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ORIGINAL PAPER

Cancer in First Nations people living in British Columbia, Canada: an analysis of incidence and survival from 1993 to 2010

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Abstract
Background For First Nations (FN) peoples living in British Columbia (BC), little is known regarding cancer in the population. The aim of this study was to explore cancer incidence and survival in the FN population of BC and compare it to the non-FN population.
Methods All new cancers diagnosed from 1993 to 2010 were linked to the First Nations Client File (FNCF). Age-standardized incidence rates (ASIR) and rate ratios, and 1- and 5-year cause-specific survival estimates and hazard ratios were calculated. Follow-up end date for survival was December 31, 2011 and follow-up time was censored at a maximum of 15 years.
Results ASIR of colorectal cancer (male SRR = 1.42, 95% CI 1.25–1.61; female SRR = 1.21, 95% CI 1.06–1.38) and cervical cancer (SRR = 1.84, 95% CI 1.45–2.33) were higher overall in FN residents in BC, compared to non-FN residents. Incidence rates of almost all other cancers were generally similar or lower in FN populations overall and by sex, age, and period categories, compared to non-FN residents. Trends in ASIR over time were similar except for lung (increasing for FN, decreasing for non-FN) and colorectal cancers (increasing for FN, decreasing for non-FN). Conversely, survival rates were generally lower for FN, with differences evident for some cancer sites at 1 year following diagnosis.
Conclusion FN people living in BC face unique cancer issues compared to non-FN people. Higher incidence and lower survival associated with certain cancer types require further research to look into the likely multifaceted basis for these findings.

Keywords Cancer · Incidence · Survival · First Nations · Canada · British Columbia

Introduction

For First Nations (FN) peoples living in British Columbia (BC), little is known regarding incidence and survival rates of cancer in this population. Such a paucity of data and the subsequent lack of understanding is not unusual in the realm of cancer for FN people in Canada, and indeed, in Indigenous populations on a global scale [1]. Given that research can drive change in areas such as clinical decision making and health policy, it is vital that FN cancer data is collected, analyzed, and becomes part of how we approach cancer care for this distinct population, as has been done for minority groups in other jurisdictions [2]. Contrasting the incidence and outcomes from cancer in population subgroups is important for the understanding of the determinants of the disease and the measurement of equity.

In the Canadian context, comparison of population subgroups can include FN and other Aboriginal groups versus non-Aboriginal Canadians, as well as between Aboriginal populations. However, there is limited and conflicting knowledge when such comparisons in cancer measures have been studied [1]. Previous research has found that Indigenous populations differ across regions in

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their cancer risks and vary in the degree to which they differ from non-Indigenous populations [1, 3]. For example, research in the United States has found that in some regions, Native American populations have higher rates of cancer than non-Native American populations in the same region whilst in other regions it is reversed [1]. These varying results highlight the importance of determining the incidence of various cancers and the subsequent clinical outcomes in order for organizations to adequately serve Indigenous peoples within their jurisdiction. With this level of data, an objective and evidence-based method to tailor health services may be utilized rather than relying on generalization of provincially-based administrative data that to date have not been evaluated through a distinct Indigenous lens.

There are three distinct Indigenous groups in Canada: Inuit, Metis, and FN. There are over 600 recognized FN bands in Canada representing a diverse array of unique cultures, histories and traditions, including language, ceremonies, and healing practices. In BC, there are 203 recognized FN bands, the most of any province in the country. FN bands in BC also have the greatest diversity, with 26 cultural groups and 34 languages (more than 60% of the country's FN languages). In total, 155,000 (3.6% of the BC population) people in BC self-identify as FN, the second highest population amongst Canadian provinces and territories.

Policy and legislation implemented as a result of colonization has created challenges for FN peoples to achieve equitable access to resources for health and wellness, which today includes everything from cancer prevention and treatment, to health service utilization, to the upstream factors of the determinants of health. In Canada, federal legislation defines criteria that individuals with FN heritage must meet to be eligible for Indian Status and therefore receive statutory benefits including some federally funded health care. While healthcare for those with Indian Status lies in the jurisdiction of Canada's federal government, there continues to be a lack of clarity about jurisdictional responsibility for FN healthcare [4]. Indeed, much of the healthcare services for FN are actually provided through the publicly funded healthcare plans in Canada's provinces and territories, including most cancer care, screening, and prevention services. While not in the scope of this paper, the complexity of health care delivery and funding for population subgroups is an important field of study—even within Canada's "universal" health care system.

In order to investigate cancer in FN peoples in BC, a joint project between the First Nations Health Authority (FNHA) and the BC Cancer Agency (BCCA) was carried out to measure the incidence of various cancer types and the subsequent survival rates in the FN population and compare it to the non-FN population of BC. FNHA is the first and only province-wide, population-based health authority in Canada, created specifically for FN through a tripartite partnership between BC FN and the provincial and federal governments [5]. FNHA works to improve health and wellbeing by reforming the way healthcare is delivered to BC FN by promoting partnerships, collaborations, and innovation. BCCA is an agency within the BC Provincial Health Services Authority that manages radiation oncology services, most systemic therapy, and some of the cancer screening services for the province. The remaining cancer screening, systemic therapy, and most surgical oncology is provided in the public health care system outside of the jurisdiction of the BCCA.

Methods

Data was obtained from three sources: (1) British Columbia Cancer Registry (BCCR), a population-based cancer registry for BC residents, (2) Statistics Canada Sub-Provincial Population Projections 2014 (P.E.O.P.L.E 2014) and, (3) 2014 FNHA First Nations Client File (FNCF), a cohort of FN people registered with Indian Status who have lived in BC at some point since 1992, and their children who may be eligible to be registered with Indian Status under the Indian Act. It is important to note that since the inception of the Indian Act, eligibility for Indian Status has changed multiple times, most recently in 2011.

The FNCF is created annually and is the product of a multi-step probabilistic record linkage between an extract of the Indigenous and Northern Affairs Canada (INAC) Indian Registry, the BC Ministry of Health Client Roster and BC Vital Statistics birth and death records. The INAC Indian Registry is used to identify Status FN people, Vital Statistics data is used to confirm births and deaths, including those that are not yet captured due to late reporting within the INAC Indian Registry, and the Client Roster is used to determine BC residency based on BC Ministry of Health service requirements. Therefore, for the purposes of this study, individuals within this FNCF were classified as FN.

Data on BC residents with a diagnosis of invasive cancer or a death from cancer occurring in an 18 year period from January 1st 1993 to December 31st 2010 were extracted from the BCCR. Non-melanoma skin cancers and in situ cases other than bladder were excluded. Cancer diagnoses were classified according to the International Classification of Diseases for Oncology, Third Edition (ICD-O-3) and cancer types were defined as per the Canadian Cancer Statistics cancer definitions [6]. Data extracted from the BCCR included patient and disease characteristics and death information. This was linked to the FNCF using a unique personal health number to identify diagnoses of

cancer in a FN person. The FNCF was also used to provide sex-, age-, and year-specific counts of the eligible FN population which were then subtracted from the analogous BC Statistics Canada population estimates to provide estimates of the non-FN population by sex, age, and year in BC.

Age-standardized cancer incidence rates were calculated using five-year age intervals for males and females separately. Due to small numbers, age-standardized incidence rates (ASIR) by disease site were calculated using 10-year age intervals. Direct standardization was performed to the World-Standard Population [7]. ASIR ratios (SRR) were calculated along with associated 95% confidence intervals for all cancer types [8]. Trends and age-specific incidence rates were examined for selected cancers for each sex; lung, cervical, colorectal and breast for females, and lung, prostate, and colorectal for males. For each sex, all other cancers that were not examined separately were combined into 'other cancers' classification and examined for trends.

Since FN all-cause mortality rates are known to differ from the general population [9], cancer-specific survival was used to represent the survival experience and deaths from cancers where the death was attributed to the cancer according to the defined SEER cause-specific death classification variable. Other deaths were considered censoring events [10]. Cancer-specific survival was calculated for cancer types that were the 10 most common for incidence or mortality, for either female or males and for either FN or non-FN. Follow-up end date for survival was December 31, 2011 (to permit for minimum of 1 year follow-up) and follow-up time was censored at a maximum of 15 years. The Kaplan–Meier method was used to calculate crude 1- and 5-year cause-specific survival estimates, along with the associated variances. Cox proportional models were used to estimate the age-adjusted hazard ratios and 95% confidence intervals for cancer survival for FN versus non-FN. Age group was included in the model. All models were sex-specific.

Results

The FN populations (all ages) according to the FNCF in 1993 and 2010 were 108,721 and 154,870, respectively, an increase in population over the study period of 42%. The non-FN population according to Statistics Canada Sub-Provincial Population Projections 2014 estimates in 1993 and 2010 were 3,459,051 and 4,311,054, respectively, an increase of 25% over this same time period. In the study period, 333,327 cancers were diagnosed and 4,106 (1.2%) occurred in FN people (FN cases) with the remainder, 329,221 (98.8%) occurring in non-FN people. Table 1 shows the number of new cases and sex-specific ASIR and rate ratios by age group, diagnosis period and disease site by sex. For all cancer combined, ASIR were significantly lower for FN compared to non-FN in both females and males. When examined by age (Table 1) the difference between FN and non-FN rates were greatest for the under 50s and the difference decreased and became non-significant for age 70+ and this was consistent for both males and females. For FN females compared to non-FN females, significantly higher ASIR were seen in cervical, colorectal, kidney, and stomach cancers, and significantly lower ASIR were seen in cancers of the bladder (including in situ), brain, lung, ovary, and uterus, as well as for Hodgkin lymphoma, leukemia, melanoma, and non-Hodgkin lymphoma. For FN males compared to non-FN males, ASIR were significantly higher for colorectal cancer and multiple myeloma, and significantly lower for cancers of the bladder, brain, lung, and prostate, as well as for leukemia, melanoma, Hodgkin lymphoma, and non-Hodgkin lymphoma.

When analyzed by diagnosis period, incidence rates were lower in each interval (SRR < 1) in FN compared to non-FN in both sexes (where appropriate) in the following sites: lung, breast, prostate, and 'other cancers' classification and higher (SRR > 1) for colorectal and cervical cancers (Figs. 1, 2). Trends in incidence rates differed in FN and non-FN. Incidence rates of lung cancer converged in both sexes (due in large part to increased incidence rates in the FN population), and rates of colorectal cancer diverged in both sexes, (again due in large part to the increased incidence rates in the FN population). The incidence rates for cervical cancer fluctuated for FN women with recent increased rates while rates for non-FN remain relatively constant. No obvious convergence or divergence is noted in the 'other cancers' category.

When analyzed by age (<50, 50–69 & 70+), rates for FN versus non-FN again displayed consistent patterns (Figs. 3, 4) and were lower at all age groups for FN in both sexes for lung, breast, prostate and 'other cancers' classification and higher for cervical cancer, and colorectal cancer in both men and women. There appeared to be a larger difference between FN and non-FN age-specific incidence rates in men compared to women for colorectal cancer.

For site-specific survival rates, consistent and concerning patterns were seen when comparing FN to non-FN (Table 2). Poorer survival (HR > 1) was seen in the FN population in 10 of the 15 cancer sites examined in women and 10 of the 12 cancer sites examined in men. Significantly elevated hazard rates were seen in the FN population for non-Hodgkin lymphoma for females, and non-Hodgkin lymphoma and colorectal, kidney, oral, and prostate cancers for males.

Table 1 Incidence counts, age-standardized incidence rates and standardized rate ratios (SRRs) by sex, age group within sex, diagnosis period and by disease site for each sex, in FN and non-FN populations 1993–2010

	Incidence		Age-standardized incidence rate (95% CI)		SRR (95% CI)
	FN	Non-FN	FN	Non-FN	
Sex					
Female (F)	2,246	154,598	227.9 (218.2–237.6)	255.7 (254.3–257.1)	0.89 (0.86–0.93)
Male (M)	1,860	174,623	260.4 (248.0–272.8)	310.3 (308.8–311.8)	0.84 (0.80–0.88)
Age group					
F: <50	491	67,342	59.8 (55.2–64.3)	77.6 (76.6–78.6)	0.77 (0.72–0.82)
F: 50–69	1,071	60,868	741.1 (696–786.1)	801.5 (795.1–807.8)	0.92 (0.87–0.98)
F: 70+	684	26,388	1,538.0 (1,401.7–1,674.3)	1,635.9 (1,622.8–1,649.1)	0.94 (0.86–1.02)
M: <50	566	84,850	34.8 (31.2–38.4)	50.6 (49.8–51.4)	0.69 (0.63–0.75)
M: 50–69	926	73,595	804.5 (751.5–857.4)	987.3 (980.2–994.4)	0.81 (0.77–0.87)
M: 70+	375	16,178	2,596.0 (2,381.4–2,810.7)	2,796.2 (2,777.1–2,815.3)	0.93 (0.86–1.01)
Diagnosis period					
F: 1993–1998	533	43,448	226.9 (206.5–247.3)	252.9 (250.4–255.5)	0.90 (0.82–0.98)
F: 1999–2004	712	51,627	221.6 (204.7–238.5)	255.4 (253.0–257.8)	0.87 (0.81–0.93)
F: 2005–2010	1,001	59,523	233.6 (218.9–248.4)	258.6 (256.3–260.9)	0.90 (0.85–0.96)
M: 1993–1998	422	49,308	241.5 (216.8–266.2)	312.4 (309.6–315.3)	0.77 (0.71–0.85)
M: 1999–2004	588	58,468	259.5 (237.4–281.7)	314.8 (312.2–317.5)	0.82 (0.76–0.89)
M: 2005–2010	850	66,847	270.2 (251.3–289.0)	304.5 (302.1–306.9)	0.89 (0.83–0.95)
Females: disease type					
Bladder	28	4,026	9.19 (5.61–12.8)	17.2 (16.6–17.8)	0.53 (0.40–0.71)
Brain	24	2,042	6.55 (3.77–9.34)	13.2 (12.5–13.9)	0.50 (0.37–0.67)
Breast	767	45,478	224.0 (207–241)	240.0 (238–243)	0.93 (0.87–1.01)
Cervical	134	2,810	33.1 (27.0–39.3)	17.2 (16.6–17.9)	1.92 (1.49–2.48)
Colorectal	292	18,226	92.9 (81.5–104)	76.4 (75.1–77.6)	1.22 (1.06–1.39)
Esophagus	14	1,031	4.66 (2.01–7.32)	4.22 (3.93–4.51)	1.11 (0.61–2.02)
Hodgkin lymphoma	8	770	2.17 (0.60–3.73)	6.13 (5.67–6.59)	0.35 (0.23–0.54)
Kidney	74	2,520	21.5 (16.3–26.7)	12.6 (12.0–13.1)	1.71 (1.25–2.34)
Larynx	7	346	2.44 (0.49–4.40)	1.83 (1.63–2.04)	1.33 (0.53–3.36)
Leukemia	40	3,683	12.3 (8.36–16.2)	20.2 (19.4–21.0)	0.61 (0.47–0.78)
Liver	16	846	4.75 (2.28–7.22)	3.94 (3.63–4.24)	1.21 (0.68–2.14)
Lung	212	20,327	71.3 (61.1–81.6)	93.9 (92.5–95.3)	0.76 (0.67–0.86)
Melanoma (skin)	26	5,388	7.72 (4.58–10.8)	30.5 (29.6–31.4)	0.25 (0.21–0.31)
Multiple myeloma	19	1,690	6.23 (3.31–9.14)	7.30 (6.92–7.69)	0.85 (0.55–1.32)
Non-Hodgkin lymphoma	66	6,184	19.5 (14.4–24.6)	29.7 (28.9–30.6)	0.66 (0.53–0.81)
Oral	38	2,486	12.6 (8.25–16.9)	12.6 (12.1–13.1)	1.00 (0.71–1.42)
Ovary	63	5,270	21.2 (15.6–26.8)	27.8 (27.0–28.7)	0.76 (0.60–0.96)
Pancreas	34	3,890	11.7 (7.53–15.9)	15.6 (15.0–16.1)	0.75 (0.55–1.02)
Stomach	49	2,116	16.2 (11.4–21.1)	8.89 (8.47–9.31)	1.82 (1.23–2.72)
Thyroid	62	2,994	16.2 (11.8–20.7)	19.2 (18.4–19.9)	0.85 (0.66–1.09)
Uterus	78	8,608	22.6 (17.3–28.0)	45.1 (44.1–46.1)	0.50 (0.42–0.59)
All other cancers	195	13,867	63.0 (53.5–72.6)	63.2 (61.9–64.4)	1.00 (0.86–1.16)
Males: disease type					
Bladder	29	11,988	13.0 (7.83–18.1)	59.2 (58.0–60.3)	0.22 (0.18–0.26)
Brain	34	2,786	8.95 (5.66–12.2)	18.4 (17.6–19.1)	0.49 (0.38–0.63)
Colorectal	366	21,834	154 (137–171)	111 (109–113)	1.39 (1.22–1.58)
Esophagus	39	2,542	16.6 (11.1–22.1)	13.3 (12.7–13.8)	1.25 (0.86–1.81)
Hodgkin lymphoma	9	976	2.36 (0.70–4.02)	7.46 (6.97–7.95)	0.32 (0.21–0.47)

Table 1 continued

	Incidence		Age-standardized incidence rate (95% CI)		SRR (95% CI)
	FN	Non-FN	FN	Non-FN	
Kidney	70	4,464	29.0 (21.6–36.4)	25.0 (24.2–25.8)	1.16 (0.88–1.53)
Larynx	23	1,757	8.57 (4.86–12.3)	9.82 (9.34–10.3)	0.87 (0.58–1.31)
Leukemia	64	5,302	23.1 (16.6–29.7)	31.8 (30.8–32.7)	0.73 (0.57–0.93)
Liver	41	2,462	15.7 (10.5–21.0)	13.4 (12.8–13.9)	1.18 (0.82–1.69)
Lung	182	23,874	81.5 (68.8–94.1)	123 (121–124)	0.66 (0.59–0.75)
Melanoma (skin)	12	6,354	4.38 (1.60–7.17)	35.9 (35.0–36.8)	0.12 (0.10–0.15)
Multiple myeloma	41	2,123	17.4 (11.7–23.1)	10.8 (10.3–11.2)	1.62 (1.07–2.45)
Non-Hodgkin Lymphoma	82	7,916	27.1 (20.7–33.6)	44.0 (42.9–45.0)	0.62 (0.51–0.74)
Oral	73	4,929	27.7 (20.5–34.8)	28.3 (27.5–29.1)	0.98 (0.76–1.26)
Pancreas	43	3,820	18.0 (12.2–23.7)	19.2 (18.6–19.9)	0.94 (0.68–1.28)
Prostate	424	49,913	209 (188–230)	262 (260–264)	0.80 (0.73–0.87)
Stomach	60	4,007	23.2 (16.9–29.6)	20.5 (19.8–21.2)	1.13 (0.85–1.52)
Testis	58	1,957	12.2 (8.99–15.4)	14.9 (14.2–15.6)	0.82 (0.64–1.04)
Thyroid	24	1,065	7.77 (4.32–11.2)	6.65 (6.24–7.07)	1.17 (0.72–1.89)
All other cancers	186	14,554	71.8 (60.3–83.3)	77.6 (76.3–79.0)	0.92 (0.79–1.08)

Discussion

This study examined cancer incidence and survival in the BC FN population, including comparisons between FN and non-FN in BC. The finding of lower overall cancer incidence in the BC FN population in this study is similar to what was found amongst Indigenous populations in Australia and the USA during similar time periods, but was not the case for Indigenous populations in the Canadian province of Alberta, which borders BC [1]. These varying observations between studies underscore the importance of determining cancer incidence and outcomes by jurisdiction and not relying solely on generalizability. With the paucity of data on cancer within BC's FN population and the heterogeneous findings in this baseline study (some cancers demonstrating significantly greater incidence and/or mortality), more understanding is necessary.

Significantly higher colorectal cancer incidence in the FN population compared to non-FN population was observed in both males and females, with a trend towards increasing incidence in the FN population for both sexes, as compared to no trend in the non-FN population. A higher risk of colorectal cancer in Indigenous people was also observed in studies in Alaska, Alberta, and in an earlier period, 1968–1991, in Ontario [1, 11] and the trend to increasing incidence in FN people was also observed in Manitoba, although no difference in stage of diagnosis was observed [12]. Well accepted risk factors for colorectal cancer include: alcohol consumption, low fiber diet, increased red meat and processed food consumption, lack of physical activity and obesity [13]. Self-reported survey data shows that the majority of FN people living in FN communities in BC over 12 years old do not always or almost always consume a balanced diet, are categorized as being "moderately" physically active, and are more likely to be obese but less likely to consume alcohol (18 years old +) compared to non-FN people [14]. More research is needed to understand the reasons for the increase over time in colorectal cancer incidence in FN people.

This study also observed significantly higher incidence of cervical cancer amongst FN women compared to non-FN women. Again, similar findings have been observed amongst Indigenous women in other Canadian jurisdictions [1, 11, 12]. This may indicate that access to geographically available and/or culturally safe cervical cancer screening services may be a continuing barrier for FN women. Cervical cancer screening rates in BC were much lower in FN women compared to non-FN women between 1990 and 1992 [15], as was also seen in older Indigenous women in other jurisdictions [11]; unfortunately, more recent BC-specific data on cervical cancer screening rates don't exist. However, a commentary in 2012 suggests that screening differences between Indigenous and non-Indigenous Canadians may have been reduced in more recent years [16]. Since cervical cancer screening identifies dysplasia (cancer precursor) that can be treated to prevent invasive malignancy, the continued excess incidence in the FN population in 2005–2010 in our study may indicate that disparities in screening still exist, or that poor access to or utilization of follow-up care for abnormal screening results

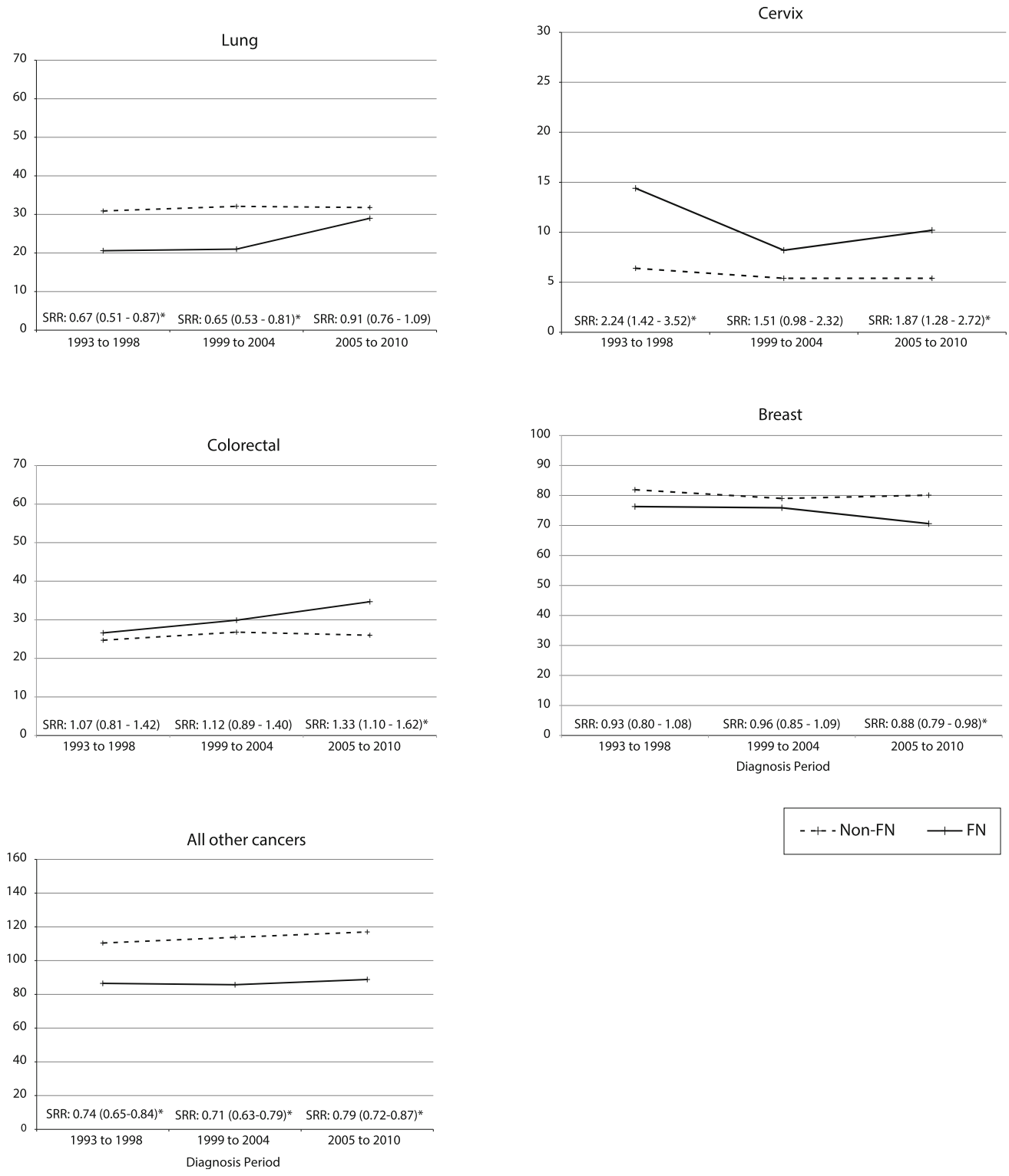

Fig. 1 Age-standardized incidence rates (per 100,000) with SRR (95% CI) for females by period within disease site

is an issue. To better serve the cervical cancer health needs of the FN population, examination of: (1) screening participation, (2) follow-up rates for results and treatment plans, (3) barriers to access, and (4) human papillomavirus (HPV) infection patterns and HPV vaccination rates is needed.

A lower incidence of prostate cancer in the FN males was seen in this study compared to non-FN males. This

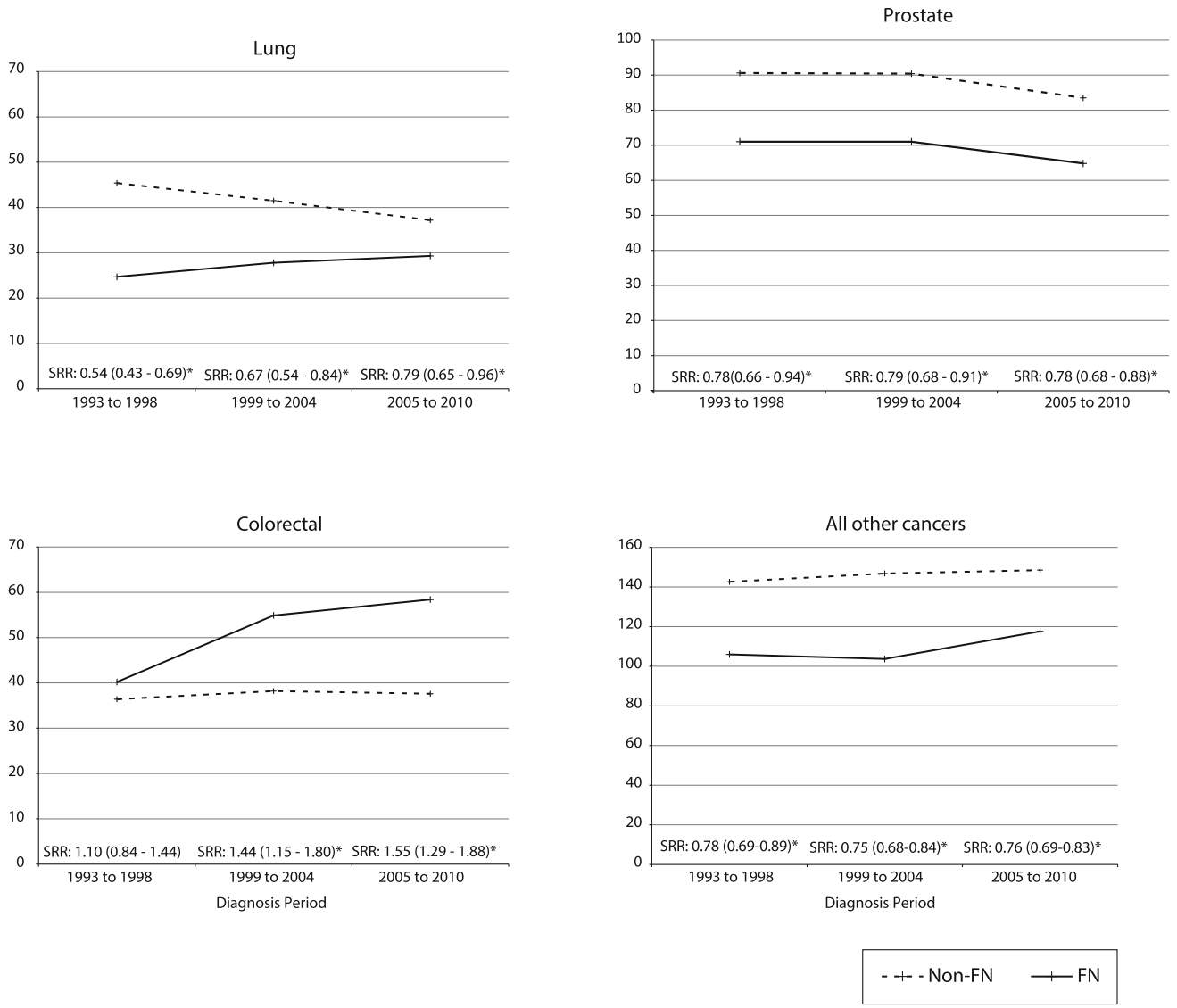

Fig. 2 Age-standardized incidence rates (per 100,000) with SRR (95% CI) for males by period within disease site

may be due to differences in prostate specific antigen (PSA) testing. PSA testing results in the detection of many cases of asymptomatic prostate cancer, but has not been shown to result in a decrease in overall mortality [17]. If the prevalence of PSA testing is higher in the non-FN population, the over diagnosis associated with this testing could lead to a higher incidence and better survival in the non-FN population. The decline in prostate cancer incidence in the later period, 2005–2010 in both FN and non-FN populations may be a result of reduced PSA testing. Given that stage of diagnosis was not available in this study, further investigation is required to understand the lower cause-specific survival rates in FN men with prostate cancer.

Lung cancer incidence was also seen as being significantly lower in FN males compared to non-FN males in this study, despite current prevalence of commercial tobacco use (smoking) in the FN population being double that of the non-FN population [18]. In Canadian males, a drop in smoking began in the mid-1960s. Consequently, a drop in lung cancer incidence was seen about 20 years later [19]. In our data, we see these rates consistently dropping throughout the study period of 1993–2010 in non-FN males. However, in FN males, our study data shows lung cancer rates have been raising slightly over the same time period. Smoking in Canadian females did not begin to drop until the mid-1980s. In this study, lung cancer incidence for non-FN females showed a flat trend across the study period suggesting that we might expect to see a decrease in the non-FN female rates in the coming years. However, a different pattern was seen in FN females, whereby lung cancer incidence was higher in the last period compared to

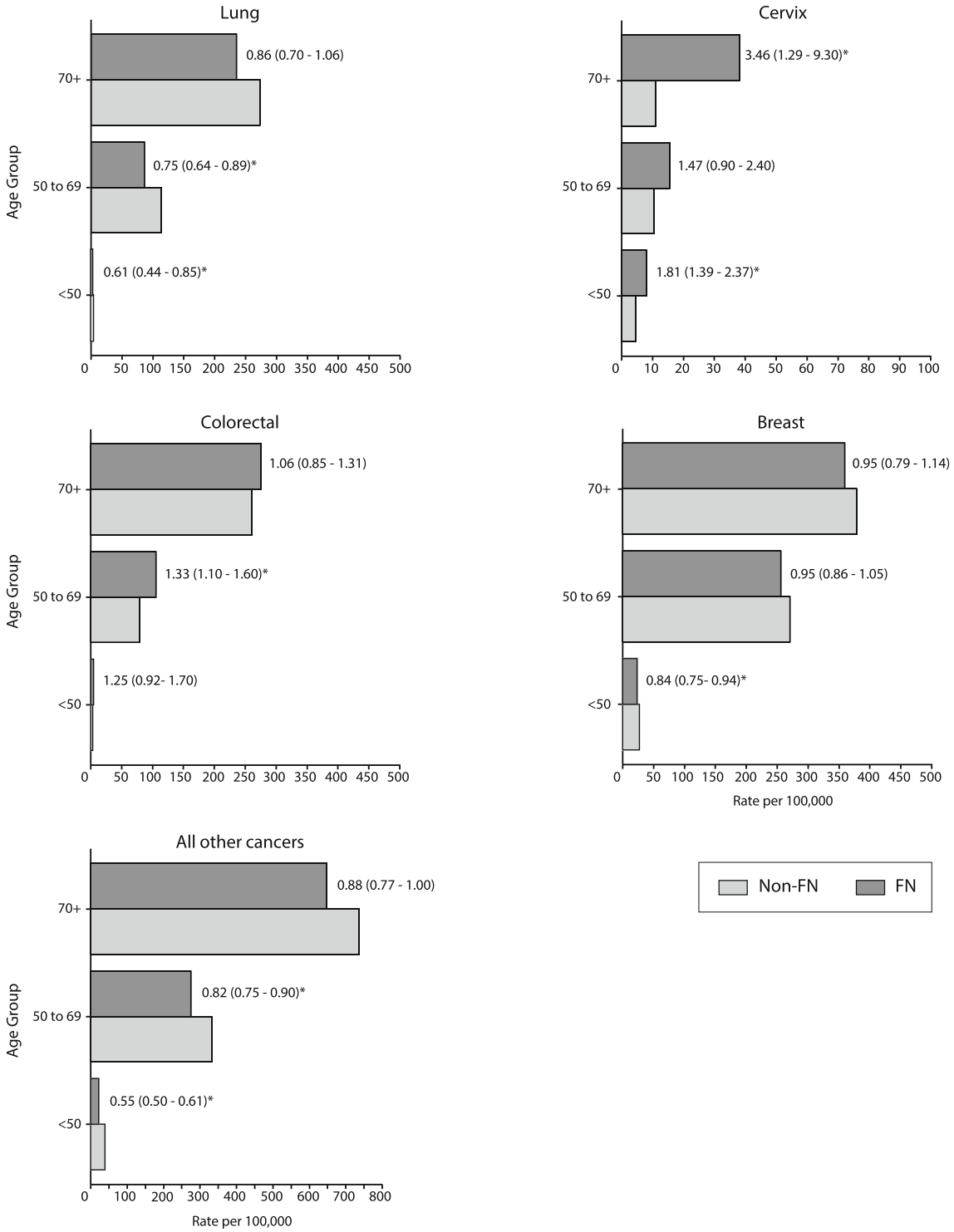

Fig. 3 Age-standardized incidence rates (per 100,000) with SRR (95% CI) for females by age group within disease site

the first period—a concerning rise in a malignancy with poor survival rates. When considering the role of 'smoking' in this particular cancer, it must be understood that natural tobacco is an integral part of FN culture and even considered a sacred medicine with healing benefits in many parts of BC. Commercial tobacco use associated with malignancy (i.e., smoking cigarettes, chewing tobacco, etc.) is not a traditional part of FN culture.

Breast cancer was the most common malignancy diagnosed in this study in both FN and non-FN women, but no

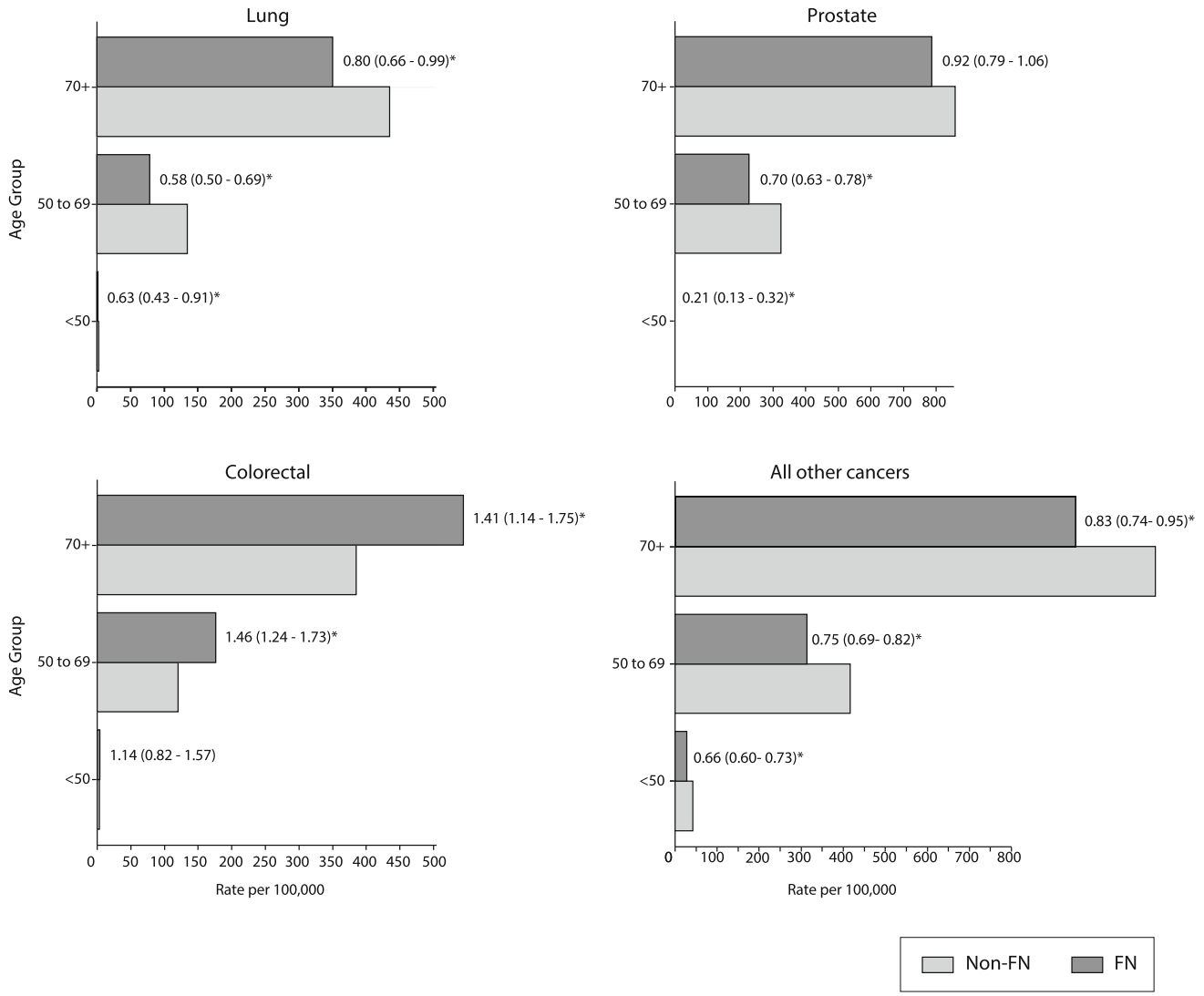

Fig. 4 Age-standardized incidence rates (per 100,000) with SRR (95% CI) for males, by age group within disease site

major differences were observed between the two populations, except a significantly lower breast cancer incidence in the most recent time period. Our findings are similar to those seen in other jurisdictions [1, 20]. Lower number of children and older age at the time of first birth are well known individual risk factors for breast cancer, and based on a Statistics Canada report, FN women on average have higher fertility rates and earlier age of first birth compared to non-FN women [21]. In addition, residence in the higher as opposed to the lowest neighborhood income quintile has been associated with a 15% higher risk of breast cancer in Canadian women and the income in FN populations is known to be lower compared to BC overall [22, 23]. One study demonstrated significantly lower uptake in screening mammography in the lowest neighborhood income quintile compared to the highest [24]. In addition, Canadian studies have shown higher rates of advanced stage breast cancer in FN women [11, 25]. While breast cancer survival in this study appeared similar between FN and non-FN, further research is needed to examine utilization rates and barriers to screening mammography, stage of breast cancer diagnosis, and the subsequent cancer pathways for FN in BC.

Higher incidence rates for the FN population compared to the non-FN population were also observed in this study for less commonly diagnosed cancers. Higher incidence of kidney and stomach cancers was observed in FN females but not in FN males. Higher incidence of multiple myeloma was observed in FN males but not FN females. Further research is needed to better understand these findings, and to determine if causal factors can be identified.

Poorer survival was seen in the FN population in 10 of the 15 cancer sites examined in women and 10 of the 12

Table 2 Observed 1-year and 5-year cause-specific survival and age-adjusted cause-specific hazard ratio (95% CI) by disease site in FN and non-FN populations, 1993–2010

	FN incidence	1-year age-standardized cause-specific survival		5-year age-standardized cause-specific survival		Age-standardized HR (95% CI)
		FN	Non-FN	FN	Non-FN	
Female: disease type						
Breast	767	0.97 (0.95–0.98)	0.96 (0.96–0.97)	0.83 (0.80–0.86)	0.85 (0.85–0.86)	1.14 (0.96–1.35)
Cervical	134	0.89 (0.82–0.93)	0.89 (0.88–0.90)	0.73 (0.64–0.80)	0.73 (0.71–0.75)	1.19 (0.84–1.67)
Colorectal	292	0.82 (0.77–0.86)	0.78 (0.78–0.79)	0.57 (0.50–0.63)	0.57 (0.56–0.57)	1.16 (0.97–1.39)
Esophagus	14	0.57 (0.28–0.78)	0.36 (0.33–0.39)	0.22 (0.04–0.48)	0.12 (0.10–0.14)	0.74 (0.39–1.40)
Kidney	74	0.81 (0.69–0.88)	0.75 (0.74–0.77)	0.70 (0.57–0.81)	0.59 (0.57–0.61)	0.84 (0.54–1.29)
Leukemia	40	0.63 (0.42–0.78)	0.68 (0.67–0.70)	0.45 (0.25–0.63)	0.52 (0.50–0.54)	1.58 (0.93–2.68)
Lung	212	0.41 (0.34–0.48)	0.41 (0.41–0.42)	0.18 (0.13–0.24)	0.17 (0.16–0.17)	1.08 (0.92–1.26)
Myeloma	19	0.78 (0.51–0.91)	0.74 (0.72–0.76)	0.45 (0.19–0.67)	0.33 (0.30–0.35)	0.66 (0.34–1.27)
Non-Hodgkin lymphoma	66	0.78 (0.66–0.86)	0.80 (0.79–0.81)	0.55 (0.41–0.67)	0.63 (0.62–0.65)	1.63 (1.12–2.37)
Oral	38	0.89 (0.73–0.96)	0.83 (0.81–0.84)	0.58 (0.35–0.76)	0.64 (0.62–0.66)	1.00 (0.57–1.77)
Ovary	63	0.78 (0.65–0.87)	0.76 (0.75–0.77)	0.41 (0.28–0.53)	0.42 (0.41–0.44)	1.14 (0.82–1.59)
Pancreas	34	0.24 (0.11–0.39)	0.17 (0.16–0.18)	0.09 (0.02–0.21)	0.04 (0.03–0.04)	0.92 (0.64–1.31)
Stomach	49	0.33 (0.20–0.47)	0.44 (0.42–0.47)	0.19 (0.09–0.31)	0.23 (0.21–0.25)	1.33 (0.96–1.84)
Thyroid	62	1.00 (NE–NE)	0.96 (0.96–0.97)	0.96 (0.86–0.99)	0.95 (0.94–0.95)	1.33 (0.49–3.61)
Uterus	78	0.95 (0.86–0.98)	0.93 (0.92–0.93)	0.77 (0.64–0.86)	0.82 (0.82–0.83)	1.45 (0.86–2.46)
Male: disease type						
Colorectal	366	0.78 (0.73–0.82)	0.81 (0.81–0.82)	0.51 (0.45–0.57)	0.57 (0.56–0.57)	1.30 (1.12–1.52)
Esophagus	39	0.38 (0.23–0.53)	0.38 (0.36–0.40)	0.14 (0.04–0.32)	0.11 (0.10–0.13)	1.03 (0.72–1.49)
Kidney	70	0.78 (0.65–0.87)	0.75 (0.74–0.76)	0.51 (0.37–0.64)	0.59 (0.58–0.61)	1.49 (1.05–2.12)
Leukemia	64	0.70 (0.54–0.82)	0.72 (0.70–0.73)	0.50 (0.33–0.65)	0.55 (0.54–0.57)	1.39 (0.91–2.14)
Lung	182	0.30 (0.24–0.37)	0.35 (0.35–0.36)	0.17 (0.11–0.24)	0.13 (0.12–0.13)	1.12 (0.95–1.32)
Myeloma	41	0.80 (0.63–0.90)	0.73 (0.71–0.75)	0.37 (0.20–0.54)	0.32 (0.30–0.35)	0.90 (0.59–1.37)
Non-Hodgkin lymphoma	82	0.68 (0.56–0.77)	0.77 (0.76–0.78)	0.50 (0.37–0.61)	0.58 (0.57–0.59)	1.53 (1.10–2.11)
Oral	73	0.73 (0.60–0.82)	0.82 (0.80–0.83)	0.40 (0.27–0.52)	0.59 (0.57–0.60)	1.93 (1.40–2.66)
Pancreas	43	0.17 (0.07–0.29)	0.18 (0.17–0.19)	0.04 (0.00–0.14)	0.04 (0.03–0.05)	1.11 (0.81–1.52)
Prostate	424	0.96 (0.94–0.98)	0.97 (0.97–0.97)	0.85 (0.81–0.89)	0.89 (0.88–0.89)	1.52 (1.20–1.92)
Stomach	60	0.50 (0.36–0.62)	0.45 (0.43–0.46)	0.21 (0.10–0.34)	0.19 (0.18–0.20)	0.97 (0.72–1.31)
Thyroid	24	0.96 (0.74–0.99)	0.93 (0.92–0.95)	0.83 (0.54–0.94)	0.88 (0.85–0.90)	2.11 (0.85–5.22)

cancer sites examined in men. This result could be caused by a combination of differences in underlying risk of each specific cancer, access to or utilization of screening programs and primary care and/or, high quality, timely, appropriate and effective cancer treatment. The ongoing impacts of colonization, including the relationship between cultural safety and utilization of health care services for FN in BC is also an important consideration and may be a factor in the poorer survival of the FN population compared to the non-FN population seen in this study. The appearance of survival differences by 1 year following diagnosis suggest that later stage at presentation may be a major contributor as early deaths are primarily due to more advanced cancers. Further investigation is required to better understand these results.

Differences in 5-year survival between Indigenous and non-Indigenous persons who completed the 1991 Canadian Long Form census (approximately 20% of the British Columbia and Canadian population) were examined in a recent Canadian study [26]. The results for lung, prostate and breast cancer differed from those observed in our BC-specific study, suggesting regional variation in survival differences between Canadian provinces. This comparison again supports the need for monitoring the cancer burden in

the FN population within individual jurisdictions in order to meet local Indigenous population cancer control needs.

Strengths and limitations

This study has several major strengths. We report cancer incidence and survival from cancer in the FN population in BC over an 18-year period based on over 4,000 cancer diagnoses using the FNCF, the best available population cohort used to support decision making and policy development at the population level. The FNCF is created through a series of logic-based data linkage processes that are meant to identify individuals who are highly likely to be FN with Status living in BC.

Another strength includes the use of disease-specific survival to measure survival following cancer diagnosis, which is generally not used when comparing survival across populations, but has the potential advantage of reduced confounding with respect to risk factors related to cancer and non-cancer causes of death. Also, in this study, death certification is undertaken within the general BC registration system common to both FN and non-FN.

The study also has a number of limitations. The FNCF only attempts to capture those with Status and those who may be eligible for Status, and does not attempt to include all Indigenous people living in BC, including those without Status or who are Inuit or Metis. Therefore, the results may not be generalizable to the entire Indigenous population in BC. This can also make comparisons between studies using other means of identifying FN populations difficult to interpret. In addition, information on stage of disease at diagnosis was not available in the BCCR nor was information regarding utilization of screening for breast, colorectal or cervical cancer, which would have greatly improved our interpretation of the findings. However, despite these limitations, this study highlights significant disparities and trends in common cancers between FN and non-FN in BC which may mirror gaps in healthcare across the spectrum from health care status, access to culturally safe health services, and upstream social determinants of health.

Conclusions

We have found that colorectal and cervical cancer incidence rates are significantly higher in FN residents in BC. Rates of lung cancer are lower in the FN population but are rising and may soon overtake declining rates in the non-FN population. Survival from cancer was lower for the FN population compared to non-FN for almost all cancer types considered. These findings suggest that a multifactorial and complex basis for these disparities is involved in cancer outcomes and that further studies along the entire spectrum of cancer care—from wellness and prevention, to diagnosis and treatment—are required. It is also clear that research in these areas needs to be conducted within jurisdictions to account for the heterogeneity of Canada's Indigenous populations.

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