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Executive Summary

Cancer is the leading cause of mortality in Nunavut and is a significant cause of illness with an average of 59 cases per year from 1999 to 2011. Although the 2011 numbers are preliminary, the age-standardized incidence rate (ASIR) of cancer for Nunavut in 2011 was 362.3 per 100,000 as compared to the Canadian rate of 406.0 per 100,000. The epidemiology of cancer in Nunavut is distinct from Canada in leading cancers as well as gender distribution.

Nunavummiut experience higher rates of lung, colorectal, oral and digestive cancers and lower rates of reproductive, hematopoietic, bladder and thyroid cancers than Canadians. The top 5 cancers affecting Nunavummiut between 1999 and 2011 are: (1) lung, (2) colorectal, (3) breast, (4) oral and (5) prostate. These cancer groups account for 68% of all cancers. The female Nunavummiut ASIR exceeds the national rate by 30%, while the male Nunavummiut ASIR is 52% lower than the national rate. These differences in cancer rates may be attributable to variance in demography, heredity, health services, environmental exposures, lifestyles and illness patterns.

There are multiple programs in place in Nunavut that address cancer risk factors. Amongst them are: Tobacco Reduction Strategy, Nutrition North and Public Health immunization programs. Further efforts are required to promote healthy lifestyles and environments as well as to prevent chronic and communicable diseases. Accessible screening programs are also needed in communities to enable early detection and treatment to improve prognosis.

List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>ASIR</td>
<td>Age standardized incidence rate</td>
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<td>BMI</td>
<td>Body mass index</td>
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<td>COPD</td>
<td>Chronic obstructive pulmonary disease</td>
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<td>EBV</td>
<td>Epstein-Barr virus</td>
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<td>HPV</td>
<td>Human papilloma virus</td>
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<td>HTLV-1</td>
<td>Human T-cell lymphotropic virus type 1</td>
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<td>ICD-10</td>
<td>International Classification of Disease, 10th revision</td>
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<td>ICD-O-3</td>
<td>International Classification of Diseases Oncology, 3rd revision</td>
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<tr>
<td>NWT</td>
<td>Northwest Territories</td>
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<td>TB</td>
<td>Tuberculosis</td>
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Background: Nunavut cancer risk factors

Nunavut is the largest, northern most territory in Canada with an 85% Inuit population. The population of 33,551 people is spread over 25 fly-in communities covering 2,093,190 km$^2$.

The demographic distribution of Nunavut differs from Canada, with the majority of the population under 25 years (Figure 1). The life expectancy of Nunavummiut at birth is trending up (72.1 years) but is still 8.5 years lower than Canada (80.6 years). The crude birth rate in Nunavut is 2.3 times the national average and the total fertility rate is 1.8 times the national average.

Healthcare service delivery is different in Nunavut than the rest of Canada due to its remoteness. Each community has a health centre with Community Health Nurses who provide the majority of health services. The average nurse to population ratio in communities (excluding Iqaluit) is 1:268. There are 29.5 physician positions, half of which are staffed by short-term locums, with permanent positions in Iqaluit, Rankin Inlet, Cambridge Bay and Arviat.

Figure 2. Medical travel patterns

If a patient’s condition exceeds the capacity of the health centre, they are taken by medevac or scheduled medical travel to a major health centre (Figure 2). There is generally no specialty diagnostic equipment (e.g. mammography) or specialists (e.g. oncologists) in most communities, impacting availability and timeliness of services. Cancer screening, diagnosis and treatment often require travel, separating patients from their social networks within communities.

Housing has health impacts influencing communicable disease transmission and environmental contaminant exposure (e.g. environmental tobacco smoke). Nunavut households are more crowded, having an average of 3.7 people per household compared to 2.5 people in the rest of Canada, potentially affecting cancer risk.

Contaminant concentrations in the Arctic are affected by global wind and water patterns, bioaccumulating in marine mammals. Contaminants found include: (1) polychlorinated biphenyls (PCBs), (2) pesticides, (3) organochlorines and (4) heavy metals (e.g. mercury). Pollutants can affect cancer risk by mimicking hormones and interacting with nutrients and other contaminants.

Physical activity level has decreased due to a western lifestyle. Canadians were 7% more physically active during leisure-time than Nunavummiut. Males were consistently more physically active in both the Canadian and Nunavut population, with the exception of non-aboriginal males in Nunavut. Inuit in Nunavut were 10% more active than their non-aboriginal Nunavummiut counterparts. Overall, Nunavummiut have significantly lower levels of physical activity than Canadians, potentially contributing to the higher rate of some cancers.

Contaminant concentrations in the Arctic are affected by global wind and water patterns, bioaccumulating in marine mammals. Contaminants found include: (1) polychlorinated biphenyls (PCBs), (2) pesticides, (3) organochlorines and (4) heavy metals (e.g. mercury). Pollutants can affect cancer risk by mimicking hormones and interacting with nutrients and other contaminants.
**Dietary patterns** in Nunavut have historically been distinct from Canada; this pattern is currently in flux. Traditional foods are high in nutrients including macronutrients, vitamins, antioxidants and minerals. In a western diet, fruits and vegetables are an important nutrient source. As refined, store bought foods become a bigger part of diets, there is a loss of the traditional source of nutrients without replacement with fruits and vegetables. Nunavut’s rate of fruit and vegetable consumption is consistently, significantly lower than the national age-standardized rate (ASIR) by an average of 75%.

Further complicating nutrition in Nunavut is food insecurity, which impacts overall diet quality. The ASIR for those living with moderate or severe food insecurity in Nunavut is 37.8 per 100,000, which is 5 times higher than the national average. Diet is an important protective factor in cancer prevention; poor diet quality and nutrient deficits may contribute to higher cancer rates.

**Substance use** in Nunavut is distinct from Canada, specifically tobacco and alcohol use. Nunavut exceeds the Canadian ASIR for current daily or occasional smokers by 3.4 times with 60% of the population smoking. Inuit in Nunavut smoke 1.4 times more than Inuit in Canada, and non-aboriginals in Nunavut smoke 1.6 times more than Canadians. The smoking rate is 14% higher for Nunavut females than males, unlike Canada where the male rate exceeds the female rate by 31%. Ninety percent of households in the Inuit Health Survey had at least one smoker with individuals smoking an average of 10-13 cigarettes per day. The higher tobacco use in Nunavut is reflected in the higher rate of some cancers.

Alcohol is controlled in Nunavut; some communities prohibit alcohol and others regulate it. The reported Nunavut ASIR for heavy drinking (≥5 drinks per occasion at least monthly in the past year) is 4% lower than Canada for the 10 communities included. Males in both national and territorial populations have a higher rate of heavy drinking. Within Nunavut, the non-aboriginal population exceeds the Inuit population by 1.4 times for heavy drinking. Literature indicates more heavy drinking in aboriginal and Inuit populations; however, Inuit in Nunavut have a 55% lower rate of heavy drinking than Inuit outside Nunavut. Heavy drinking is only one measure of alcohol use and does not describe binge drinking, moderate use or chronicity of alcohol use.

**Infection** is an important contributor to the burden of cancer. In 2008, diagnosed cancers attributable to infection was globally 16.1% (7.4% for developed regions and 22.9% for developing regions). The primary communicable diseases impacting cancer risk in Nunavut are: (1) tuberculosis (TB), (2) human papilloma virus (HPV), (3) Epstein-Barr virus (EBV), (4) viral hepatitis, (5) *Helicobacter pylori* (*H. pylori*) and (6) human T-cell lymphotropic virus type 1 (HTLV-1). Nunavut has patterns of communicable disease that differ from Canada, potentially contributing to higher rates of some cancers.

**Chronic conditions** are thought to affect cancer risk through inflammation and impact on the endocrine system. Diabetes incidence in Nunavut has remained relatively stable between 2005 and 2011 and does not significantly differ from the national rate. Overall, in 2011 diabetes had a 3.1% prevalence in Nunavummiut. Chronic obstructive pulmonary disease (COPD) has trended down between 2005 and 2011. The 2011 ASIR for Nunavut was 23.7 per 100,000, which is 6.2 times higher than the national average. Overall, in 2011 COPD had a 14.3% prevalence in Nunavummiut.

Adipose tissue is active endocrine tissue that affects hormone levels. Therefore, excess body fat can impact cancer risk. From 2003 to 2012, people who are overweight or obese has steadily trended up in Canada with an average ASIR of 49.6 per 100,000. Nunavut sporadically exceeds the Canadian ASIR with a rate fluctuating between 52.7 and 63.7 per 100,000, which is on average 1.2 times higher than the national rate. Only Nunavut’s female rate is consistently, significantly higher than the national female rate. The rate of chronic conditions is likely mirrored in the increased rate of some cancers in Nunavut.
Cancer overview

Approximately 40% of Canadians will develop cancer and it is also the national leading cause of death. Nationally, lung, breast, colorectal and prostate cancers account for 52% of cases and cancer is the fourth most costly disease accounting for $2.6 billion in direct healthcare costs.

A total of 773 Nunavummiut (405 female, 368 male) were diagnosed with cancer between 1999 and 2011. For Nunavummiut, cancer was the leading cause of death between 2000 and 2009. During this period Nunavut’s age-standardized mortality rate exceeded the national rate 2.2-fold.

The cancer pattern among Nunavummiut is different than Canadians (Figure 3). Comparing the Canadian and Nunavut ASIR, lung, oral and digestive cancers exceed the national rate whereas reproductive and hematopoietic cancers are lower, a finding consistent with other circumpolar regions. In 2011, the all-cancer ASIR was lower for Nunavummiut (362.3 per 100,000) than Canada (406.0 per 100,000). The gender-specific ASIR patterns differed with Nunavummiut females exceeding Canadian females by 30% (481.4 versus 369.0 per 100,000) and with Nunavummiut males having a 52% lower rate (239.4 versus 456.0 per 100,000) than Canadian males.

Overall, both Nunavut and Canada have lung, colorectal and breast or prostate cancer in the top 5 cancers. The leading 5 sites for females nationally are: breast, lung, colorectal, body of uterus and thyroid. Whereas the leading 5 sites for females in Nunavut are: lung, colorectal, breast, oral and kidney. Canadian females appear to be more affected by reproductive cancers while Nunavummiut females appear to be more affected by lung and colorectal cancer.

The leading 5 sites for males nationally are: prostate, lung, colorectal, bladder and Non-Hodgkin lymphoma. The leading 5 sites for males in Nunavut are: lung, colorectal, oral, prostate and kidney. Canadian males appear to be more affected by reproductive cancers while Nunavummiut males appear to be more affected by lung and colorectal cancer.

Since cancers have a long latency period, current cancer trends are reflective of factors prevalent in the population decades ago. With changing lifestyles and diet, it is likely that cancer patterns will change as

Figure 3. Ratio of Nunavut 3 year moving average and Canadian age standardized incidence rate, 2011

Figure 4. Top 10 cancer groups*: Proportion by gender and Nunavut, 1999-2011

* Other* and “unknown” categories excluded from calculating top 10 cancer groups
** 1 male breast cancer case excluded from analysis

Overall, both Nunavut and Canada have lung, colorectal and breast or prostate cancer in the top 5 cancers. The leading 5 sites for females nationally are: breast, lung, colorectal, body of uterus and thyroid. Whereas the leading 5 sites for females in Nunavut are: lung, colorectal, breast, oral and kidney. Canadian females appear to be more affected by reproductive cancers while Nunavummiut females appear to be more affected by lung and colorectal cancer.

The leading 5 sites for males nationally are: prostate, lung, colorectal, bladder and Non-Hodgkin lymphoma. The leading 5 sites for males in Nunavut are: lung, colorectal, oral, prostate and kidney. Canadian males appear to be more affected by reproductive cancers while Nunavummiut males appear to be more affected by lung and colorectal cancer.

Since cancers have a long latency period, current cancer trends are reflective of factors prevalent in the population decades ago. With changing lifestyles and diet, it is likely that cancer patterns will change as
Lung & Bronchus Cancer

Lung cancer is the leading cancer amongst Nunavummiut with 247 cases (114 female, 133 male) accounting for 32% of reported cancer cases between 1999 and 2011. Other respiratory tract cancers accounted for an additional 1% of reported cancer cases with 7 cases (3 female, 4 male) between 1999 and 2011.

Nunavut’s lung cancer rate is amongst the highest globally and is 3 times higher than the Canadian rate. The top three histologies are: squamous cell carcinoma (SCC), non-small cell carcinoma, and unspecified small cell carcinoma. The development of lung cancer is complex with risk factors working both independently and synergistically.

What are the risk factors for lung cancer?

1. **Family history** of disease, independent of smoking, increases the chance of developing lung cancer 1.4-fold [1.2-1.7]. There are numerous genes and mechanisms implicated in the risk of developing lung cancer. For example, the p53 gene mutation occurs in 33% of lung cancers and this percentage increases with tobacco consumption. Another example is genomic polymorphism of the XRCC1 gene, implicated in DNA repair, which increased lung cancer chances 1.9-fold [1.3-2.9] independent of smoking.

2. **Gender** also influences risk, not only for biological factors like hormones but also for gender-specific roles that dictated exposure to carcinogens. For example, women were more often exposed to environmental tobacco smoke and men were more often exposed to occupational carcinogens.

3. **Infection and inflammation** are well-established risk factors in cancer development, thus acute and chronic illness as well as infectious diseases contribute to cancer risk.

Acute illness in never smokers, like pneumonia history, increases cancer risk 1.4-fold [1.1-1.7]. For those with chronic illness like COPD, chronic bronchitis or emphysema, the risk increases 1.5-fold [1.2-1.9]. In 2011, the Nunavut prevalence for COPD was 14.3%.

Infectious diseases increase lung cancer risk independent of smoking: TB increases risk 1.9-fold [1.5-2.5] and HPV increases the risk of SCC 3.5-fold [1.7-7.5]. In Nunavut, the average TB rate is 30 times the national rate; at this time the HPV incidence rate is not available.

In Nunavut, respiratory-related concerns are the primary reason for people accessing community health centres. The high occurrence of chronic and infectious diseases in Nunavut likely contributes to higher lung cancer rates experienced by Nunavummiut.


4. **Environmental Factors**

**Smoking** is the primary etiologic agent implicated in lung cancer, increasing risk 20-fold, and is thought to be responsible for up to 90% of cases in countries where smoking is common. Smoking also works synergistically with infectious diseases and has been found to increase HPV susceptibility, further increasing lung cancer risk.

Smoking has been found to alter gene expression and transcription. Many genes return to near normal levels after smoking cessation; however, there are genes that are either slow to recover or do not normalize even decades after smoking cessation. These findings highlight the importance of both never smoking as well as smoking cessation.

Presently, 60% of Nunavummiut 12 years or older report smoking, which is 3 times the Canadian average. The tobacco use rate in Nunavut is likely a major contributing factor to the higher lung cancer rate experienced by Nunavummiut.

**Carving** is an important industry in Nunavut. With the introduction of power tools in the 1980s, the health impacts have changed. Power tool users are exposed to 90 times more dust than non-users. This dust, whether it be rock or animal product, has been associated with respiratory inflammation.

In a study of 75 of Nunavut’s carving rock quarries, four were noted to have asbestos. Another study analyzing territorial rock samples found that 19% of samples had tremolite and 7% of samples had chrysotile, substances that are part of the asbestos family. Asbestos has long been linked to lung cancer development.

A 2003 study of carvers found that only 58% wore dust masks. Of these individuals, only 28% always wore a mask, 55% mostly to sometimes wore a mask and 16% did not often wear a mask. Thus with technological changes, rock composition and lack of personal protection, carvers are potentially at increased risk of lung cancer.

**Other environmental risk factors** independent of smoking include: environmental tobacco smoke, which increases risk 1.3-fold [1.2-1.4] and cooking oil fumes (moderate levels of cooking) which increases risk 3-4-fold [1.5-8.9].
What are lung cancer rates in Nunavut and how do we compare to the rest of Canada?

The Nunavut ASIR has generally trended down over time but still significantly exceeds national and NWT rates. In fact, the Nunavut rate is 3 times higher than the national rate.

Lung cancer rates are reflective of smoking patterns, but lag about 20 years. The noted downward trend is thought to be associated with historic efforts in smoking cessation.

Are there regional differences in lung cancer rates across Nunavut?

Of all the regions, Baffin had the highest rate (76.3 cases per 100,000) followed by Kivalliq (50.6 cases per 100,000) and then Kitikmeot (44.5 cases per 100,000).

Looking at the number of cases, Baffin had the highest proportion of cases (65%) followed by Kivalliq (22%) and then Kitikmeot (13%).

Are there age-related trends in lung cancer incidence in Nunavut?

In Nunavut, the average age at diagnosis was 66.2 years (range 36-92 years, standard deviation 9.7 years).
Are there gender-related trends or differences in lung cancer rates in Nunavut?

Nationally, males have a significantly higher rate than females; this difference is consistent over time. In Nunavut, the male rate slightly exceeds the female rate 2005 to 2010; however, the rate difference by gender does not significantly differ over time.

Compared to Canada, the Nunavut 2011 rate for females was 3.5 times higher and for males was 2.1 times higher; the magnitude of this difference by gender is also true for the overall Canadian Inuit population as compared to Canada. Within the circumpolar region, the Canadian lung cancer incidence exceeds Alaska and Greenland by 1.5 times in men and 2-3 times in women.

What mortality data are available for lung cancer?

Death clearance data are obtained from Statistics Canada and are available for years 1999-2008. For Nunavummiut diagnosed with lung cancer, 62% died within one year of diagnosis.

Discussion: What does this information mean for Nunavummiut?

Nunavummiut experience much higher rates of lung cancer as compared to Canada. Higher rates of infectious and chronic disease as well as tobacco use are likely major contributing factors to Nunavut’s lung cancer rate.

Creating smoke-free environments is important; legislated and home smoking bans effectively reduce nicotine dependence and promote smoking cessation. Smoking bans are also shown to positively affect non-smokers, reducing presentation of inflammatory lung conditions like asthma. Continued implementation of the Nunavut Tobacco Reduction Strategy is pivotal to reducing cancer risk.

Further efforts in infectious and chronic disease prevention, smoking cessation and early detection are pivotal to curtailing lung cancer rates and improving prognosis. However, impacts may take years to manifest due to a long latency period between risk factor exposure and lung cancer development.
Colorectal cancer is the second leading cancer affecting Nunavummiut, accounting for 19% of cancer cases diagnosed between 1999 and 2011. In the circumpolar region, colorectal cancers account for 15% of Inuit cancer cases; this is expected to trend up with changing lifestyles. Consistent with literature, the predominant histological type of colorectal cancer in Nunavut is adenocarcinoma (91%).

What are the risk factors for colorectal cancer?

1. **Hereditary factors** are thought to contribute 12-13% to risk. Examples of known susceptibility genes include: APC gene which is associated with polyposis, MSH2 and MLH1 genes which are implicated in non-polyposis colorectal cancer syndrome. Family history impacts risk with a greater than 2-fold increase in risk when at least one first-degree relative is diagnosed. The risk of developing colorectal cancer after the age of 40 years was calculated to be 4.7% [4.0-5.6%] for the general population and 9.6% [6.3-14.2] for those with a family history of disease.

2. **Obesity** (body mass index (BMI) ≥ 30 kg/m²) is consistently associated with higher risk of colorectal cancer and is found to increase risk 1.2-fold [1.1-1.3]. The risk is higher in men and is consistently higher in both genders for developing cancers of the colon than rectum. For colorectal cancer, obesity is estimated to contribute 28-35% in men and 14-21% in women for the United States and Europe. One analysis found that for every 2kg/m² increase in BMI there was an associated 1% increase in colorectal cancer risk.

3. **Chronic illness** like inflammatory bowel disease is thought to increase risk. One meta-analysis determined risk for colorectal cancer increased 2.5-fold [1.3-4.7] with Crohn’s disease, with risk accumulating over time. The results were similar for ulcerative colitis. Diabetes is also implicated in colorectal cancer risk; in one meta-analysis where physical activity and BMI were controlled for, there was a 1.3-fold [1.2-1.5] increase in risk.

4. **Lifestyle** factors impact colorectal cancer risk. Alcohol has a dose relationship, increasing risk by 5% [1-9%] for colon and 9% [8-12%] for rectal cancer with 25g/day and 21% [5-39%] for colon and 42% [30-55%] for rectal cancer with 100g/day. Diet is correlated with colorectal cancer risk where fruit, vegetable and fish consumption is found to be protective (i.e. decrease risk) and red meat consumption is found to increase risk. Physical activity is also found to be independently protective.
What are colorectal cancer rates in Nunavut and how do we compare to the rest of Canada?

In Nunavut, there were 146 cases (68 female, 78 male) diagnosed between 1999 and 2011.

Overall, the Nunavut ASIR has trended down over time and as of 2011 it was 1.4 times higher than the national rate.

With the exception of 2004, 2010 and 2011, Nunavut significantly exceeds the national rate.

Are there regional differences in colorectal cancer rates across Nunavut?

![Figure 10. Colorectal Cancer Average Incidence Rate per 100,000 by Region, 1999-2011](image)

Of all the regions, Baffin had the highest rate (41.2 cases per 100,000) followed by Kitikmeot (34.8 cases per 100,000) and then Kivalliq (30.4 cases per 100,000).

Looking at the number of cases, Baffin had the highest proportion of cases (59%) followed by Kivalliq (24%), then Kitikmeot (17%).

Are there age-related trends in colorectal cancer incidence in Nunavut?

In Nunavut, the average age at time of diagnosis 59.9 years. However, age ranged between 23-90 years (standard deviation 13.7 years).

![Figure 11. Colorectal Cancer Incidence Rate per 100,000 by Age Group, Nunavut, 1999-2011](image)
Are there gender-related trends or differences in colorectal cancer rates in Nunavut?

With the exception of 2002, colorectal cancer rates do not significantly differ between men and women. While the female rate generally exceeds the male rate, this is not always the case. Nationally, the male rate significantly and consistently exceeds the female rate. According to literature, there is an interaction between gender and BMI with obese men being 30% more likely to develop colorectal cancer than obese women.11, 79

What mortality data are available for colorectal cancer?

Death clearance data are obtained from Statistics Canada and are available for years 1999-2008. For Nunavummiut diagnosed with colorectal cancer, 26% died within one year of diagnosis.

Discussion: What does this information mean for Nunavummiut?

As there are changes in lifestyles and diet as well as a corresponding increase in chronic diseases, it is expected that colorectal cancer rates will trend up.27 Promotion of healthy lifestyles as well as prevention and control of chronic diseases is paramount to reducing risk.

Screening provides an opportunity for early case identification and improved prognosis. Targeted screening based on identified risk factors and population-based screening is an efficient way to make a difference in colorectal cancer prognosis and to potentially improve survival.
Digestive System: Oral Cancer

Oral cancers are rare in most parts of the world, but common among Inuit as well as populations in Southern China and North Africa. Genetic markers in the Inuit population indicate Asian heritage, thus oral cancer trends in Southern China are relevant to Nunavut’s population. In Inuit populations, oral cancer is found to be 25-40 times more frequent than in non-Inuit populations in the USA, Canada and Denmark. This malignancy accounts for 4-7% of all malignancies in Inuit as opposed to less than 0.1% in non-Inuit populations in USA, Canada and Denmark. In Nunavut, oral cancer accounted for 6% of all cancers affecting Nunavummiut between 1999 and 2011.

What are the risk factors?

Research suggests that there are overlapping risk factors in oral cancer development: (1) genetics, (2) environment including toxins like tobacco, alcohol and dietary items and (3) infectious agents like EBV and HPV. These factors can act independently or synergistically: it was noted that HPV increased risk 2-fold, smoking increased risk 5.8-fold, and HPV plus smoking increased risk 15-fold. Differentiated and undifferentiated tumor types are also distinctly influenced by these risk factors.

Oral cancer tumors fall into two major categories: (1) differentiated and (2) undifferentiated. Differentiated tumors are strongly associated with tobacco use, and risk was found to increase according to duration and frequency of use. Undifferentiated tumors are strongly associated with viral infection accounting for a 2-4-fold increase in risk. In high incidence areas generally undifferentiated nasopharyngeal cancer dominates. Further examination is required to determine the dominant tumor grade in Nunavut.

1. Genetics — Inuit generally retain their risk of oral cancer even after decades of migrating to low prevalence areas, indicating involvement of genetic factors or early life environmental factors that influence risk. Genetic predisposition is supported by reports of familial clustering with an 8-fold [4.1-14.0] increase in risk experienced by first degree relatives of Inuit with nasopharyngeal carcinoma.

2. Environmental Factors — Presently, 60% of Nunavummiut 12 years or older report smoking, which is three times higher than the national average. In one study, heavy tobacco and alcohol use accounted for 57% [16-98%] of differentiated tumors. It has also been found that ingesting preserved foods during childhood that contain nitrosamines like Chinese salt-preserved fish, preserved meat and vegetables from North Africa and traditional Inuit dried fish increases risk of oral cancer later in life.

3. Infectious Agents — Worldwide, infection is estimated to contribute 25.6% to oropharyngeal cancer risk and 85.5% to nasopharyngeal cancer risk. Both EBV and HPV have been implicated in oral cancer. EBV is a well-established risk factor, especially with childhood infection, and evidence is mounting for HPV. Inuit children have a distinct pattern of EBV acquisition characterized by early primary infection and high antibody titres, increasing their risk for oral cancer later in life. HPV presence in the oral cavity is associated with a 3.7-fold [1.5-9.3] increased risk of oral cancer, independent of alcohol and tobacco exposure. It is possible that the distinct pattern of infectious agents in Nunavut contribute to higher oral cancer rates.
What are oral cancer rates in Nunavut and how do we compare to the rest of Canada?

In Nunavut, there were 46 cases (26 female, 20 male) diagnosed between 1999 and 2011.

Overall, the Nunavut ASIR has slightly increased over time and as of 2011 it was three times higher than the national rate.

Are there regional differences in oral cancer rates across Nunavut?

Of all the regions, Kitikmeot had the highest rate (12.7 cases per 100,000) followed by Kivalliq (11.7 cases per 100,000) and then Baffin (11.3 cases per 100,000).

However, if one looks at the number of cases, Baffin had the highest proportion of cases (52%) followed by Kivalliq (28%) then Kitikmeot (20%).

This means that while the rate is highest in the Kitikmeot region, there is a greater number of people affected by oral cancer in the Baffin region.

Are there age-related trends in oral cancer incidence in Nunavut?

In Nunavut, the average age at diagnosis was 52.1 years, although age ranged between 12 and 75 years (standard deviation 15.0 years).
Are there gender-related trends or differences in oral cancer rates in Nunavut?

While Nunavut rates by gender do not significantly differ over time, the female rate generally exceeded the male rate up until 2009. Looking at the national picture, the male rate is consistently higher than the female rate and this difference is significant.

What mortality data are available for oral cancer?

Death clearance data are obtained from Statistics Canada and are available for years 1999-2008. For Nunavummiut diagnosed with oral cancer, 9% died within one year of diagnosis.

Discussion: What does this information mean for Nunavummiut?

Overall, oral cancer rates are significantly higher in Nunavut as compared to the national average and are trending up. Factors influencing this dynamic and potentially affecting cancer risk are diverse and interrelated with genetics, environmental factors and infectious agents. While it is not possible to change genetic risk, strategic increases in screening targeting individuals who have a family history of disease can potentially assist with early detection and improve prognosis.

Behaviour modification is also essential to reducing oral cancer rates. Smoking is a major modifiable risk factor; continued efforts with the Nunavut Tobacco Reduction Strategy are essential to reducing risk. Prevention and control of communicable diseases are also important in risk reduction (e.g. HPV immunization).

Further work in Nunavut is necessary to determine the tumor grade in order to better tailor risk reduction strategies.
Digestive System:

Esophagus, Stomach, Liver, Pancreas, Other Gastrointestinal

Esophageal cancer accounted for 1% (10 male) of cancers between 1999 and 2011, averaging 1 case per year with a median diagnosis age of 70 years (range 42-77, standard deviation 12.47 years). In Nunavut, 70% of the identified cases were adenocarcinomas. Nunavut’s rate fluctuates but generally exceeds the national rate; in 2011 it was three times higher than the national rate. For Nunavummiut diagnosed with esophageal cancer, 33% died within one year of diagnosis.

Incidence and etiology of esophageal cancer varies by histology.\(^5,6\) The primary determinants of adenocarcinoma are: (1) gastro-esophageal reflux disease, (2) high BMI and (3) tobacco use but it is affected to a lesser degree than squamous-cell carcinoma (SCC).\(^5,6\) SCC is primarily affected by tobacco and alcohol use; there is evidence that family history impacts both histological types.\(^5,6,114,115\) There is consistent evidence that diet impacts esophageal cancer risk, with fruits and vegetables reducing risk.\(^5,6,115\)

Stomach cancer accounted for 3% (8 female, 15 male) of cancers between 1999 and 2011, averaging 2 cases per year with an average age at diagnosis of 59.9 years (range 30-92, standard deviation 16.7 years). Stomach cancer etiology differs by topography.\(^114\) Of the 23 cases: 17% were cardia, 39% were non-cardia and 43% were unspecified topography. Nunavut rates increased between 2001 and 2005 then trend down. For Nunavummiut diagnosed with stomach cancer, 55% died within one year of diagnosis.

Statistical modeling suggests the contribution of risk factors to stomach cancer development is: 28% genes, 10% shared environmental factors and 62% environmental factors.\(^63\)

Worldwide, the population attributable fraction of infectious agents in non-cardia gastric carcinoma is 74.7% with \(H.\) pylori most strongly associated.\(^36\) In Nunavut, 50 to 60% of adults tested positive for \(H.\) pylori exposure.\(^39,80\) Overcrowding, number of siblings and narrow age gap between siblings independently increase risk of acquiring \(H.\) pylori infection.\(^65\)

Other factors consistently associated with increased risk of stomach cancer are: (1) peptic ulcers and chronic gastritis, although both are associated with \(H.\) pylori infection, (2) ionizing radiation, (3) pernicious anemia and (4) nitrosamine compounds found in preserved meats.\(^63\) Fruit and vegetable consumption, independent of other dietary factors, reduces stomach cancer risk.\(^63\)
Liver cancer accounted for 1% (2 female, 4 male) of all cancers between 1999 and 2011, averaging 0.5 cases per year. The average age at diagnosis was 62.2 years (range 49-78, standard deviation 12.2 years). The Nunavut gender ratio is consistent with literature where the male rate is 2-4 times higher than the female rate.\textsuperscript{85} There are too few cases to trend; however, this cancer is on the rise in the Canadian population, an increase attributed to increasing viral hepatitis rates.\textsuperscript{35, 116}

Viral hepatitis plays a major role in the development of primary liver cancer, with chronic infection being associated with 80% of incident cases globally.\textsuperscript{94}

The percentage of liver cancer cases in developed countries attributable to Hepatitis B infection is 23% and for Hepatitis C is 20%.\textsuperscript{85} In the Canadian Arctic the prevalence of Hepatitis B is about 5% and Hepatitis C is between 1-18%.\textsuperscript{83}

Other recognized liver cancer risk factors include: (1) Afloatoxin, a group of mycotoxins found in improperly stored foods, (2) alcohol consumption, with 25 g/day increasing risk 1.2-fold [1.1-1.3] and with 100g/day further increasing risk to 1.8-fold [1.5-2.2].\textsuperscript{25, 32} Alcohol works synergistically with cirrhosis and Hepatitis C to significantly increase risk, (3) tobacco use, which increases risk 1.6-fold [1.3-1.9], (4) obesity (BMI ≥ 30), which increases risk 1.9-fold [1.5-2.4] and (5) diabetes, which is an independent factor.\textsuperscript{35, 44, 71}

Pancreatic cancer accounted for 2% of all cancers (11 female, 7 male) between 1999 and 2011, averaging 1 case per year with a median age at diagnosis of 65 years (range 6-77, standard deviation 19.8 years). Pancreatic cancer in Nunavut was briefly lower than the national rate between 2005 and 2008, but generally exceeds the national rate.

For Nunavummiut diagnosed with pancreatic cancer, 88% died within one year of diagnosis. This high mortality rate is consistent with literature.\textsuperscript{16, 72}

Factors contributing to the development of pancreatic cancer are not well understood; however, tobacco use is a well established risk factor increasing risk 1.7-fold [1.5-1.9].\textsuperscript{44}

Other factors associated with disease risk are: (1) family history of disease (found in 5-10% of cases), (2) particular genetic alterations (e.g. BRCA2), (3) long-standing history of type II diabetes (5-10 years), which increases chances of disease 1.5-fold [1.3-1.8], (4) chronic pancreatitis and (5) diet.\textsuperscript{57, 75, 98}

Other gastrointestinal cancers accounted for 3% of all cancer cases (12 female, 8 male) between 1999 and 2011, averaging 2 cases per year.
Urinary System: Bladder and Kidney

Bladder cancer accounted for 1% of cancers (2 female, 5 male) between 1999 and 2011, averaging 0.5 cases per year with a median diagnosis age of 44 years (range 2-68, standard deviation 25.3 years).

Nunavut rates appear to be trending up but still remain a fraction of the national rate. This is consistent with findings throughout the circumpolar region that bladder cancer is rare among Inuit. 8

Risk factors include: (1) smoking (associated with a 2.8-fold [2.2-3.5] risk increase (including renal pelvis)), (2) exposure to chemical compounds (e.g. benzidine, beta-naphthylamine, polycyclic aromatic hydrocarbons, diesel exhaust), (3) infectious diseases (e.g. Schistosoma haemarobium, HPV) and (4) hereditary factors, which are thought to contribute 7% to risk. 34, 44, 76, 92

Kidney cancer accounted for 4% of all cancer cases (14 female, 15 male) between 1999 and 2011, averaging 2 cases per year with a median diagnosis age of 62 years (range 1-76, standard deviation 19.3 years). Kidney cancer in Nunavut was briefly lower than the national rate in 2006 and 2007, but otherwise exceeds the national rate.

Lifestyle factors consistently associated with risk include smoking and obesity. Smoking is associated with a 1.5-fold [1.3-1.7] risk increase (excluding renal pelvis). 44

Obesity is estimated to account for 31-43% of renal cancers in the United States and Europe. 11 For overweight or obese individuals, it is estimated that for every 5kg/m² weight increase there is a risk increase of 24% for men and 34% for women. 91

Other risk factors include: (1) hypertension, (2) industrial agents such as trichloroethylene (used as a metal degreaser and chemical additive) and (3) hereditary factors, which are thought to contribute 7% to risk; this is further supported by the increased risk seen in those with first degree relatives diagnosed with kidney cancer. 24, 26, 34

There is inconsistent evidence around the risk associated with cadmium, uranium, arsenic, nitrate and radon. 24 Protective factors include diets rich in fruits and vegetables. 24
Gynecological Cancers:
Breast, Cervix, Ovary, Uterus (Body), Other

Gynecological cancers account for 10-15% of all cancers globally and in Nunavut, they account for 12%. Traditionally, Inuit experience lower rates of gynecological cancers than their non-Inuit counterparts, although with changing lifestyles this trend is changing.

What are the risk factors for gynecological cancers?

Gynecological cancers are differentially affected by risk factors including: genetics, hormones, lifestyle and infectious agents. In considering breast cancer risk, it is important to recognize that breast cancer is not a single disease but a molecularly distinct group of cancers. Each group has a distinct etiology and pathology due to differences in: (1) estrogen-receptor positivity, (2) progesterone-receptor positivity and (3) HER2 status and as such are differentially affected by risk factors.

1. Genetics — There are multiple genes implicated in gynecological cancers. For example, the BRCA1 and BRCA2 genes play a role in DNA repair. With mutation of these genes, the cumulative risk by age 70 for breast cancer is 55% [50-59%] for BRCA1 and 47% [42-51%] for BRCA2. For ovarian cancer, the cumulative risk is 39% [34-45%] for BRCA1 and 17% [13-21%] for BRCA2. Genetic factors are thought to contribute 27% to breast cancer risk and 22% to cervical cancer risk.

2. Hormones — Estrogen levels are increased in ovulating women thus any factor influencing ovulation decreases breast, ovarian and uterine cancer risk including: (1) pregnancy (high frequency and young age at first birth), (2) later age of menarche, (3) early onset of menopause and (4) removal of ovaries. Oral contraceptives also influence risk of gynecological cancers, providing a strong protective effect for ovarian cancer (reducing risk 0.50-fold [0.33-0.75]) and also a protective effect for uterine cancer. The affect of contraceptives on breast cancer is weak with suggestions that older, high-hormone formulas actually increase risk, a risk which is mitigated in newer, low-dose formulas.

3. Lifestyle — With a trend towards adopting a westernized lifestyle, gynecological cancer risk has been increasing in circumpolar women due to: (1) decreased birth rate, (2) increased mean maternal age at first birth and (3) pattern of breast feeding (e.g. decreased duration). Alcohol also plays a dose-dependent role, increasing breast cancer risk 1.3-fold [1.2-1.3] with 25g/day and 2.4-fold [2.1-2.8] with 100g/day. Smoking is associated with a 1.8-fold [1.5-2.2] increase in cervical cancer. Uterine cancer risk is associated with: (1) obesity (2-3-fold increase in risk), (2) physical inactivity and (3) diabetes.

4. Infectious Agents — Globally, an estimated 70% of invasive cervical cancer cases were associated with either HPV16 or 18, with an additional 18% of cases attributable to HPV strains 31, 33, 35, 45, 52 and 58. The prevalence of oncogenic HPV types (16 and 18) in one Nunavut study was 25.8% [23.8-27.9].

Nunavut offers a publically funded HPV vaccination program to girls in grade 6 (≥ 9 years). Presently, Gardasil is used which protects against HPV types 6, 11, 16 and 18 and is found to be 99% effective in girls aged 16-26 years with series completion. Presently, territorial HPV coverage rates are not available.
What are Nunavut gynecological cancer rates and how do we compare to Canada?

**Breast cancer** is the leading cancer type amongst female Nunavummiut and accounts for 8% (63 cases) of all cancer cases diagnosed between 1999 and 2011 (excluding 1 male). The average age at diagnosis is 53.4 years (range 25-77, standard deviation 11.3 years). The rate is below the national and Northwest territories (NWT) rates; this difference is not significant.

**Cervical cancer** accounts for 2% (16 cases) of all cancer cases diagnosed between 1999 and 2011. The average age at diagnosis is 42.8 years (range 26-60, standard deviation 9.2 years). The rate exceeds the Canadian rate, but not significantly.

**Ovarian cancer** accounts for 1% (7 cases) of all cancer cases diagnosed between 1999 and 2011, averaging 0.5 cases per year. The median age at diagnosis was 58 years (range 23-72, standard deviation 17.1 years). The ASIR is generally 1.2 times lower than Canada.

**Uterus (Body) cancer** accounts for 0.6% (5 cases) of all cases diagnosed between 1999 and 2011. The median age at diagnosis was 46 years (range 28-50, standard deviation 9.3 years). There are too few cases to trend; however, the ASIR is consistently lower than Canada.

**Other gynecological cancers** accounted for 1% of all cancers (8 cases) between 1999 and 2011.

Are there regional differences in female reproductive cancer rates across Nunavut?

Baffin had the highest breast cancer rate (92.2 cases per 100,000) followed by Kitikmeot (44.5 cases per 100,000) and then Kivalliq (34.0 cases per 100,000). Baffin had the highest proportion of cases (47%) followed by Kivalliq (28%) and Kitikmeot (25%).

Baffin had the highest cervical cancer rate (21.7 cases per 100,000) followed by the Kitikmeot (8.5 cases per 100,000). Baffin had the highest proportion of cases (81%) with the rest of cases in Kitikmeot (19%).
Are there age-related trends in female reproductive cancer incidence in Nunavut?

Age-related trends for gynecological cancers in Nunavut cannot be established due to low case counts and sporadic incidence. For gynecological cancers in Canada, 30% of cases were younger than 50 years and 46% were between 50 and 70 years. The exception to this distribution is cervical cancers where the majority (58%) of cases were under 50 years. Given that the majority of Nunavut’s population is under 50 years, this has implications for both breast and cervical cancer screening.

What mortality data are available for female reproductive cancer?

Death clearance data are obtained from Statistics Canada and are available for years 1999-2008. For Nunavummiut diagnosed with:

- Breast cancer: 8% died within one year of diagnosis.
- Cervical cancer: 8% died within one year of diagnosis.

Discussion: What does this information mean for Nunavummiut?

Nunavut offers a Well-Woman clinic that includes screening for gynecological cancers. The 2011 Nunavut Well-Woman guidelines recommend cervical screening annually until three normal results are established, then every two to three years for all sexually active women ending at age 70 if recent tests were normal. The Well-Woman clinics include a clinical breast exam and guidelines recommend mammography every 1-2 years for low-risk women aged 50 to 69 (for women with a family history, screening should start 5-years prior to the age of the diagnosed relative). It is ideal that Well-Woman clinics combine reproductive care and cancer screening as a study in Nunavik found cervical screening to be related to accessing healthcare for reproductive care and family planning.

One systematic review found that in a follow-up of invasive cervical cancer cases, 54% [46-66%] of the women had a history of never being screened or being inadequately screened. This quantifies the potential to improve early detection and thus improve the prognosis for cervical cancer through screening. In Canada (excluding territories, Quebec, Prince Edward Island), when controlled for hysterectomy, 74% of women age 20 to 69 had been screened at least once between 2006 and 2008. Based on these data, cervical cancer screening can likely be improved in Nunavut and meaningfully impact case detection.

Cervical and breast cancer screening are essential to early detection and improving prognosis. Presently, cervical screening guidelines are being revised and mammography guidelines are not followed due to logistical difficulties of screening in remote communities. HPV vaccination promotion and sexual health messaging are paramount to lowering cervical cancer rates. In addition, further investigation into tumor grade for breast cancer in order to identify specific breast cancer groups may provide insight to tailor prevention and screening programs.
Male Reproductive Cancers: Prostate, Testis, Other

Nunavut male reproductive cancer rates have historically been lower than the national average, but with changing lifestyles this trend is changing.20, 42

What are male reproductive cancer rates in Nunavut and how do we compare to the rest of Canada?

Prostate cancer is the third leading cancer site amongst male Nunavummiut and accounts for 3% of all cancer cases (24 cases) diagnosed between 1999 and 2011. The Nunavut rate is significantly below the national average with the exception of 2003 and 2004. This finding is consistent with other circumpolar regions.8, 37, 42

There are likely both genetic and lifestyle factors that impact prostate cancer risk. This assertion is supported by the finding that Inuit who emigrate are at increased risk for prostate cancer but their risk remains 70% lower than the destination country.8

Non-modifiable factors thought to be related to risk are: (1) genetics (e.g. lower androgen receptor activity, which is protective) and (2) increasing age, which increases risk.46, 93

Modifiable factors thought to be related to risk are: (1) diet (traditional diets high in omega-3 fatty acids are protective and high-calorie diets increase risk), (2) obesity, which increases risk and (3) physical activity, which is protective.42, 112

Testicular cancer accounts for 0.7% of all cancers (5 cases) diagnosed between 1999 and 2011. There are too few cases to trend; however, the rate is generally 2 to 5 times lower than the national rate. In recent years, this trend seems to be changing with the 2010 rate being almost equal to the national rate and the 2011 rate being 1.6 times higher than the national rate.

Testicular cancer risk factors are not well understood but it has been noted to predominantly occur in those of European ancestry and is most consistently associated with failure of the testicles to descend (4.3-fold [3.6-5.1]), prior testicular cancer history and family history of disease.26, 31

Other male cancer accounted for 0.4% of all cancers (3 cases) diagnosed between 1999 and 2011.
Are there regional differences in male reproductive cancer rates across Nunavut?

Baffin had the highest prostate cancer rate (14.1 cases per 100,000) followed by Kivalliq (8.9 cases per 100,000) and then Kitikmeot (8.3 per 100,000). Baffin had the highest proportion of cases (67%) followed by Kivalliq (21%) and Kitikmeot (12%).

There are too few testicular cancer cases to regionally trend.

Are there age-related trends in male reproductive cancer incidence in Nunavut?

Prostate cancer incidence generally trends up by age group, sharply declining after 80-84 years.

Testicular cancer cases are clustered between 28 and 34 years.

What mortality data are available for prostate cancer?

Death clearance data are obtained from Statistics Canada and are available for years 1999-2008. For Nunavummiut diagnosed with prostate cancer, 0% died within one year of diagnosis.

Discussion: What does this information mean for Nunavummiut?

A reversal of the trend of lower prostate cancer incidence has been noted in Alaskan Inuit and is thought to be attributable to the adoption of a western lifestyle.\textsuperscript{69, 100} As high-calorie diets, obesity, and low physical activity become more common and there is an increase in life expectancy, it is anticipated that there may be a corresponding increase in prostate cancer incidence in the coming decades.\textsuperscript{20, 42, 93} Healthy lifestyles and screening are essential to reducing male reproductive cancer risk and improving prognosis.
Hematopoietic & Lymph node Cancers:
Hodgkin Lymphoma, Leukemia, Multiple Myeloma, Non-Hodgkin Lymphoma, Other Lymph

Hematopoietic cancers remain lower in Nunavut than nationally. Risk factors differ by cancer type and subgroupings within each type.

There are no clear, overarching lifestyle or dietary risk factors for leukemia and lymphoma; risk differs by subgroupings. Smoking has been consistently associated with Hodgkin lymphoma; its effects on other lymphomas is unclear. Chemical exposure and radiation exposure in childhood are associated with leukemia.

Infectious diseases are also associated: (1) EBV is implicated in Hodgkin and non-Hodgkin lymphoma, (2) H. pylori is implicated in B-cell lymphomas in mucosa-associated lymph tissue, increasing risk 7.2-fold (3) Chlamydia psittaci in eye tissues are linked to B-cell lymphomas in this area, (4) Campylobacter jejuni is linked with B-cell lymphomas in the small intestine, (5) HTLV-1 is implicated in Adult T-cell leukemia and lymphoma, and (6) Hepatitis C is associated with non-Hodgkin lymphoma.

Hodgkin Lymphoma accounted for 2 cases (2 male) between 1999 and 2011 which was 0.3% of all cancer cases and averages 0.2 cases per year. This sample size is too small to provide a meaningful epidemiologic description.

Leukemia accounted for 12 cases (6 female, 6 male) between 1999 and 2011 which was 2% of all cancer cases and averages one case per year. The median age at diagnosis was 31.5 years (range 1-67, standard deviation 25.9 years).

Multiple Myeloma has accounted for a single case between 1999 and 2011 which was 0.1% of all cancer cases and averages 0.1 cases per year. This sample size is too small to provide a meaningful epidemiologic description.

Non-Hodgkin Lymphoma accounted for 7 cases (3 female, 4 male) between 1999 and 2011 which was 1% of all cancer cases and averages 0.5 cases per year. The average age at diagnosis was 60.7 years (range 50-72, standard deviation 8.8).

Other lymph cancers accounted for 1 case between 1999 and 2011.
Thyroid and Other Endocrine

**Thyroid cancer** accounted for 1% of all cases (9 female, 2 male) between 1999 and 2011, averaging one case per year. The average age at diagnosis was 42.3 years (range 22-66, standard deviation 14.8 years). The Canadian thyroid cancer rate is trending up especially in women. This is reflected globally and is not entirely explained by a change in diagnostic techniques. Since 2003, the Nunavut rate has been 4-12 times below the national rate.

Histology and grade are both important considerations for risk factors. Follicular tumors are more common than papillary tumors in regions of iodine insufficiency and differentiated carcinoma are most frequently diagnosed in women. In Nunavut, all cases were papillary tumors and grade was unavailable.

Exposure to ionizing radiation in childhood and a history of thyroid abnormalities are the only widely-recognized risk factors for thyroid cancer.

**Other endocrine cancers** accounted for 2 cases (2 female) between 1999 and 2011.

Brain

**Brain cancer** accounted for 2% of all cancer cases (10 female, 5 male) between 1999 and 2011. On average brain cancer accounts for 1 case per year with a median diagnosis age of 29 years (range 1-81 years, standard deviation 23.6 years).

Because of the small annual case counts, the Nunavut rate is highly unstable. When the Nunavut brain cancer rate is averaged over the 11-year period under study it does not differ significantly from the national rate.

Connective & Soft Tissue Cancers:

**Bone, Joint, Soft Tissue, Melanoma, Other Skin**

**Bone and joint cancers** accounted for 2 cases (1 female, 1 male) between 1999 and 2011. **Soft tissue cancers** accounted for 2 cases (2 female) between 1999 and 2011. **Melanoma** accounted for 4 cases (1 female, 3 male) between 1999 and 2011. **Other skin cancers** accounted for 6 cases (4 female, 2 male) between 1999 and 2011.

Unknown

**Unknown cancers** accounted for 2% of all cancer cases (8 female, 9 male) diagnosed between 1999 and 2011.
Summary

Cancer is the leading cause of mortality and significantly contributes to illness in Nunavut. Nunavut’s pattern of cancer is distinct from the rest of Canada with a higher rate of lung, colorectal and oral cancers and lower rates of reproductive cancers. When looking at all cancers combined, the overall cancer rate is higher among Nunavut women when compared to the national rate while the rate in Nunavut men is a fraction of the national rate.

Nunavummiut have a different risk factor profile than Canada. Factors increasing cancer risk include: higher tobacco use rates, lower physical activity, dietary patterns, crowded housing conditions, different patterns of infectious diseases and increasing chronic disease rates. However, the Tobacco Reduction Strategy, federal and territorial nutrition programs, alcohol restriction and public health immunization programs have likely reduced the risk of some cancers.

Further work is required to lower cancer rates and cancer mortality in Nunavut. Particular focus on prevention and early detection is required for the top cancers affecting Nunavummiut. Programs already in place regarding tobacco reduction, nutrition and immunization are essential to reducing the cancer rate in Nunavummiut. Further programs for screening and healthcare accessibility are required to enable early detection, thereby improving prognosis and enabling Nunavummiut to remain as close as possible to their communities for screening and treatment.

Recommendations

Timely, complete cancer surveillance data to guide policy:
- Regular auditing of the Nunavut cancer registry
- Regular reporting schedule

Timely risk factor surveillance data:
- Implement surveillance program to collect data on risk factors identified in this report
- Advocate for improved representativeness on Canadian Community Health Survey

Cancer prevention strategies:
- Continue Tobacco Reduction Strategy
- Continue alcohol regulation strategy
- Continue Food Security Strategy
- Reduce communicable disease transmission (including but not limited to: EBV, HPV, TB, H. pylori)

Targeted early detection strategies:
- Continue to improve the quality of the cervical cancer screening program
- Review the breast cancer screening program
- Colorectal screening program

Obtain further histological grading and molecular information on select cancers to tailor prevention strategies.
References:


McDonald JT, Trenholm R. Cancer-related health behaviours and health service use among Inuit and other residents of Canada’s north. Social Science & Medicine 2010;70:1396-1403.


Statistics Canada. Table 102-4505: Crude birth rate, age-specific and total fertility rates (live births), Canada, provinces and territories. Source: http://www5.statcan.gc.ca/cansim/a26?

Statistics Canada. Table 102-0563: Leading causes of death, total population, by sex, Canada, provinces and territories. Source: http://www5.statcan.gc.ca/cansim/a26?


Appendix A: Data sources and Limitations

The Canadian Cancer Registry (CCR): Incident Data

Population Health Information in collaboration with Cancer Care Ontario identifies incident cancer cases; this data is then provided to the Health Statistics Division at Statistics Canada. Nunavut data is available for 1999-2011, with 2011 cases being provisional. National data is available from 1984 to 2007, with data from 2008 and onwards being projections done by the Public Health Agency of Canada.

The CCR provides data on demographic and clinical factors. Patients are registered according to jurisdiction of residence at the time of diagnosis. The database is structured to prevent duplicate person or tumor entry. This information is also linked with mortality data to ensure database completeness. Cancer is classified using the International Classification of Diseases for Oncology, 3rd revision (ICD-O-3).

Limitations: (1) missing data due to out of territory diagnosis and difficulty in case finding, and (2) timeliness of data, there is an 18-month delay on data release.

The Canadian Vital Statistics death database (CVS:D): Mortality Data

The Nunavut Vital Statistics office registers territorial deaths; this data is provided to the Health Statistics Division at Statistics Canada for inclusion in the CVS:D.


Cause of death is classified using the International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10). To be classified as a cancer death it needs to be certified by a physician.

Limitations: (1) missing data due to out of territory deaths secondary to lack of territorial tertiary facilities, (2) timeliness of data due to out of territory deaths and completing autopsy reports, and (3) misclassification of cause of death during certification process resulting in the possible underreporting of deaths attributable to cancer.

Population Data: Nunavut and Canada

Population projections based on the 5-year national census data obtained from the Nunavut Bureau of Statistics was used for the Nunavut population. Population projections based on the 5-year national census data from Statistics Canada was used for the Canadian population.

Limitations: Assumptions of growth for projection calculations.

The Canadian Community Health Survey (CCHS): Risk Factor Data

CCHS is a national, cross-sectional, self-report survey targeting Canadians 12 years and older. From 2000 to 2005 it was conducted every two years; from 2007 onward it has been done annually. In Nunavut, 350 individuals from 10 communities (Iqaluit, Rankin Inlet, Cambridge Bay, Kugluktuk, Cape Dorset, Igloolik, Pond Inlet, Baker Lake and Arviat) are surveyed each year providing a 71% coverage rate.

Limitations: (1) non-representative sample and biased information due to non-random community selection, (2) self-report bias, and (3) small sample size.

Inuit Health Survey (IHS): Risk Factor Data

IHS is a cross-sectional, health status survey conducted in Inuit-inhabited areas of Canada excluding Quebec in 2007 and 2008. There were 33 coastal and three inland communities targeted. In Nunavut, 1,923 residents 18 years and older and self-identified as Inuit were surveyed in 25 communities. An average of 1.4 people per household participated.

Limitations: (1) Cross-sectional design, (2) self-report bias, and (3) exclusion of homeless population.

Community Health Service Records (CHSR): Community Health Centre Visits

The CHSR is an administrative database. When an individual accesses a health centre, the practitioner completes a CHSR form listing the reason for accessing services and the ICD-10 code. These forms are then mailed to Iqaluit for entry into the database.

Limitations: (1) Incorrect codes, (2) incomplete forms, (3) missing information, and (4) data entry error.
## Appendix B: Cancer site classification: ICD-O-3

<table>
<thead>
<tr>
<th>Cancer</th>
<th>ICD-O-3 Code</th>
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<tbody>
<tr>
<td>Oral</td>
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<td>Other buccal cavity &amp; pharynx</td>
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<td>Esophagus</td>
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<td>Stomach</td>
<td>C16</td>
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<tr>
<td>Colorectal</td>
<td>C18-20, C26.0</td>
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<td>Liver</td>
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<td>Pancreas</td>
<td>C25</td>
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<td>Other digestive system including small</td>
<td>C17, C21, C22.1, C24, C26.8-26.9, C48.0-48.8</td>
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<tr>
<td>intestine and anal</td>
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<td>Larynx</td>
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<td>Lung</td>
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<td>Melanoma</td>
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<td>Other endocrine</td>
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<td>Other lymph</td>
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<td>Leukemia</td>
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<tr>
<td>Soft tissue</td>
<td>C38.0, C47, C49</td>
</tr>
<tr>
<td>Unknown</td>
<td>C42.0-42.4, M-8000 to M-9049, M-9056 to M-9139, M-9141 to M-9589; C76.0-76.8, M-8000 to M-9049, M-9056 to M-9139, M-9141 to M-9589; C77.0-77.9, M-8000 to M-9049, M-9056 to M-9139, M-9141 to M-9589; C80.9, M-8000 to M-9049, M-9056 to M-9139, M-9141 to M-9589; M-9740, M-9741, M-9750 to M-9758, M-9760 to M-9769, M-9950 to M-9962, M-9970 to M-9989</td>
</tr>
</tbody>
</table>
Appendix C: Methodology

**Age Statistics**

For age, the mean is provided as a summary measure for estimates that have a normal distribution. In cases where the data is skewed the median is provided.

**Confidence intervals and statistical significance**

Confidence intervals are a measure of variability; when available the 95% confidence interval is provided in square brackets next to the estimate.

The confidence interval overlap method was used to determine statistical significance in rate comparisons. The confidence intervals for rate comparisons were calculated using the Fleiss method.

**Three-year moving average**

A three-year, simple moving average for Nunavut ASIR data was used to smooth trends and facilitate interpretation.

**Incidence rates: Nunavut & Canada**

Nunavut incident rates were calculated from the territorial cancer registry which is collaboratively maintained with Cancer Care Ontario. The 2011 data is considered provisional. Canadian incident rates were calculated from the CCR.

The cancer registry is a dynamic database, thus incidence rates may change as more data becomes available.

**Age-standardized incident rate (ASIR)**

Incident data was standardized to the 1991 Canadian population using the direct method. The direct method involves weighting the ASIRs for each 5-year age group according to the age distribution of the 1991 Canadian population.