortality rates for most cancers in Canada support the success of various strategies including cancer screening, prevention through lifestyle and behavioural changes, and improvements in environmental hygiene. Despite these successes, the need for reinforcing primary prevention remains important as several cancers continue to show stable or rising incidence trends.

Acknowledgements

This work was produced with in-kind contributions from the Canadian Cancer Society, the Public Health Agency of Canada and Statistics Canada. The authors thank the Steering Committee of Canadian Cancer Statistics for their critical review of the manuscript: Heather Chappell (Canadian Cancer Society); Dagny Dryer (PEI Cancer Treatment Centre); Maureen MacIntyre (Cancer Care Nova Scotia); Loraine Marrett (Cancer Care Ontario); Les Mery (Public Health Agency of Canada); and Hannah Weir (U.S. Centers for Disease Control and Prevention).

The Canadian Cancer Registry is maintained by Statistics Canada. It is made up

of data supplied by the provincial and territorial cancer registries whose cooperation is gratefully acknowledged.

Conflict of interest: none.

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