Cancer incidence among First Nations adults in Canada: follow-up of the 1991 Census Mortality Cohort (1992–2009)

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Abstract

Objectives Estimate site-specific cancer incidence rates for a wide range of cancers in First Nations adults in Canada, and compare these with rates in non-Aboriginal adults.

Methods Responses from persons aged 25 and older to the 1991 Long Form Census were linked to national mortality and cancer databases. First Nations- and non-Aboriginal-specific incidence rates were age-standardized to the world standard population. The sex- and site-specific relative risks (RR) of cancer in First Nations compared to those in non-Aboriginal adults were estimated with Poisson regression. Results were stratified by residence on-reserve (all cancers combined) and region of Canada (four most common cancer sites).

Results Compared to non-Aboriginal adults, First Nations had higher incidence of colon and rectum, kidney, cervix, and liver cancers and lower incidence of prostate, breast, bladder, uterus, ovary, and brain cancers, as well as non-Hodgkin lymphoma, leukemia, and melanoma. First Nations women additionally had higher incidence of stomach, gallbladder, and laryngeal cancers and lower incidence of thyroid cancers compared to non-Aboriginal women. The higher relative incidence of stomach and gallbladder cancers was observed only among First Nations adults who reported living on-reserve. Incidence of lung cancer was similar for First Nations and non-Aboriginal adults nationally, though variation by region of Canada was observed.

Conclusion First Nations people in Canada have disproportionately high rates of certain cancers, providing evidence to support public health policy and programming. More research is needed to identify factors contributing to the significantly lower incidence observed for various cancer types. Novel methods for studying disparities in cancer incidence among First Nations people are required to support ongoing cancer control planning and advocacy.

Résumé

Objectifs Estimer les taux d'incidence de certains types précis de cancer chez les adultes des Premières nations au Canada, et les comparer aux taux des adultes non autochtones.

Méthodes Les réponses de sujets de 25 ans et plus au questionnaire détaillé du recensement de 1991 ont été liées aux bases de données nationales sur la mortalité et le cancer. Les taux d'incidence propres aux Premières nations et aux personnes non autochtones ont été normalisés selon l'âge par rapport à la population mondiale standard. Les risques relatifs (RR) du cancer propres au type de cancer et au sexe du patient des Premières nations ont été estimés en les comparant à ceux des adultes non autochtones à l'aide de la régression de Poisson. Les résultats ont été stratifiés par résidence dans les réserves (tous cancers confondus) et par région du Canada (pour les quatre types de cancer les plus courants).

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Résultats Par comparaison avec les adultes non autochtones, les Premières nations présentaient des taux d'incidence plus élevés de cancers du côlon et du rectum, du rein, du col de l'utérus et du foie et des taux d'incidence plus faibles de cancers de la prostate, du sein, de la vessie, de l'utérus, de l'ovaire et du cerveau ainsi que de lymphome non hodgkinien, de leucémie et de mélanome. Les femmes des Premières nations présentaient aussi des taux d'incidence plus élevés de cancers de l'estomac, de la vésicule biliaire et du larynx et des taux d'incidence plus faibles de cancer de la thyroïde par rapport aux femmes non autochtones. L'incidence relative plus élevée de cancers de l'estomac et de la vésicule biliaire chez les adultes des Premières nations a été observée seulement chez les adultes qui ont déclaré vivre dans les réserves. L'incidence du cancer du poumon chez les Premières nations et chez les adultes non autochtones du pays était similaire, bien qu'un écart ait été observé dans certaines régions.

Conclusion Les Premières nations du Canada présentent des taux démesurément élevés de certains cancers. Ces données permettront de prendre des décisions éclairées en matière de politiques et de programmes de santé publique. Des travaux de recherche supplémentaires devront être menés pour cerner certains facteurs contribuant à l'incidence significativement plus faible observée pour plusieurs types de cancers. De nouvelles méthodes doivent être élaborées pour étudier les disparités en matière d'incidence du cancer chez les membres des Premières nations afin de contribuer aux activités continues de planification et de promotion de la lutte contre le cancer.

Keywords First Nations · Cancer incidence · Canada

Mots-clés Premières nations · Incidence du cancer · Canada

Introduction

Three groups are collectively recognized by Canada's Constitution Act of 1982 as the “aboriginal peoples of Canada”, who are the “Indian [now referred to as “First Nations”], Inuit, and Métis peoples” (Government of Canada 1982). First Nations are the largest of these three groups, with a diverse population of over 950,000 self-identified First Nations people, over 600 recognized First Nations bands, and over 60 First Nations languages (Canada 2017). The majority of First Nations people live in Ontario (24%) and the western provinces of British Columbia (18%), Alberta (14%), Manitoba (13%), and Saskatchewan (12%). The 2006 Canadian census estimated 40% of First Nations people lived on-reserve (land held by the Crown for the “use and benefit of [First Nations]”) (Government of Canada 1985) and 21% of the off-reserve population lived in rural areas (Statistics Canada 2008).

First Nations people experience many health inequities relative to non-Indigenous people in Canada, including higher rates of avoidable mortality (Park et al. 2015) and lower overall life expectancy (Tjepkema et al. 2009). These inequities can in part be explained by the determinants of Indigenous peoples' health, including poverty, racism, and a history of colonialism, that continue to influence their ability to achieve and maintain good health (Greenwood et al. 2015). Additionally, First Nations people living in rural areas and on-reserve face unique challenges in accessing and using health services, which can contribute to poorer health outcomes (Shah et al. 2003; Ministerial Advisory Committee on Rural Health 2002).

Cancer is the second leading cause of death among First Nations women and ranks third among First Nations men (Tjepkema et al. 2009). Our previous report noted poorer cancer survival for First Nations compared to non-Aboriginal adults in Canada for most cancer types (Withrow et al. 2017). Cancer patterns between First Nations and non-Aboriginal adults in Canada are understudied, primarily due to a lack of ethnic identifiers in cancer registries. There have been no national studies of cancer incidence in First Nations people to date. The few previous studies of cancer incidence in First Nations people were conducted provincially or regionally, all of which indicated different patterns compared to their non-Aboriginal counterparts. For example, incidence rates were generally lower compared to the non-Aboriginal population for cancers of the breast (McGahan et al. 2017; Decker et al. 2016; Marrett & Chaudhry 2003) and prostate (McGahan et al. 2017; Marrett & Chaudhry 2003; Moore et al. 2015) and elevated for cancers of the cervix (McGahan et al. 2017; Marrett & Chaudhry 2003; Moore et al. 2015; Decker et al. 2015) and gallbladder (Marrett & Chaudhry 2003), while time trends demonstrated rapidly rising rates of colorectal cancer (McGahan et al. 2017; Decker et al. 2016; Marrett & Chaudhry 2003), eventually equaling or surpassing those in the non-Aboriginal population. None of these studies examined cancer incidence by residence on-reserve nor did they examine the role of socio-economic factors such as income or rurality.

The objectives of this study were to examine national site-specific incidence for a wide range of cancer types among adults reporting First Nations ancestry in the 1991 Long Form Census and to evaluate their risk of cancer relative to

that of non-Aboriginal adults. We also sought to explore potential effect modification by residence on-reserve and confounding by income and rurality.

Methods

Cohort

The 1991 Canadian Census Health and Environment Cohort (previously known as the 1991 Census Mortality Cohort), created by Statistics Canada, has been described in detail elsewhere (Wilkins et al. 2008; Peters et al. 2013). Briefly, to form the cohort, respondents to the 1991 Long Form Census aged 25 and older on June 4, 1991 (census day) were probabilistically linked to non-financial tax summary files for 1990 and 1991 tax years to add personal identifiers not stored with the census. Those found to have a tax record in one of these years were subsequently matched to the Canadian Mortality Database (1992–2009), the Canadian Cancer Registry (1992–2009), and tax summary files that included name changes, deaths, and updated postal codes up until 2009 (Peters et al. 2013). The final cohort is composed of 2.7 million individuals who represent a 15% sample of the Canadian population aged 25 and older on census day (Wilkins et al. 2008).

The Canadian Mortality Database is an administrative database maintained by Statistics Canada containing demographic and medical (cause of death) information for all deaths from all provincial and territorial vital statistics registries (Statistics Canada. Vital Statistics - Death database. [Internet] 2016). The Canadian Cancer Registry is an amalgamation of the 13 provincial/territorial cancer registries and includes all cancers diagnosed in Canadian residents since 1992 (Statistics Canada. Canadian Cancer Registry (CCR). [Internet] 2016).

Definitions

Diagnosis of cancer

Invasive cancers of any type diagnosed from 1992 to 2009 among individuals aged 25 to 99 at diagnosis were ascertained through linkage with the Canadian Cancer Registry. Cancers were grouped according to the SEER Site Recode for ICD-O-3 (National Cancer Institute 2003). Multiple invasive cancers in the same individual were counted according to the International Agency for Research on Cancer multiple primary rules (IARC Working Group 2005). A small number of individuals with a death date prior to their diagnosis date were excluded (< 1% of First Nations and non-Aboriginal people). All cancers with case counts greater than or equal to 30 in First

Nations (both sexes combined and sex-specific cancers) were included in the site-specific analysis.

Date of death

Date of death was ascertained using a derived variable based on date of death as reported in the Canadian Mortality Database, tax summary files, and the Canadian Cancer Registry.

Census-derived variables

Persons were classified as First Nations or non-Aboriginal based on questions pertaining to Aboriginal ancestry in the 1991 Long Form Census. Respondents were asked to select the cultural group(s) to which their ancestors belonged with no limit on the number of ancestries that could be reported. In this study, a person was considered to have First Nations ancestry if they reported North American Indian ancestry only and/or were registered under the Indian Act and/or were a member of an Indian Band or First Nation. The development of this definition was informed by comparing responses to the identity and ancestry concepts in later censuses, whereby most of the individuals meeting the above-described definition of First Nations based on ancestry also reported First Nations identity. A person was considered to be of non-Aboriginal ancestry if they were not First Nations (as defined above), or Métis (those who reported two or fewer ancestries, one of which was Métis), or Inuit (those reporting Inuit ancestry only).

Area-level income adequacy quintiles were constructed by Statistics Canada using a ratio of total income from all sources combined across all members of an economic family unit to low-income cutoffs from the 1991 Census Dictionary (Statistics Canada 1991). Respondents were ranked according to the low-income cutoff ratio, and quintiles of population were constructed within each census metropolitan area (CMA), census agglomeration (CA), or rural area. Rurality was a dichotomous area-level variable defined by Statistics Canada as the population living in towns and municipalities outside the commuting zone of larger urban centres (i.e., the non-CMA/CA population) (du Plessis et al. 2001). Region was determined based on province of residence on census day. Residence on-reserve was assigned based on census subdivision of residence (Statistics Canada 1991). Newfoundland and Labrador, Nova Scotia, New Brunswick, and Prince Edward Island were grouped as “Atlantic Provinces,” while the Yukon, Northwest Territories, and Nunavut were grouped as “Northern Territories” due to small numbers of First Nations people in these two parts of the country.

Statistical analysis

Person-years at risk for incidence of “all sites combined” were accumulated from January 1, 1992, to the first of date of death or end of study period (December 31, 2009). For site-specific cancer incidence, follow-up was censored at the date of diagnosis of that cancer if one was diagnosed. Incidence rates were age-standardized to the world standard population (Parkin et al 1992). Relative risk (RR) comparing the rate of cancer in First Nations to that in non-Aboriginal adults was estimated using Poisson regression models controlling for age and sex (where applicable). Results were further stratified for First Nations by residence on-reserve. Exploratory analyses were performed to assess (1) any variation in relative risk by region for the four most common cancer sites and (2) the effect of controlling for income and rurality. Results of these exploratory analyses are presented in supplementary figures and tables. All analyses were performed using SAS version 9.4 (2014, SAS Institute Inc.).

Results

The 62,360 adults aged 25–99 reporting First Nations ancestry were more likely than non-Aboriginal adults to be female, aged less than 45 years; reside in western provinces, rural areas, and on-reserve; and have lower education and income (Table 1). Over the study period (1992–2009), 5080 cancers were diagnosed in First Nations adults over 1.04 million person-years. The most commonly diagnosed cancers, in order of absolute number of cases, were those arising in the colon and rectum ($n = 810$), female breast ($n = 785$), lung ($n = 775$), prostate ($n = 520$), and kidney ($n = 150$).

Cancer incidence for all sites combined was significantly lower for First Nations men ($RR = 0.89$, $95\%CI = 0.86–0.93$) and similar for First Nations women ($RR = 0.98$, $95\%CI = 0.94–1.02$) compared to their non-Aboriginal counterparts (Table 2). First Nations men and women had significantly higher incidence than non-Aboriginal men and women for cancers of the colon and rectum ($RR_{men} = 1.14$, $95\%CI = 1.04–1.25$; $RR_{women} = 1.34$, $95\%CI = 1.22–1.47$), kidney ($RR_{men} = 1.66$, $95\%CI = 1.43–1.94$; $RR_{women} = 2.22$, $95\%CI = 1.88–2.68$), and liver ($RR_{men} = 1.50$, $95\%CI = 1.11–2.01$; $RR_{women} = 2.86$, $95\%CI = 1.98–4.13$). First Nations women additionally had higher incidence of cancers of the cervix ($RR = 2.36$, $95\%CI = 2.02–2.75$), stomach ($RR = 1.62$, $95\%CI = 1.27–2.06$), gallbladder ($RR = 3.46$, $95\%CI = 2.43–4.92$), and larynx ($RR = 1.67$, $95\%CI = 1.03–2.70$). The incidence of gallbladder cancer was also considerably higher in First Nations men compared to non-Aboriginal men, though not statistically significant ($RR = 1.86$, $95\%CI = 0.99–3.48$).

First Nations men had significantly lower incidence of cancer of the prostate ($RR = 0.74$, $95\%CI = 0.68–0.80$) compared to non-Aboriginal men, and First Nations women had significantly lower incidence of cancers of the breast ($RR = 0.85$, $95\%CI = 0.79–0.91$), uterus ($RR = 0.61$, $95\%CI = 0.51–0.73$), ovary ($RR = 0.79$, $95\%CI = 0.65–0.97$), and thyroid ($RR = 0.55$, $95\%CI = 0.43–0.71$). First Nations adults of both sexes had lower incidence of non-Hodgkin lymphoma ($RR_{men} = 0.72$, $95\%CI = 0.61–0.86$; $RR_{women} = 0.62$, $95\%CI = 0.50–0.76$), bladder cancer ($RR_{men} = 0.41$, $95\%CI = 0.32–0.53$; $RR_{women} = 0.34$, $95\%CI = 0.21–0.54$), leukemia ($RR_{men} = 0.58$, $95\%CI = 0.44–0.77$; $RR_{women} = 0.57$, $95\%CI = 0.41–0.79$), brain cancer ($RR_{men} = 0.56$, $95\%CI = 0.38–0.81$; $RR_{women} = 0.51$, $95\%CI = 0.34–0.77$), and melanoma ($RR_{men} = 0.15$, $95\%CI = 0.09–0.24$; $RR_{women} = 0.22$, $95\%CI = 0.15–0.33$).

In general, subgroup analyses of First Nations living on or off-reserve showed similar patterns of cancer incidence relative to non-Aboriginals, with a few notable exceptions (Table 3): incidence rates for cancers of the lung and larynx were similar to those for non-Aboriginal adults among First Nations living on-reserve, but significantly higher among those living off-reserve ($RR_{lung} = 1.16$, $95\%CI = 1.05–1.29$; $RR_{larynx} = 1.98$, $95\%CI = 1.43–2.76$); First Nations living on-reserve had significantly higher incidence of cancers of the stomach ($RR = 1.29$, $95\%CI = 1.05–1.57$) and gallbladder ($RR = 3.95$, $95\%CI = 2.84–5.49$) and significantly lower incidence of thyroid cancer ($RR = 0.45$, $95\%CI = 0.32–0.62$), while those living off-reserve had incidence rates similar to those in non-Aboriginals for these three cancers.

The relative risk of lung cancer varied by region (Fig. 1): compared to non-Aboriginal adults, incidence was significantly higher for First Nations adults living in the Atlantic Provinces ($RR = 1.49$, $95\%CI = 1.15–1.94$) and in Ontario ($RR = 1.30$, $95\%CI = 1.15–1.55$), while in British Columbia, it was significantly lower ($RR = 0.67$, $95\%CI = 0.55–0.82$). Lung cancer incidence was also higher in Quebec and Saskatchewan, and lower in Manitoba, although differences were not statistically significant in these provinces. Colon and rectum cancer incidence was significantly higher in First Nations in the Northern Territories ($RR = 1.40$, $95\%CI = 1.02–1.82$), Ontario ($RR = 1.40$, $95\%CI = 1.16–1.57$), and British Columbia ($RR = 1.43$, $95\%CI = 1.24–1.64$). Colon and rectum cancer incidence was also higher for First Nations in Alberta, though the difference was not statistically significant. For all other regions, incidence rates for cancers of the colon and rectum were similar among First Nations and non-Aboriginal adults. First Nations had lower incidence rates for breast and prostate cancer in most regions.

Adjusting for income and rurality lowered the relative risk for cancers of the lung and oral cavity and pharynx for First

Table 1 Demographic characteristics of cohort members, aged 25–99, by ethnicity

Characteristic	Non-Aboriginal		First Nations	
	<i>n</i> = 2,652,770	Percent	<i>n</i> = 62,360	Percent
Sex				
Female	1,332,225	50.2	35,045	56.2
Male	1,320,545	49.8	27,315	43.8
Age at entry (1991)				
25–34	738,335	27.8	26,595	42.6
35–44	695,985	26.2	17,295	27.7
45–54	456,715	17.2	9610	15.4
55–64	344,905	13.0	5065	8.1
65–74	268,165	10.1	2635	4.2
75+	148,665	5.6	1160	1.9
Region of residence (1991)				
Northern Territories (YK, NWT, NT)	15,080	0.6	3420	5.5
BC	315,290	11.9	12,240	19.6
AB	236,200	8.9	6520	10.5
SK	92,580	3.5	7650	12.3
MB	105,085	4.0	10,670	17.1
ON	982,175	37.0	11,030	17.7
QC	687,485	25.9	7775	12.5
Atlantic Provinces (NB, NS, PEI, NFLD)	218,875	8.3	3055	4.9
Highest level of schooling (1991)				
No high school	907,200	34.2	35,465	56.9
High school—with/without trades certificate	968,885	36.5	19,135	30.7
Postsecondary non-university	413,065	15.6	6295	10.1
University degree	363,620	13.7	1465	2.3
Income quintile (1991)				
1 (lowest)	439,965	16.6	25,055	40.2
2	510,690	19.3	15,720	25.2
3	550,505	20.8	10,800	17.3
4	570,155	21.5	7150	11.5
5 (highest)	581,450	21.9	3635	5.8
Rurality (1991)				
Rural	600,715	22.6	47,550	76.3
Urban	2,052,055	77.4	14,810	23.7
Residence on-reserve (1991)				
No	2,648,975	99.9	23,985	38.5
Yes	3795	0.1	38,375	61.5

Nations men and women, those living on- and off-reserve, and in every region (for lung cancer, numbers too small to examine oral cavity and pharynx by region) compared to their non-Aboriginal counterparts (Supplementary Tables 1 and 2, and Supplementary Fig. 1). This suggests that the higher proportion of First Nations people living in low-income and/or rural areas may in part explain their higher risk for cancers of the lung, oral cavity, and pharynx. For all other cancer sites, adjusting for income and rurality had very little or no impact on relative risk.

Discussion

Overall, cancer incidence was not significantly different between First Nations women and non-Aboriginal women and all-cancer incidence was lower for First Nations men. First Nations adults in Canada had higher incidence of colon and rectum, kidney, cervical, and liver cancers and lower incidence of prostate, female breast, bladder, uterus, ovary, and brain cancers as well as non-Hodgkin lymphoma, leukemia, and melanoma compared to non-

Table 2 Age-standardized cancer incidence (per 100,000 person-years) among First Nations adults and non-Aboriginal adults, relative risk and 95% confidence intervals, 1992–2009, by sex and cancer site, Canada

Site	Men				Women			
	N*	NA ASR [†]	FN ASR [†]	RR [‡] (95% CI)	N*	NA ASR [†]	FN ASR [†]	RR [‡] (95% CI)
All sites	2290	560.7	506.0	0.89 (0.86–0.93)	2790	457.4	458.1	0.98 (0.94–1.02)
Colon and rectum	400	75.4	88.6	1.14 (1.04–1.25)	410	50.3	69.2	1.34 (1.22–1.47)
Female breast	—	—	—	—	785	146.0	122.8	0.85 (0.79–0.91)
Lung	395	89.8	89.7	0.95 (0.87–1.05)	380	57.5	67.1	1.09 (0.99–1.20)
Prostate	520	157.3	124.5	0.74 (0.68–0.80)	—	—	—	—
Kidney	150	18.0	30.9	1.66 (1.43–1.94)	125	9.4	21.3	2.22 (1.88–2.68)
NHL	105	30.8	22.3	0.72 (0.61–0.86)	75	20.6	12.2	0.62 (0.50–0.76)
Stomach	80	14.9	15.9	1.07 (0.86–1.33)	65	6.4	10.0	1.62 (1.27–2.06)
Cervix	—	—	—	—	165	11.0	27.7	2.36 (2.02–2.75)
Oral cavity and pharynx	70	16.9	15.2	0.86 (0.70–1.07)	40	6.7	6.9	1.01 (0.76–1.33)
Uterus	—	—	—	—	105	28.4	16.2	0.61 (0.51–0.73)
Pancreas	50	12.7	11.3	0.87 (0.67–1.13)	50	9.9	8.5	0.87 (0.67–1.14)
Ovary	—	—	—	—	85	16.5	14.2	0.79 (0.65–0.97)
Multiple myeloma	40	7.4	8.4	1.04 (0.76–1.41)	35	4.7	6.4	1.18 (0.85–1.64)
Liver	45	5.8	9.8	1.50 (1.11–2.01)	25	1.6	4.7	2.86 (1.98–4.13)
Thyroid	15	4.9	3.5	0.72 (0.47–1.13)	50	15.3	8.7	0.55 (0.43–0.71)
Bladder	45	26.5	10.4	0.41 (0.32–0.53)	15	7.3	2.8	0.34 (0.21–0.54)
Leukemia	30	8.9	6.1	0.58 (0.44–0.77)	30	5.6	4.9	0.57 (0.41–0.79)
Esophagus	40	7.4	8.3	1.12 (0.84–1.51)	15	2.1	2.4	1.34 (0.85–2.12)
Brain	25	10.0	5.2	0.56 (0.38–0.81)	20	6.9	3.8	0.51 (0.34–0.77)
Gallbladder	10	1.1	2.3	1.86 (0.99–3.48)	35	1.5	5.7	3.46 (2.43–4.92)
Larynx	30	7.0	6.3	0.99 (0.73–1.36)	15	1.4	1.9	1.67 (1.03–2.70)
Melanoma	10	17.9	2.1	0.15 (0.09–0.24)	20	15.2	2.9	0.22 (0.15–0.33)

Abbreviations: FN ASR First Nations age-standardized incidence rate, NA ASR non-Aboriginal age-standardized incidence rate, RR relative risk, CI confidence interval, NHL non-Hodgkin lymphoma

*Number of cancers in First Nations

[†] Age-standardized to the World Standard Population (Parkin et al 1992)

[‡] Adjusting for age. Values in bold represent a statistically significant difference

Aboriginal adults. First Nations women additionally had higher incidence of stomach, gallbladder, and laryngeal cancers and lower incidence of thyroid cancers compared to non-Aboriginal women. The higher relative incidence of stomach and gallbladder cancers was observed only among First Nations adults who reported in 1991 that they were living on-reserve. Although nationally the incidence of lung cancer was similar for First Nations and non-Aboriginal adults, there was variation by 1991 region of residence.

The higher incidence of certain cancers observed for First Nations adults in Canada (i.e., colorectal, kidney, liver, cervical, gallbladder) is similar to what has been reported for Indigenous populations in other high-income countries, such as Australia, New Zealand, and the US (Moore et al. 2015). These findings are also consistent with results from regional studies of First Nations in Canada (McGahan et al. 2017;

Decker et al. 2016; Marrett & Chaudhry 2003; Moore et al. 2015; Decker et al. 2015).

Cancer is a complex disease with many different potential causes—lifestyle, societal, and genetic—which vary by cancer type. Higher rates of specific cancers in First Nations relative to non-Aboriginal Canadians are likely explained by a combination of these factors.

Smoking is associated with an increased risk for many cancer types, including cancers of the lung, oral cavity and pharynx, stomach, liver, pancreas, colon and rectum, bladder, cervix, and kidney (World Cancer Research Fund/American Institute for Cancer Research (AICR) 2007). Obesity is also a major risk factor for several cancer types, with convincing evidence of an association with cancers of the kidney, colon and rectum, pancreas, liver, esophagus, and breast (post-menopausal) and probable evidence for gallbladder, ovary, and advanced prostate cancer (World Cancer Research Fund/

Table 3 Age-standardized cancer incidence (per 100,000 person-years) among First Nations adults by cancer site and residence on-reserve, relative risk compared to non-Aboriginal adults and 95% confidence intervals, 1991–2009, Canada

Site	NA ASR [†]	First Nations living on-reserve*			First Nations living off-reserve*		
		N [‡]	FN ASR [†]	RR [§] (95% CI)	N [‡]	FN ASR [†]	RR [§] (95% CI)
All sites	514.3	3105	470.5	0.92 (0.89–0.96)	1975	494.6	0.99 (0.95–1.04)
Colon and rectum	63.9	500	76.6	1.20 (1.10–1.31)	310	79.7	1.29 (1.16–1.44)
Female breast	146.0	450	118.7	0.81 (0.74–0.89)	340	128.7	0.90 (0.81–1.00)
Lung	73.3	455	71.6	0.95 (0.87–1.04)	320	86.6	1.16 (1.05–1.29)
Prostate	157.3	345	127.8	0.75 (0.68–0.83)	175	117.3	0.72 (0.63–0.83)
Kidney	13.9	190	27.2	2.04 (1.78–2.33)	90	22.8	1.63 (1.34–1.98)
NHL	26.1	105	15.6	0.62 (0.52–0.74)	75	18.4	0.76 (0.62–0.94)
Stomach	10.8	90	13.2	1.29 (1.05–1.57)	50	11.4	1.22 (0.93–1.60)
Cervix	11.0	115	32.4	2.82 (2.35–3.38)	50	20.7	1.69 (1.28–2.23)
Oral cavity and pharynx	11.9	60	9.0	0.80 (0.64–1.00)	55	13.0	1.11 (0.86–1.43)
Uterus	28.4	80	19.7	0.75 (0.61–0.93)	30	11.2	0.40 (0.29–0.57)
Pancreas	11.6	65	9.8	0.87 (0.69–1.10)	35	9.7	0.85 (0.63–1.16)
Ovary	16.5	55	14.4	0.80 (0.61–1.04)	35	13.8	0.79 (0.57–1.09)
Multiple myeloma	6.1	50	7.7	1.17 (0.89–1.53)	25	6.5	0.98 (0.66–1.45)
Liver	3.7	40	6.4	1.58 (1.16–2.15)	30	7.6	2.31 (1.65–3.25)
Thyroid	10.3	30	5.4	0.45 (0.32–0.62)	35	8.1	0.80 (0.60–1.08)
Bladder	16.9	25	4.4	0.28 (0.20–0.38)	35	9.0	0.61 (0.45–0.83)
Leukemia	7.4	35	5.5	0.50 (0.38–0.67)	25	5.4	0.71 (0.52–0.97)
Esophagus	4.8	30	4.9	1.08 (0.79–1.49)	20	5.2	1.33 (0.90–1.96)
Brain	8.6	25	3.8	0.46 (0.31–0.67)	25	5.6	0.67 (0.45–1.00)
Gallbladder	1.3	40	5.6	3.95 (2.84–5.49)	5	1.8	1.10 (0.49–2.45)
Larynx	4.2	20	2.5	0.67 (0.44–1.02)	25	6.3	1.98 (1.43–2.76)
Melanoma	16.9	20	3.1	0.19 (0.13–0.28)	10	1.8	0.18 (0.11–0.30)

Abbreviations: FN ASR First Nations age-standardized incidence rate, NA ASR non-Aboriginal age-standardized incidence rate, RR relative risk, CI confidence interval, NHL non-Hodgkin lymphoma

*At the time of the census (1991)

[†] Age-standardized to the World Standard Population (Parkin et al 1992)

[‡] Number of cancers in First Nations

[§] Adjusting for age and sex (where applicable). Values in bold represent a statistically significant difference

American Institute for Cancer Research (AICR) 2007). Because cancers included in this study were diagnosed up to 25 years ago, and because there is often a lag between a harmful exposure and cancer diagnosis, our results reflect historical rather than contemporary prevalence of risk factors such as smoking and obesity, for which limited data exist. In one study, results of the 1997 First Nations and Inuit Regional Health Survey were compared with the 1994 National Population Health Survey (general Canadian population), demonstrating age-adjusted daily smoking prevalence was twice as high in First Nations people living on-reserve compared to non-Aboriginal people (First Nations and Inuit Regional Health Survey National Steering Committee 1999). More recent national estimates indicate that the prevalence of smoking was twice as high and obesity 1.6 times higher among First Nations living off-reserve compared to the non-

Aboriginal population (Gionet & Roshanafshar 2013), and may be even higher among First Nations living on-reserve (though there is no age-adjusted comparison) (First Nations Information Governance Centre (FNIGC) 2012), suggesting a high burden of tobacco- and obesity-related cancers in future. For example, Inuit living in Nunavut have had very high prevalence of smoking going back at least to 1991 (69% daily smokers) (Bougie & Kohen 2017) and, in 2000–2008, had the highest recorded lung cancer incidence rates in the world (Young et al. 2016).

Unlike for other cancer types, the relative risk for lung cancer in First Nations decreased considerably after adjusting for income and rurality, suggesting that living in low income and/or rural areas are independently strongly associated with their higher lung cancer risk. This is consistent with literature demonstrating significantly higher rates of lung cancer among

Fig. 1 Relative risk of cancer in First Nations compared to non-Aboriginal adults adjusting for age and sex (where applicable), 1992–2009, by site and region, Canada

disadvantaged populations (those with low compared to high income and education as well as those employed in unskilled jobs or with no occupation, compared to managerial occupations) (Mitra et al. 2015).

Cervical cancer incidence and mortality in Canada has declined significantly over time as a result of widespread improvements in cervical screening participation with the Papanicolaou (Pap) test (Dickinson et al. 2012). Still, our study shows relatively high rates of cervical cancer in First Nations women, consistent with other regional studies of Aboriginal populations in Canada and internationally (McGahan et al. 2017; Marrett & Chaudhry, 2003; Moore et al. 2015; Decker et al. 2015). Historically, some evidence suggests prevalence of cervical screening among First Nations was lower than that among non-First Nations in Canada (Hislop et al. 1996); however, more recent studies suggest cervical screening uptake among First Nations is improving, with estimates approaching or meeting those for the general population (Withrow et al. 2014; Demers et al. 2012). Given fairly consistent evidence of increased burden of cervical cancer among Indigenous populations, research to better understand their participation in screening and follow-up of abnormal tests, as well as barriers and limitations of cervical screening implementation and/or human papillomavirus vaccination uptake, is warranted.

Environmental exposures and their association with cancer risk are often priority concerns cited by First Nations communities (Environmental Stewardship Unit 2009; Sharp et al. 2016). There is limited evidence evaluating the link between environmental factors and cancer risk specifically among First Nations

communities in Canada, though some First Nations communities have partnered with CAREX Canada, a national evidence-based carcinogen exposure surveillance program, to develop environmental resources (e.g., briefing notes, fact sheets, interactive maps) to assess and address exposures to carcinogens in the local environment (CAREX Canada 2017).

The pattern of incidence for certain cancers may be partly explained by genetic factors. For example, the high incidence of gallbladder cancer observed in this and at least one other study (Marrett & Chaudhry 2003) is consistent with high incidence of gallbladder disease more generally in Aboriginal people in Canada (Young & Roche 1990) and in American Indian communities in the US (Everhart et al. 2002) for which these studies have suggested a potential role of genetic susceptibility. Similarly, the significantly lower rates of bladder cancer in First Nations compared to non-Aboriginal adults might be partly explained by the presence of protective genes in the First Nations population, especially considering smoking is a major cause of this cancer (World Cancer Research Fund/American Institute for Cancer Research (AICR) 2007) and studies have shown the age-adjusted prevalence of daily smoking is at least two times higher among First Nations people, as described earlier.

Strengths and limitations

This was an inclusive cohort of First Nations across Canada, not limited to a given province, registration under the Indian Act, or residence on- vs. off-reserve. Using the Long Form Census

allowed for the consideration of income and rurality, and for the identification of First Nations according to self-reported ancestry. However, the ideal classification of First Nations is one based on self-identity, which was only introduced on the 1996 census. An advantage of this cohort being initiated over 20 years ago is that it has sufficient power to measure cancer burden in First Nations across regions or on-reserve. However, our results by residence on-reserve and region of Canada do not take into account population mobility, and since residence was only ascertained at the time of the census, use of these variables results in misclassification. We did not measure trends over time since this is a study of a closed-cohort, where no persons enter after 1991 and the cohort ages throughout the follow-up period, limiting our ability to compare different time periods. Our data sources did not include behavioural risk factors for cancer (e.g., smoking, alcohol, physical inactivity) and we were consequently unable to explore their role in the observed disparities. Income was measured at the aggregate (rather than individual) level and rurality was dichotomized, not taking into account potential differences between rural and remote areas. As a result, we cannot definitively conclude that there does not remain residual confounding by these factors.

Conclusion

First Nations have higher incidence for a number of cancer types, including cancers of the colon and rectum, kidney, liver, and cervix. These results provide evidence to support culturally appropriate risk-reduction strategies to reduce the burden of potentially avoidable cancers, emphasizing tobacco prevention and cessation, healthy body weight, and regular participation in cancer screening. Given the increased incidence of cancer observed in this study, and poorer survival observed in our earlier study of the same First Nations cohort (Withrow et al. 2017), efforts to improve access to cancer treatments including traditional healing methods are also warranted. This study also found significantly lower incidence for various cancer types among First Nations people, for which additional research is warranted to investigate possible contributing factors. Regional variation in the relative risk of lung and colon and rectum cancers supports the need for a tailored approach to priority setting and planning in each jurisdiction. For example, Ontario has an Aboriginal cancer strategy including focuses on cancer screening and prevention (Aboriginal Cancer Control Unit 2015) and has documented policy recommendations for reducing the risk of chronic diseases such as cancer in First Nations, Inuit, and Métis populations (Cancer Care Ontario 2016). Our limited knowledge and understanding of cancer risk and burden in First Nations people in Canada stems from a lack of Aboriginal identifiers in Canadian cancer registries. Ongoing monitoring of the burden of cancer among First Nations people in

Canada, including in various subregions, is required. This pursuit will be supported by the development, in partnership with First Nations people, of more comprehensive information systems that include ethnic identifiers. Such endeavours must encompass the First Nations principles of Ownership, Control, Access and Possession (OCAP®) (First Nations Information Governance Centre 2018).

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval The study was approved by the research ethics board of the University of Toronto (protocol 29323). This manuscript was reviewed by staff of the Assembly of First Nations. Their feedback was incorporated in the final published version.

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