An investigation of cancer incidence in a First Nations community in Alberta, Canada, 1995–2006

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Abstract

Objective: To determine colorectal and overall cancer incidence as part of a three-pronged investigation in response to the concerns of a First Nations community in Alberta, Canada, located close to sulfur-rich natural gas installations, and to determine whether the incidence of cancers observed in this reserve was higher than expected.

Methods: A population dataset with information identifying First Nations status and band affiliation was linked to the Alberta Cancer Registry to determine cancer incidence cases between 1995 and 2006 for on- and off-reserve study populations. Using indirect standardized incidence ratios, observed cancer incidence cases for the study populations were compared with cases expected based on three separate reference populations.

Results: Observed colorectal and overall cancer incidence cases within the First Nations community were not higher than expected. Cervical cancer incidence cases, however, were higher than expected for on- and off-reserve populations; public health measures designed to address this risk have been implemented and on-going surveillance of cancer incidence in the community will be maintained.

Keywords: *neoplasms; Alberta; Indians, North American; epidemiological methods; First Nations*

Introduction

Hydrogen sulfide (H_2S) is a colourless gas with a distinctive rotten egg smell. It occurs naturally in geothermal environments such as volcanoes and hot springs, and is emitted by pulp and paper installations, sewage treatment plants, and natural gas and petroleum operations.[1] Oil and gas fields in Alberta contain a high concentration of sulfur-rich natural gas, known as sour gas.[1,2]

While low-level frequent or persistent exposures to H_2S have been shown to cause headache, sleep disturbance or nausea,[3,4] no long-term adverse health effects, including increased risk of cancer, have been documented.[2,3,5-7] In addition, H_2S has not been identified as a carcinogen by any internationally recognized cancer, environmental or occupational health agency; the carcinogenicity of H_2S has not been reviewed by the International Agency of Research on Cancer;[8,9] and H_2S has not been assigned a carcinogenicity designation by the American Conference of Governmental Industrial Hygienists.[9] Further, in response to southern Alberta residents' concerns about chronic exposure to sour gas emissions, Spitzer et al.[10] evaluated multiple health measures such as mortality rate, reproductive problems, respiratory function and incidence of cancer; the study found that the residents did not experience significantly more adverse health outcomes compared to an unexposed population.[10] A simultaneous cohort study of these residents examining the rates of all cancer and specific cancer sites found no statistically significant differences compared to the reference populations.[11]

The band leadership and administration of a First Nations community in Alberta, Canada, reported concerns about the health effects of sulfur-rich natural gas installations located near their reserve. One of the concerns was a perceived increase in cancer incidence within the community; specifically, it was reported that six of seven children within one family (all under 30 years of age) had been diagnosed with colorectal cancer. As a result, First Nations and Inuit Health (FNIH), Health Canada, Alberta Region launched a three-pronged field investigation that focused on the potential familial colorectal cancer cluster—defined as a greater than expected number of cancer cases in a group of people, geographic area and time.[12] This included a familial cancer cluster investigation by a Field Epidemiologist from the Public Health Agency of Canada, an environmental risk assessment by Environmental Health Officers with Health Canada and a cancer incidence investigation by the Surveillance Department of the Alberta Cancer Board.

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The objectives of this study are to contribute to the three-pronged colorectal cancer cluster investigation by identifying the number of colorectal cancer cases (colon, rectum and rectosigmoid) diagnosed within this particular First Nations on-reserve community located close to sulfur-rich natural gas installations, and to address community concerns about overall cancer incidence in the area by determining whether the incidence of cancers observed in this First Nations reserve was higher than expected.

Methods

To maintain anonymity, as part of a publication agreement, the First Nations community involved in this study is referred to as "X" and the Regional Health Authority (RHA) within which the X First Nations reserve is located is referred to as "Y." Further measures have been taken throughout this report to prevent the identification of both the First Nations community and individuals.

Data sources and population

An Alberta Cancer Board representative accompanied a Field Epidemiologist (from the Public Health Agency of Canada) and Environmental Health Officers (from Health Canada) to the X First Nations community as part of the three-pronged approach to the investigation. The X First Nations leadership and administration were consulted about the selection of the study population and analysis plan; in support of the analytic process, a letter was sent to Alberta Health and Wellness (AHW) by an X First Nations band council member permitting the release of information identifying First Nations individuals to the Alberta Cancer Board. This Alberta Health Care Insurance Plan (AHCIP) administrative data contained First Nations status indicators and population estimates for all study and reference groups up until 2007; the dataset did not contain easily decipherable X First Nations band membership identifiers prior to 1995, limiting the timeframe that X First Nations individuals could be identified to 1995 to 2007.

Two study populations and three reference populations were used; the first study population included all X First Nations band members living in the province of Alberta, and the second restricted the X First Nations band member population to those living on-reserve. The reference populations included all First Nations in Alberta, the residents of the Regional Health Authority in which the X First Nations reserve is located (RHA Y) and the overall Alberta population. All persons living in the province of Alberta, including all First Nations individuals, were identified by age, sex, year and residential postal code information from Alberta Health and Wellness data. The associated Regional Health Authority was defined by the RHA designation within the population dataset. All First Nations individuals were identified by First Nations status; band affiliation was established through X First Nations band number designation within the population dataset. Those X First Nations individuals living on-reserve were identified by X First Nations band number and one of two residence postal codes covering an area around the reserve.

For each study and reference population (all X First Nations, on-reserve X First Nations, all First Nations in Alberta, Regional Health Authority Y and all of Alberta), yearly estimates were averaged over a 12-year period between 1995 and 2006. Population averages within each group were used to calculate indirect standardized incidence ratios (ISIR). In addition, we calculated the proportion of the averaged study and reference populations within three age groups (0-19, 20-54 and 55 + years) and by sex, and determined the proportion of the total population distributed across three age groups (0-19, 20-54 and 55 + years) for each year between 1995 and 2006 for the overall X First Nations population in Alberta, as well as the population of X First Nations individuals living on-reserve.

Cancer case counts

Population estimates from the AHCIP dataset and cancer incidence data from the Alberta Cancer Registry (ACR) were used to identify the number and type of cancer cases diagnosed in X First Nations band members. At the time of the study, 2006 was the last complete year for data entry of cancer cases housed within the ACR and therefore marked the most recent boundary for the study period. The healthcare numbers (obtained from the AHCIP dataset) of all individuals identified as X First Nations at any point between 1995 and 2007 were linked with the ACR. On- or off-reserve designation for cancer cases was based on postal code within the ACR at the time of diagnosis. Cases diagnosed in individuals living in RHA Y were identified in the ACR by RHA designation at the time of diagnosis.

To identify the number of colorectal cancer cases accounted for in the familial cancer cluster investigation, we extracted colorectal cancer cases (ICD-O-3* topography codes C18, colon; C19, rectosigmoid; and C20, rectum) diagnosed in identified X First Nations individuals during any year in the ACR (not restricted to the study period) and all other invasive cancer incident cases, excluding non-melanoma skin cancer, diagnosed between 1995 and 2006 in identified X First Nations individuals from the ACR.

Indirect standardized incidence ratios

To determine whether or not cancer incidence was higher than expected in the X First Nations reserve, the number of observed cancer cases in this population was compared to the expected number of cancer cases for all cancer cases combined and for specific cancer types observed over the study time period (1995 to 2006). The number of cancer cases observed between 1995 and 2006 in all X First Nations band members in Alberta and X First Nations band members living on-reserve were compared with an expected number of cases that were adjusted by age (by five-year age group), sex and year using incidence data from two different reference populations for all X First Nations (all First Nations in Alberta and the general Alberta population) and from three different reference populations for on-reserve X First Nations

* *International Classification of Diseases for Oncology, 3rd Edition*

(all First Nations in Alberta, RHA Y and the general Alberta population). The X First Nations study population was excluded in all calculations of the expected number of cases based on any reference population. In order to determine whether the results were statistically significant, we calculated a 95% confidence interval (CI) for each ISIR using methods described by Liddell.[13]

Results

Population

The average population distribution between 1995 and 2006 for all X First Nations band members in Alberta, on-reserve X First Nations band members, all First Nations in Alberta and the general Alberta population is shown in Table 1. To protect confidentiality, only inexact population numbers for all and on-reserve X First Nations are shown and the population of Regional Health Authority (RHA) Y was omitted. For each population group, the sex distribution was approximately 1:1. The percentage of the total population aged 55 years and over was 20.1% and 18.6% for RHA Y and Alberta general populations, respectively. First Nations populations had a lower proportion of those over the age of 55: 4.8%, 6.0% and 6.5% for all X First Nations band members, on-reserve X First Nations band members and all First Nations in Alberta, respectively.

Further analysis of the population distribution between 1995 and 2006 in on-reserve and all X First Nations revealed that the proportion of people within the youngest age group, 0 to 19 years, decreased over the study period while the proportion between 20 and 54 years old increased (not shown). For on-reserve X First Nations, the proportion of the population over 55 years of age increased from 4.5% in 1995 to 7.1% in 2006; a similar increase was noted in the percent of X First Nations people in this age group across the province, rising from 3.6% to 6.0% over the same time period.

Cancer case counts

The extraction of all colorectal cancer cases from the Alberta Cancer Registry (ACR) for individuals identified as X First Nations in the AHCIP administrative dataset at any point between 1995 and 2007 revealed fewer than five colorectal cancer cases, all diagnosed in individuals over the age of 25 years; only one of the observed colorectal cancer cases corresponded to the original six cases reported. All six incident cases, however, were followed-up as part of the familial cancer cluster investigation and will be reported on separately.

The total number of X First Nations cancer cases diagnosed between 1995 and 2006 was 25: 14 on-reserve and 11 off-reserve. There were 11 cases of cervical cancer diagnosed in X First Nations women between 1995 and 2006; for all other cancer types, there were fewer than five cases diagnosed over the study period. A list of cancer sites observed in the study population between 1995 and 2006 is shown in Table 2.

TABLE 1
Population distribution by age group and sex for various populations, Alberta, 1995–2006

Population category	Average population[a]	Age group (%)			Sex (%)	
		0-19 years	20-54 years	55+ years	F	M
X First Nations all Alberta	< 2 000	52.5	42.7	4.8	49.9	50.1
X First Nations on reserve[b]	< 1 000	53.4	40.6	6.0	49.8	50.2
All First Nations Alberta	138 079	43.9	49.6	6.5	49.9	50.1
Regional Health Authority Y	—	30.4	49.5	20.1	50.1	49.9
Alberta general population	2 993 731	28.5	52.9	18.6	50.1	49.9

Abbreviations: F, female; M, male.

[a] Average population over the 12-year study period is based on administrative data provided by Alberta Health and Wellness. To protect confidentiality, inexact population numbers for all X First Nation and on-reserve X First Nation individuals are provided, and the population of Regional Health Authority Y was omitted.

[b] On-reserve is based on postal codes that cover a larger area than the reserve and, therefore, might include individuals living in the postal code area but not on-reserve.

Indirect standardized incidence ratios

All X First Nations in Alberta. The observed number of colorectal cancer cases for both men and women in all X First Nations in Alberta were slightly lower than the number expected based on all First Nations in Alberta (ISIR = 0.77, 95% CI: 0.02-4.31) and the general Alberta reference populations (ISIR = 0.72, 95% CI: 0.02-4.01), though neither observation was statistically significant (Table 2). However, a significantly higher number of cervical cancer cases was observed in X First Nations women compared to all First Nations women in Alberta (ISIR = 11.43, 95% CI: 5.71-20.45) and the general female population of Alberta (ISIR = 20.03, 95% CI: 10.00-35.85).

A higher number of retroperitoneal and peritoneal cancers was also noted for men and women of X First Nations (ISIR = 24.44, 95% CI: 2.96-88.28 compared with all First Nations; ISIR = 20.42, 95% CI: 2.47-73.75 compared with the general population of Alberta). Upon review, the cancer cases observed within this category included cases of cyst adenocarcinoma (cancer of the glandular tissue) and of sarcoma (cancer of the soft/connective tissue), and varied by location of residence; they were diagnosed in individuals living on-reserve and off-reserve.

A higher number of overall cancer cases was observed in all X First Nations men and women in Alberta compared to the number of cases expected based on all First Nations in the province (ISIR = 1.36, 95% CI: 0.88-2.01) and the general population of Alberta (ISIR = 1.06, 95% CI: 0.69-1.57); however, these results were not statistically significant.

On-Reserve X First Nations. The number of colorectal cancer cases observed between 1995 and 2006 for on-reserve X First Nations men and women was slightly higher than expected based on all First Nations (ISIR = 1.08, 95% CI: 0.03-6.01), but slightly lower than expected based on RHA Y (ISIR = 0.94; 95% CI: 0.02-5.25) and all of Alberta (ISIR = 0.98, 95% CI: 0.02-5.45); none were statistically significant (Table 3).

There was a statistically significant higher number of observed cervical cancer cases

TABLE 2

Indirect standardized incidence ratio[a] (ISIR) for all X First Nation band members using all First Nations in Alberta and the general Alberta population as reference populations, Alberta, 1995–2006

	All First Nations in Alberta		General Alberta population	
Cancer site	ISIR	95% CI	ISIR	95% CI
Mouth, other and unspecified	23.01	0.58 - 128.21	28.46	0.72 - 158.55
Colorectal	0.77	0.02 - 4.31	0.72	0.02 - 4.01
Biliary tract, other and unspecified	7.68	0.19 - 42.77	14.39	0.36 - 80.18
Bronchus/lung	0.86	0.10 - 3.09	0.86	0.10 - 3.10
Retroperitoneum & peritoneum	24.44	2.96 - 88.28	20.42	2.47 - 73.75
Cervix uteri	11.43	5.71 - 20.45	20.03	10.00 - 35.85
Ovary	2.92	0.07 - 16.29	2.33	0.06 - 13.00
Prostate gland	1.13	0.14 - 4.08	0.72	0.09 - 2.60
Meninges & CNS	5.17	0.63 - 18.67	2.69	0.33 - 9.73
Leukemia	1.20	0.03 - 6.71	0.93	0.02 - 5.16
Multiple myeloma & plasmacytoma	4.48	0.11 - 24.95	4.87	0.12 - 27.12
All cancer excluding NMSC	1.36	0.88 - 2.01	1.06	0.69 - 1.57

Abbreviations: CI, confidence interval; CNS, central nervous system; ISIR, indirect standardized incidence ratio; NMSC, non-melanoma skin cancer.

[a] Adjusted by age, sex and year. Excludes non-melanoma skin cancer (NMSC). The number of observed and expected cases has been removed to maintain confidentiality; there were a total of 25 cases combined, 11 cases of cervical cancer, and fewer than 5 cases of every other cancer type over the study period.

TABLE 3

Indirect standardized incidence ratio[a] (ISIR) for on-reserve X First Nation band members[b] using all First Nations in Alberta, Regional Health Authority Y and the general Alberta population as reference populations, Alberta, 1995–2006

	All First Nations in Alberta		Regional Health Authority Y		General Alberta population	
Cancer site	ISIR	95% CI	ISIR	95% CI	ISIR	95% CI
Mouth, other and unspecified	0.00	-	0.00	-	0.00	-
Colorectal	1.08	0.03 - 6.01	0.94	0.02 - 5.25	0.98	0.02 - 5.45
Biliary tract, other and unspecified	10.89	0.28 - 60.69	24.07	0.61 - 134.13	19.79	0.50 - 110.26
Bronchus/lung	1.14	0.14 - 4.12	1.18	0.14 - 4.24	1.16	0.14 - 4.18
Retroperitoneum & peritoneum	17.79	0.45 - 99.10	11.92	0.30 - 66.41	14.70	0.37 - 81.89
Cervix uteri	6.68	1.82 - 17.11	9.90	2.70 - 25.35	12.17	3.32 - 31.16
Ovary	4.20	0.11 - 23.39	3.14	0.08 - 17.50	3.46	0.09 - 19.25
Prostate gland	1.61	0.19 - 5.80	1.07	0.13 - 3.85	0.99	0.12 - 3.58
Meninges & CNS	4.40	0.11 - 24.54	1.93	0.05 - 10.77	2.10	0.05 - 11.70
Leukemia	0.00	—	0.00	—	0.00	—
Multiple myeloma & plasmacytoma	6.00	0.15 - 33.43	8.24	0.21 - 45.89	6.55	0.17 - 36.48
All cancer excluding NMSC	1.09	0.60 - 1.83	0.85	0.47 - 1.43	0.86	0.47 - 1.44

Abbreviations: CI, confidence interval; CNS, central nervous system; ISIR, indirect standardized incidence ratio; NMSC, non-melanoma skin cancer.

[a] Adjusted by age, sex and year. Excludes non-melanoma skin cancer (NMSC). The number of observed and expected cases has been removed to maintain confidentiality; for the on-reserve population there were a total of 14 cases combined, and fewer than 5 cases of every cancer type over the study period.

[b] On-reserve is based on postal codes that cover a larger area than the reserve and, therefore, might include individuals living in the postal code area, but not on-reserve.

diagnosed in X First Nations women living on-reserve compared to the expected number of cases calculated using all reference populations: all First Nations in Alberta (ISIR = 6.68, 95% CI: 1.82-17.11), RHA Y (ISIR = 9.90, 95% CI: 2.70-25.35) and the general Alberta population (ISIR = 12.17, 95% CI: 3.32-31.16). A statistically significant increase in cancers classified as "biliary tract, other and unspecified" in women (not shown) was also noted when all three reference populations were used: all First Nations (ISIR = 40.58, 95% CI: 1.03-226.10), RHA Y (ISIR = 61.82, 95% CI: 1.57-344.43) and the general Alberta population (ISIR = 44.73, 95% CI: 1.13-249.22).

Using all First Nations in Alberta as the reference population, the number of observed cancer cases between 1995 and 2006 for X First Nations men and women identified as living on-reserve were slightly higher than expected; however, this elevation was not statistically significant (ISIR = 1.09, 95% CI: 0.60-1.83). Comparisons between the overall observed number of cancer cases and the expected number of cases that were calculated based on the remaining two reference populations, RHA Y (ISIR = 0.85, 95% CI: 0.47-1.43) and all Alberta (ISIR = 0.86, 95% CI: 0.47-1.44), revealed that the observed overall cancer case numbers were lower than expected, though not statistically significant.

The magnitude of the ISIR results differ between the cancer site-specific values and the overall ISIRs calculated. Major cancer sites such as "lung" and "prostate" have relatively small ISIRs compared to less common cancer sites such as "biliary tract, other and unspecified." Additionally, the ISIRs for each cancer site observed were based on a comparison of the numbers of cancer site-specific cases observed in the study populations versus the number of site-specific cases expected based on the reference populations. For all cancers combined, however, this comparison was between all cancers observed in the study populations (comprising 11 different cancer sites) and the number of overall cancers expected based on the reference populations; the overall cancer sites expected

would be based on more than the 11 cancer sites observed in the study populations.

Discussion

In response to concerns expressed by the X First Nations band leadership and administration, a three-pronged investigation was launched by FNIH, Health Canada, Alberta Region. This included a follow-up of the six incident cases through a familial cancer cluster investigation by the Public Health Agency of Canada and an environmental risk assessment by Health Canada; the results of these two investigations will be reported separately (Tustin J et al., Drobina MW et al.; submitted manuscripts). The objectives of the third investigation, a cancer incidence investigation, were to support the three-pronged investigation through the identification of the number of colorectal cancer cases diagnosed within the on- and off-reserve X First Nations and to address general community concerns through the evaluation of cancer incidence in the X First Nations population.

A search of the entire Alberta Cancer Registry revealed fewer than five cases of colorectal cancer cases diagnosed in identified X First Nations individuals; only one observed colorectal cancer case matched the original six cases reported. We also compared the number of observed cancer cases diagnosed in X First Nations individuals between 1995 and 2006 and the number of cases that would be expected in this period derived from calculations using all First Nations in Alberta, Regional Health Authority Y and the Alberta general population as reference populations. There were no statistically significant differences between the number of colorectal or overall cancer cases observed in either all X First Nations people across Alberta or the on-reserve population compared to the number of colorectal or overall cancer cases expected. Postal codes included in the X First Nations population cover a larger area than the reserve and would be expected to overestimate the detection of the cluster. The results of this investigation, therefore, did not support a colorectal cancer cluster in the X First Nations population.

Because Canadian cancer registries do not collect information on ethnicity, it is difficult to identify First Nations study populations to investigate cancer incidence in these groups. In this study, administrative data containing registered First Nations individual identifiers was linked with the Alberta Cancer Registry. The administrative dataset containing First Nations identifiers does not distinguish between registration through heredity or marriage. In addition, First Nations populations tend to be relatively small, leading to considerable random variation and calculations that yield low statistical power. This was apparent in the current study through seemingly statistically significant elevations in specific cancer sites that were based on fewer than five cases. The uncertainty in interpreting statistical findings based on small numbers is one of the reasons why, despite many requests for cancer cluster investigations throughout North America, few lead to further study.[14,15]

Although there was no evidence of a higher than expected number of colorectal cancer cases in the X First Nations population, the 11 cervical cancer cases observed in all X First Nations women in Alberta was 11 times higher than the number expected based on other First Nations women in the province and 20 times higher than expected based on the general population of Alberta, a statistically significant elevation. As a result of this investigation, this important public health issue is being addressed by the FNIH Medical Officer of Health and Nursing Unit in collaboration with public health officials within RHA Y. Preventative interventions include the introduction of the Human Papilloma Virus (HPV) vaccination program to school-aged girls and increasing access to Pap smear screening services for women in the X First Nations community.

This study also revealed that the proportion of all and on-reserve X First Nations people within the 20 to 54 years and the 55 years and over age groups increased between 1995 and 2006, while the proportion within the youngest age group (0-19 years) decreased. The risk of an individual developing cancer increases with age; consequently, increases in cancer diagnoses can be expected. It has also been noted that First Nations peoples throughout North America are experiencing an epidemiologic transition where the rates of chronic disease are increasing as infectious disease occurrence is decreasing.[16-18] A recent study in First Nations men and women in Ontario, Canada, found that although current incidence rates of all cancers combined and for colorectal cancer were significantly lower than the general population, First Nations groups experienced different distribution of cancer types and faster increases in cancer incidence rates for all cancers combined and for colorectal cancers and lung cancer compared to the general population, possibly as a result of lifestyle risk factors such as high obesity rates and changes in diet and physical activity levels, as well as sociocultural or genetic factors.[19] Differences between the cancer rates in First Nations and non-First Nations in Alberta have also been observed. An investigation into cancer incidence in Fort Chipewyan, Alberta, noted that although the rates of lung and colon cancer were not different, Alberta First Nations had a significantly lower rate for all cancers combined, breast cancer and leukemia and a higher rate of cholangiocarcinoma compared to non-First Nations peoples across the province.[20] Our study attempted to adjust for potential differences in cancer risk in First Nations peoples by comparing cancer cases observed in X First Nations individuals to those expected based on other First Nations in the province.

The results, conclusions and recommendations from each of the three prongs of the investigation were presented in-person to the X First Nations band leadership and administration and followed by a question and discussion period. As part of the collaborative process, the Surveillance Department of the Alberta Cancer Board (recently renamed Cancer Surveillance, Surveillance and Health Status Assessment, Population and Public Health – Alberta Health Services) arranged for follow-up with community leadership and administration in one year's time. On-going examination of cancer incidence within the X

First Nations population will ensure that potential increases in rates are monitored, evaluated and managed.

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