Cancer

IN NEW BRUNSWICK COMMUNITIES

Investigating the environmental connection

PART 2

Fourteen Urban and Rural Areas (1989-2005)

Inka Milewski and Lily Liu

Conservation Council *of* New Brunswick
Conseil de conservation *du* Nouveau-Brunswick

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Executive Summary

Health Watch, a program of the Conservation Council of New Brunswick, undertook a two-year study to examine cancer rates and their risk factors among communities in New Brunswick between 1989 and 2005. The program's first report (*Cancer in New Brunswick Communities: Investigating the environmental connection, Part 1. Moncton Saint John and Fredericton*) examined the incidence rates (1991-2005) of four major cancer types in the province's three largest cities (Saint John, Moncton and Fredericton) and compared them with rates at the national, provincial and health region level. The study found that lung cancer incidence rates among males and females in Saint John, one of the province's most industrial communities, were significantly higher than rates reported for Fredericton and Moncton as well rates reported for Saint John's health region (Health Region 2), the province and Canada. The study also found that occupation and air pollution were likely more significant risk factors for lung cancer in Saint John than smoking.

The first step in the development of effective community health promotion and cancer prevention programs is understanding disease patterns and risk factors at the community level. This second report provides never-before-published rates of cancer for eight urban (Bathurst, Caraquet, Dalhousie, Edmundston, Fredericton, Miramichi, Moncton and Saint John) and six rural areas (Base Gagetown, Belledune, Drummond-Denmark, Harvey, Minto and Upper Miramichi) in New Brunswick.

Incidence rates (1989-2005) of fourteen primary malignant or invasive cancers (lung, colorectal, breast, prostate, non-Hodgkin's lymphoma, kidney, bladder, pancreatic, brain/central nervous system, thyroid, leukemia, ovarian, bone/joints and Hodgkin's disease) were calculated for each study area. Rates were calculated based on cancer counts provided by the New Brunswick Cancer Registry Database and reported as unadjusted (crude) incidence rates per 100,000 population. These rates were compared with provincial rates for the same time period.

One limitation of this study was that data were not available to calculate cancer incidence rates for all cancer types in all study areas. Where data were available, the communities studies were ranked by each cancer type for males and females. They were also ranked overall based on four major cancer types for males and three major cancer types for females.

The results of this study confirm the findings of the Conservation Council's first cancer report. Cancer statistics, when reported for large geographic areas, tend to obscure important community-level health information and fail to identify or call attention to specific communities that are clearly experiencing unusually high rates of certain types of cancer.

Major findings of this study include:

- For males, Dalhousie ranked highest among the 14 communities studied based on four major cancer types (lung, prostate, colorectal and bladder); the Minto and Harvey areas ranked second and third, and Saint John ranked fourth;

- For females, the Minto area ranked highest among the 14 communities studied based on three major cancer types (lung, breast, and colorectal); Dalhousie and Bathurst ranked second, and Saint John and the Upper Miramichi area both ranked third;
- In general, males and females in Caraquet and the Drummond-Denmark and Base Gagetown areas had the lowest cancer incidence rates among the 14 communities studied with two exceptions: males in Caraquet had the highest rate of pancreatic cancer and women in the Base Gagetown area had the highest rate of brain cancer, along with women in the Upper Miramichi area;
- Several of the 14 communities studied had cancer rates that were double the provincial rates for these cancers (e.g. pancreatic cancer among males in Caraquet, non-Hodgkin's lymphoma among males in Dalhousie, and lung and colorectal cancers among females in Minto). And the rate of ovarian cancer in Dalhousie was triple the reported provincial rate for this cancer.

The consensus among the majority of cancer researchers is that most cancers are not inherited but acquired over the course of a lifetime and that the majority of cancers are preventable. One key to understanding the incidence of cancers, even in families with a history of a particular cancer type, is to examine shared family lifestyles factors (e.g. smoking, alcohol consumption, diet, level of physical activity), as well as occupational and environmental exposures to pollutants.

This study assembled and examined data and information on key risk factors for each cancer type and each community studied. Data on key lifestyle risk factors at the community level were not available. This type of data is available only at the provincial or health region level. Published data on cancer incidence in various occupational setting were also unavailable. Industrial pollutant releases and air quality data were available, but only for some communities.

Information on environmental contaminants in communities was limited and, where available, it was based on studies and monitoring reports prepared by federal and provincial agencies and/or industry. In view of the absence of provincial data on lifestyle, occupational and environmental risk factors, peer-reviewed scientific publications examining the role of these factors in relation to the occurrence of specific types of cancer were reviewed.

In general, this study found that communities that have higher overall rates of cancer such as Dalhousie, Minto, Saint John and Belledune seem to have more industrial activity and/or potential for environmental contamination than those that have lower rates of cancer such as Caraquet and the Base Gagetown and Drummond-Denmark areas.

In addition, some of the communities that were studied shared high rates of specific cancers and certain occupational and environmental risk factors linked to those cancer types. For example, lung cancer rates among males and females in the Minto area, Dalhousie and Saint John were found to be the highest among the 14 communities studied. These communities are also known to have been subjected to substantial, long term releases of industrial pollutants including fine particulates and carcinogens, as well as with occupations known to be significant risk factors for lung cancer (e.g. coal mining, petroleum refining, pulp and paper production).

Similarly, males and females in the Minto area and Dalhousie all shared high rates of bladder cancer as well as probable environmental exposure to arsenic, which is known to be a key risk factor for bladder cancer.

Male cancer rankings among 14 urban and rural areas in New Brunswick (1989-2005)

Urban/Rural Area	Individual Cancers											Overall Rank[2]
	Lung	Colorectal	Prostate	Non-Hodgkin's Lymphoma	Bladder	Kidney	Pancreas	Brain	Thyroid[1]	Hodgkin's Disease[1]	Leukemia[1]	
Base Gagetown Area	11	13	12	13	7	12	7	*	*	*	*	11
Bathurst	6	6	5	4	6	6	6	3	*	*	*	5
Belledune Area	4	10	1	*	11	1	*	*	*	*	*	7
Caraquet	14	12	13	9	13	8	1	*	*	*	*	12
Dalhousie	2	1	2	1	1	2	3	*	*	*	*	1
Drummond-Denmark Area	12	14	14	11	14	11	8	*	*	*	*	13
Edmundston	5	4	10	7	12	10	9	5	1	*	1	8
Fredericton	13	9	8	8	8	9	10	1	4	3	4	9
Harvey Area	8	3	3	2	3	*	*	*	*	*	*	3
Miramichi	9	8	11	10	10	5	11	7	2	1	*	9
Minto Area	1	2	4	3	2	*	2	*	*	*	*	2
Moncton	10	11	9	6	9	7	4	4	5	2	3	10
Saint John	3	5	6	5	5	4	5	6	3	4	2	4
Upper Miramichi Area	7	7	7	12	4	3	*	2	*	*	*	6

Female cancer rankings among 14 urban and rural areas in New Brunswick (1989-2005)

Urban/Rural Area	Individual Cancers												Overall Rank[3]
	Lung	Colorectal	Breast	Non-Hodgkin's Lymphoma	Bladder	Kidney	Pancreas	Brain	Ovary	Thyroid[1]	Hodgkin's Disease[1]	Leukemia[1]	
Base Gagetown Area	12	14	13	*	8	*	9	1	*	4	*	*	9
Bathurst	5	3	5	7	9	2	1	6	8	2	*	*	2
Belledune Area	8	4	11	*	*	*	*	*	*	*	*	*	6
Caraquet	13	12	12	4	*	*	3	*	*	*	*	*	8
Dalhousie	2	7	4	2	1	1	2	*	1	*	*	*	2
Drummond-Denmark Area	14	13	14	10	5	5	8	*	*	*	*	*	10
Edmundston	7	11	9	11	7	8	10	7	7	1	1	*	7
Fredericton	10	8	1	9	10	7	11	2	4	6	*	2	7
Harvey Area	9	5	3	*	*	*	*	*	*	*	*	*	4
Miramichi	4	10	7	5	6	3	4	3	3	3	*	*	5
Minto Area	1	1	10	3	2	*	*	*	*	*	*	*	1
Moncton	6	9	8	6	4	6	7	4	6	7	2	1	6
Saint John	3	6	6	8	3	4	5	5	5	5	3	3	3
Upper Miramichi Area	11	2	2	1	*	*	6	1	2	*	*	*	3

25-49% above provincial rate

50-74% above provincial rate

75-99% above provincial rate

100 +% above provincial rate

[1] Insufficient data to calculate provincial rates for the same time period.

[2] Ranking based on lung, colorectal, prostate and bladder cancer rates only.

[3] Ranking based on lung, colorectal and breast cancer rates only.

* Insufficient data to calculate incidence rates

There are certain cancers (some rare) where the evidence that a specific contaminant is linked to a specific cancer type is strong or sufficient to make a positive association (e.g asbestos exposure and mesothelioma of the thoracic cavity, occupational exposure to wood dust and sino-nasal cancer, and specific classes of pesticides such as chlorophenoxy and hexachlorobenzene herbicides with laryngeal, multiple myeloma and testicular cancer). The incidence rate of these cancer were not examined in this study.

The findings of this study raise several questions that strongly suggest the need for more detailed, community-focused epidemiological studies of cancer and other chronic disease rates.

Communities are where people live and work, where occupational and environmental exposures occur, and where industrial emissions often tend to be concentrated. Cancer (and other health) statistics reported at the health region or provincial level fail to identify communities at-risk and delay research that could lead to the development and implementation of appropriate risk reduction and cancer prevention programs in those communities. Better community-focused health data, like that assembled in this report, could help identify communities at-risk and enable early intervention that could prevent cancer, reduce health care costs, and save lives.

Based on the results of this study, the Conservation Council of New Brunswick is recommending that the Minister of Health:

- Direct the New Brunswick Cancer Network to begin public reporting of cancer rates at the community level;
- Work with the Minister of Environment to improve air and water quality standards and require industries to eliminate releases of carcinogens from their operations;
- Direct the New Brunswick Cancer Network to expand cancer prevention outreach and educational programs to include occupational and environmental risk factors such as exposure to pesticides, household and industrial chemicals, and air and water pollution; and
- Enlist the assistance of government and non-government agencies and academic institutions to effectively address the questions raised in this report.

The Minister of Health will need to assign a high priority to an integrated program of epidemiological studies and public policy changes in order to address the findings and questions raised by this study. New financial commitments should not be required. Rather, the Minister should reorder some of the department's priorities and reallocate certain of its human and financial resources.

A copy of the full 91-page report can be downloaded from the Conservation Council of New Brunswick website www.conservationcouncil.ca or purchased from the office by calling (506) 458-8747.

Introduction

Currently most health statistics, including cancer rates, are reported by large geographic areas. This type of reporting offers no insight into cancer and other disease conditions at the community level where people live and work, and where environmental exposures and industrial emissions are concentrated. It fails to identify cancer hotspots and their key risk factors and delays the development and implementation of appropriate risk intervention programs that could prevent additional cancers.

In 2007 Health Watch, a program of the Conservation Council of New Brunswick, undertook a two-year study to examine cancer rates and their risk factors among communities in New Brunswick between 1989 and 2005. The program's first report (*Cancer in New Brunswick Communities: Investigating the environmental connection, Part 1. Moncton Saint John and Fredericton*) demonstrated that cancer rates reported by large geographic areas (e.g. health region or province) obscures important information about the health of New Brunswickers at the community level.[1] The study found that lung cancer incidence rates among males and females in Saint John, one of the province's most industrial communities, were significantly and consistently higher than rates reported for Fredericton and Moncton as well as rates reported for Saint John's health region (Health Region 2), the province and for Canada. The study also found that occupation and air pollution were likely more significant risk factors for lung cancer in Saint John than smoking.

The first step in the development of effective community health promotion and cancer prevention programs is understanding disease patterns and risk factors at the community level. This report builds on the findings of the first report and examines the cancer incidence rates of fourteen major cancer types in fourteen urban and rural areas for males and females in New Brunswick between 1989 and 2005. Community-level rates were compared to provincial rates for the same time period where data were available. Lifestyle, environmental and occupational risk factors for each cancer type were also examined.

Study Methods

Each new case of cancer is recorded with the New Brunswick Cancer Registry Database by sex, age, year of diagnosis, type of cancer and geographic location. This data is shared with the National Cancer Registry. The geographic location of each cancer diagnosed is recorded using Statistics Canada's census subdivision (CSD) codes and not the location where the cancer diagnosis or treatment occurred. For example, if a cancer diagnosis occurred in the city of Miramichi (CSD code 09 050) but the patient lived in the village of Blackville (CSD code 09 019) or the parish of Blackville (CSD code 09 018), the cancer incidence or death would be recorded using the CSD code for the town of Blackville or Blackville Parish.

Cancer types are classified according to the *Surveillance, Epidemiology and end Results (SEER) Groups for Primary Site* which is based on an international cancer classification system. This study focused on the incidence of fourteen primary malignant or invasive cancers in fourteen urban and rural areas in New Brunswick. The cancer types were: lung (and bronchus); colorectal, breast, prostate, non-Hodgkin's lymphoma (NHL), kidney, bladder, pancreas, brain/central nervous system, thyroid, leukemia, ovary, Hodgkin's and bone/joints.

Cancer incidence rates are generally reported as unadjusted (crude) or age-standardized incidence rates (ASIR) per 100,000 population. Unadjusted or crude rates are not age standardized. Age-standardization involves adjusting the population age structure of a province, health region or community to the age structure of the 1991 Canadian population age structure. The effect of age-standardization is to adjust (increase or decrease) cancer rates depending on how much the population age-structure in a community varies from the 1991 standard Canadian population. Standardization allows populations with different age demographics to be more accurately compared. Factors that could change the age structure in a community include large increases in immigrant populations, large-scale emigration and large increases/decreases in birth and or death rates. None of these major changes have occurred in the communities in this study (Appendix A) or in New Brunswick in general.[2]

New Brunswick's information privacy policy restricts what cancer (or other health) data are released. Any data which could potentially lead to the identification of an individual are withheld. In this study, if the number of new cases of a specific cancer type was less than six counts in a particular year or time period for a particular community or area, the New Brunswick Department of Health withheld the data. For example, if there were fewer than six cases of bladder cancer in Caraquet between 1989 and 2005, the data would be withheld.

Given the province's privacy policy, age-standardization of incidence rates was not possible for all the urban and rural areas in this study. All cancer rates in this study are reported as unadjusted (crude) incidence rates per 100,000 population unless otherwise indicated.

Male and females cancer counts for 14 cancer types

between 1989 and 2005 were obtained from the New Brunswick Cancer Registry Database for 14 urban and rural areas. The average population for four census periods (1991, 1996, 2001 and 2005) in each of the 14 study areas was used to calculate cancer incidence rates per 100,000 population (1989-2005). The population in each of the 14 study areas varied an average of ± 6% over a 17-year period. It was not possible to calculate incidence rates for all 14 cancer types for all study areas due to low cancer counts for some cancers types (e.g. less than six recorded between 1989 and 2005). Provincial cancer counts for the same cancer types and time period were obtained from the NB Cancer Registry Database and the Statistics Canada Cancer Registry Database.

Across Canada, lifestyle factors (e.g. smoking, alcohol consumption, physical inactivity, diet, etc) associated with some diseases and cancer types are not reported at the community level or census subdivision level, with one exception. Statistics Canada does report some risk factor data for selected census metropolitan areas (CMAs) in Canada. Some risk factor data are reported at the health region level within provinces as well as at the provincial level.

The lack of data at the community-level made it impossible to assess the role smoking and other lifestyle risk factors may have played in cancer incidence rates for each study area. Scientific studies on lifestyle and other risk factors linked to each cancer type in this study were reviewed.

A wide range of social and economic indicators (e.g. population, income, unemployment rates, education, composition of the labour force) were compiled for each study area for 1991, 1996, 2001 and 2006 (Appendix A). The source of the data was Statistics Canada's community profile database.

Data on the source and release of industrial pollutants were obtained from Environment Canada's National Pollutant Release Inventory and from summaries prepared by PollutionWatch which is under the auspices of Environmental Defense and the Canadian Environmental Law Association (Appendix A). Information on air quality was obtained from the province's annual air quality monitoring reports.

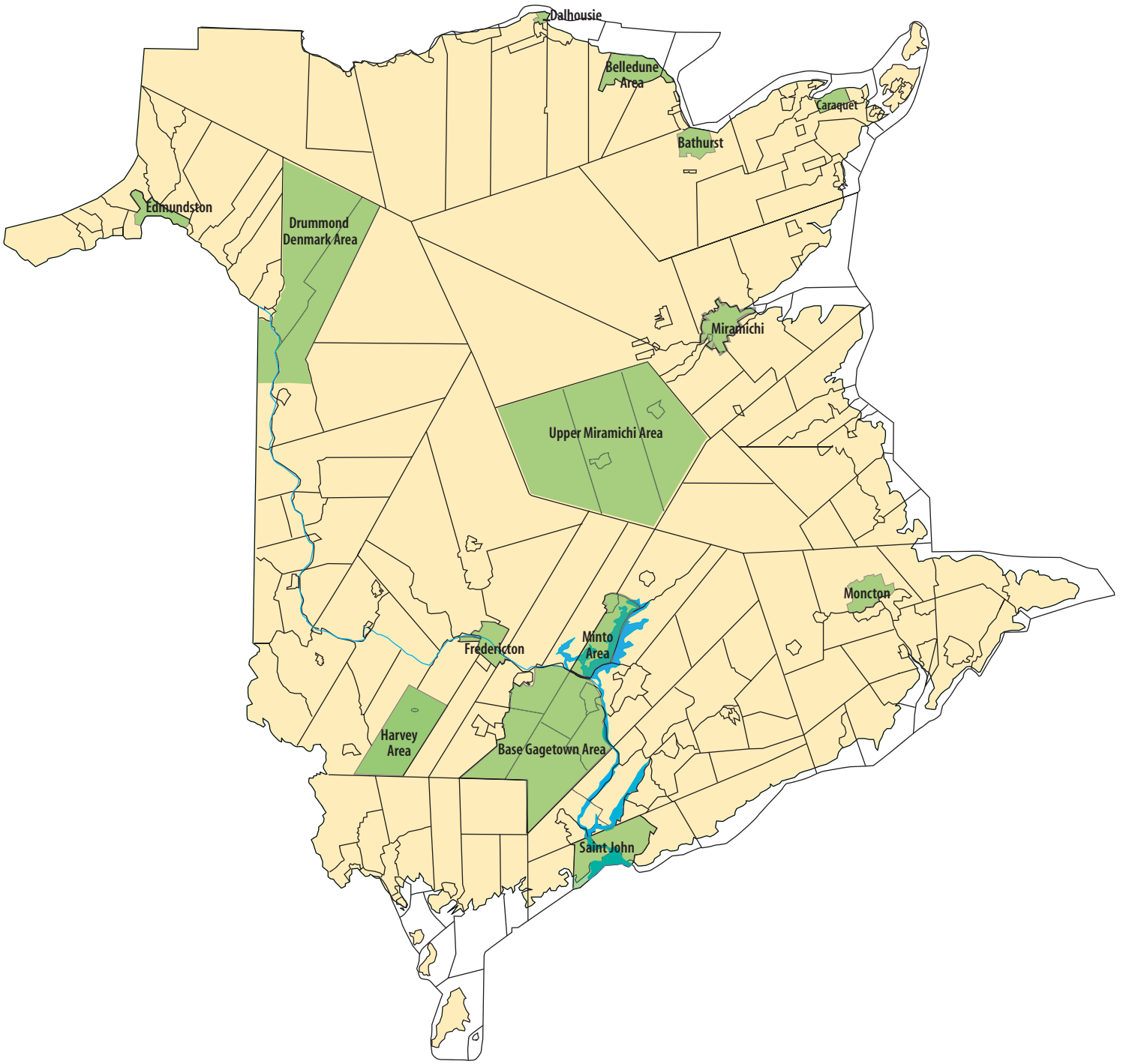
Study Areas

Fourteen urban and rural areas were selected for this study. They include the cities of Saint John (01 006), Moncton (07 022), Fredericton (10 032), Miramichi (09 050), Bathurst, C (15 011) and Edmundston, C (13 027) and the towns of Caraquet (15 028) and Dalhousie (14 017). (The number in brackets indicates Statistic Canada's CDS code for the community/area.) The city of Miramichi was created in 1992 when the towns and/or villages of Chatham (1309008), Loggieville (1309007), Nelson-Miramichi (1309015), Newcastle (1309032) and Douglastown (1309033) were amalgamated. In 1998, Edmundston became a city when it amalgamated with the villages of Verret (1313030), Saint-Jacques (1313026) and Saint-Basile (1313019). The cancer counts obtained for this study (1989-2005) include the counts for the town and villages added to the amalgamated cities.

Each of the six rural areas in this study encompasses several villages and parishes. These are: Drummond-Denmark area (Drummond parish 12 021, Drummond village 12 023, Denmark parish 12 014 and Grand Falls parish 12 016); Minto area (Canning parish 04 021 and the village of Minto 04 022); Base Gagetown area which excludes the town of Oromocto (Gagetown village 04 005, Gagetown parish 04 004, Burton parish 03 011, Blissville parish 03 001; Petersville parish 04 001, Hampstead parish 04 006); Upper Miramichi area (Blackville village 09 018, Blackville parish 09 019, Blissfield parish 09 021,

Doaktown village 09 022 and Ludlow parish 09 024), the Harvey area (Harvey village 10 005 and Manners Settlement parish 10 004) and the Belledune area (Belledune 14 025 and Pointe-Verte village 15 013). Belledune (14 025) is the result of an amalgamation that took place in 1995 when the village of Jacquet River (14002) and surrounding local service districts were amalgamated with what was then the village of Belledune (15034). The cancer counts for the Belledune area included cancer counts for both villages, as well as the village of Pointe-Verte. A map of the study areas appears on page 9.

Statistics Canada's Census Subdivisions for New Brunswick: Fourteen Urban and Rural Study Areas



Economic and Environmental Overview of Study Areas

Historically, and to this day, agriculture and natural resource extraction - forestry, mining and fishing - have been the staples of New Brunswick's economic development. Secondary industries have developed from these activities including pulp and paper production, base-metal smelting and seafood and food processing. Tertiary industries that provide services (e.g. power generation, transportation, port development) to the secondary industries have also evolved over time. Table 1 is a summary of the major economic activities (1989-2005) in the 14 urban and rural areas in this study.

Until recently, Dalhousie, Edmundston, Saint John, Bathurst and Miramichi had pulp and/or paper mills and other wood-products manufacturing operations. The Miramichi kraft paper mill was the largest mill of its kind in Canada. Beginning in 2006, pulp and paper mills in Dalhousie, Miramichi and Bathurst began to close. Sawmills still operate in some of these communities and only the pulp and paper mills in Edmundston and Saint John are still in operation.

Dalhousie was also the site of a chlor-alkali chemical manufacturing plant. It produced chlorine and caustic soda for the pulp and paper industry using a mercury-based process. Between 1973 and 1989, total mercury emissions (to air and water) were reduced from 2,100 kilograms per year (kg/yr) to 40 kg/yr.[3] It was the last facility of its kind in Canada and it closed in 2008.

One of the world's largest deposit of zinc is located 21 kilometres southwest of Bathurst. It has been mined from Brunswick No.12 since the early 1960s. Zinc ore concentrates were shipped via rail to Dalhousie and stored in open piles on the town wharf. The concentrates, which also contained arsenic, lead and cadmium, were shipped to Belgium for smelting. The practice of transporting and storing zinc concentrates at Dalhousie ceased in 1997. Lead, a significant component of the ore mined in Brunswick No.12 was sent to Belledune for smelting. The Belledune smelter began operating in 1967. Shortly thereafter, acid, fertilizer and gypsum plants were added to the smelter complex. Ten years ago the smelter added a battery recycling operation. The acid, fertilizer and gypsum plants closed in recent years and recycling has become a more significant component of the smelter's operation. By the 1980s, New Brunswick's northern shore, between Bathurst and Dalhousie, would be identified as one of the most contaminated areas in Atlantic Canada.[4]

Over the past 40 years, hundreds of federal and provincial government reports, studies and environmental assessments have documented contamination of air, water, soil, fish, wildlife and/or vegetation in Saint John, Belledune, Miramichi, Bathurst and Dalhousie.[5] Human health risk assessments have been done in several communities over the past 10 years as part of proposed industrial expansion, development or remediation projects. They concluded that current levels of benzene and aldehydes in Saint John, arsenic in Dalhousie and lead, benzo-a-pyrene, cadmium and arsenic levels in Belledune posed cancer and non-cancer health risks to residents

above provincial health guidelines.[6] No health risk assessments have been done in Edmundston, Bathurst, Miramichi or the Minto area.

During the mid 1800's, the fisheries in New Brunswick were described in superlatives. Cod, herring, pollock, haddock and mackerel dominated the coastal fisheries and salmon in the Saint John, Restigouche and Miramichi Rivers were described as "prodigious".[7] Shellfish such as oyster, clams, mussels, whelks, crabs and shrimp were also abundant. Today, the fishery has changed. Where it was once dominated by cod and herring, the fishery is now primarily lobster, shrimp and crab and it is now largely confined to the outer Bay of Fundy and the Acadian Peninsula. Fish and shellfish aquaculture operations have increased in number and scale.

Caraquet, along with Shippagan and Lamèque are the three most important fishing ports and seafood processing communities on the Acadian Peninsula.

The Drummond-Denmark area (Victoria county) as well as adjacent Carleton county, in northwestern New Brunswick are part of the province's large potato-growing region. Employment in this rural area is primarily linked to farming, forest harvesting and the transportation sectors (Appendix A). During the late 1970's and 1980's, several provincially sponsored studies and task forces examined associations between agricultural and forestry pesticide use and human health in New Brunswick. The 1983 Hatcher task force on chemicals in the environment and human reproductive problems found birth defects (neural tube defects, facial clefts

Table 1. Major economic activities in 14 urban and rural areas in New Brunswick (1989-2005)[1]

Urban/Rural Area	Agriculture	Coal mining	Fossil fuel power generating stations	Chemical manufacturing	Fishing and fish processing	Transportation	Manufacturing	Pulp and/or paper production	Wood products manufacturing (plywood, strand board, lumber)	Metal mining	Oil refining and associated industries	Sawmills/ wood harvesting	Port development	Smelting
Saint John			■	■		■	■	■			■		■	
Moncton						■	■							
Miramichi						■	■	■	■			■		
Caraquet					■	■	■							
Bathurst						■	■	■	■	■		■		
Dalhousie			■	■		■	■	■				■	■	
Edmundston						■	■	■	■			■		
Fredericton						■	■					■		
Minto Area		■	■			■	■		■			■		
Harvey Area						■				■		■		
Base Gagetown Area						■						■		
Upper Miramichi Area						■			■			■		
Belledune Area			■	■		■						■	■	■
Drummond-Denmark Area	■					■						■		

[1] Sources: Statistics Canada Community Profile data for 1991, 1996, 2001 and 2006, Environment Canada's National Pollutant Release Inventory and New Brunswick's Department of Environment Registry of Operating Approvals.

and incomplete kidney development [bilateral renal agenesis]) and still births were higher in Carlton and Victoria counties than in other counties in New Brunswick.[8] The study suggested these reproductive problems could be attributed to agricultural chemicals without specifying which chemicals (e.g. nitrates and/or pesticides) were responsible. High nitrate concentrations in drinking water have been associated with reproductive effects (specifically neural tube defects and still births) as well as with specific cancers (e.g. bladder, kidney, uterine, and non-Hodgkin's lymphoma).[9]

Two years after the Hatcher report was published, a consultant for the provincial health department found 18% of wells sampled in Carleton County had nitrate levels as high as 30% above Canadian drinking water guidelines.[10] (Wells in Victoria county were not sampled.) All the wells in the study area had various levels of ethylene thiourea, a breakdown product of the pesticide mancozeb. No drinking water guidelines existed for this compound. No follow-up epidemiological studies or health risk assessments were done to examine possible health effects of exposure to agricultural pesticides or nitrates in drinking water in Carlton or Victoria counties.

The Upper Miramichi area in Northumberland county is an area of approximately 3000 square kilometres and includes the villages of Blackville and Doaktown. This rural area has relied almost exclusively on forest-related activities, primarily wood (spruce) harvesting, processing (sawmills) and transportation. The area was also part of the longest and most extensive aerial pesticide spray program to control spruce budworm in the world.[11] Spraying began in 1952 with DDT. In 1965, fenitrothion (an organophosphate insecticide) replaced DDT and, from 1975 to 1985, a carbamate insecticide was used. The spruce budworm spray program ended in 1992. There was only one year, 1959, where spraying did not occur. Between 1952 and 1990, 100,000 mt of DDT and fenitrothion were applied to New Brunswick's forests.[12]

In 1982, a provincial task force was convened to examine the relationship between aerial spraying of fenitrothion in New Brunswick and cancer incidence. The Spitzer task force determined that, between 1972 and 1981, Northumberland county had the highest frequency of exposure to fenitrothion followed by Victoria, Madawaska and Restigouche counties.[13] Fentirothion use in 1976, considered to be the year of most extensive forest spraying, was estimated at 800 mt. The task force concluded that stomach, uterine and lymphatic system (other than leukemia) cancers were highest in counties with above average spraying of forest pesticides (Northumberland, Victoria, and Restigouche counties).[14]

When the task force compared cancer rates between New Brunswick and Nova Scotia where aerial spraying was not done at the time, cancer incidence rates (1969-78) were significantly higher in New Brunswick for 11 cancers in males (lip, stomach, nose, skin, breast, prostate, brain, lymphosarcoma, Hodgkin's disease and other leukemias) and 11 cancers in females (mouth, pancreas, multiple myeloma, connective tissues, melanoma (and other skin cancers), bladder, nervous system, endocrine glands and other leukemias).[15]

The task force made several recommendations including further epidemiological case-control studies. It also recommended maintaining the exposure data-base developed by the task force to permit future efficient surveillance of the health effects and environmental impacts of pesticides used in forest management and agriculture. However, no additional health studies or risk assessments have been done in areas of intensive forest and agricultural pesticide use in New Brunswick.

Like the Drummond-Denmark and Upper Miramichi areas, the Harvey and Base Gagetown areas are rural regions. There are no large-scale industrial or manufacturing operations in these areas. Economic activity is currently based on agricultural and forestry-related activities (wood harvesting and sawmills). Employment in these rural areas is centered around the transportation sector rather than manufacturing, utilities or trades (Appendix A). Antimony mining took place (on and off) in the Harvey area from the late 1890s to 1996. Antimony is used in the manufacture of flame retardants used in plastics, vinyls and synthetic fibres and as an alloy in lead that is used for making automotive batteries; the addition of antimony increases the strength and hardness of the lead.[16] The Harvey area is also known to have naturally high levels of arsenic, radon and uranium in drinking water and radon gas in homes.[17] Radon is an established human lung carcinogen and viewed as a second leading risk factor for lung cancer after smoking.[18] No health studies or risk assessments have been done in the Harvey area.

The Base Gagetown area is so named because it encompasses Canadian Forces Base (CFB) Gagetown. (The town of Oromocto, headquarters for the Base's military personnel, was not part of this study.) The military base covers an area of 110,000 hectares (1100 square kilometres) and provides employment for residents living around the Base.

Since 1956, a wide-range of herbicides (e.g. 2,4-D and 2,4,5-T, known as Agents Orange and Purple; chlorophenoxy, hexachlorobenzene, picloram and paraquat; tebuthiuron; tichlopyr; pentachlorophenol; trichlorbenzoic acid, and glyphosate known as Vison or RoundUp) were applied to an estimated 30,000 hectares reserved for military training.[19] Pesticides were applied through ground and aerial spraying Between 1956 and 2004, a total of 37 different herbicide products were used. Conservatively, the quantity of five herbicides (Agent Orange, Agent Purple, Agent White, picloram, and hexachlorobenzene) used in the spray program has been estimated at 1.4 million litres of chemicals in solution and an addition 1 million kilograms of dry chemicals. In the 50-year history of spraying at the Base, there were only six years where no herbicides were used. Military and non-military personnel were involved in various aspects of the spraying including mixing and loading herbicides, flagging and post-application bush clearing.[20]

In 2005, the federal government ordered several studies to investigate the extent and potential health effects from the use of herbicides used at CFB Gagetown from 1952 to 2003. The epidemiological study encompassed a large geographic area. It included 35 towns, villages and parishes around the Base including the city of Fredericton and the parish of Queensbury to the west Fredericton. The study extended south to the village and parish of Westfield adjacent to the city of Saint John and to parishes northwest of Sussex (e.g. Brunswick parish). The control or reference population for the study was the province of New Brunswick.

The study concluded that specific populations were at possible risk. These included individuals directly involved in herbicide applications, post-application brush clearing, family members of individuals involved in spraying through take-home or track-in pathways and bystanders when spraying occurred.[21] The study reviewed the available scientific literature and found there was sufficient or suggestive evidence to make positive associations between some herbicide exposures (e.g. chlorophenoxy, pentachlorophenol, glyphosate and hexachlorobenzene) and various cancers (e.g. soft tissue sarcoma, non-Hodgkin's lymphoma, laryngeal, multiple myeloma, rectal, breast, prostate and

testicular) as well as other diseases (e.g. spina bifida, spontaneous abortions, Parkinson's disease, and Type 2 diabetes).[22]

Dalhousie, Saint John and the Belludune and Minto areas have provincially-owned fossil-fuel power generating stations. (Saint John is also the site of Canada's largest oil refinery.) The Dalhousie facility began by burning coal, then a bitumen-water slurry called orimulsion and now burns heavy fuel oil. The Belledune power station burns a mixture of coal and petroleum coke. The Saint John power station (Coleson Cove) burned heavy fuel oil until 2004 and now burns a mixture of heavy oil and petroleum coke. Historically the Minto, Belledune and Dalhousie facilities burned locally mined and imported coal.

The Minto-area facility, known as the Grand Lake station, burns locally-mined coal from the province's only coal mine. Minto coal is classified as soft or bituminous coal. Bituminous coal has the highest content of volatile compounds, including sulphur, of all coal types, as well as arsenic and other metals.[23] In the Minto area, high levels of arsenic have been reported in groundwater and/or drinking water, soil, fish and in the sediments and water of Grand Lake.[24] A 2003 community health assessment of the villages of Minto, Chipman and the parishes of Canning, Chipman, Northfield and Sheffield reported the mortality rates for men and women due to cancer and heart and respiratory diseases were higher than the provincial average.[25] In September 2009, the provincial government announced it would close the Grand Lake power station and the coal mine.

Cancer incidence rates and their major risk factors

A summary of the cancer counts and incidence rates for each cancer type in each study area and the province appears in Appendix B. Where cancer counts were below six, data was suppressed by the health department and, therefore, cancer incidence rates could not be calculated for some cancer types.

As identified in previous studies and reports, prostate, breast, lung and colorectal cancers are the dominant cancers among New Brunswickers and Canadians in general, and rates of these cancers vary for males and females.[26] The following section discusses the results, compares rates in the study areas with provincial rates where data is available and examines the major risk factors associated with each cancer type.

Lung Cancer

The provincial unadjusted incidence rates of lung cancer (1989-2005) per 100,000 population were 97.2 for males and 52.6 for females. These rates are generally consistent with the average age-standardized incidence rates (ASIRs) per 100,000 population for New Brunswick for the same time period. Based on Statistics Canada data, the average ASIRs for lung cancer for New Brunswick males and females (1989–2005) were 98.2 and 43.9 respectively.[27] The New Brunswick Department of Health reported unadjusted incidence rates (1997-2001) of 97.4 and

FIGURE 1 **Male Lung Cancer Rates (1989-2005)**
unadjusted incidence rates per 100,000 population

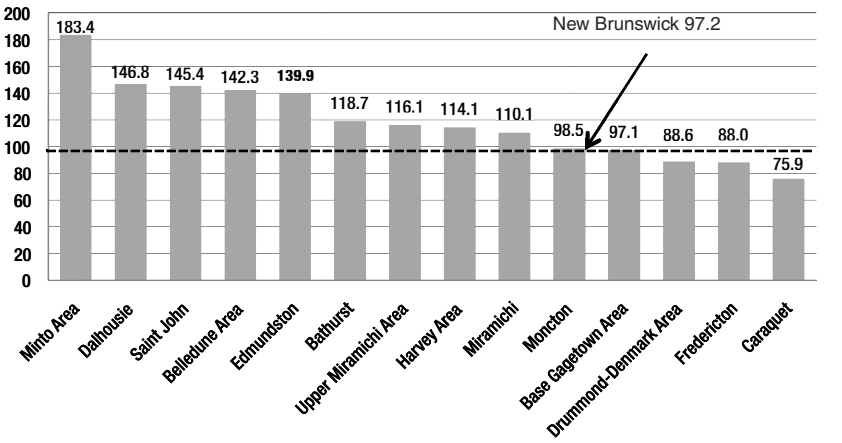
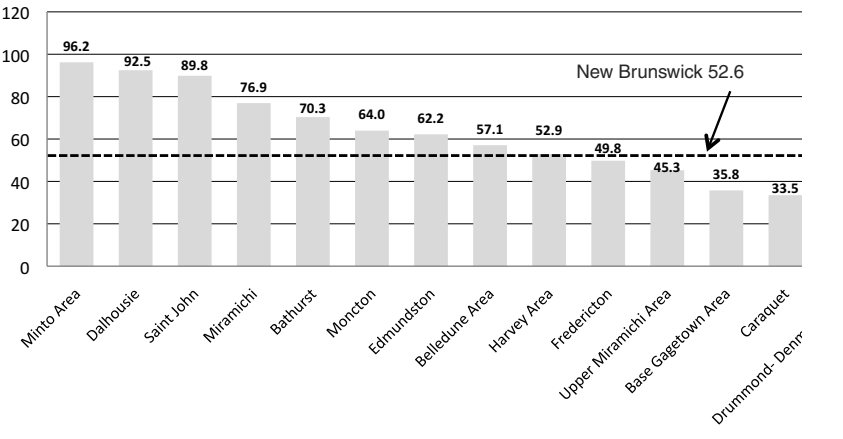


FIGURE 2 **Female Lung Cancer Rates (1989-2005)**
unadjusted incidence rates per 100,000 population



56.2 for males and females respectively.[28]

Lung cancer rates among males and females in the Minto area were almost twice the provincial rate (Figure 1 and 2). Dalhousie and Saint John males and females had the second and third highest rates of lung cancer. Cancer rates among Dalhousie and Saint John males were 50% higher than the provincial rate. Among females, Dalhousie and Saint John rates were 76% and 71% higher than the provincial unadjusted rate.

Males in Edmundston and the Belledune area also had rates of lung cancer significantly higher (44% and 42% respectively) than the provincial rate. Among females, Miramichi and Bathurst had rates significantly higher (46% and 34% respectively) than the provincial rate.

A direct comparison between cancer rates calculated for Moncton, Fredericton and Saint John in this study can not be made with those calculated in a previous study (unadjusted versus age-standardized rates). However, this study confirmed the finding of the previous study. Lung cancer rates for men and women in Saint John are significantly higher than rates in Moncton and Fredericton.

Lung Cancer Risk Factors

Smoking

Smoking is a leading risk factor for lung cancer followed by occupational exposure and outdoor (and increasingly indoor) air pollution. Smoking rates among New Brunswickers have dropped significantly since the 1960s as they have for all Canadians (Figure 3, page 18). Smoking rates among New Brunswick males have not been significantly different from national rates since the mid 1990's.[29] For females, smoking rates briefly rose above the national rate in the mid-1990s, and by 2000/2001 smoking rates had dropped to meet the national rates for females.

Statistics Canada, as part of its Canadian Community Health Survey initiated in 2000/2001, began reporting smoking and other factors affecting health (e.g. physical activity, alcohol consumption, body mass index, etc.) by health region and census metropolitan areas (CMAs). The only CMA identified in New Brunswick between 2000/2001-2005 was the Saint John CMA.

Table 2 summarizes Statistics Canada Community Health Survey results for the percentage of daily or occasional smokers aged 12 and over in New Brunswick between 2000/2001 and 2005 by province and health regions. Data identified with an 'e' needs to be interpreted with caution because the coefficient of variation around the mean is high (16.6% to 33.3%).[30] Although the data is somewhat unreliable for some health regions and does not provide a direct measure of the smoking rates in the urban and rural areas in this study, it does provide some insight into the variation in smoking rates within the province.

Within New Brunswick, males in Health Region 4 and 5 had the highest smoking rates in the province between 2000/2001 and 2005. Health Regions 4 and 5 include the communities of Edmundston and Dalhousie and portions of the rural areas of Belledune and Drummond-Denmark. Among males, there appears to be some correlation between higher smoking rates in health regions and higher rates of lung cancer in some study areas (e.g. Dalhousie and Edmundston which are in Health Region 5 and 4 respectively) although not for other areas (e.g. Minto area and Saint John which are in Health Region 2 and 3 respectively).

Among females, there appears to be less variability in smoking rates among the health regions and any correlations between high smoking and high lung

Table 2. Percentage of daily or occasional smokers aged 12 and over in New Brunswick (2000/2001-2005)[1]
Communities and areas in bold type indicate urban and rural areas in this study.

Geography	Sex	2000/ 2001	2003	2005	2000 / 2001 -2005 Average
Canada	**Males**	28	25	23.6	25.5
	Females	23.8	20.9	19.8	21.5
Province	**Males**	27.9	26.1	25.2	26.4
	Females	24.9	24.6	19.3	22.9
Health Region 1 (encompasses many communities including **Moncton**, Dieppe, Sackville, Shediac, Bouctouche Richibucto)	**Males**	28.4	24.9	24.0	25.8
	Females	26.9	24.4	18.5	23.3
Health Region 2 (encompasses many communities including Rothesay, Quispamsis, **Saint John**, Sussex, St. George and St. Stephen)	**Males**	24.2	21.2	26.6	24.0
	Females	24.7	24.3	20.5	22.5
Health Region 3 (encompasses many communities including **Fredericton**, Oromocto, **Harvey Area, Minto Area,** Woodstock, **Base Gagetown Area** and portions of the **Drummond-Denmark Area** and **Upper Miramichi Area**)	**Males**	28.3	29.9	25.3	27.8
	Females	25.7	22.3	19.4	22.5
Health Region 4 (encompasses many communities including **Edmundston**, Grand Falls, Kedgwick and portions of the **Drummond-Denmark Area**)	**Males**	31.2	33.0	27.3e[2]	30.5e
	Females	23.2	28.8	22.2e	24.7e
Health Region 5 (encompasses many communities including **Dalhousie,** Charlo, Balmoral, Campbellton, portions of the **Belledune Area**)	**Males**	37.2e	26.8	24.4e	29.5
	Females	29.4	26.0	21.6e	25.7e
Health Region 6 (encompasses many communities including portions of the **Belledune Area, Bathurst, Caraquet,** Shippagan, Tracadie Sheila)	**Males**	24.3	26.3	26.3	25.6
	Females	23.4	25.0	17.1e	21.8e
Health Region 7 (encompasses many communities including Tabusintac, Neguac, **Miramichi**, portions of the **Upper Miramichi Area**)	**Males**	33.8	26.8	20.8e	27.1e
	Females	24.1	27.3	17.0e	22.8e

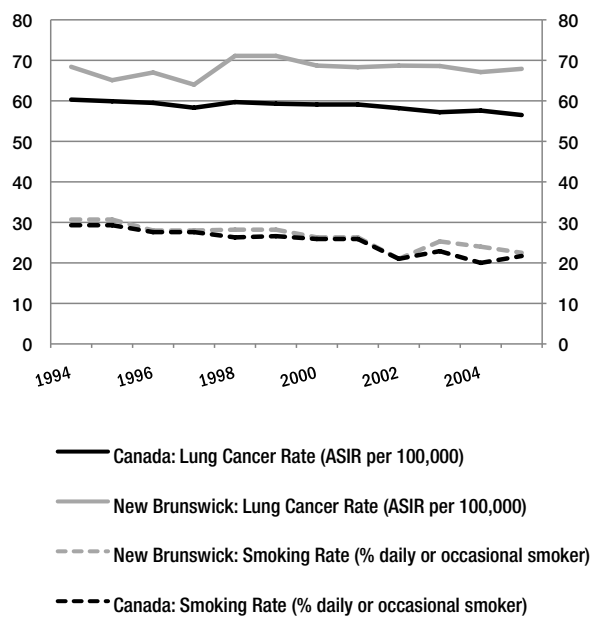
[1] Statistics Canada. Tables 105-0027, 105-0227, 105-0327. Percent of population who smoked, by age group and sex, household population aged 12 and over, Canada, provinces, territories, health regions (January 2000 boundaries) and peer groups, CANSIM (database).

[2] Data with a coefficient of variation from 16.6% to 33.3% are identified with an (e) and should be interpreted with caution.

cancer rates are not immediately apparent. As with males, the highest rates of smoking among females appears to be in Health Region 4 and 5. According to this study, lung cancer rates are highest in the Minto area (Health Region 3) followed by Dalhousie (Health Region 5), Saint John (Health Region 2) and Miramichi (Health Region 7).

A 2003 community health assessment of an area that encompassed the villages of Minto, Chipman and the parishes of Canning, Chipman, Northfield and Sheffield reported that the smoking rate per household (males and females combined) was 31.9 %.[31] Rates were based on a random selected survey of 678 households in an area with 2435 households. The study found that the rate of death among males from lung cancer and respiratory and heart diseases was higher than the provincial average for males. Among females, the rate of death due to respiratory disease and breast cancer was significantly higher than the provincial rate for females. The study suggested higher smoking rates could explain the high rates of respiratory diseases and lung cancer in the area. The study did not examine the role of occupational exposure or air quality.

FIGURE 3 **Lung Cancer and Smoking rates (both sexes) 1994-2005**



Data Source: Statistics Canada

Smoking rates nationally, provincially and across health regions are higher among males than females but the differences are low (2-5%). New Brunswick smoking rates have not been statistically different from national rates since at least the 1990s, however, lung cancer rates have been significantly higher than the national rate (Figure 3).

As demonstrated in the Conservation Council's first cancer report, health information measured and reported by large geographic area provides an imprecise and misleading reflection of community-level health status. Similarly, any meaningful assessment of the role of smoking or other lifestyle risk factors in lung (or other) cancer rates among communities must be based on community-level data.

Occupational Exposure

Occupational exposures play a major role in causing lung cancer, as well as other cancer types.[32] The number of cancers attributed to occupational exposure has increased from estimates of 2-10% in 1981 to 15-20% in 2007 because the number of agents/chemicals considered to be definite occupational carcinogens has increased from 16 in 1981 to 28 in 2007, with an additional 140 chemicals listed as probable or possible industrial carcinogens.[33] The risk for some cancers increases even further for workers who smoke.

Researchers at the Boston University School of Public Health and the University of Massachusetts recently published a review of new evidence linking

occupational, as well as environmental, exposure to various cancers.[34] Table 3 summarizes the evidence for occupational exposure to carcinogens.

In Canada, numerous peer-reviewed scientific studies have examined mortality and incidence rates of various cancers and their link to occupational exposure in Canada.[35] Studies done in British Columbia have observed excess risk for all lung cancers for men employed in primary metal and mining industries, machining/welding, transportation, carpentry/wood processing, ship building, agriculture, electrical/utility occupations and protective services (e.g. military).[36] The risks were associated with exposure to metals, chlorinated pesticides and compounds such as PCBs and dioxins, asbestos, radon, wood dust and polyaromatic hydrocarbons (PAHs) such as benzene. These agents/compounds have been classified as carcinogens by the International Agency for Research on Cancer (IARC). Workers who smoked added to their risk of lung cancer.

A 2007 Ontario study examined the trends and characteristics of compensated occupational cancers in Ontario between 1937-2003. Overall, females made up a very small proportion of the workers with allowed cancer claims. Of the claims made by males, lung cancers were the most frequently compensated cancer cases and the cases were associated with workplace exposure in manufacturing, construction and mining industries (including coke ovens and sintering plants where ore is roasted). Cancers were associated with asbestos, arsenic, benzene and other PAHs, silica, radon, uranium and nickel exposures.[37] Mesothelioma (primarily the result of asbestos exposure) and skin cancer were the second and third most commonly compensated cancers between 1990 and 2003. Firefighters made up a significant proportion of brain cancer (86%), non-Hodgkin's lymphoma (83%), bladder cancer (35%), leukemia (29%) and kidney cancer (29%) claims between 1990 and 2003.[38] In 2007, Ontario amended its policy to include these and other (colorectal, ureter and esophageal) cancers as compensable diseases for full-time firefighters.[39] In May 2009, the New Brunswick government introduced proposed amendments to the *Firefighters' Compensation Act* that would provide coverage to active and retired firefighters who had served the required number of years of service and who had been diagnosed with a specified cancer.

On average, the Minto area has had the highest percentage of males employed in the manufacturing, processing, utilities, trades and transportation sectors among the 14 study areas between 1991 and 2006 (Appendix A).[40] The power generating station and coal mining in this area likely contribute to the higher percentage of males employed in trades such as welding, electrical, pipefitting and insulation. Males in the Minto area also had the highest rate of lung cancer among the 14 study areas (Figure 1). Fredericton, Moncton and Caraquet had the lowest participation rates in these sectors and their rates of lung cancer were among the lowest of the 14 study areas (Appendix A).

Studies done elsewhere have linked lung and other cancers to occupational exposures associated with coal mining, pulp and paper mills and metal smelters (Table 3).[41] No peer-reviewed epidemiological cancer studies have been done on coal miners in the Minto area, lead smelter workers in the Belledune area or pulp and paper mill workers in Dalhousie, Saint John, Edmundston, Bathurst and Miramichi. Community health studies done in the Minto/Chipman and surrounding areas (2003) and the Belledune area (2005) did find that mortality and/or incidence rates of lung cancer were higher among males than rates in their respective health regions.[42] These studies did not examine the potential link between cancer incidence and occupation.

Table 3. Selected carcinogenic agents and their occupational links with cancer.[1]

Carcinogenic Agent	Occupation	Cancer site and strength of evidence[2]		Latency Period in years[3]
		Strong	Probable and Suspected	
Arsenic	metal mining and smelting; coal mining and burning; oil refineries; wood preserving operations	bladder; lung; skin; soft tissue sarcoma (angiosarcoma of the liver)	brain/central nervous system; liver; prostate; soft tissue sarcoma	10+
Asbestos	mining; insulation and shipyard workers;	lung; laryngeal; mesothelioma		4-40
Benzene	oil and petrochemical industries; transportation; manufacturing of plastics, resins, some types of rubbers and lubricants	leukemia; non-Hodgkin's Lymphoma	brain/central nervous system; lung; nasal & nasopharynx; multiple myeloma	6-14
Butadiene	oil refineries; petrochemical industries	lung	leukemia	
Cadmium	metal mining and smelting; electrical workers; battery plant and alloy workers; painters		pancreatic; kidney; prostate	
Chromium	steel and alloy producers; chrome plating operations; wood preserving operations	lung; nasal and nasopharynx		5-15
Creosotes; Coal tars	roofing; road paving; aluminum smelting and coking	bladder (coal tars); lung; skin		
Ethylene oxide	laboratory workers; hospital workers; fumigators	leukemia	breast	
Formaldehyde	plywood and oriented strand board manufacturing; appliance, telephone and electrical control manufacturing		nasal and nasopharynx	
Ionizing radiation	high-voltage equipment operators; nuclear reactors; uranium mining	bone; brain & CNS; nervous system; breast; leukemia; liver & biliary; lung; multiple myeloma; soft tissue sarcoma; skin; thyroid	bladder; colon; nasal and nasopharynx; ovarian; stomach	
Lead	metal smelting and mining; battery manufacturing/recyclers		brain/central nervous system; lung; kidney; stomach	
Nickel	nickel smelters, mixers and roasters; electrolysis workers	lung, nasal and sinuses;	laryngeal; pancreatic; stomach	3-30
Pesticides	agriculture and forestry workers; landscapers		brain/ central nervous system, breast; kidney; prostate; lung; leukemia; NHL; colon; Hodgkin's; multiple myeloma; ovarian; pancreatic; soft tissue sarcoma; stomach; testicular	
Silica	mining; foundries, brickmaking and sandblasting; solar panel manufacturing	lung		
Straight oils, soluble oils, synthetic and semi-synthetic fluids	metal machining; print press operations	bladder; laryngeal; lung nasal and nasopharynx; rectal; skin; stomach	esophageal; pancreatic; prostate	
toluene	manufacturing of paint, thinners, adhesives and rubber; oil refineries		brain/central nervous system; lung; rectal	
wood dust	carpentry; furniture and cabinetry making	lung; nasal and nasopharynx	laryngeal	

[1] Source: Adapted from Clapp RW, Jacobs MM and Loechler EL. 2007. Environmental and Occupational Causes of Cancer: New Evidence, 2005-2007. Prepared for: Cancer Working Group of the Collaborative on Health and the Environment. Lowell Center for Sustainable Production. University of Massachusetts. 45 p.

[2] Strong causal evidence of a link is based primarily on a Group 1 (known carcinogen) designation by the International Agency for Research on Cancer. Suspected evidence of a link is based on Clapp et al. 2007 assessment of existing epidemiologic studies.

[3] Source: Adapted from Davis DL. 2007. *Secret History of the War on Cancer.* Basic Books. New York, NY. p. 258-261.

In 1994, wood dust was recognized by the International Agency for Research on Cancer (IARC) as a human carcinogen. Numerous epidemiological studies have associated pulp and paper and other wood-product industries with higher risks of lung, nasal and sino-nasal cancers as well as other types of cancer (e.g. pancreas, bladder, kidney and colorectal cancers and Hodgkin's disease).[43] Wood dust can be contaminated with known and potential carcinogens (e.g. arsenic, chlorophenols, formaldehyde, sulfuric acid and chloroform) depending on the manufacturing process.[44] Exposure to wood dust could explain the higher rates of lung cancers among males in communities with wood-processing operations such as those in Dalhousie, Saint John, Edmundston, Bathurst, Miramichi and the Upper Miramichi area.

While occupational exposure could explain the higher rates of lung cancer among males in the Minto, Belledune, Dalhousie, Saint John, Edmundston, Bathurst and Miramichi areas, few women in these communities and areas are employed in the manufacturing, processing, utilities, trades and transportation sectors. However, females in the Minto area, Dalhousie, Saint John and Miramichi had lung cancer rates more than 40% higher than the provincial rate (Figure 2). Air pollution, another significant risk factor for lung cancer, could explain the higher rates among women in these communities.

Air Pollution

Over the past two decades hundreds of studies have highlighted the role of airborne particulate matter (dust) in cardiovascular diseases and lung cancer[45], two leading causes of death in New Brunswick and Canada. Major sources of particulate matter are vehicle exhaust, industrial smoke, fossil fuel combustion and waste incinerators. The negative health effects of particulate air pollution are known to increase as the particle size decreases. Fine particles penetrate deeper into the respiratory tract and have a high retention rate (i.e. are not coughed up).

Fine (less than 2.5 microns in diameter) and ultrafine (less than 1.0 microns) particulate matter can include a number of contaminants including metals (e.g. arsenic, cadmium, nickel and lead), ions (e.g. nitrates), organic compounds (e.g. dioxins, PAHs, benzene, butadiene), reactive gases (e.g. radon) and material of biologic origin (e.g. wood dust), all of which have been classified as known or probable carcinogens by the IARC.

Considerable research has been done to determine the underlying mechanism of how air pollution causes cancer. There is a consensus among researchers that the cancer-causing effect of particulate matter is a combination of DNA repair suppression and enhancement of DNA replication errors.[46] The World Health Organization's working group of experts on the health aspects of air pollution reported in 2003 that there were no safe levels of exposure to fine particulate matter.[47]

Scientific studies report that each 10 $\mu g/m^3$ (microgram per cubic meter) increase in fine particulate pollution ($PM_{2.5}$) significantly increased the risk of cardiopulmonary and lung cancer deaths.[48] After controlling for smoking effects, the incremental increase in risk was found to be as high as 4% for cardiopulmonary diseases and 8% for lung cancer.[49] Scientists with the World Health Organization (2004) have estimated that an annual average $PM_{2.5}$ concentration of 7.5 $\mu g/m^3$ is the theoretical minimum-risk exposure for cancer; levels above this value increase the risk of cancer.[50] For coarse particulate matter (PM_{10}), the annual minimum risk-exposure value was estimated at 15 $\mu g/m^3$.[51] The Canada-wide 24-hour air quality standard for $PM_{2.5}$ is 30 $\mu g/m^3$. There are no Canada-

wide or provincial monthly or annual average standards for $PM_{2.5}$ or PM_{10}.

Since 1999, the New Brunswick Department of Environment has been monitoring $PM_{2.5}$ at several sites around the province. Monitoring methods (e.g. dichotomous sampler, tapered element oscillating microbalance (TOEM), and beta attenuation method (BAM)) have changed and are not consistent within and between communities. For example, the BAM continuous sampler gives consistently higher $PM_{2.5}$ results than the TOEM system.[52]

TOEM monitors are located in Saint John (Forest Hill), Fredericton (Aberdeen Street), Edmundston (near Fraser paper mill), Bathurst (Rough Waters Drive), Moncton (Highfield Street) and St. Andrews (Brandy Cove Road). BAM monitors are located in Saint John (five sites), Canterbury (southwest of Nackawic) and Miramichi (two sites near the former Weyhaeuser oriented-strandboard mill).

Differences in monitoring methods make it difficult to compare long-term trends within and between communities. The provincial department of environment has compared average one-hour $PM_{2.5}$ monitoring (TOEM) results for Saint John (Forest Hill BAM monitor), Fredericton, Moncton, St. Andrews, Edmundston and Bathurst between 2001 and 2007. Saint John and Edmundston consistently had higher $PM_{2.5}$ levels.[53]

Annual provincial air quality monitoring reports indicate that, depending on monitor location and type, stations in Saint John, Canterbury, Edmundston and Miramichi have all recorded violations of the province's 24-hour air quality standard for $PM_{2.5}$ (2001-2007).[54] Annual average PM_{10} levels measured in Saint John (provincial building location) consistently and significantly exceeded (1984-2000) the estimated PM_{10} cancer risk level estimated by the WHO (15 $\mu g/m^3$).[55] Some monitoring stations in Saint John record annual average $PM_{2.5}$ levels over 7.5 $\mu g/m^3$ [56], a value the WHO has estimated as being a theoretically minimum risk level for cancer. Annual average $PM_{2.5}$ levels in Edmundston are near the WHO cancer risk level.

According to Environment Canada's National Pollutant Release Inventory (NPRI), 10 of the 14 urban and rural areas in this study have facilities that report to the NPRI.[57] The NPRI is a database containing information on the annual on-site releases of 367 substances and groups of substances to the air, water and land from industrial sources. Companies are legally obligated to report to the NPRI if they release one or more of the listed substances and they employ approximately 10 or more full-time employees. If a facility or operation is involved in waste or sewage sludge incineration, wood preservation, fuel terminal operations, municipal waste water collection and treatment, stationary combustion equipment or quarrying, a report may be required regardless of the number of employees.

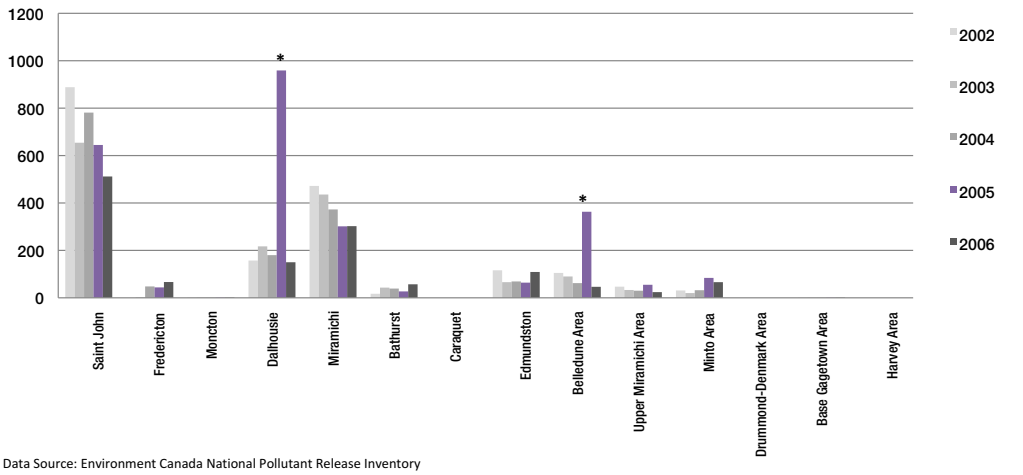
The province's environment department also stipulates how often facilities must measure and report pollutant releases from their stacks. Under the provincial *Clean Air Act*, facilities are classified based on their estimated annual emissions of sulphur dioxide and particulate matter. Generally, facilities designated as Class 2, 3 or 4 test and report their emissions only when ordered to do so by the province. Large Class 1 facilities (e.g. power stations, pulp mills and smelters) continuously monitor carbon dioxide, nitrogen oxides and sulphur dioxide and, depending on the facility, total suspended particulates (TSPs). Class 1 facilities must measure other pollutants (e.g. metals, volatile organic compounds (VOCs) and coarse and fine particulates - $PM_{2.5}$ and PM_{10}) once a year using methods prescribed by the provincial environment

department. The results of a stack test (usually done over a three-day period) are the basis on which a facility estimates its total annual emission of pollutants. Methods for estimating pollutant releases based on stack tests have varied over time.

In 2005, Saint John had the most facilities (23) reporting to the NPRI followed by Moncton (8) and Miramichi (4). Fredericton, Dalhousie, Bathurst and Edmundston each had three facilities and the Belledune, Upper Miramichi and Minto areas had two each. Saint John had the highest annual $PM_{2.5}$ releases from industrial sources between 2002-2006 (Figure 4). (Data prior to 2002 is not available, as reporting of $PM_{2.5}$ releases to the NPRI was not required.) Miramchi ranked second and was followed by Dalhousie, Edmundston and Belledune.

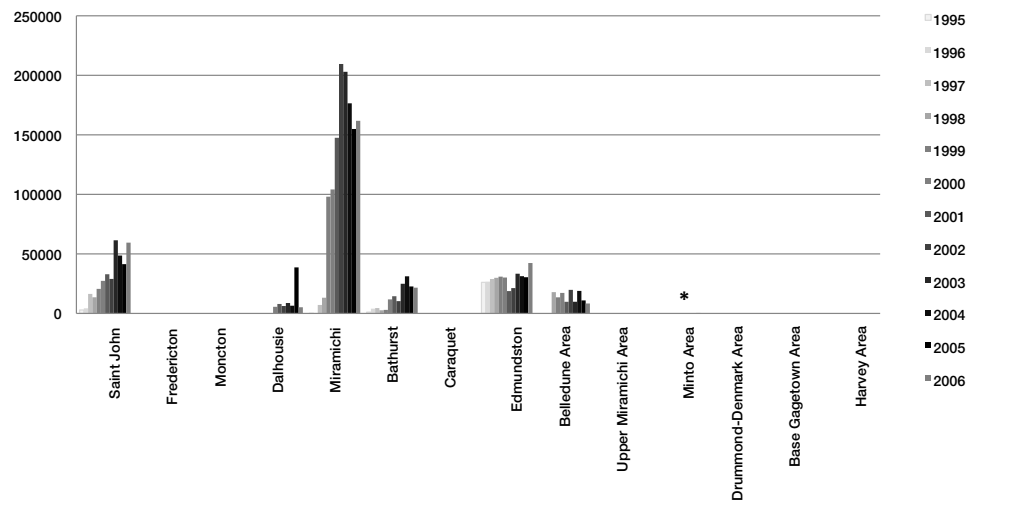
Fine particulates can be contaminated with carcinogens, making the "dust" a more potent carcinogen. Figure 5 illustrates the total release of carcinogens (core chemicals and supplementary chemicals) to the atmosphere from facilities in this study. Core chemicals are a common set of carcinogens consistently reported to the NPRI during 1995-2005 and supplementary chemicals are all other carcinogens that are reported. Miramichi has had the highest amount of carcinogens released into the air,

FIGURE 4 **Annual fine particulates ($PM_{2.5}$ released in metric tonnes from industrial sources in 14 urban and rural areas in New Brunswick (2002-2006)**



Data Source: Environment Canada National Pollutant Release Inventory
Higher 2005 values in communities with an asterisk (*) reflect changes NB Power made in their methods for estimating stack releases from their power generating stations.

FIGURE 5 **Annual air releases (in kilograms) of carcinogens from industrial sources in 14 urban and rural areas in New Brunswick (1995-2006)**



Data Source: Environment Canada National Pollutant Release Inventory

* Releases averaged 278 kg (2001-2006)

primarily formaldehyde from a mill producing oriented strandboard. It was followed by Saint John, Edmundston, Bathurst, Belledune and Dalhousie. With the exception of Belledune, all communities had pulp and paper mills. As of 2009, most of these mills have closed except for those in Saint John and Edmundston.

The 2005 spike in carcinogen releases in Dalhousie was associated with the NB Power generating station and related to higher reported releases of nickel. (Fine particulates from the facility were also significantly higher in 2005.) In both instances, companies cited changes in methods for estimating releases as the reason for difference between 2005 and 2006.[58] Higher carcinogens reported in Edmundston in 2006 were related to significantly higher chloroform releases in that year from the Fraser pulp and paper mill.

The high volume of fine particulates and carcinogen releases from industries and long-term exposure to air pollution levels above minimum risk-exposure levels suggest that air quality could be a leading lung cancer risk factor for males and females in Dalhousie, Minto and Saint John. These areas have significantly higher rates (> 50%) of lung cancer than the province as a whole and other areas examined in this study. Detailed case-control population studies would be required to more accurately assess the role smoking, occupation and air quality play in the high rates of lung cancer in these communities.

Colorectal Cancer

The provincial unadjusted incidence rate of colorectal cancer per 100,000 population (1989-2005) was 62.5 for males and 56.2 for females. These rates are consistent with the ASIRs per 100,000 population for New Brunswick for the same time period. Based on Statistics Canada data, the average ASIRs for colorectal cancer among New Brunswick males and females (1989-2005) were 62.5 and 44.2 respectively.[59] The New Brunswick

FIGURE 6 **Male Colorectal Cancer Rates (1989-2005)**
unadjusted incidence rates per 100,000 population

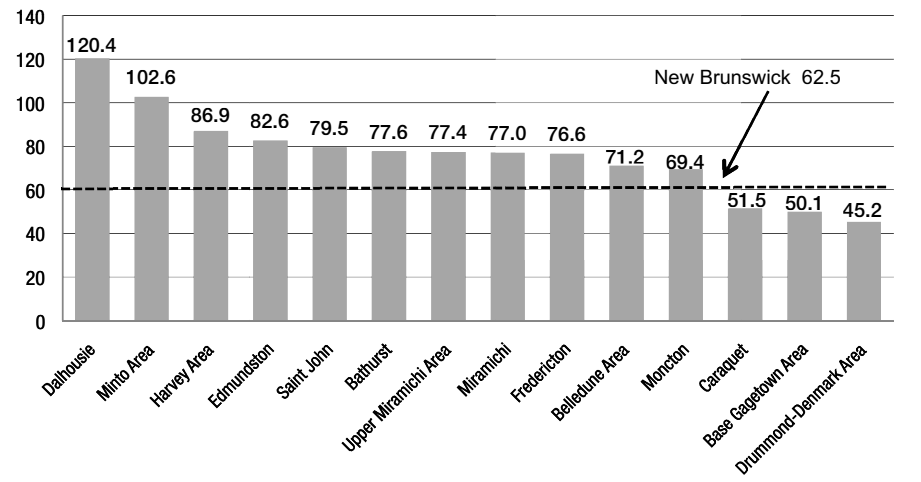
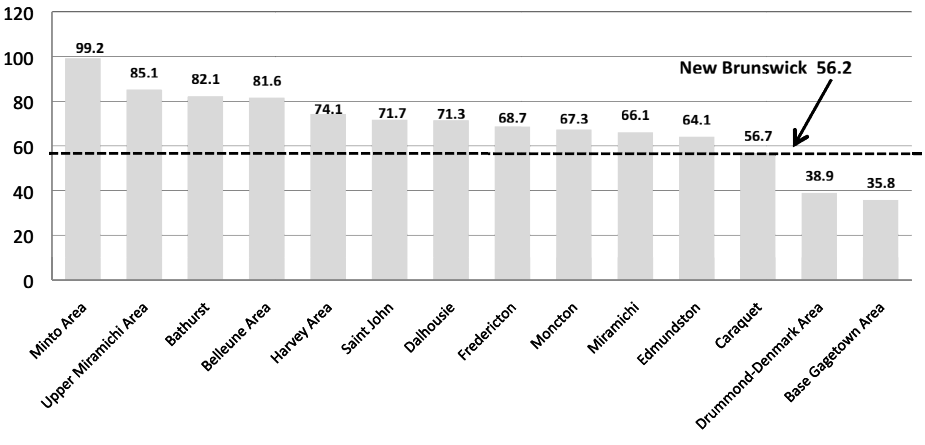


FIGURE 7 **Female Colorectal Cancer Rates (1989-2005)**
unadjusted incidence rates per 100,000 population



Department of Health reported ASIRs (1999-2003) of 62.9 and 45.6 for males and females respectively.[60]

Males in Dalhousie had almost twice the provincial rate of colorectal cancer and the rate in the Minto area was 64% above the provincial rate (Figure 6). Rates in the Harvey area, Edmundston and Saint John were more than 25% above the provincial rate. Rates in Caraquet, Base Gagetown and the Drummond-Denmark areas were below the provincial rate for males.

Among females, colorectal cancer rates in the Minto area were 77% above the provincial rate and the rate in the Upper Miramichi area was 51% higher than the provincial rate (Figure 7). Rates in Bathurst and the Belledune area were 46% and 45% higher than provincial rates. Rates among women in Saint John and Dalhousie were more than 25% higher than the provincial rate. Caraquet and the Drummond-Denmark and Base Gagetown areas were at or below the provincial rate.

Colorectal Cancer Risk Factors

Like most cancers, a very small percentage (3%) of colorectal cancer cases have been linked to genetic syndromes, specifically familial adenomatous polyposis and hereditary nonpolyposis colon cancer.[61] A family history of colorectal cancer in first-degree relatives has been estimated to occur in 12-15% of colon cancer cases.[62] Since genetic factors play such a small role in colorectal cancer, the contribution of shared family lifestyle and

Table 4. Population attributable fractions (PAF)* for selected cancers and risk factors.[1]

Cancer Type	High-income countries	Low-income countries	Worldwide
colon and rectum	overweight/obesity - 14% physical inactivity - 14% low fruit/ vegetable intake - 1%	overweight/obesity - 9% physical inactivity - 15% low fruit/vegetable intake - 2%	overweight/obesity - 11% physical inactivity - 15% low fruit/vegetable intake - 2%
breast	alcohol - 9% overweight and obesity - 13% physical inactivity - 9%	alcohol - 4% overweight and obesity - 7% physical inactivity - 10%	alcohol - 5% overweight and obesity - 9% physical inactivity - 10%
bladder	smoking - 41%	smoking - 21%	smoking - 28%
pancreatic	smoking - 33%	smoking - 15%	smoking - 28%
leukemia	smoking - 17%	smoking - 6%	smoking -9%
all cancers	alcohol - 4% smoking - 29% low fruit/ vegetable intake - 3% overweight and obesity -3% physical inactivity - 2%	alcohol - 5% smoking - 18% low fruit/vegetable intake - 6% overweight and obesity - 1% physical inactivity - 2%	alcohol - 5% smoking - 21% low fruit/vegetable intake - 5% overweight and obesity - 2% physical inactivity - 2%

* The World Health Organization has developed a methodology for quantifying the effects of selected risk factors on cancer incidence and mortality in a population, otherwise known as the population attributable fraction (PAF).

[1] Source: Danaei et al. 2005. Causes of cancer in the world: comparative risk assessment of nine behavioural and environmental risk factors. *Lancet* 366:1784-93.

environmental risk factors are key to understanding the incidence of colorectal (and other) cancers.

A wide range of diet and lifestyle factors (e.g. excessive fat consumption, high meat - low fibre intake, obesity, lack of physical activity, smoking and alcohol consumption) have been identified as potential risks for colorectal cancer.[63] Physical inactivity and so-called 'white collar' or sedentary jobs have been frequently (although not consistently or conclusively) linked to increased risk of colorectal cancer.[64] Similarly, the evidence for high dietary intake of red meat, low fruit and vegetable consumption and obesity as colorectal risk factors is mixed.[65] A 2005 international study used methods developed by the World Health Organization to estimate the percentage of different risk factors, primarily lifestyle factors, that could be attributed to 12 different cancers in seven World Bank regions. The study estimated that, for high-income countries, obesity, inactivity and low fruit and vegetable consumption account for 29% of cancers of the colon and rectum (Table 4).

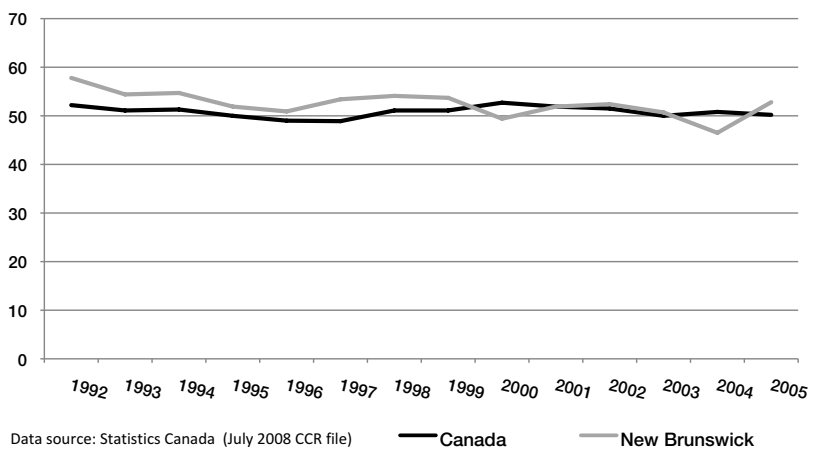
An increasing number of researchers believe that fat and red meat *per se* are not carcinogens but rather the process of cooking meat at high temperatures forms carcinogenic compounds such as N-nitroso compounds and polycyclic aromatic hydrocarbons.[66] Fatty diets can activate specific liver enzymes that enhance the metabolism and toxicity of environmental chemicals in the body associated with the induction of specific liver enzymes.[67] Similarly, obesity or over-weight *per se* has never been shown to cause or initiate cancer.[68] An alternative explanation for the apparent link between overweight/obesity and cancer is that fat tissues are reservoirs for lipophilic (fat-loving) environmental chemical carcinogens that eventually are released into the blood stream and increase the risk of cancer.[69]

Cancers of the colon and rectum have also been associated with occupational and environmental exposures to pesticides, dyes, metals, PCBs, metals, metal-working fluids (e.g. straight, soluble and synthetic oils).[70]

Provincial-level data for potential diet and lifestyle factors associated with colorectal (or other cancers) are very limited. According to Statistics Canada data for 1994/95 to 2005, New Brunswickers had lower physical activity and higher obesity rates than the national average rates.[71] If these factors represent key risks for colorectal cancer, New Brunswickers should have higher rates of colorectal cancer. In fact, colorectal cancer rates among New Brunswickers are similar to national rates (Figure 8).[72]

Comparable long-term community-level data on the lifestyle risk factors associated with colorectal cancer (e.g. physical inactivity, poor diet, smoking) are not available for New Brunswick communities and therefore risk factor comparisons among communities were not possible in this study.

FIGURE 8 Colorectal Cancer Rates (both sexes) for Canada and New Brunswick (1992-2005)
age-standardized incidence rates per 100,000 population

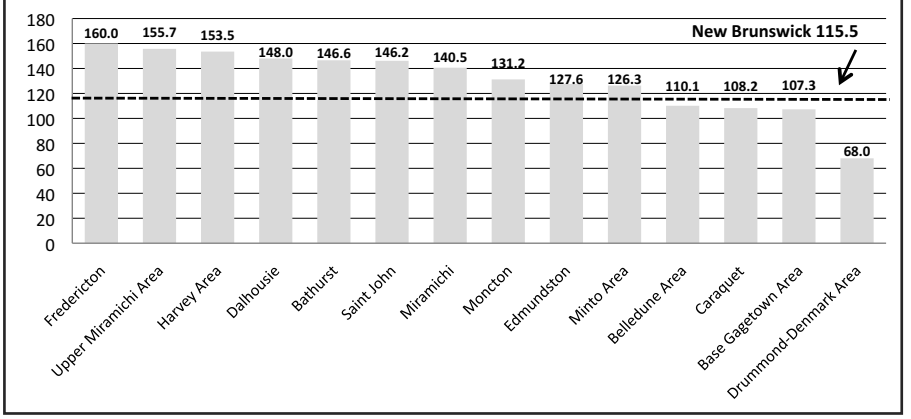


Breast Cancer

The provincial unadjusted incidence rate of breast cancer per 100,000 population (1989-2005) was 115.5. Based on Statistics Canada data, the average ASIR per 100,000 population for breast cancer in New Brunswick (1989-2005) was 98.0.[73] The New Brunswick Department of Health reported the ASIR per 100,000 population for breast cancer (1999-2003) was 101.5.[74] The unadjusted incidence rate per 100,000 population reported by the province (1997-2001) was 124.4.[75]

Seven of 14 study areas (Fredericton, Upper Miramichi, Harvey, Dalhousie, Bathurst, Saint John and Miramichi) had breast cancer rates at least 25% higher than the provincial rate (Figure 9). Fredericton had the highest rate of breast cancer which was 38.5% above the provincial rate. Upper Miramichi and the Harvey area had rate 35 and 33% above the provincial rate.

FIGURE 9 **Female Breast Cancer Rates (1989-2005)**
unadjusted incidence rates per 100,000 population



The relative order of breast cancer rates (from highest to lowest) for Fredericton, Saint John and Moncton in this study were consistent with the finding in the Conservation Council's first cancer report.[76]

Breast Cancer Risk Factors

It is widely accepted that genetic mutations account for a very small percentage (2-10%) of all breast cancers.[77] Approximately 20 genes are known to contribute to inherited breast cancers. Mutations in the so called "breast cancer genes", BRCA 1 and BRCA 2, are the most common and account for a small fraction (10%) of all breast cancer diagnoses.

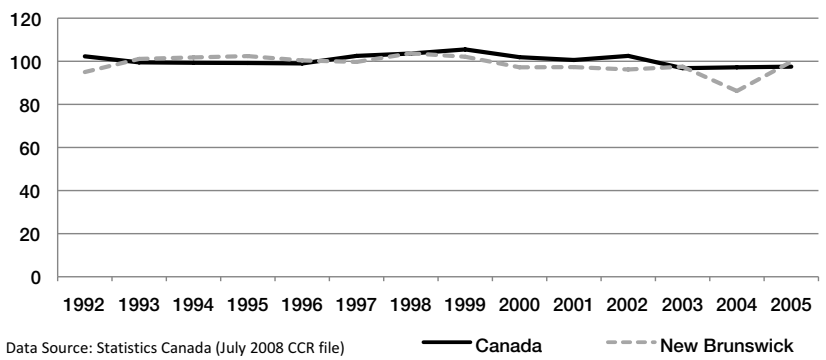
Lifestyle factors with unknown or no apparent consistent effects on breast cancer incidence include diet (coffee/tea consumption, high fat intake, low fruit and vegetable consumption) as well as smoking and physical inactivity.[78] Researchers have estimated that alcohol, overweight and physical inactivity account for approximately 33% of breast cancers in high-income countries (Table 4, page 25).[79] Conservatively, half of all breast cancer risks can be attributed to a wide range of risk factors including genetics, family history, alcohol intake, obesity, hormonal exposure, menopause and increased breast density.[80] Many researchers now believe the rise in breast cancer is associated with lifestyle modifications linked to hormone treatments and changes in reproductive behaviour (e.g. age at first pregnancy, low birthrates), and to increased levels of estrogen mimics (xenoestrogens) in the environment.[81]

One of the most significant risk factors for breast cancer is life-time exposure to synthetic estrogens.[82] A substantial (and growing) body of peer-reviewed scientific literature has demonstrated that many classified carcinogens are also estrogen mimics that disrupt estrogen pathways and are risk factors for breast cancer (Table 5). For example, known carcinogens like organochlorine pesticides (e.g. DDT, hexachlorobenzene), polychlorinated biphenyls

(PCBs) and dioxins are also estrogen mimics.[83] These compounds are lipophilic (fat loving) and deposit in fatty tissue such as breasts where they have been found to generate estrogenic microenvironments that influence the growth, shape and behaviour of breast tumours.[84] These compounds also cross the placental barrier and affect the developing fetus. Numerous studies have linked increased risks of breast and other cancers to pesticide exposure.[85] Exposures to various forms of radiation are also risk factors for breast cancer.[86]

Overall, breast cancer rates in New Brunswick are similar, if not generally lower, than national rates (Figure 10). Yet, breast cancer rates in 10 of 14 urban and rural areas in this study were above the provincial rate (Figure 9). Seven of 14 study areas had rates 25% above the provincial rate. These include Fredericton, Upper Miramichi, Harvey, Dalhousie, Bathurst, Saint John and the Minto area. With the exception of Fredericton, all of these communities have documented environmental issues (e.g. arsenic, mercury, lead and cadmium in Dalhousie; arsenic, radon and uranium in the Harvey area; arsenic in the Minto area; lead, vanadium, aluminum, benzene and other VOCs in Saint John; and forest pesticides in the Upper Miramichi area).

FIGURE 10 **Female Breast Cancer Rates for Canada and New Brunswick (1992-2005)** Age-standardized rates per 100,000 population



Data Source: Statistics Canada (July 2008 CCR file)

Many of these compounds have been identified as being cancer-causing or estrogen mimics (Table 5).

It is not readily apparent why Fredericton has the highest breast cancer rates, however a study done in the United States may yield some clues. When an epidemiological study found breast cancer rates in nine of 15 towns on Cape Cod were 20% above the average rate for the state of Massachusetts, researchers raised questions about possible environmental exposure.[87] Follow-up studies on indoor air and dust of 120 homes found 52 different hormonally active agents and mammary carcinogen compounds in air and 66 in dust.[88] The number of compounds detected per home ranged from 13 to 28 in air and from 6-42 in dust. The most abundant were plasticizers, disinfectants and certain flame retardants that were banned in 1977. Twenty-three pesticides, including those long-banned such as DDT, heptachlor, and chlordane, were detected in air and 27 in dust. Detected concentrations exceeded government health-based guidelines for 15 compounds, but no guidelines were available for 28 compounds. In another related study, researchers found synthetic estrogens in septic tanks, groundwater and private wells.[89]

Researchers also examined whether there was an association between high breast cancer rates and length of residence on Cape Cod[90] and community versus individual-level socioeconomic status (e.g. income, education, unemployment).[91] They found that the longer a women lived on Cape Cod, the greater her risk of breast cancer - and the risk was not associated with socio-economic status. However, when the risk was calculated using community-level socioeconomic data, the study found that breast cancer risks were higher in

Table 5. Some compounds linked to breast cancer[1]

Compound	International Agency for Research on Cancer (IARC) Classification			Endocrine Disrupting Compounds
	Known	Probable	Possible	
Dioxins - by-product of incinerating chlorinated compounds and industrial process that use chlorine (e.g. pesticide manufacturing)	■			■
PCBs - insulation fluids, plastics, inks, paints, dyes		■		■
DDT/DDE - insecticide			■	■
Hexachlorobenzene - herbicide				■
Atrazine - herbicide				■
Heptachlor - insecticide				■
Dieldrin and Aldrin - insecticides				■
Other pesticides				■
Polycylic aromatic hydrocarbons (PAHs) - fossil fuel combustion, industrial air pollution, oil refining				■
Bisphenol A (BPA) - hard/soft plastic containers labelled with a triangle and the numbers 3, 6 or 7				■
Alkylphenols - surfactants, detergents, some pesticides				■
Some metals - smelters, oil refineries, battery recycling	■			■
Phthalates -plasticizer for PVC polymers				■
Benzene - solvents, fossil fuel combustion, oil refineries	■			
Vinyl chloride - resins for production of plastic pipes, floor covering, food packaging, appliances, credit cards	■			
Organic solvents - (e.g. styrene, formaldehyde, toluene, methylene chloride, trichlorethylene) used in manufacturing computer components, cleaning products and cosmetics	■	■		
1,3 - Butadiene - oil refining and fossil fuel combustion; production of polymers for paints, carpet backing, tires and other rubber products		■		
Ethylene oxide - disinfectant and pesticide; used in making resins, films and antifreeze	■			
Aromatic amines - manufacture of polyurethane foams, dyes, pharmaceuticals; diesel exhaust		■		■

[1] Source: Adapted from Gray et al. 2009. State of the Evidence: The connection between breast cancer and the environment. *International Journal of Occupational and Environmental Health* 15:43-78.

communities with higher socio-economic status. In other words, there was something about living in higher socio-economic communities that conferred a higher risk of breast cancer. One possible explanation is that community-level analysis may be encompassing (although not measuring) the collective effects of community-wide exposure to environmental contaminants which are not captured when examining individual-level data. In addition, households with higher incomes are likely to have more disposable income and, therefore, are more able to purchase a greater number and wider range of consumer products some of which may contain compounds that are cancer-causing or estrogen mimics (e.g. cleaning products, air fresheners, cosmetics, pesticides, detergents, paint, packaged food).

The results of this study highlight the need for more detailed case-control population studies to determine why breast cancer rates are significantly higher than the provincial rate in several New Brunswick communities.

Ovarian Cancer

The provincial unadjusted incidence rate of ovarian cancer per 100,000 population (1989-2005) was 13.5. Based on Statistics Canada data, the average ASIR per 100,000 population for ovarian cancer in New Brunswick (1989-2005) was 11.5.[92] Based on provincial data, the average unadjusted incidence rate of ovarian cancer (1992-1996) was 13.5.[93] The unadjusted incidence rate for 1997-2001 was 13.0.[94]

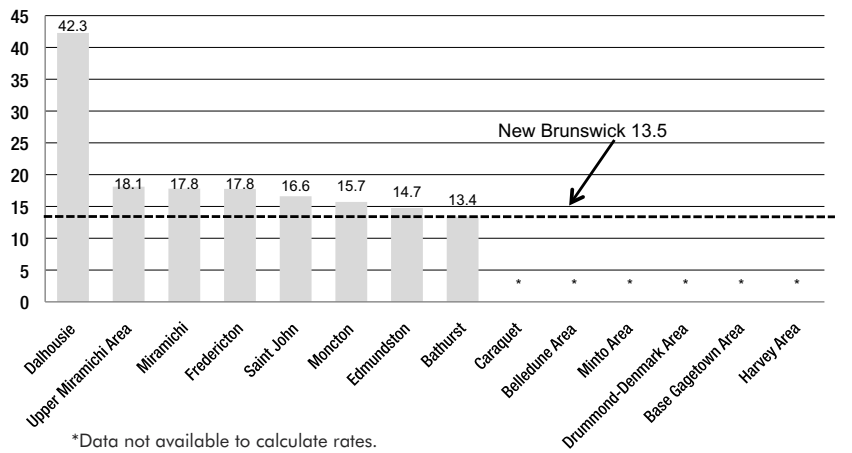
The rate of ovarian cancer in Dalhousie was 213% above the provincial rate (Figure 11). Rates in Upper Miramichi, Miramichi and Fredericton were at least 30% above the provincial rate. Saint John, Moncton, Edmundston and Bathurst were slightly above the provincial rate. Data were not available to calculate ovarian cancer rates for Caraquet, Belledune and the Minto, Drummond-Denmark, Base Gagetown and Harvey areas.

Ovarian cancer is the second leading gynecologic cancer and the fifth most commonly diagnosed cancer among women in Canada.[95] Worldwide, it accounts for almost 4% of all female cancers.[96] The majority of ovarian cancers (90%) are referred to as epithelial (surface cells of the ovary) carcinomas. These are further classified into four subtypes: serous, mucinous, endometrioid and clear cells.

Ovarian Cancer Risk Factors

As with breast cancer, genetic mutations account for a small percentage (5-10%) of all ovarian cancers. The majority of hereditary ovarian cancers can be linked to mutations in the BRCA1 and BRCA2 breast cancer gene.[97] In population-based studies, BRCA1 and BRCA2 mutation explained 5-15% of ovarian cancer cases.[98] Ovarian cancer also occurs in families with Lynch syndrome II, a type of hereditary colorectal cancer.[99]

FIGURE 11 Ovarian Cancer Rates (1989-2005)
unadjusted incidence rates per 100,000 population



Family history is a risk factor for ovarian cancer. However, the lifetime risk of ovarian cancer for women with one affected relative was found to be 5% and for two affected relatives the risk was 7%.[100]

As with breast cancer, hormones are thought to be involved in the promotion of ovarian cancer. In the case of ovarian cancer, estrogen is believed to stimulate the proliferation and survival of both normal ovarian epithelial (surface) cells and ovarian cancer cells while progesterone exposure is thought to enhance epithelial and cancer cell death and interfere with and repress estrogen-induced gene expression.[101] One theory suggests that the process of ovulation, the frequent rupture and repair of the cells of the surface of the ovary, increases the likelihood of DNA mutation and hence cancer.[102] Several studies have found that pregnancy, breast feeding and oral contraceptives, which suppress ovulation, are associated with decreased risk of ovarian cancer.[103] Late age-at-menopause, infertility and hormone replacement therapy have been identified as possible risk factors.[104]

Studies that have examined lifestyle risk factors for ovarian cancer (e.g. smoking, alcohol consumption, diet, overweight/obesity, physical inactivity) are inconsistent and highly variable in their conclusions.[105] Studies have found that smoking increased the risk of mucinous, but not other epithelial, ovarian cancers.[106]

Several studies have demonstrated a link between ovarian cancer and obesity, particularly in pre-menopausal women.[107] While adipose (fat) tissue *per se* has never been shown to cause or initiate cancer, fat tissue is becoming increasingly recognized as an endocrine-active organ that is able to produce many hormones (including estrogen) and peptides (organic compounds made up of two or more amino acids).[108] An excess production of estrogen in obese or overweight individuals could affect the development of estrogen-related cancers (e.g. those of the breast, thyroid and ovary). Also, exposure to synthetic hormone mimics, often referred to as endocrine disrupting compounds (EDC), can alter normal fat metabolism and development and result in obesity.[109] These EDCs have been termed obesogens.[110]

Like breast cancer, exposure to EDCs is thought to increase the risk of ovarian cancer. Hormones and auxiliary signaling chemicals such as enzymes and growth factors regulate the growth and functioning of various tissues and organs. EDCs de-rail hormones which are often referred to as the body's chemical communication system.[111] EDCs have been implicated in a wide-range of estrogen-, androgen- and progesterone-related health effects such as infertility, birth defects, early puberty, reproductive cancers and thyroid diseases as well as other human health conditions such as diabetes, obesity and other cancers.[112] As described in the previous section (breast cancer risks), many known and probable carcinogens (Table 5) are EDCs or hormone mimics.

Studies on lifestyle risk factors in ovarian (and other) cancers often do not consider occupational and environmental (other than smoking) exposures as potential confounding risk factors. Several studies have linked occupational exposure to pesticides, organic dusts, aromatic amines, and PAHs (diesel, gasoline, engine exhaust) to ovarian cancer.[113] Many of these compounds are known EDCs (Table 5, page 29). It is difficult to draw firm conclusions about the relationship of specific environmental or occupational exposures and ovarian cancer due to the low number of studies done to date.

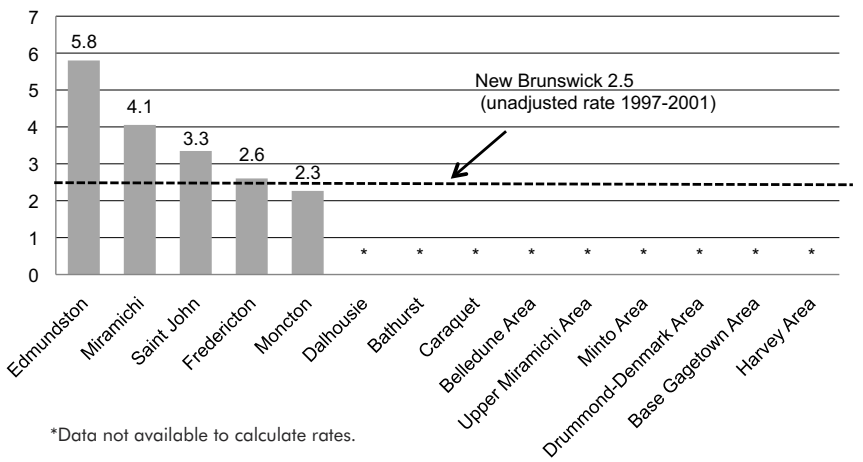
The results of this study highlight the need for more detailed case-control population studies to determine why ovarian cancer rates in Dalhousie are more than three times the provincial rate.

Thyroid Cancer

Data were not available to calculate the provincial incidence rate of thyroid cancer between 1989 and 2005. Based on provincial health data, the unadjusted incidence rate of thyroid cancer per 100,000 population (1997-2001) was 2.5 and 8.4 for males and females respectively.[114]

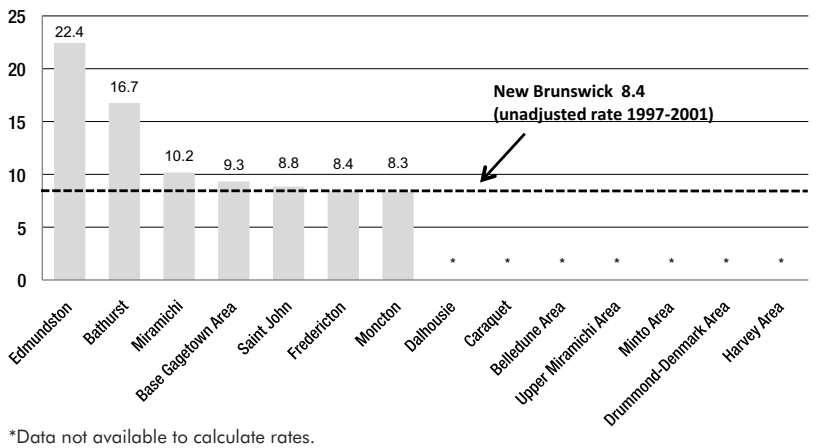
Thyroid cancer rates were highest among males and females in Edmundston and more than double the unadjusted provincial rate (1997-2001) (Figures 12 and 13). The rate among females in Bathurst was almost double the provincial rate and males in Miramichi had an incidence rate 60% higher than the provincial rate. Data were not available to calculate thyroid cancer rates for males and females in Dalhousie, Caraquet, Belledune, Upper Miramichi, Minto, Drummond-Denmark and Harvey area or for males in Bathurst and the Base Gagetown area.

FIGURE 12 Male Thyroid Cancer Rates (1989-2005)
unadjusted incidence rates per 100,000 population



*Data not available to calculate rates.

FIGURE 13 Female Thyroid Cancer Rates (1989-2005)
unadjusted incidence rates per 100,000 population



*Data not available to calculate rates.

Thyroid cancer incidence has been steadily rising provincially, nationally and globally since the 1970s and rates among females are significantly higher than for males.[115] Thyroid cancer is the most common cancer overall in young females (15-29 years of age) and represents about 19% of diagnoses per year between 1992 and 2005, followed by Hodgkin's lymphoma and melanoma.[116] In New Brunswick the average annual increases in ASIR rates among females was 6.6% between 1989 and 2001.[117] The annual increase nationally (1991-1999) for females was 3.9%.[118] Between 2001-2005, women in Ontario, Alberta and New Brunswick ranked first, second and third highest among provinces in their rates of thyroid cancer.[119]

There is considerable debate within the scientific community as to whether the dramatic rise in thyroid cancer rates since the 1970s reflects actual increases in incidence rates or simply changes in detection practices. Some researchers have suggested that increased use of diagnostic tools (e.g. ultrasonography) and fine-needle aspiration biopsy have

resulted in increased detection of small (less than 2 cm) tumours. Results of studies to resolve this debate are inconsistent in their conclusions.[120] Still others have (controversially) suggested that, in the general population, small primarily micropapillary (less than 1 cm) thyroid tumours are normal, with relatively few tumours ever developing into malignant cancers.[121]

Thyroid Cancer Risk Factors

The best-known and well-established risk factor for thyroid cancer is exposure to ionizing radiation (e.g. x-rays, gamma rays associated with nuclear reactions, sunlight, high-voltage equipment) particularly during childhood.[122] Ionizing radiation may inflict DNA damage or mutation by altering the atomic composition of cell structures, breaking chemical bonds and/or inducing free radical formation thereby increasing the risk of malignancy or cell death.

Studies have found little or no support for smoking or alcohol and coffee consumption as risk factors.[123] Genetic risk factors account for a small percentage (5%) of differentiated thyroid cancers, the most common (90%) form of thyroid cancer. Other potential risk factors that have been examined include family history, iodine deficiency and reproductive hormones in females.

Increased exposure to ionizing radiation associated with greater use of diagnostic devices (e.g. x-rays, PET, CT – computerized tomography – scanners), as well as the increased use of therapeutic radiation (e.g. cancer treatment), has been suggested as a possible explanation for the increased incidence of thyroid cancer.[124] US data indicates that although the dose for routine diagnostic x-ray exams has decreased over the decades, the frequency of exams have increased from 790 x-rays exams per 1,000 population in 1980-1984 to 962 in 1991-1996.[125] The use of CT scans which have a higher effective dose per exam than x-rays (8.8 mSv for CT versus 1.3 mSv for x-rays) increased significantly in the 1990s.[126] The thyroid is at particular risk of ionizing radiation because iodine, which is trapped by the thyroid gland, blocks and traps photons (radiant energy), thereby causing DNA breaks that lead to mutations.[127]

Numerous studies have linked secondary cancers, including thyroid cancer, to radiation therapy used to treat primary cancers.[128] Second primary malignancies (SPMs) occur in 16% of individuals treated for primary cancers in the United States.[129] The risk of SPMs due to radiation therapy generally decreases with age and SPMs are greater in women than in men. The reason for this difference is unknown. Children and adolescents are more susceptible to the risk of radiation-induced SPMs, particularly leukemia and brain, breast, bone and thyroid cancers.[130] Several explanations have been suggested for the increased risk in SPMs in children.[131] Children have a higher number of stem cells (a cell that can undergo division to become another cell type) in their tissues. These cells are dividing rapidly thereby increasing the chances of DNA replication errors. A second suggestion is that the mechanisms that prevent cells from growing out of control in some organs are less effective or perhaps less developed in children. Another possible explanation is that growth hormones, which have been linked to cancer promotion, are likely greater in children.

Occupational exposure to ionizing radiation and the risk of thyroid and other cancers have been examined for radiologists and radiologic technicians. Evidence of a risk of thyroid cancer or thyroid nodule formation in radiological workers is variable depending on period and duration of occupational exposure.[132] The evidence indicates that the risk is higher in women than in men and, overall, the risk of breast, leukemia and lung cancers may be

stronger than the risk of thyroid cancer.[133] Occupational studies have also suggested a link between the risk of thyroid and other cancers and nuclear and radiation workers in general (e.g. nuclear, industrial, medical and dental).[134]

Most of our knowledge of the impacts of environmental radiation exposure and risk of thyroid and other cancers is based on the study of atomic-bomb survivors in Japan and survivors of the 1986 Chernobyl nuclear accident. Thousands of studies have examined the effects of internally deposited radionuclides and external radiation on cancer induction. It is widely acknowledged that exposure to radiation in utero increases the risk of childhood cancers and childhood exposure is associated with increased risks of adult-onset cancers. Ten years after the accident in Chernobyl, children living in three countries (Belarus, Russia and Ukraine) around the Chernobyl nuclear facility had elevated rates of thyroid cancer.[135]

Several studies have examined the risk of thyroid and other cancers (particularly leukemia in children) for residents living in the vicinity of nuclear power-generating facilities.[136] The results of these studies are inconsistent or inconclusive and often challenged by alternative analyses.[137]

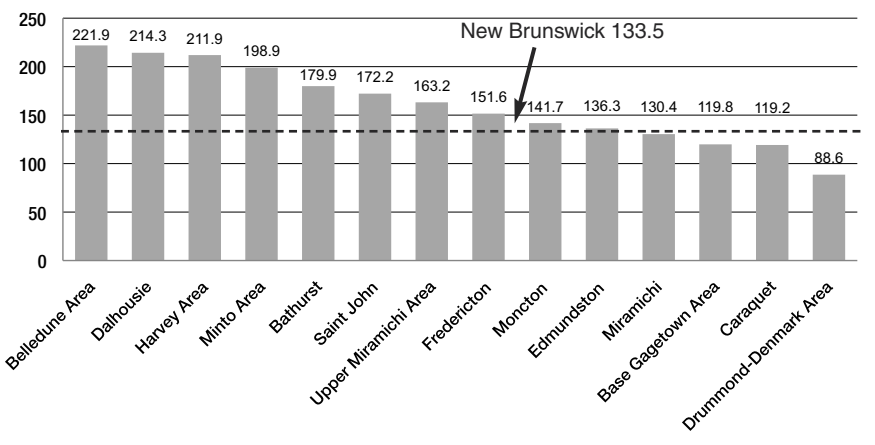
The results of this study identify significantly higher thyroid cancer rates among males and females in Edmundston. A case-control population study should be done to determine why rates in this community are double the provincial rate.

Prostate Cancer

The provincial unadjusted incidence rate of prostate cancer per 100,000 population (1989-2005) was 133.2 (Figure 14). These rates are consistent with the average age-standardized incidence rates (ASIRs) per 100,000 population for New Brunswick for the same time period. Based on Statistics Canada data, the average ASIRs for prostate cancer among New Brunswick males (1989-2005) was 135.0.[138] The provincial unadjusted incidence rate for 1997-2001 was 137.7.[139]

Men in the Belledune area had the highest rate of prostate cancer (221.9); 66.5% above the provincial rate. This finding is consistent with the results of a 2005 community health assessment done in the area. That study, sponsored by the provincial government, found prostate cancer rates (1989-2001) in the Belledune area were higher than rates in their health regions (Health Region 5 and 6) and the province.[140] The study did not examine potential links between high rates of prostate cancer and occupation. Belledune has been the site of a lead smelter and its associated industries (acid, fertilizer and gypsum plants) since 1967. Numerous studies and

FIGURE 14 **Prostate Cancer Rates (1989-2005)**
unadjusted incidence rates per 100,000 population

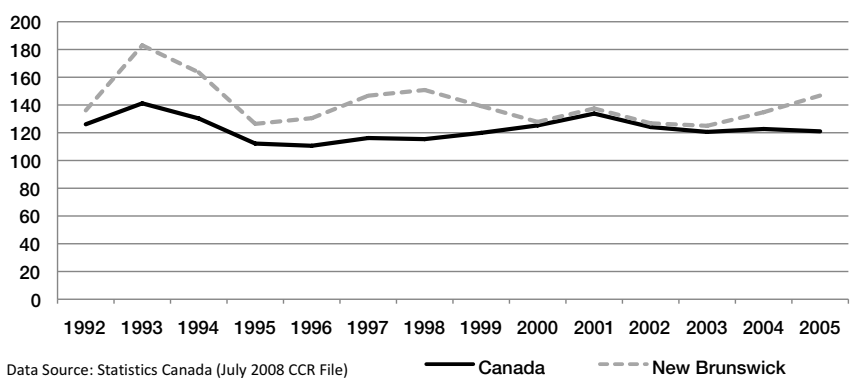


monitoring reports have documented lead, arsenic and cadmium contamination of soil, water, seafood, produce and forage within an eight kilometre radius of the smelter.[141] A human health risk assessment in the area concluded that levels of known (arsenic and cadmium) and probable (lead) carcinogens released from industrial facilities were high enough in the environment to pose a health risk (above provincial health guidelines) for residents for periods of more than thirty years.[142]

Rates among men in Dalhousie and the Harvey area were also significantly higher (at least 60%) than the provincial rate. Men in Miramichi, Caraquet and the Base Gagetown and Drummond-Denmark area had rates below the provincial rate.

Between 1992 and 2000, prostate cancer rates in New Brunswick were significantly higher than national rates (Figure 15). For a brief period (2000-2003), rates matched the national rates, but in 2004 and 2005 rates were once again higher than the national rate. When prostate cancer rates in this study are compared to the national average (1989-2005) ASIR per 1000,000 population (135.0), 10 of the 14 study areas have rates above the Canadian average rate.

FIGURE 15 **Prostate Cancer Rates for Canada and New Brunswick (1992-2005)** Age-standardized rates per 100,000 population



Data Source: Statistics Canada (July 2008 CCR File)

Prostate Cancer Risk Factors

As with breast cancer, genetic susceptibility and family occurrence explain a very small portion of the incidence of prostate cancer. Genetic mutations account for less than 2% and family history accounts for 5-20%.[143] There is little (or inconclusive evidence) that high vegetable and fruit diets reduce the risk, or that animal fat, meat, coffee or smoking increase the risk of prostate cancer.[144] And, like breast cancer, prostate cancer is a hormone-related cancer and there is strong and growing evidence that exposure to synthetic hormone (endocrine) disrupting compounds affects prostate cancer development and progression.[145] In addition, researchers believe that male infants and children exposed to endocrine disrupting compounds may be at increased risk of developing prostate cancer as they age, since these compounds can pass through the placenta into the developing fetus, and the prostate appears to be more sensitive to these compounds during critical period of development (e.g. *in utero* and in early childhood).[146]

Occupational exposure to compounds that mimic hormones (e.g. pesticides, metals, PAHs, and chlorinated compounds like dioxins and PCBs) has been linked to increased risks of prostate cancer (see Table 3, page 20).[147] Studies consistently show that farmers and men with occupational pesticide exposure are at greater risk of prostate cancer.[148]

Occupational and environmental exposure to arsenic has been strongly linked to lung, bladder and skin cancers, and the evidence of a link to prostate cancer is growing.[149] The International Agency for Research on Cancer (IARC) has concluded that there is a "consistent pattern of increased mortality from

prostate cancer in areas that are highly contaminated by arsenic, and there is evidence of a dose-related response".[150] Arsenic compounds, specifically inorganic forms, are potent multi-site human carcinogens. In addition to cancer, exposure to inorganic arsenic can also result in a wide range of non-cancer diseases such as hypertension, heart and liver diseases, diabetes, neuropathy and arteriosclerosis.[151]

Arsenic occurs naturally in the environment and also as a result of human activity. The environment can become contaminated with arsenic by natural weathering of rock containing high levels of arsenic, air emissions from metal mining and smelting operations, coal and oil burning, fly ash from coal- and oil-fired power plants, sewage incineration, land application of sewage, tobacco smoke, some pesticides, air and water emissions from some industries and the manufacturing of (and burning or leaching from) some "pressure-treated" wood products.

High rates of prostate cancer in Belledune, Dalhousie and the Harvey and Minto areas may be linked to occupational and environmental exposures to arsenic and/or cadmium. (Occupational and environmental exposures to cadmium have also been strongly linked to lung cancer, and evidence of a link to prostate, kidney and pancreatic cancers is also growing.[152]) Environmental monitoring reports and studies in Dalhousie, Belledune and the Harvey and Minto areas have reported high levels of arsenic in the environment that have been linked to an ore concentrate storage facility (Dalhousie), power plants (Dalhousie, Minto and Belledune), a coal mine (Minto), lead smelter (Belledune) and naturally occurring sources (Harvey area, Dalhousie). The New Brunswick Groundwater Chemistry Atlas (2008) has identified high (>0.025 mg/l) levels of arsenic in wellwater sampled in the Dalhousie, Minto, Upper Miramichi, Harvey and Bathurst areas as well as other communities and urban areas which were not examined in this study.[153]

These results highlight the need for more detailed case-control population studies to determine why prostate cancer rates are significantly higher in some communities examined in this study and in New Brunswick in general.

Bladder Cancer

The provincial unadjusted incidence rates per 100,000 population (1989-2005) of bladder cancer were 33.1 for males and 10.9 for females. These rates are consistent with the average age-standardized incidence rates (ASIRs) per 100,000 population for New Brunswick for the same time period. Based on Statistics Canada data, the average ASIRs for bladder cancer among New Brunswick males and females (1989-2005) were 34.5 and 8.8 respectively.[154] The provincial unadjusted incidence rate of bladder cancer for males and females (1997-2001) was 33.2 and 10.5 respectively.[155] The average unadjusted incidence rates for males and females (1992-1996) were 28.9 and 9.6 respectively.[156]

In general, bladder cancer rates among males were three time the rate among females (Figures 16 and 17). This three-fold difference between males and females is consistent with the pattern of bladder cancer rates in other developed countries.[157] Males in Dalhousie and the Minto area had bladder cancer rates 50% higher than the provincial rate and rates among males in the Harvey and Upper Miramichi areas were 47% higher than the provincial rate. Rates in Saint John were also significantly higher (32%) than the provincial rate. Rates in Belledune, Edmundston, Caraquet and the Drummond-Denmark area were at or below the provincial rate for males.

Similarly, bladder cancer rates among women in the

Dalhousie and Minto area were significantly higher (70% and 65% respectively) than the provincial rate. Women in the Base Gagetown area, Bathurst and Edmundston had bladder cancer rates below the provincial rate. Data were not available to calculate bladder cancer rates for Caraquet, Belledune or the Upper Miramichi and Harvey areas.

Bladder Cancer Risk Factors

Smoking has been identified as a key risk factor for bladder cancer (Table 4, page 25). Forty to 50% of all bladder cancers have been linked to tobacco smoking.[158] Numerous epidemiological studies have demonstrated no association between bladder cancer and alcohol and coffee drinking, low fruit and vegetable intake or high meat consumption.[159]

Occupational exposures account for a significant percentage (up to 25%) of bladder cancers depending upon the occupation. Bladder cancer risks have been associated with mining and smelting (arsenic), transportation sectors (diesel or gasoline exhaust), mechanics (PAHs), machinists (straight and soluble oils), hairdressers (hair dyes), dry cleaning workers (solvents, specifically tetrachloroethylene), painters (paints and solvents) and petrochemical workers (PAHs).[160]

Environmental exposure to arsenic (via drinking water) is a well-known and significant risk factor for bladder cancer. High levels of arsenic have been reported in groundwater and/or drinking water in the Harvey, Minto and Belledune areas and in Dalhousie.[161]

There is also growing evidence that chlorination by-products, specifically trihalomethanes (THMs) from water disinfection, are a risk factor for bladder cancer.[162] THMs are a group of compounds that can form when the chlorine used to disinfect drinking water reacts with naturally occurring organic matter (e.g., decaying leaves and vegetation). According to Health Canada, the majority of drinking water treatment plants in Canada use some form of chlorine to disinfect drinking water, by treating water directly in the

FIGURE 16 Male Bladder Cancer Rates (1989-2005)
unadjusted incidence rates per 100,000 population

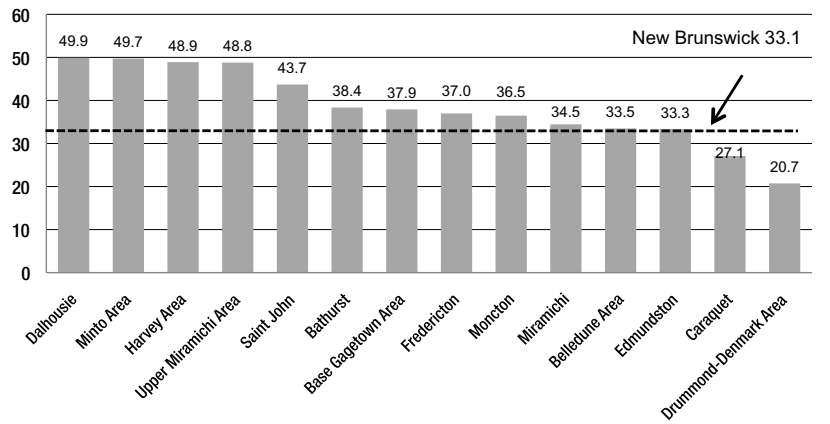
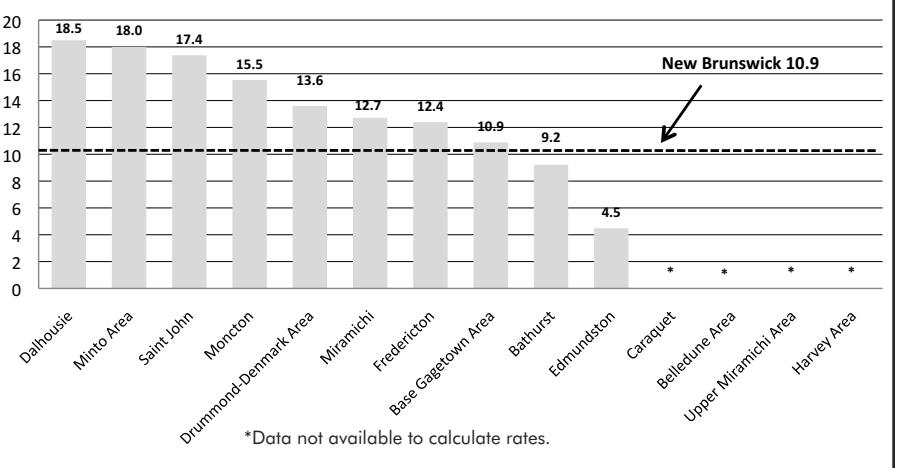


FIGURE 17 Female Bladder Cancer Rates (1989-2005)
unadjusted incidence rates per 100,000 population



*Data not available to calculate rates.

treatment plant and/or by maintaining a chlorine residual in the distribution system to prevent bacterial regrowth. Health Canada has set the maximum acceptable concentration of THMs in drinking water at 0.1 mg/L.[163] Exposure to THMs can occur through drinking water, inhalation and absorption through the skin during bathing or showering, and in swimming pools.[164] Testing done by Health Canada (1993-94) found that several cities across Canada had levels of THMs above the agency's guidelines.[165] In 2007, high levels of THMs were reported in the water supply of residents living in west Saint John.[166] Health officials acknowledged the need for a better water treatment facility for the city.

Except for Dalhousie and the Minto area, the pattern of bladder cancer rates among communities is different for females than for males. The fact that men in Dalhousie and the Minto area have three times the rate of bladder cancer than women in these areas could be a function of generally higher smoking rates among men than women. (Data on smoking rates in those communities does not exist.) It could also be attributed to occupational exposure. Men in Dalhousie and the Minto area have worked (and still work) in industries associated with arsenic exposure (e.g. coal mining, fossil fuel power plants), a known risk factor for bladder and other cancers. Occupational exposure is unlikely to explain the high rates of bladder cancer for women in Dalhousie and Minto. Smoking and environmental exposures are potential risk factors. Environmental monitoring in the Dalhousie, Minto, Belledune and Harvey areas indicate high levels of arsenic in the environment. Data were not available to calculate bladder cancer rates for females in the Belledune or Harvey areas.

In 1982, the provincial Department of Health began an investigation of potential arsenic contamination in Dalhousie when a 28 year old female was diagnosed as suffering from chronic arsenic poisoning. Subsequently, 244 residents had their urine analyzed for total arsenic.[167] Twelve percent (12%) of samples were at or above 40 micrograms arsenic per litre (µg As/l) – the upper limit of normal that was arbitrarily assigned by the report's author.[168] The report identified several possible sources of arsenic including marine sediments and seafood from near the wharf area, the coal-fired power plant, the paper mill, which burned Minto coal until the 1970s, dust and leachate from fly ash piles at the mill and power plant and ore concentrate piles. The report concluded there was no connection between urinary arsenic levels and environmental contamination and attributed high urinary arsenic levels to intake of seafood, particularly lobsters and clams.

Almost 25 years later, the owners responsible for the ore concentrate piles in Dalhousie hired consultants to examine the health risks of high lead, cadmium and arsenic levels reported in residential soils in the vicinity of their operation. Ore concentrates were shipped via open railcar from various mines in northern New Brunswick and stored in open piles at the Dalhousie wharf at the centre of town from 1964 to 1996. While the facility was operating, there were constant complaints by Dalhousie residents about the dust from the ore piles. Residents living in towns and villages along the rail line also complained about the fugitive dust blown from the open railcars. By the late 1980's, efforts by the company to control the dust from railcars were more successful than their efforts to control the dust from the piles on the wharf. The company stopped shipping and stockpiling ore concentrates in 1997.

The 2006 Dalhousie study found that current arsenic levels pose a risk of cancer for residents that exceeds the province's health guideline.[169] There was an order of magnitude higher cancer risk associated with soil arsenic levels for Dalhousie residents when

they were compared with residents living 15-30 km southwest of Dalhousie (Atholville and Maple Green and McLeod area).[170] The study concluded that at current arsenic levels, soil and indoor and outdoor dust (either inhaled or ingested) were not health risks and that there would be no benefit to cleaning up the soil in Dalhousie because soil represented only a small proportion of the overall arsenic risk. The study did not examine the historic health risk when dust from the open piles was a chronic problem in the community. According to the study, drinking water, local seafood and supermarket food were the main risk pathways in Dalhousie as well as for typical New Brunswick residents.

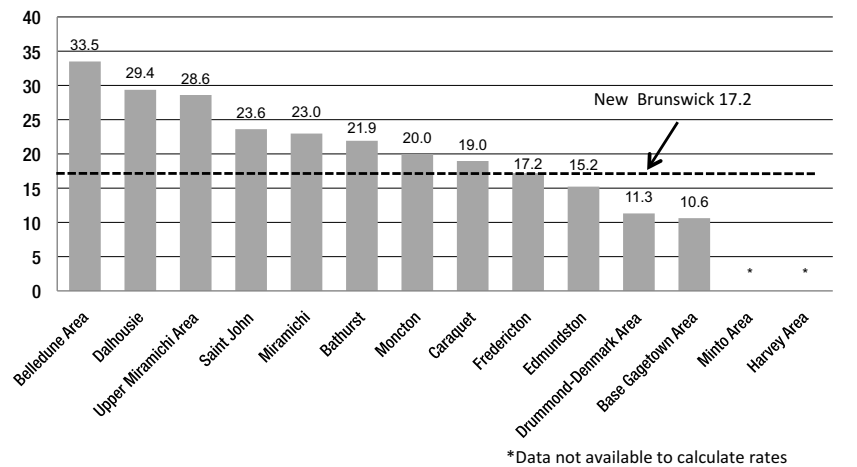
The results of the present study highlight the need for more detailed case-control population studies to determine why bladder cancer rates among men and women in the Dalhousie and Minto area are more than 50% higher than the provincial rate.

Kidney Cancer

The provincial unadjusted incidence rate of kidney cancer per 100,000 population (1989-2005) was 17.2 for males and 11.8 for females. These rates are consistent with the average age-standardized incidence rates (ASIRs) per 100,000 population for New Brunswick for the same time period. Based on Statistics Canada data, the average ASIRs for kidney cancer among New Brunswick males and females (1989-2005) were 16.7 and 9.9 respectively.[172] The average provincial unadjusted incidence rate of kidney cancer for males and females (1992-1996) was 16.2 and 10.7 respectively.[173]

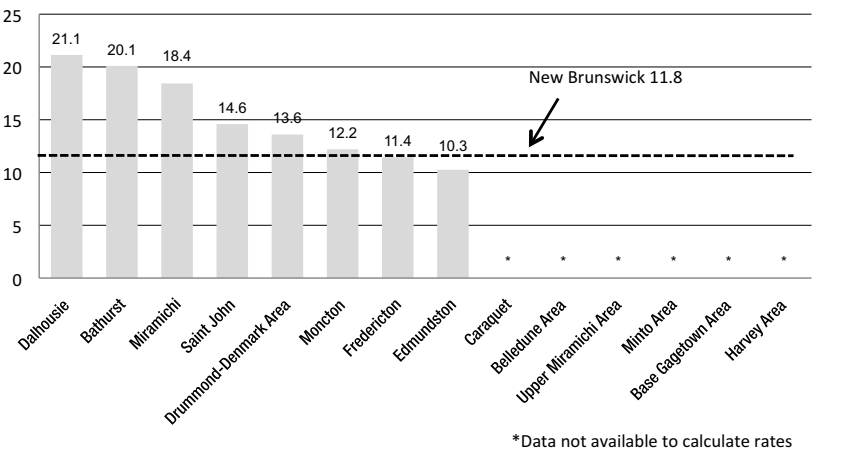
Males in the Belledune area had kidney cancer rates almost double the provincial rate (Figure 18). This finding is consistent with the results of the 2005 Belledune area health study. That study found kidney cancer rates (1989-2001) among males in the Belledune area were higher than rates in their health regions (Health Regions 5 and 6) and the province.[174] Males in Dalhousie and the Upper Miramichi area also had rates significantly above (71% and 66% respectively) the provincial rate.

FIGURE 18 **Male Kidney Cancer Rates (1989-2005)**
unadjusted incidence rates per 100,000 population



*Data not available to calculate rates

FIGURE 19 **Female Kidney Cancer Rates (1989-2005)**
unadjusted incidence rates per 100,000 population



*Data not available to calculate rates

Males in Fredericton, Edmundston and the Drummond-Denmark and Base Gagetown areas had rates at or below the provincial rate. Data were not available to calculate kidney cancer rates for males in the Minto and Harvey areas.

Women in Dalhousie had kidney cancer rates 79% above the provincial rate (Figure 19). Rates in Bathurst and Miramichi were also significantly above the provincial rate (70% and 56% respectively). Data were not available to calculate kidney cancer rates for women in Caraquet and the Belledune, Upper Miramichi, Minto, Base Gagetown or Harvey areas.

Kidney Cancer Risk Factors

Kidney (renal cell) cancers represent a small percentage (3-4%) of total cancer incidence rates in Canada (as well as the United States).[175] A key lifestyle risk factor for kidney cancer is smoking.[176] High blood pressure (hypertension) and high body-mass index have been found to increase the long-term risk of kidney cancer in men.[177] Coffee, tea and alcohol consumption have not been linked to kidney cancer.[178] Some studies indicate a moderate consumption of alcohol may decrease the risk of kidney cancer in men and in women (mainly postmenopausal women).[179] Studies examining the association between fat and meat (red meat, processed meat, poultry and seafood) consumption and physical inactivity and the risk of kidney cancer reflect contradictory conclusions.[180]

There is considerable evidence that exposure to trichloroethylene, a chlorinated solvent commonly used as a degreaser in several occupations (e.g. metal workers, mechanics, printers, railroad workers and service station employees) is a risk factor for kidney cancer.[181] Exposure to known or suspected carcinogens such as chromium compounds, cadmium, lead, benzene, vinyl chloride, asbestos, pesticides and herbicides have been linked to increased risk of kidney cancer.[182]

Cadmium was designated a known carcinogen by the IARC in 1993 and was associated with increased risk of lung cancer. Since the IARC designation, there has been growing evidence linking cadmium exposure to prostate, kidney, pancreas and breast cancer.[183] Occupational exposures to cadmium include those who work in mining, smelting and refining metals, battery recycling, cement-manufacturing, plants burning oil or coal, and sewage sludge incinerators.[184] Environmental exposures occur as a result of air emissions or effluent releases from these operations which can contaminate soil, air, water, produce, vegetation, wildlife, fish and seafood. Cadmium is poorly excreted from the body and accumulates mainly in the liver and kidneys where it has a half-life (the time it takes for half the cadmium to be removed) of 10-30 years.[185] Cadmium also has non-cancer health effects. It is toxic to kidneys and interferes with calcium metabolism in bones leading to pains in bones and joints and reduced bone density.

Cadmium, as well as lead and arsenic, have long been a concern for workers at the Belledune smelter. In 1987, after years of complaints by workers at the smelter, a joint (industry-province) occupation health and hygiene study of workers in the Belledune smelter was done by McGill University. The study found that workers throughout the smelter were overexposed to levels of dust, SO_2, lead, cadmium, and arsenic.[186]

Three years later, a clinical health study of smelter workers was conducted by a researcher from Dalhousie University.[187] The study found that 26.3% of workers had lung abnormalities, 24% had unacceptable levels of lead, cadmium and arsenic in their blood, 69% had hearing problems, 23.6% complained of chest pains, 24.5% had joint and muscle pains, and 19.8% had severe itching of the skin.[188] Although the study did not predict the long-term health effects of continued exposure to these

metals, the author suggested that arsenic could cause lung cancer, cadmium could result in kidney disease and a combination of the metals could affect skin, lungs, kidneys, gonads, nerves, bones and muscles.[189]

As a result of the Dalhousie University study, more than 100 smelter workers were flown to a medical centre in Baltimore for further examination. When they returned, several workers were put on long-term disability. No follow-up occupational health study of smelter workers in Belledune was ever done.

In 2007, the provincial health department announced another health study to examine whether high cancer rates in the Belledune area were linked to lifestyle risk factors. The study would compare the lifestyles of Belledune residents to those of Beresford, a community 40 km east of the smelter. The results of the study were due in September 2008 but have not been released as of the publication of this report.

Occupational exposure to cadmium could also occur in mine workers. Base-metal mining operations (e.g. Brunswick 12, Heath Steele, Caribou mines) have been a major economic activity in northern New Brunswick since the early 1960's. The mine workforce has been drawn from many northern communities including some of those examined in this study (Dalhousie, the Upper Miramichi area, Miramichi and Bathurst). No occupational health studies have examined cancer incidence rates among miners in New Brunswick.

According to this study, kidney (as well as prostate) cancer rates among men in the Belledune area were the highest among the 14 study areas, followed by Dalhousie. (Data were not available to calculate kidney cancer rates among women in the Belledune area.) An occupational health study should be done to determine why rates of kidney (and prostate) cancer are so high in Belledune and Dalhousie.

Pancreatic Cancer

Provincial unadjusted incidence rates of pancreatic cancer per 100,000 population (1989-2005) were 12.0 for males and 11.6 for females. These rates are consistent with the average age-standardized incidence rates (ASIRs) per 100,000 population for New Brunswick for the same time period. Based on Statistics Canada data, the average ASIRs for pancreatic cancer among New Brunswick males and females (1989-2005) were 12.0 and 8.8 respectively.[190] The average provincial unadjusted incidence rates of pancreatic cancer for males and females (1992-1996) were 10.3 and 10.4 respectively.[191] Unadjusted incidence rates between 1997-2001 for males and females were 17.0 and 12.8 respectively.[192]

Caraquet males had twice the provincial rate (1989-2005) of pancreatic cancer (Figure 20). Rates among males in the Minto area and Dalhousie were 82% and 71%, respectively, above the provincial rate. Rates in Saint John, Bathurst and Moncton were 30% above the provincial rate. Data were not available to calculate pancreatic cancer rates for the Belledune, Upper Miramichi and Harvey areas.

Females in Bathurst had the highest rates of pancreatic cancer, almost double the provincial rate. Rates among women in Dalhousie, Caraquet and Miramichi were 82%, 55% and 48%, respectively, above the provincial rate (Figure 21). Data were not available to calculate pancreatic cancer rates for the Belledune, Minto and Harvey areas.

Pancreatic cancer occurs at approximately the same rate for males and females, and rates in Canada and New Brunswick have been relatively stable for the past three decades.

Pancreatic Cancer Risk Factors

Genetic mutations in pancreas-specific genes have yet to be identified.[193] Only 4-16% of individuals with pancreatic cancer have a family history of the disease.[194] In families with a history of pancreatic cancer, other genes such as those associated with the BRCA2 breast-ovarian cancer gene, Peutz-Jeghers syndrome, Lynch syndrome, hereditary pancreatitis and hereditary colorectal cancer have been identified as risk factors.[195] However, these factors account for a very small proportion of pancreatic cancer cases.

Numerous studies have examined lifestyle risk factors and their potential association with pancreatic cancer. The most consistent findings are for smoking.[196] An estimated 33% of pancreatic cancers have been attributed to smoking.[197] The evidence for alcohol, specifically heavy consumption, as a potential risk factor for pancreatic cancer is more consistent than that for obesity, diet, inactivity and coffee consumption.[198]

Few studies have specifically examined the incidence of pancreatic cancer and occupational risk factors. A limited number of studies have reported an increased risk of pancreatic cancer to be associated with pesticides, organic solvents and metal (specifically nickel and cadmium) exposures, and work in food industries.[199]

The high rates of pancreatic cancer among males and females in Caraquet merit investigation given that rates of most other cancers (for males and females) in this community are among the lowest in this study.

FIGURE 20 Male Pancreatic Cancer Rates (1989-2005)
unadjusted incidence rates per 100,000 population

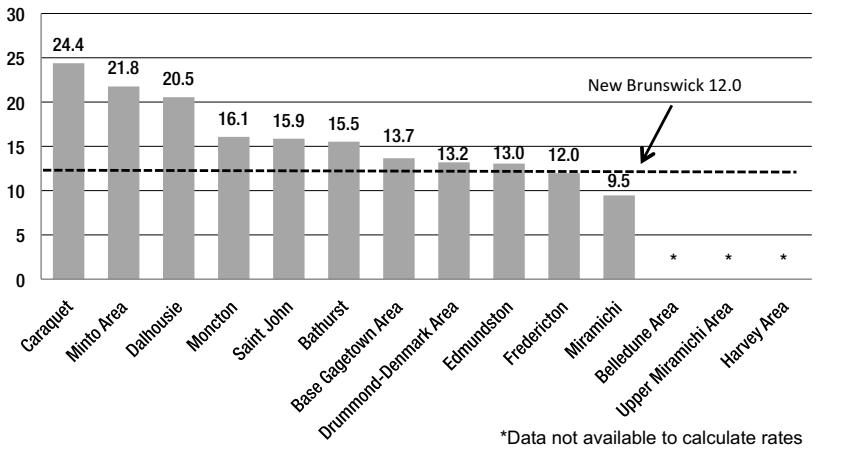
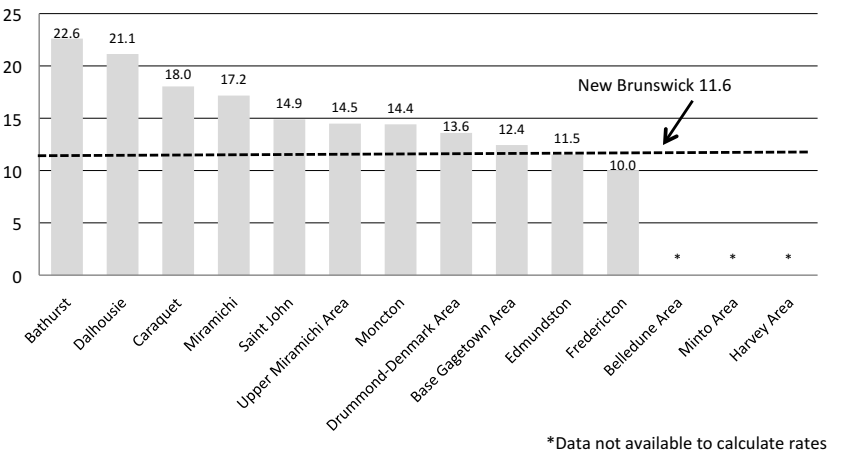


FIGURE 21 Female Pancreatic Cancer Rates (1989-2005)
unadjusted incidence rates per 100,000 population



Non-Hodgkin's Lymphoma (NHL)

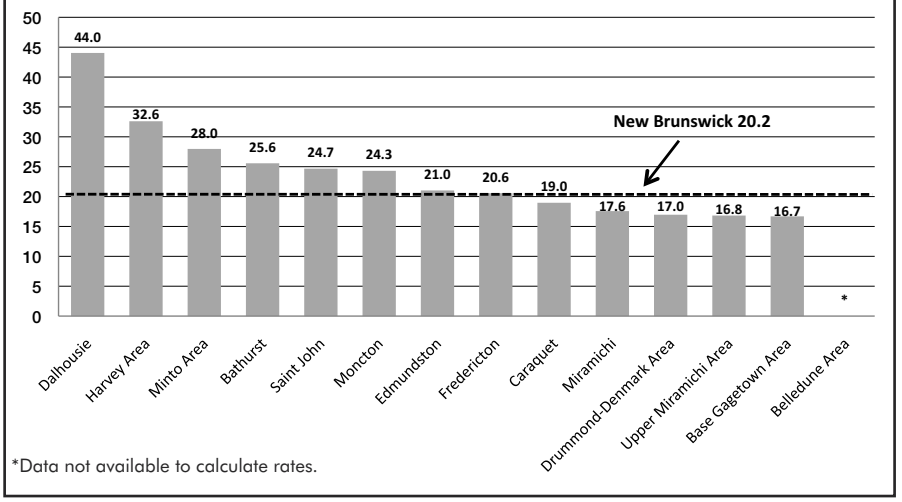
Provincial unadjusted incidence rates of non-Hodgkin's lymphoma per 100,000 population (1989-2005) were 20.2 for males and 17.6 for females. These rates are consistent with the average age-standardized incidence rates (ASIRs) per 100,000 population for New Brunswick for the same time period. Based on Statistics Canada data, the average ASIRs for NHL among New Brunswick males and females (1989-2005) were 19.7 and 14.5 respectively.[200] Average unadjusted NHL incidence rates for New Brunswick males and females (1992-1996) were 20.8 and 16.0 respectively and unadjusted rates for 1997-2001 were 21.9 and 16.5 for males and females respectively.[201]

Males in Dalhousie had the highest NHL rates in this study (Figure 22). Their rates were 118% above the provincial rate. Rates in Fredericton, Caraquet, Miramichi and the Drummond-Denmark, Upper Miramichi and Base Gagetown areas were at or below the provincial rate. Data were not available to calculate NHL rates for males in the Belledune area.

Females in the Upper Miramichi area had the highest incidence rates of NHL; 85% above the provincial rate (Figure 23). NHL rates in Drummond-Denmark and Edmundston were at or below the provincial rate. Data were not available to calculate NHL rates for the Belledune, Base Gagetown or Harvey areas.

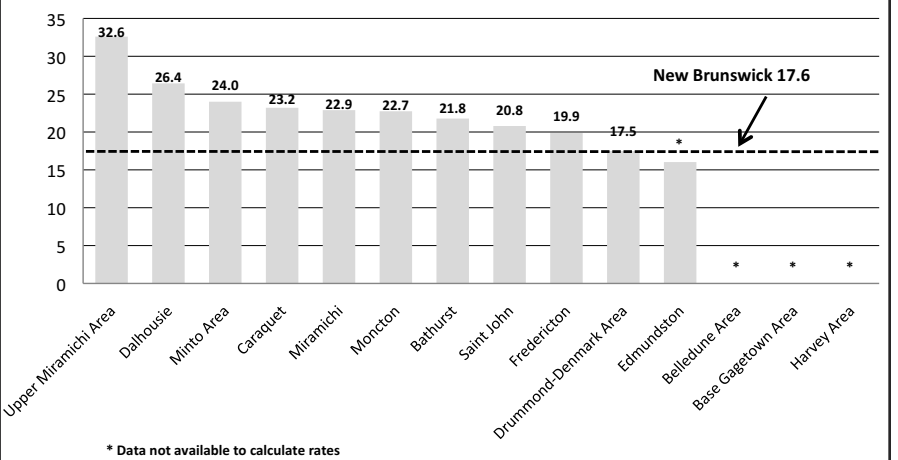
The body's primary defense mechanism against the spread of infection and tumours is the lymphatic system. Lymphoma and multiple myeloma are cancers that begin in the cells of the immune system. The lymphatic system consists of lymph vessels, lymph (which contain lymphocytes) and lymph nodes. Lymph nodes trap, destroy and remove bacteria or other harmful substances that may be in the lymph. If this does not occur, the lymph nodes can become the site of secondary cancers. The lymph system can also

FIGURE 22 **Male Non-Hodgkin's Lymphoma Rates (1989-2005)**
unadjusted incidence rates per 100,000 population



*Data not available to calculate rates.

FIGURE 23 **Female Non-Hodgkin's Lymphoma Rates (1989-2005)**
unadjusted incidence rates per 100,000 population



* Data not available to calculate rates

carry cancerous cells between various parts of the body in a process called metastasis.

There are more than 40 different types of lymphomas. Non-Hodgkin's lymphoma (NHL), one of the more common lymphomas, is part of a group of approximately 20 cancers that arise primarily in the lymph nodes.[202]

Incidence rates of NHL have increased dramatically in developed countries.[203] In Canada, NHL rates doubled in almost every age group between 1970 and 1990.[204] Since then rates appear to have reached a plateau depending on the age group.[205]

Lymphomas are the third most common (leukemias and central nervous system cancers are first and second) cancers among children (0-14 years of age) in Canada; incidence rates for Hodgkin's disease are higher than those for non-Hodgkin's lymphoma in New Brunswick.[206] Lymphomas (Hodgkin's and non-Hodgkin's combined) are also the most commonly diagnosed cancer in Canadian adolescents and young adults (15-29 years of age).[207] The rate among males in this age category is almost 20% higher compared to that among females.

In Canada, cancer incidence rates in children are highest among the 0 to 4 age category.[208] Males tend to have higher cancer incidence rates than females. For lymphomas, the ratio of males to females for new cases (0-4 years of age) in Canada is 2.1 to 1.[209] NHL incidence rates in Canada doubled among children 0 to 4 years of age between 1970 and 1990.[210]

Non-Hodgkin's Lymphoma Risk Factors

The best described (although not the main) risk factor for NHL is immune deficiency. People on immune suppression therapy after organ transplants, with HIV/AIDS or with congenital immunological deficiencies (e.g. rheumatoid arthritis, systemic lupus, celiac disease) are at increased risk of NHL[211] A very small portion of the overall increase in NHL has been attributed to the increased incidence of AIDS, since approximately 10% of people who have HIV develop non-Hodgkin's lymphoma. A number of other viruses and microbes have also been associated with NHL. However, both immune deficiency and viruses account for a relatively small proportion of total NHL cases. Hereditary and familial lymphomas also account for a very small percentage of all NHL cases.[212]

Hundreds of studies have evaluated the role of smoking, diet, alcohol consumption, overweight/obesity and physical inactivity as risk factors for NHL. In general, most studies found no strong or consistent associations between these lifestyle factors and increased risk of NHL. Many studies on alcohol consumption and sunlight have found an inverse relationship with NHL; moderate alcohol consumption and sun exposure appear to be a protective factor against NHL.[213]

Cancer is a disorder in cell growth, and cell replication is under the control of genes. While the actual mechanisms responsible for initiating cancer are complex and unknown, it is well known that viruses, various forms of radiation and some chemicals affect gene replication and/or repair. When cells lose the ability to replicate without errors or the DNA repair mechanism does not work properly, abnormal growth occurs. In the case of NHL, researchers believe that chronic antigen stimulation (in response to a harmful substances) causes specific cells (B-cells) in the lymph nodes to proliferate, which in turn increases the chance of a random genetic mistake and can result in abnormal tissue growth (cancer).[214]

Many researchers believe the dramatic rise in NHL rates (as well as other cancer types) since the 1950s could be related to exponential increases in

pesticide and other chemical use over this period. Exposure to pesticides, including herbicides and fungicides, and incidence rates of NHL have been the subject of hundreds of epidemiological studies.[215] Evidence for a link between organochlorine and organophosphate pesticides, herbicides, fungicides and NHL is variable and inconsistent. There are many reasons for different conclusions among these studies. The number of people participating in a study, the magnitude and duration of exposure to a pesticide or chemical, exposures to multiple substances and the timing of a study post-exposure can all influence study results and limit the comparability of study conclusions. Despite these factors, most studies consistently find a link between the risk of NHL and exposure to phenoxy herbicides such as 2,4-D.[216] Also, studies on occupational exposure and NHL consistently find that crop farmers and machinists are at higher risk of NHL and this risk increases with their duration of employment.[217] Occupational exposure to PCBs, personal hair dyes, diesel exhaust and organic solvents have also been linked to increased risk of NHL.

New Brunswick is one of Canada's largest producers of potatoes. Large-scale potato production requires the application of multiple pesticides, particularly fungicides, to control a wide range of pests and diseases. A 1984 New Brunswick task force on the environment and cancer reported that, in 1976, 500 tonnes of pesticides were applied to about 50,000 hectares of agricultural land (10 kg/ha).[218] This figure included fungicides (49%), insecticides (25%) and herbicides (20%).[219] In 2001, Prince Edward Island (Canada's largest producer of potatoes) and New Brunswick spent more on herbicides, insecticides, fungicides and other chemcials (not including fertilizers) per hectare of land in crops ($121 and $74 respectively) than any of the other provinces.[220] Between 1995 and 2000, the area of crop land in New Brunswick sprayed with herbicides, insecticides and fungicides increased 19%, 11.2% and 11.5 % respectively, with further increases reported in 2005. Most of New Brunswick's large-scale potato production is concentrated in Carleton and Victoria counties.

New Brunswick also had the largest and longest-running aerial pesticide spray program in Canada for combating spruce budworm. Spray operations were conducted every year beginning in 1959. A very conservative estimate of the amount of pesticides used in the spray program between 1952-1990 is 100,000 tonnes. Between 1975 and 1986, a total of 19.4 million hectares of forest in New Brunswick were treated with pesticides.[221] The only other province that came close to that figure was Quebec with 13.7 million hectares, followed by Newfoundland with 0.598 million, Nova Scotia with 0.22 million and Ontario with 0.28 million hectares. The 1984 Spitzer task force which examined the incidence of cancer and the use of pesticides to control spruce budworm in New Brunswick's forests concluded that stomach, uterine and lymphatic system (other than leukemia) cancers were highest in counties with above average spraying of forest pesticides (Northumberland, Victoria, and Restigouche counties).

A decades old ground and aerial herbicide spray program also takes place at Canadian Forces Base (CFB) Gagetown. Between 1956 and 2004, a total of 37 different herbicide products were used. A 2006 federal government study on herbicide use at CFB Gagetown found that, for men involved with aerial and ground spraying of pesticides, there was sufficient evidence or a positive association between some herbicide exposures and various cancers including non-Hodgkin's lymphoma.[222]

In general, NHL rates among New Brunswick males and females (1992-2005) are higher than national

rates (Figure 24).[223] The average ASIRs for NHL in Canada (1989-2005) for males and females were 18.5 and 13.3 respectively. For the same time period, NHL rates for New Brunswick males and females were 19.7 and 14.5 respectively. On average (2000-2005), males in New Brunswick had the highest incidence rates of NHL among all the Canadian provinces.[224]

In this study, areas with potentially high occupational and environmental exposure to pesticides (agricultural, forestry or military exposures) include the Upper Miramichi, Drummond-Denmark, Base Gagetown, Harvey and Minto areas and the communities of Dalhousie, Bathurst and Miramichi where forestry-related employment has been historically high. Rates of NHL in these areas were above, at or below provincial rates depending on sex. Except for the 1984 Spitzer task force and 2006 CFB Gagetown study, no other health studies or risk assessments have been done on workers or residents exposed to agricultural or forest pesticides in New Brunswick. In order to determine whether there is link between historic agricultural and forest pesticide use in New Brunswick and the higher than average NHL rates in the province, appropriate epidemiological studies should be done.

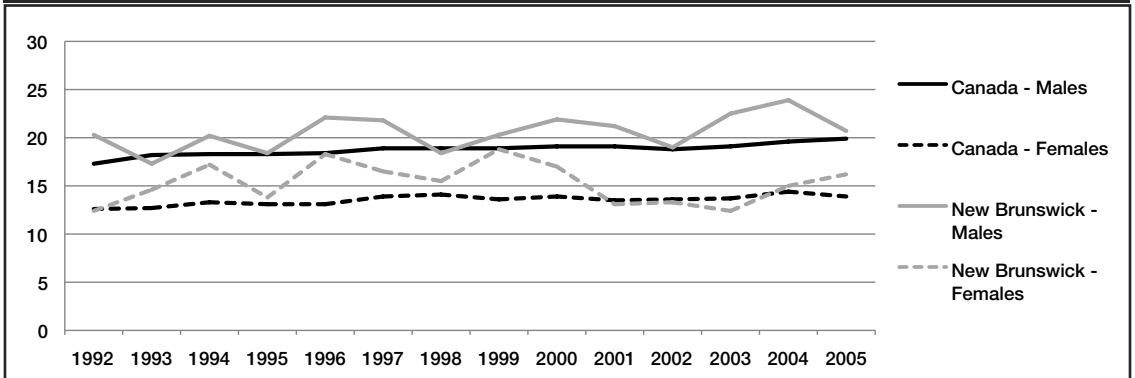
Hodgkin's Disease

Data were not available to calculate the provincial unadjusted incidence rates of Hodgkin's disease (sometimes referred to as Hodgkin's lymphoma) between 1989 and 2005. Average, unadjusted Hodgkin's disease incidence rates per 100,000 population for New Brunswick males and females (1992-1996) were 2.7 and 2.1 respectively and the unadjusted rates for 1997-2001 were 2.1 and 0.8 for males and females respectively.[225]

Among the study areas where data were available, males in Miramichi and females in Fredericton had the highest rates of Hodgkin's disease (Figures 25 and 26).

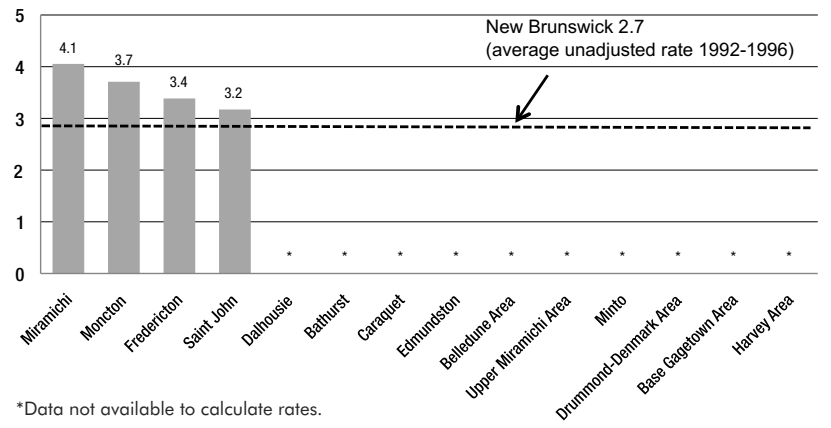
Hodgkin's disease is a type of lymphoma that start in the lymph nodes and then spreads to surrounding areas of the body. The frequency of occurrence in the population is very low, and it affects mostly (but not exclusively) men between the ages of 15 and 40 and men over 50. Hodgkin's disease and non-Hodgkin's lymphoma may cause similar symptoms, but the conditions themselves are different. Rates of Hodgkin's disease have been declining. The distinction between Hodgkin's disease and non-Hodgkin's lymphoma is made by examining tissue (taken from a biopsy or aspiration of the tumor tissue) under a microscope. The type of abnormal cells identified in the sample determines whether a lymphoma is classified as Hodgkin's disease or non-Hodgkin's lymphoma.

FIGURE 24 **Non-Hodgkin's Lymphoma Rates for Canada and New Brunswick (1992-2005)**
Age-standardized rates per 100,000 population



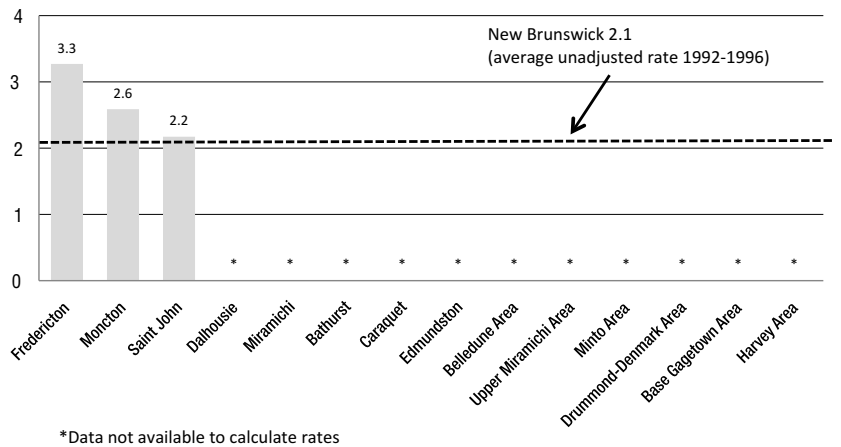
Data Source: Statistics Canada (July 2008 CCR file)

FIGURE 25 **Male Hodgkin's Disease Rates (1989-2005)**
unadjusted incidence rates per 100,000 population



*Data not available to calculate rates.

FIGURE 26 **Female Hodgkin's Disease Rates (1989-2005)**
unadjusted incidence rates per 100,000 population



*Data not available to calculate rates

Hodgkin's Disease Risk Factors

Like non-Hodgkin's lymphoma, immune deficiencies and infectious diseases are risk factors for Hodgkin's disease.[226] Genetic susceptibilities are a small percentage of the risk factors for the disease. There is little evidence that lifestyle (e.g. smoking, alcohol consumption) are risk factors for Hodgkin's disease.[227] Adults and children treated for Hodgkin's disease are at higher risk of developing secondary primary cancers.[228] Patients treated with radiation for Hodgkin's disease were also at higher risk of developing cardiovascular diseases and strokes.[229]

Occupational exposure to solvents, aromatic hydrocarbons (e.g. toluene, benzene, xylene) and employment in paper mills and woodworking have been identified as potential risk factors for Hodgkin's disease.[230] Historically, a high percentage of males in Miramichi worked in paper mills and wood-processing industries (e.g. plywood and oriented strandboard mills). The Miramichi pulp and paper mill was the largest kraft paper mill in Canada. (It closed in 2007.)

Appropriate epidemiological studies are needed to assess the role occupational exposure may play in the higher rates of Hodgkin's disease among men in Miramichi compared with those in the other urban and rural areas examined in this study.

Leukemia

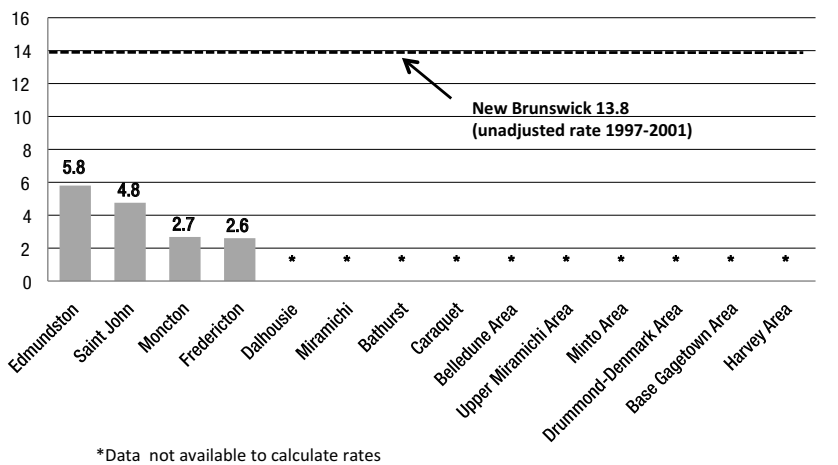
Data were not available to calculate the provincial unadjusted incidence rates of leukemia between 1989 and 2005. Average, unadjusted leukemia incidence rates per 100,000 population for New Brunswick males and females (1992-1996) were 11.4 and 8.2 respectively.[231] The unadjusted rates for 1997-2001 were 13.8 and 8.1 for males and females respectively.[232]

Male and female leukemia rates were well below the unadjusted provincial rates (1992-2001) for those communities where data were available (Figures 27 and 28). Leukemia incidence rates in New Brunswick are among the lowest in Canada.[233] Males in Prince Edward Island generally have the highest incidence rates in Canada (1998-2005).[234]

Leukemia is a type of cancer of the bone marrow and blood. There are numerous types of leukemia which are classified in several ways. They are grouped based on how quickly the disease develops and progresses. Leukemia is either chronic (gets worse slowly) or acute (gets worse quickly). Leukemias are also grouped by the type of white blood cell affected. Leukemia can arise in lymphoid cells or myeloid cells. Leukemia that affects lymphoid cells is called lymphocytic leukemia. Leukemia that affects myeloid cells is called myeloid leukemia or myelogenous leukemia.

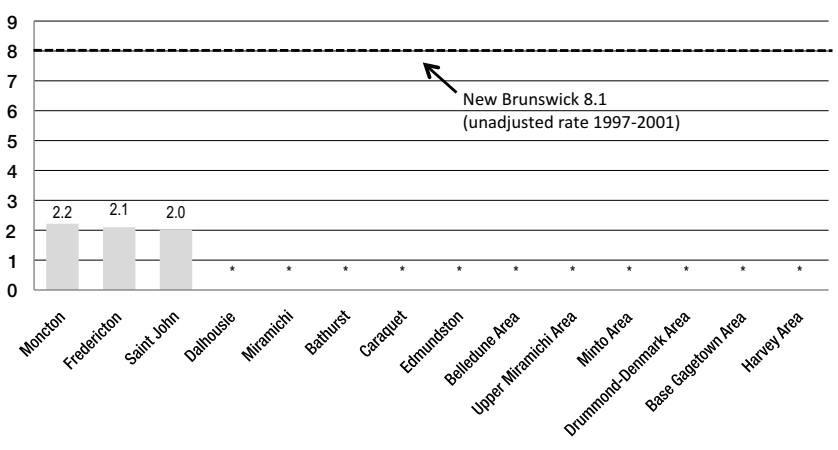
There are four common types of leukemia: 1) chronic lymphocytic leukemia (CLL) which affects mostly adults; 2) chronic myeloid leukemia (CML); 3) acute lymphocytic leukemia (ALL), the most common type of leukemia (and cancer in general) among young children (0-14 years of age); and 4) acute myeloid leukemia (AML) which occurs in both adults and children. (Hairy cell leukemia (HCL) is a rare type of chronic leukemia.)

FIGURE 27 Male Lukemia Rates (1989-2005)
unadjusted incidence rates per 100,000 population



*Data not available to calculate rates

FIGURE 28 Female Lukemia Rates (1989-2005)
unadjusted incidence rates per 100,000 population



*Data not available to calculate rates

Generally, leukemia rates among men (and boys) are higher than among women (and girls). Leukemia is the most common childhood cancer in Canada. Between 2000-2004, leukemia accounted for 33% of new cases of cancer among Canadian children 0-14 years of age.[235]

Leukemia Risk Factors

Genetic and familial risk factors play a small role in the occurrence of leukemia. The evidence for lifestyle differences (e.g. smoking, obesity and dietary intake) as risk factors for leukemia is variable depending on the leukemia type. Evidence linking smoking to leukemias, particularly myeloid leukemias, is stronger and more consistent than the evidence for obesity.[236] Studies have shown no relationship between maternal or parental smoking and childhood leukemia but have shown an increased association with alcohol consumption before or during pregnancy.[237] (However, maternal smoking and alcohol consumption have been linked to a wide range of other childhood diseases and health problems.)

Established environmental and occupational risk factors for leukemia include exposure to benzene, formaldehyde, solvents, pesticides, high dose ionizing radiation and chemotherapy. Several studies have linked higher risks of leukemia and non-Hodgkin's lymphoma for residents living in close proximity to oil refineries, petrochemical industries, gas stations and bus depots, as well as for workers associated with these industries.[238]

The developing fetus as well as children are particularly vulnerable to the affects of chemical exposure. In the womb, toxic substances can pass from the mother via the placenta into the developing fetus. At birth, children's lungs and kidneys and their immune and digestive systems are still not fully developed. Their bodies don't have the same ability as those of adults to metabolize and eliminate toxic substances. Pound for pound, children breathe more air, eat more food and drink more water than adults. Therefore, children will be exposed to higher levels of toxic substances than adults even when concentrations in the environment are very low. Several studies have confirmed a link between benzene and pesticide exposure and the risk of leukemia in children.[239]

Childhood and residential exposure to non-ionizing radiation, particularly electromagnetic field (EMF) radiation from certain power, electrical and wireless devices (e.g. cellular phones) have been linked to several adult cancers as well as to childhood leukemia and brain cancer, and also to other non-cancer diseases.[240] The International Agency for Research on Cancer (IARC) has classified extremely low frequency magnetic fields (ELG) as a possible human carcinogen based on the consistent epidemiological evidence of an association between childhood leukemia and ELFs.[241] Children are more vulnerable to ELFs (as well as ionizing-radiation) because their nervous systems are developing, their brain tissue is more conductive, penetration is greater relative to head size and they may have a longer lifetime exposure than adults.

Brain (and central nervous system) cancers

The provincial unadjusted incidence rates of brain and central nervous system (CNS) cancers per 100,000 population (1989-2005) were 8.0 for males and 6.0 for females. (Herein, brain cancers will refer to both brain and CNS cancers.) These rates are consistent with the average age-standardized incidence rates (ASIRs) per 100,000 population for New Brunswick for the same time period. Based on Statistics Canada data, the average ASIRs for brain cancer among New Brunswick males and females per 100,000 population (1989-2005) were 7.8 and 5.3 respectively.[242] Average unadjusted brain cancer incidence rates for New Brunswick males and females (1992-1996) were 7.2 and 6.3 respectively, and the unadjusted rates for 1997-2001 were 8.3 and 5.9 for males and females respectively.[243]

FIGURE 29 **Male Brain Cancer Rates (1989-2005)**
unadjusted incidence rates per 100,000 population

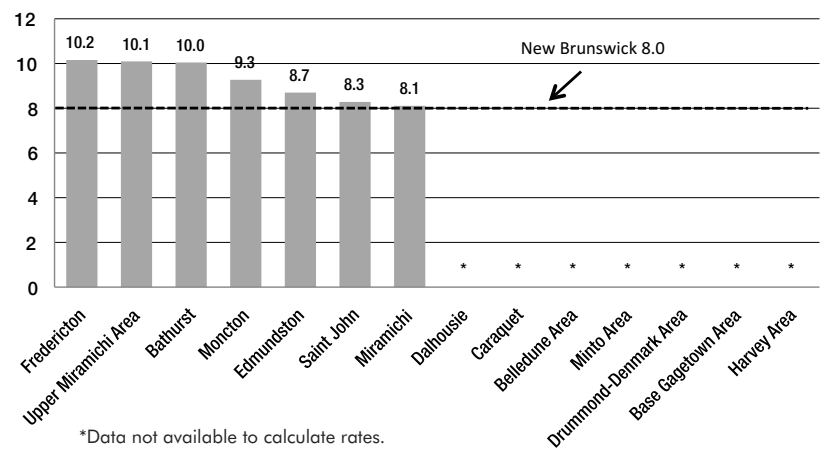
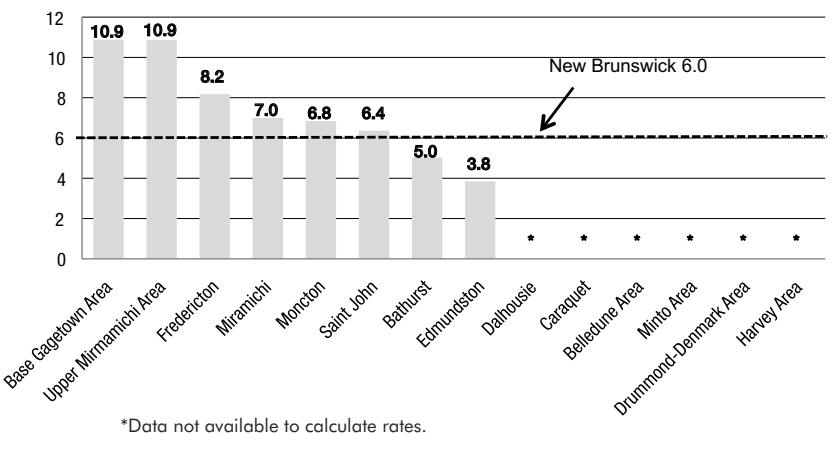


FIGURE 30 **Female Brain Cancer Rates (1989-2005)**
unadjusted incidence rates per 100,000 population



Males in Fredericton, the Upper Miramichi area and Bathurst had brain cancer rates 25% above the provincial rate (Figure 29). Men in Moncton, Edmundston and Saint John had rates slightly above the provincial rate for males. Females in the Base Gagetown and Upper Miramichi areas had brain cancer rates 82% above the provincial rate (Figure 30). Rates among women in Fredericton, Miramichi, Moncton and Saint John were also slightly above the provincial rate.

Brain tumours are classified by cell type and location. Cancers of the glial cells (gliomas) are the most common primary brain tumour. Glial cells are non-neural cells that surround nerve cells and physically hold them in place. They perform housekeeping functions for neurons such as clearing out debris and excess materials, providing nutrition and responding to injuries. They prevent nerve impulses from traveling between adjacent neurons. It is estimated that there are 10 to 50 times more glial cells than there are neurons in the brain. There are numerous types of gliomas and a glioblastoma is the

most frequently occurring brain cancer type. Secondary brain tumours are tumours that were initiated elsewhere in the body and then spread (metastasized) to the brain. For example, secondary brain tumours could begin as breast or lung cancers.

Brain cancers are the second most common cancer among children (0-14 years of age) in Canada; the highest rate occurs in the 0-4 age category.[244] Worldwide, overall incidence of brain cancers rose 1-2% during the 1980's and 1990s.[245] There is no consensus among scientists as to why these rates have increased, but many researchers believe that improvements in diagnostic procedures do not fully explain the increases.

Brain cancer risk factors

Established risk factors for brain cancer are rare hereditary syndromes, immune suppression and therapeutic radiation. These factors account for a very small percentage of brain cancers. Children, particularly those younger than 5 years of age, treated with radiation for other cancers are at high risk of developing brain tumours.[246]

Increasing public concern about potential health risks from extremely low frequency electromagnetic fields (ELFs) and radiofrequency/microwave radiation emissions (RF) from wireless communications has stimulated considerable scientific study and policy debate. ELFs and RFs have been linked to a wide range of cancers (e.g. leukemia and brain, breast and lung cancers) and other non-cancer effects (e.g. neuro-degenerative diseases, immune system deregulation, allergic and inflammatory responses, miscarriages and some cardiovascular effects.[247] Evidence of a link between ELFs and leukemia is strong and consistent. Some studies have linked long-term exposure (10 years +) to RFs, particularly cellular phone use, and to brain tumours while others have not.[248]

Smoking has not been linked to increased risk of brain cancers.[249] The IARC does not list the nervous system as a target organ for smoking-induced cancers. Some studies have linked maternal diets high in cured meats during pregnancy to increased risk of brain cancers in children.[250] These foods contain high levels of nitrites and can contain N-nitroso compounds which have been identified as potent neurocarcinogens.

Many environmental and occupational risk factors have been linked to increased rates of brain cancer. Various studies have linked employment as firefighters, electronics equipment manufacturers/operators, metal processors, construction trades workers and transport equipment operators to increased risks of brain cancer.[251] The four most common neurocarcinogens are acrylamide, 1,3 butadiene, N-nitroso compounds and polycyclic aromatic hydrocarbons (PAHs).[252] Chemicals commonly cited in occupational exposures include metals (particularly lead), asbestos, benzene and other petroleum products, mineral or lubricating oils, pesticides, solvents and hair dyes.[253] Children's exposure to these chemicals have also been identified as potential risk factors for brain cancer.[254]

A federally-sponsored study on the effects of herbicide use in the Base Gagetown area found that brain cancer incidence rates for females were significantly higher than the provincial rates for females during the years 1989-1993 but not for the years 1994-1998. The federal study found that brain cancer incidence for males were not significantly elevated compared with rates for the province.

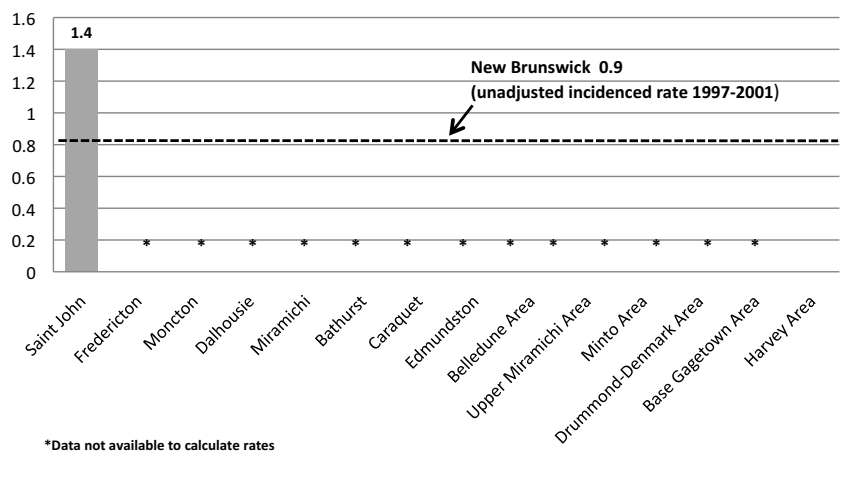
The results of the present study found that brain cancer incidence rates among women in the Base Gagetown and Upper Miramichi areas were 82% higher than the provincial rate and the highest among the 14 study areas. Unlike the federally-

sponsored study, the Base Gagetown study area in this study encompassed a much smaller geographic area and did not include the city of Fredericton which was a separate study area. In this study, brain cancer rates (1989-2005) among Base Gagetown females were 33% higher than rates among women in Fredericton (Figure 29, page 50). Brain cancer rates among males in Fredericton, Upper Miramichi area and Bathurst were the highest among the 14 study areas and 25% above the provincial rate. An appropriate epidemiological study is needed to determine why women in the Base Gagetown and the Upper Miramichi areas have brain cancer incidence rates significantly above the provincial rate.

Bone (and joint) Cancers

Data were not available to calculate the provincial incidence rates of bone (and joint) cancers between 1989 and 2005. Average unadjusted bone cancer incidence rates per 100,000 population for New Brunswick males and females (1997-2001) were 0.9 and 2.8 respectively.[255]

FIGURE 31 Male Bone Cancer Rates (1989-2005)
unadjusted incidence rates per 100,000 population



It was not possible to calculate bone cancer incidence rates among females in any of the 14 urban and rural areas in this study due to low cancer counts. Among males, bone cancer rates could only be calculated for Saint John (Figure 31). The rate among Saint John males was 50% above the provincial unadjusted incidence rate (1997-2001).

Primary bone cancers are rare, and when they do occur it is mostly in children and adolescents. Bone cancer involving older adults is most commonly the result of metastatic spread from another tumour. Bone cancer counts among males in Saint John were highest among the 15-20 age group followed by the 50+ age group.

There are many different types of bone cancer. Osteosarcoma is the most common primary malignant bone cancer.[256] It most commonly affects males between the ages of 10 and 25 but can affect older adults less commonly. This type of cancer is often very aggressive with risk of spread to the lungs. Ewing's sarcoma is the most aggressive bone tumour and generally affects younger people between 4-15 years of age.[257] It is more common in males and is very rare in people over 30 years old.

Chondrosarcoma is the second most common bone tumour and accounts for about 25% of all malignant bone tumours.[258] These tumours arise from the cartilage cells and can either be very aggressive or relatively slow-growing. Unlike many other bone tumours, chondrosarcoma is most common in people over 40 years of age. It is slightly more common in males and can potentially spread to the lungs and lymph nodes. Chondrosracoma most commonly affects the bones of the pelvis and hips.

Bone (and joint) Cancer Risk Factors

Exposure to high doses of ionizing radiation and radioactive material that build up in bones (e.g. radium, strontium and plutonium) increase the risk of developing bone cancer.[259] Evidence of low-dose environmental exposure to radiation or radioactive material and increased risk of bone cancer is variable and inconsistent. However, diagnostic radiation and radiation therapy used to treat primary cancers does increase the risk of developing second cancers including bone cancer. Cancer radiation therapy can also result in a wide range of other non-cancer bone diseases such as osteoporosis (low bone mineral density) and osteomalacia (softening of the bones).[260]

The occurrence of certain primary cancers increases the risk of developing secondary cancers or even tertiary cancers because tumour cells from the primary site can migrate to other organs.[261] The common "homing site" for cells from various primary tumours is bone.[262] The skeleton is the most common metastatic sites for breast cancer.[263] Metastasis to the bone has also been associated with prostate, lung, colorectal and pancreatic cancers.

Rates of lung, breast, prostate and various other cancers in Saint John are higher than provincial rates and higher than rates in many of the other study areas. Given these results, the high rate of bone cancer among males in Saint John could result from metastases from primary sites, particularly for those in the 50+ age category. Diagnostic radiation and radiation therapy used to treat primary cancer at an earlier age could account for the incidence of bone cancers among younger males (15-20 age category). Children and adolescents are more susceptible than adults to radiation-induced secondary cancers, particularly leukemia and brain, breast, bone and thyroid cancers.[264] As yet unidentified environmental factors could also account for the higher bone cancer rates among males.

Overall Cancer Incidence

Due to insufficient data, cancer incidence rates could not be calculated for some cancer types and some of the communities studied. Therefore, overall cancer rankings were limited to those cancer types where data were complete for all study areas. For males, overall ranking was based on four major cancer types (lung, colorectal, prostate and bladder) and, for females, it was based on three cancer types (lung, colorectal and breast). Tables 6 and 7 summarize the rankings among the 14 communities studied based on cancer types and overall cancer incidence. The tables also identity those study areas where cancer incidence rates were 25%, 50%, 75% and 100% above the provincial rates for 1989-2005.

For males, Dalhousie ranked highest among all the communities studied, based on four major cancer types (Table 6). The Minto and Harvey areas were second and third respectively, and Saint John ranked fourth. The Upper Miramichi area, Belledune and Edmundston were fifth, sixth and seventh respectively. Among males in Dalhousie, incidence rates of lung, colorectal, prostate and bladder cancer and non-Hodgkin's lymphoma were 51%, 93%, 61%, 50% and 118% respectively above provincial rates. Males in the Minto area had lung, colorectal and bladder cancer rates ranging from 50 to 99% above the provincial rates for these cancers.

Where data were available, males in Caraquet and the Drummond-Denmark and Base Gagetown areas generally had the lowest cancer incidence rates among the 14 study areas, with one exception. Males in Caraquet had the highest rate of pancreatic cancer, more than 100% above the provincial rate.

Overall, females in Minto ranked highest among the 14 communities studied based on three major cancer types (Table 7). Dalhousie and Bathurst both ranked second highest, and Saint John and the Upper Miramichi area were third. The Harvey area and Miramichi ranked fourth and fifth respectively. Incidence rate for lung and colorectal cancers among females in the Minto area were 75% above the provincial rates for these cancers, and rates of bladder cancer and non-Hodgkin's lymphoma were 65% and 36% higher than the provincial rates. Females in Dalhousie had rates of lung, bladder, kidney, non-Hodgkin's lymphoma, pancreatic and ovarian cancer that were 50-99% higher than the provincial rates. Females in Bathurst had rates of kidney and pancreatic cancer that ranged between 70% and 95% above the provincial rates.

As with males, females in Caraquet and the Drummond-Denmark and Base Gagetown areas generally had the lowest cancer rates among the 14 communities studied, with one exception. Women in the Base Gagetown area had the highest incidence rate of brain cancer, along with women in the Upper Miramichi area.

Table 6. Male cancer rankings among 14 urban and rural areas in New Brunswick (1989-2005)

Urban/Rural Area	Individual Cancers											
	Lung	Colorectal	Prostate	Non-Hodgkin's Lymphoma	Bladder	Kidney	Pancreas	Brain	Thyroid[1]	Hodgkin's Disease[1]	Leukemia[1]	Overall Rank[2]
Base Gagetown Area	11	13	12	13	7	12	7	*	*	*	*	11
Bathurst	6	6	5	4	6	6	6	3	*	*	*	5
Belledune Area	4	10	1	*	11	1	*	*	*	*	*	7
Caraquet	14	12	13	9	13	8	1	*	*	*	*	12
Dalhousie	2	1	2	1	1	2	3	*	*	*	*	1
Drummond-Denmark Area	12	14	14	11	14	11	8	*	*	*	*	13
Edmundston	5	4	10	7	12	10	9	5	1	*	1	8
Fredericton	13	9	8	8	8	9	10	1	4	3	4	9
Harvey Area	8	3	3	2	3	*	*	*	*	*	*	3
Miramichi	9	8	11	10	10	5	11	7	2	1	*	9
Minto Area	1	2	4	3	2	*	2	*	*	*	*	2
Moncton	10	11	9	6	9	7	4	4	5	2	3	10
Saint John	3	5	6	5	5	4	5	6	3	4	2	4
Upper Miramichi Area	7	7	7	12	4	3	*	2	*	*	*	6

Table 7. Female cancer rankings among 14 urban and rural areas in New Brunswick (1989-2005)

Urban/Rural Area	Individual Cancers												
	Lung	Colorectal	Breast	Non-Hodgkin's Lymphoma	Bladder	Kidney	Pancreas	Brain	Ovary	Thyroid[1]	Hodgkin's Disease[1]	Leukemia[1]	Overall Rank[3]
Base Gagetown Area	12	14	13	*	8	*	9	1	*	4	*	*	9
Bathurst	5	3	5	7	9	2	1	6	8	2	*	*	2
Belledune Area	8	4	11	*	*	*	*	*	*	*	*	*	6
Caraquet	13	12	12	4	*	*	3	*	*	*	*	*	8
Dalhousie	2	7	4	2	1	1	2	*	1	*	*	*	2
Drummond-Denmark Area	14	13	14	10	5	5	8	*	*	*	*	*	10
Edmundston	7	11	9	11	7	8	10	7	7	1	1	*	7
Fredericton	10	8	1	9	10	7	11	2	4	6	*	2	7
Harvey Area	9	5	3	*	*	*	*	*	*	*	*	*	4
Miramichi	4	10	7	5	6	3	4	3	3	3	*	*	5
Minto Area	1	1	10	3	2	*	*	*	*	*	*	*	1
Moncton	6	9	8	6	4	6	7	4	6	7	2	1	6
Saint John	3	6	6	8	3	4	5	5	5	5	3	3	3
Upper Miramichi Area	11	2	2	1	*	*	6	1	2	*	*	*	3

25-49% above provincial rate

50-74% above provincial rate

75-99% above provincial rate

100 +% above provincial rate

[1] Insufficient data to calculate provincial rates for the same time period.

[2] Ranking based on lung, colorectal, prostate and bladder cancer rates only.

[3] Ranking based on lung, colorectal and breast cancer rates only.

* Insufficient data to calculate incidence rates

Overall Risk Factors

A very small percentage of cancers (2-10%) are linked to genetic mutations or syndromes. The consensus among the majority of health researchers is that most cancers are preventable. Since genetic factors play a small role in most cancers, shared family lifestyle factors (e.g. diet, smoking, alcohol consumption, physical inactivity, reproductive history), as well as occupational and environmental exposures are important for understanding why cancers occur.

The traditional definition of 'environment' among healthcare professionals and policy makers covers a wide range of factors including lifestyle factors (smoking, alcohol consumption, physical inactivity, excess weight and obesity), pollution, viruses, bacteria, sunlight, medications (e.g. estrogen replacement therapy) and medical procedures (e.g. chemotherapy, radiation). This list of factors is a mix of initiating (or causal) factors and risk factors, a distinction that is important to cancer experts.[265]

Cancer initiating factors or agents are those physical (e.g. ionizing radiation and particles like asbestos and silica), chemical (e.g. arsenic, benzene, chlorinated compounds) and biological (e.g. viruses) factors that can cause mutations. Risk factors, on the other hand, are activities such as smoking and alcohol consumption, air pollution or occupation that enhance or increase exposure to cancer-causing agents. The proportion of cancer deaths that have been attributed to so-called "classic" lifestyle factors (such as smoking, alcohol consumption, diet, and excess weight/obesity) range from 25% to 45%, with smoking being the most significant lifestyle factor.[266]

Data on key lifestyle risk factors at the community level were not available for this study. This type of data is available only at the provincial or health region level. Published data on cancer incidence in various occupational settings were also unavailable. Industrial pollutant releases and air quality data were available, but only for some communities. This absence/scarcity of data made it impossible to undertake any statistical analysis to examine the potential links between cancer incidence rates and these risk factors. Table 8 summarizes key lifestyle, environmental and occupational risk factors linked to each type of cancer examined in this study based on peer-reviewed scientific publications.

Table 9 summarizes potential environmental and occupational exposures to selected carcinogens in the 14 communities studied. Information on environmental contaminants in communities was limited. The information that is available is based on studies and monitoring reports prepared by federal and provincial agencies and/or industry, and on industrial pollutant release data available from Environment Canada. Information on occupational exposure is based on studies done elsewhere which deal with industrial operations similar to those located in the 14 New Brunswick communities that are examined in this report. (see Table 1, page 11)

When we compared the risk factor information in Tables 8 and 9 with the ranking of individual and overall cancer rates among communities (Tables 6 and 7), we noted the communities that have higher overall rates of cancer, such as Dalhousie, Minto,

Table 8. Summary of key lifestyle, environmental and occupational risk factors linked to 14 cancer types[1]

Cancer Type	Risk Factor Type		
	Lifestyle	Environmental	Occupational
Lung	- smoking	- PAHs, silica, asbestos, wood dust, benzene, arsenic, cadmium, chromium, beryllium and nickel in outdoor air pollution - residential radon exposure - arsenic in drinking water	- smelter workers - uranium, coal and base-metal miners - petroleum refinery and petrochemical workers - wood products manufacturers - transportation workers
Colorectal	*	- pesticides	- agricultural workers, landscapers and pesticide applicators - textile workers - metal machinists - firefighters
Breast	- hormone use / treatments	- pesticides, plasticizers, metals, solvents, PAHs, dioxins found in food, air and/or drinking water - exposure to ionizing (e.g. gamma and x-rays, CT scans) and non-ionizing (e.g. microwaves, low-frequency electromagnetic fields) radiation	- pesticide applicators - radiologists and radiologic technicians
Ovarian	- hormone use /treatments	- pesticides, plasticizers, metals, solvents, PAHs and dioxins found in food, air and/or drinking water	- agricultural workers - pesticide applicators
Thyroid	*	- ionizing radiation associated with x-rays, CT scans, sunlight, high-voltage equipment, cancer treatments and gamma rays associated with nuclear reactions	- radiologists and radiologic technicians
Prostate	*	- arsenic in drinking water - cadmium in air and/or drinking water	- agricultural workers, landscapers and pesticide applicators - base-metal miners and smelter workers
Bladder	- smoking	- arsenic in drinking water - trihalomethanes in drinking water - PAHs in air pollution	- coal and base-metal miners - base-metal smelter workers - metal machinists - transportation workers
Kidney	- smoking	- arsenic, lead and cadmium in food, air and/or water	- base-metal mining and smelter workers
Pancreatic	- smoking	- emissions from industries associated with nickel smelting, plating and battery production	- computer manufacturing - food industry workers - electrical workers - nickel smelting, plating and battery production
Non-Hodgkin's Lymphoma	*	- residential pesticide use	- agricultural workers, landscapers and pesticide applicators
Hodgkin's Disease	*	- emissions and leakage from industries associated with solvent use such as dry cleaners; paint, adhesive and varnish manufacturing - residential pesticide use	- pulp and paper mill workers - woodworkers - agricultural workers, landscapers and pesticide applicators
Leukemia	*	- ionizing and non-ionizing radiation - chemotherapy - pesticides - benzene and butadiene in air and/or water	- petroleum industry workers - agricultural workers, landscapers and pesticide applicators - firefighters - laboratory and hospital workers
Brain	*	- ionizing and non-ionizing radiation - benzene and toluene in air - pesticides	- firefighters - oil refinery and petrochemical workers - agricultural workers, landscapers and pesticide applicators
Bone	*	- high doses of ionizing radiation - diagnostic radiation and radiation therapy	*

[1] References to specific studies linking risk factors to cancer types can be found at the end of this report.

* No consistent or conclusive risk factors have been identified.

Saint John and Belledune, seem to have more industrial activity and/or potential for environmental contamination than communities that have lower rates of cancer such as Caraquet and the Base Gagetown and Drummond-Denmark areas. Studies done in locations outside New Brunswick have identified (geographic) associations between residential (or work site) proximity to known or likely sources of industrial pollution and higher rates of cancer (and other diseases).[267]

Some of the 14 New Brunswick communities studied appear to share high rates of specific cancers and one or more of the occupational and environmental risk factors known to be associated with those cancers. For example, lung cancer rates among males and females in the Minto area, Dalhousie and Saint John were found to be the highest among the 14 communities studied. These communities are also known to have been subjected to substantial, long term releases of industrial pollutants, including fine particulates and carcinogens (see Figures 4 and 5, page 23). Many workers in these communities are

Table 9. Potential environmental and occupational exposure to selected known and probable carcinogens in 14 urban and rural areas in New Brunswick (1989-2005)[1]

Community/Area	Known and Probable Carcinogens[2]									
	Arsenic	Benzene and/ or other volatile organic compounds (VOCs)	Cadmium	Formaldehyde	Lead	Nickel	Pesticides	Polycylic aromatic hydrocargons (PAHs)	Radon	Wood Dust
Base Gagetown Area							■			■
Bathurst	■	■	■	■	■					■
Belledune Area	■		■		■			■		■
Caraquet										
Dalhousie	■	■	■		■	■	■	■		■
Drummond-Denmark Area							■			■
Edmundston		■								■
Fredericton										■
Harvey Area	■								■	■
Miramichi		■		■						■
Minto Area	■	■						■		■
Moncton										
Saint John	■	■			■	■		■		■
Upper Miramichi Area		■					■			■

[1] See notes 5,6, 8,10, 13, 17, 22, 24, 32, 36, 41, 43 and 45 for study references. Data on industrial releases of pollutants by community can be found on Environment Canada's National Pollutant Release Inventory website at http://www.ec.gc.ca/inrp-npri

[2] A list of known and probable carcinogens can be found on the International Agency for Research on Cancer website http://www.iarc.fr

employed in occupations known to be significant risk factors for lung cancer (e.g. coal mining, petroleum refining, pulp and paper production, see Table 8). Similarly, males and females in the Minto area and Dalhousie all shared high rates of bladder cancer as well as probable environmental exposure to arsenic, which is known to be a key risk factor for bladder cancer.

Certain cancers (some rare) are strongly associated with specific contaminants (such as exposure to asbestos and mesothelioma of the thoracic cavity and occupational exposure to wood dust and sino-nasal cancers).[268] These cancers were not examined in this study. There are also several cancer types (laryngeal, multiple myeloma and testicular cancer) for which the evidence is sufficient to establish (or be suggestive of) a positive link to some classes of pesticides (e.g. chlorophenoxy and hexachlorobenzene herbicides).[269] Incidence rates of these cancers also were not examined in this study.

All the potential risk-cancer relationships that are suggested by the findings of this study require additional epidemiological studies in order to establish or confirm these relationships.

Conclusions

This study provides never-before-reported cancer rates for 14 urban and rural areas in the Canadian province of New Brunswick. The results of this study confirmed the findings of the Conservation Council of New Brunswick's first cancer report (published June 2009). Cancer statistics, when aggregated for large geographic areas, tend to obscure important **community-level** health information and fail to identify or call attention to specific communities which are clearly experiencing unusually high rates of certain types of cancer.

Major findings of this study include:

- For males, Dalhousie ranked highest among the 14 communities studied based on four major cancer types (lung, prostate, colorectal and bladder). The Minto and Harvey areas ranked second and third, and Saint John ranked fourth;
- For females, Minto ranked highest among the 14 communities studied based on three major cancer types (lung, breast, and colorectal). Dalhousie and Bathurst ranked second, and Saint John and the Upper Miramichi area ranked third;
- In general, males and females in Caraquet and the Drummond-Denmark and Base Gagetown areas had the lowest cancer incidence rates among the 14 communities studied with two exceptions: males in Caraquet had the highest rate of pancreatic cancer and women in the Base Gagetown area had the highest rate of brain cancer, along with women in the Upper Miramichi area;
- Several of the 14 communities studied had cancer rates that were double the provincial rates for these cancers (e.g. pancreatic cancer among males in Caraquet, non-Hodgkin's lymphoma among males in Dalhousie. The rate of ovarian cancer in Dalhousie was triple the reported provincial rate for this cancer.

This study also confirmed the findings of a New Brunswick government-sponsored community health assessment done in the Belledune area. That 2005 assessment found that prostate and kidney cancer rates (1989-2001) among men in the Belledune area were higher than rates reported for its health regions (Regions 5 and 6) and for the province.

In the present study, prostate and kidney cancer rates for males in the Belledune area were found to be considerably higher than provincial rates for these cancers (1989-2005), and incidence rates for these cancers among males in the Belledune area were found to be the highest among the 14 communities studied.

In general, this study found that communities with higher rates of cancer, such as Dalhousie, the Minto area, Saint John and the Belledune area, had more industrial activity and/or potential for exposure to environmental contamination associated with their communities than those with lower rates of cancer such as Caraquet and the Base Gagetown and Drummond-Denmark areas.

Some of the communities that were studied shared high rates of specific cancers and certain occupational and environmental risk factors linked to those cancer types.

This study had several important limitations. Data for all cancer types were not available for all of the communities studied. Data on lifestyle risk factors and the occurrence of cancers associated with various occupations in New Brunswick also were not available. Certain cancers (some rare) where the evidence that specific contaminants are linked to specific cancer types is strong or sufficient to make a positive association (e.g. asbestos and mesothelioma of the thoracic cavity, occupational exposure to wood dust and sino-nasal cancer, and specific classes of pesticides such as chlorophenoxy and hexachlorobenzene herbicides with laryngeal, multiple myeloma and testicular cancer) were not examined in this study. Despite these limitations, the findings of this study strongly suggest high cancer rates are possibly linked to environmental and occupational risk factors.

The results of this study raise questions and underscore the need for more detailed, community-focused epidemiological studies of cancer and other chronic disease rates. For example:

- Why are breast cancer rates in half of the communities studied (Fredericton, Upper Miramichi and Harvey areas, Dalhousie, Bathurst, Saint John and the Minto area) at least 25% higher than the provincial rate?
- Why are ovarian cancer rates in Dalhousie more than 200% higher than the provincial rate?
- Why do men and women in Edmundston have high rates of thyroid cancer?
- Why do men in Belledune have high rates of prostate and kidney cancers?
- Why do women in the Base Gagetown and Upper Miramichi areas have high rates of brain cancer?
- Why do women in the Upper Miramichi area have high rates of non-Hodgkin's lymphoma and brain, breast, colorectal and ovarian cancers and why do men in that area have high rates of kidney, pancreatic and brain cancers?
- Why do women in Dalhousie have high rates of kidney, ovarian, bladder and pancreatic cancers and men have high rates of bladder, non-Hodgkin's lymphoma and colorectal cancer?
- Why do men and women in the Minto area have high rates of lung, colorectal and bladder cancers?

Communities are where people live and work, where occupational and environmental exposures occur, and where industrial emissions are often concentrated. Cancer rates reported at the health region or provincial level fail to identify communities at-risk and delay research that could lead to the development and implementation of appropriate risk reduction and cancer prevention programs for those communities.

Recommendations

More community-focused health data, like that assembled in this report, could help identify communities at-risk and enable early intervention that could prevent cancer, reduce health care costs, and save lives. The Conservation Council of New Brunswick is therefore recommending that the Minister of Health:

- Direct the New Brunswick Cancer Network to begin public reporting of cancer rates at the community level;
- Work with the Minister of Environment to improve air and water quality standards and require industries to eliminate releases of carcinogens from their operations;
- Direct the New Brunswick Cancer Network to expand cancer prevention outreach and educational programs to include occupational and environmental risk factors such as exposure to pesticides, household and industrial chemicals, and air and water pollution; and
- Enlist the assistance of government and non-government agencies and academic institutions to effectively address the questions raised in this report.

The Minister of Health will need to assign a high priority to an integrated program of epidemiological studies and public policy changes in order to address the findings and questions raised by this study. New financial commitments should not be necessary. Rather, the Minister should reorder some of the department's priorities and reallocate certain of its human and financial resources.

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Appendix A.

Appendix A. Social and economic profiles for 14 urban and rural areas in New Brunswick for 1991, 1996, 2001, and 2006.

	Saint John				Moncton				Fredericton			
	1991	1996	2001	2006	1991	1996	2001	2006	1991	1996	2001	2006
Land area in square km	322.88	322.88	316.31	315.49	142.37	142.37	141.15	141.17	129.58	129.58	131.23	130.68
Total population	74969	72494	69661	68043	57010	59313	61046	64128	46466	46507	47560	50535
New immigrants - % of total population	0.4	0.1	0.5	1	0.2	0.36	0.5	0.9	0.9	1.3	1.4	2.1
% lived at same address in last 5 years	53.6	56.9	57.2	59.1	52.3	51.9	54.4	51.6	52.4	53	54.8	51.9
% with university degree	7.5	9.7	12.1	11	11.8	14.2	16.7	15.1	21.8	24.7	29.6	23.2
% in low income family (after tax)	18.8	23.7	20.6	16.3	16.1	17.8	13.7	12.7	13.3	16.2	11.6	12.1
Average family income (pre-tax $): all households	37573	43243	51703	51618	41946	49746	57474	55945	44775	54864	65012	61408
Unemployment rate - %	12.1	14.4	10.3	8.6	11.6	10.1	8.2	6.5	10.1	9.6	7.9	6.6

Male Occupation: % of the total experienced labour force 15 years and over

	Saint John				Moncton				Fredericton			
	1991	1996	2001	2006	1991	1996	2001	2006	1991	1996	2001	2006
management/administration/clerical	18.5	17	21.8	21.6	24.8	24.8	27.7	27.4	23.1	22.7	25.2	25.4
sales/service	22.3	25.4	25	26.4	24.4	25.3	23.3	25.3	22.4	23.4	21.7	23.4
trades/transport/machining	27.4	27.7	27.4	24.9	20.7	22	20.4	20.9	18.5	17.1	16.5	16.5
manufacturing/processing/utilities	14.4	7.7	5.3	4.4	9.3	4.9	6.3	3.5	6.6	3.1	1.9	1.7
agriculture	1.4	0.5	0.5	0.4	0.9	0.6	0.1	0.3	1.4	1	1	0.7
forestry/mining/oil and gas/fishing	0.6	0.8	0.5	0.5	0.6	0.2	0.2	0.4	1.2	0.7	0.7	0.4

Female Occupation: % of the total experienced labour force 15 years and over

	Saint John				Moncton				Fredericton			
	1991	1996	2001	2006	1991	1996	2001	2006	1991	1996	2001	2006
medicine/health	10.9	9.6	9.7	10.6	11.4	11.7	10.5	12.8	8.3	7.4	8.1	9.1
management/administration/clerical	43.1	33.6	34.3	37	42.6	37.1	37.3	37	44.9	36.6	38.2	34.6
sales/service	30.7	37.3	38.5	33.6	28.7	32.2	32.9	30.7	26.7	32.4	28.5	30.7
social science/teaching/government	8.3	6.9	7.3	9.9	10.4	8.9	8.9	10	11.6	12	13.2	14.1
agriculture	0.1	0.3	0.2	0.1	0.2	0.2	0	0.2	0.2	0.2	0.4	0.2
forestry/mining/oil and gas/fishing	0	0	0.1	0	0.1	0	0	0.1	0.4	0	0.1	0

Data Source: Statistics Canada Community Profiles for 1991, 1996, 2001 and 2006.

Appendix A. Social and economic profiles for 14 urban and rural areas in New Brunswick for 1991, 1996, 2001, and 2006.

	Dalhousie				Miramichi				Bathurst			
	1991	1996	2001	2006	1991	1996	2001	2006	1991	1996	2001	2006
Land area in square km	13.25	13.25	14.9	14.51	85.08	175.07	179.83	179.84	90.94	90.94	91.55	91.55
Total population	4775	4500	3975	3676	15960	19241	18508	18129	14409	13815	12924	12714
New immigrants - % of total population	0	0	0	0.3	0.2	0.5	0.1	0.4	0.1	0.1	0.1	0.3
% lived at same address in last 5 years	72.2	73.2	83.2	77.8	57.7	70.8	69.3	72.7	63.6	64.3	63.5	65
% with university degree	6.5	8.3	7.2	6.4	9.4	9.7	13.1	11.2	9.6	11.5	12.5	11.5
% in low income family (after tax)	18.7	17.7	13.8	12.4	11.8	15.9	16	10.3	20.4	19.2	17.5	15.1
Average family income (pre-tax $): all households	36191	45735	52642	48850	41328	48729	52038	53413	37278	45213	52644	51634
Unemployment rate - %	14.9	18.8	16	11.7	16	16.9	14.2	12.5	17.5	14.5	11.9	8.6

Male Occupation: % of the total experienced labour force 15 years and over

	Dalhousie				Miramichi				Bathurst			
	1991	1996	2001	2006	1991	1996	2001	2006	1991	1996	2001	2006
management/administration/clerical	12.4	15.7	8.1	14.6	13.2	18.4	16.8	16.6	18.5	24.7	21	19.6
sales/service	12.4	16.2	20	21	30	20.1	21.4	23.7	20.1	24	23.4	28.3
trades/transport/machining	22.8	32.4	38.1	27.4	23.6	27.9	28	26.1	20.5	19.7	23.5	22.9
manufacturing/processing/utilities	30.3	14.8	10.6	10.2	14	13	13.2	9.7	13.8	4.3	4.8	2.7
agriculture	0.8	0.9	1.9	0	1.1	0.2	0.2	0.5	1.2	1.2	0	0.5
forestry/mining/oil and gas/fishing	2.1	0.9	2.5	1.3	2.4	1.7	2.3	2.4	5.9	3.6	3.5	3.3

Female Occupation: % of the total experienced labour force 15 years and over

	Dalhousie				Miramichi				Bathurst			
	1991	1996	2001	2006	1991	1996	2001	2006	1991	1996	2001	2006
medicine/health	14.5	15.5	15.7	16.8	14.1	12.7	9.6	14.4	10.5	10.5	11.2	11.1
management/administration/clerical	35.2	30.3	26.5	29.4	36.6	29	27.5	31.1	43.2	31.1	33.1	34.4
sales/service	28.5	36.1	36.7	32.9	31.8	37.6	41.2	36	25.8	36.1	40	34.8
social science/teaching/government	15.6	11	11.4	15.4	11.2	10.7	12.5	11	12.1	11.6	8	10.8
agriculture	0	0	0	0	0	0.5	0	0.2	0.6	0	0	0
forestry/mining/oil and gas/fishing	1.1	0	0	0	0	0	0.2	0	0	0	0	0

Data Source: Statistics Canada Community Profiles for 1991, 1996, 2001 and 2006.

Appendix A. Social and economic profiles for 14 urban and rural areas in New Brunswick for 1991, 1996, 2001, and 2006.

	Caraquet				Edmundston				Belledune Area			
	1991	1996	2001	2006	1991	1996	2001	2006	1991	1996	2001	2006
Land area in square km	67	67	68.26	68.26	102.84	102.84	106.9	106.92	51.98	207.11	202.82	202.82
Total population	4556	4653	4442	4156	17409	17716	17373	16643	2553	3182	2964	2682
New immigrants - % of total population	0	0.3	0	0.2	0.4	0.2	0.4	0.3	0.4	0	0	0
% lived at same address in last 5 years	65.3	65.4	68.2	71.7	64.5	64.9	67.7	69	80.6	83.4	79.8	81.4
% with university degree	10.7	12.3	17.5	14.8	10.3	12.9	13.6	10.9	5	3.5	3.4	5.4
% in low income family (after tax)	12.2	20.5	11.7	11.3	12.1	17.7	12.8	10.1	14.3	22.3	14.7	11.6
Average family income (pre-tax $): all households	41158	42112	52139	53473	36925	44259	54401	51146	30677	36629	44740	44599
Unemployment rate - %	15	19.5	15.6	9.2	13	12.6	9	8	20.5	23.2	19	13.9

Male Occupation: % of the total experienced labour force 15 years and over

	Caraquet				Edmundston				Belledune Area			
	1991	1996	2001	2006	1991	1996	2001	2006	1991	1996	2001	2006
management/administration/clerical	21.7	24.6	20.5	20.9	15.2	17.5	18.6	17.4	3.7	4.7	9.5	14.7
sales/service	15.7	18.1	19.3	25.8	16.6	21.7	18.3	19.6	11.2	12.1	18.9	15.5
trades/transport/machining	28.7	23.8	20.8	16.9	25.5	25.9	28.8	30.2	30.6	33.6	32.4	35.3
manufacturing/processing/utilities	14.6	6.5	6.6	6.2	14.7	10	12.7	11.4	20.1	20.1	18.2	15.5
agriculture	0.8	2.7	1.2	0	0.8	0.9	0.3	0.6	1.5	1.3	3.4	1.7
forestry/mining/oil and gas/fishing	4.7	6.5	9.7	10.7	2.4	1	0.1	1.3	17.2	13.4	8.8	8.6

Female Occupation: % of the total experienced labour force 15 years and over

	Caraquet				Edmundston				Belledune Area			
	1991	1996	2001	2006	1991	1996	2001	2006	1991	1996	2001	2006
medicine/health	11.3	10.4	9.4	8.6	14.5	11	12.3	15.9	2.3	6.1	12.3	15.2
management/administration/clerical	39.4	27.4	34.3	31.7	35.7	29.3	32.9	29.8	30.2	24.3	34	36.4
sales/service	25.3	32.1	30.9	31.7	29	34.4	33.8	33.3	40.7	40.9	34	31.3
social science/teaching/government	10	13.2	11.6	13.6	11.1	10.3	9.1	9	12.8	7	6.6	4
agriculture	1.4	0	0	0	0	0.2	0.2	0	0	0	1.9	0
forestry/mining/oil and gas/fishing	0.9	0	0	0.9	0	0	0	0	2.3	3.5	0	2

Data Source: Statistics Canada Community Profiles for 1991, 1996, 2001 and 2006.

Appendix A. Social and economic profiles for 14 urban and rural areas in New Brunswick for 1991, 1996, 2001, and 2006.

	Upper Miramichi Area				Minto Area				Drummond-Denmark Area			
	1991	1996	2001	2006	1991	1996	2001	2006	1991	1996	2001	2006
Land area in square km	3196.29	3196.29	3130.79	3130.79	204.82	204.82	204.98	204.93	1994.78	1994.78	1932.74	1932.75
Total population	6873	7064	6736	6294	4051	4006	3700	3631	6123	6307	6185	5980
New immigrants - % of total population	0	0	0	0	0	0	0	0	0.2	0	0.5	0
% lived at same address in last 5 years	84.3	82.5	79.8	84.7	71.7	72.5	79.5	67.9	80.5	79.7	75	71.9
% with university degree	3.6	3.9	6.1	3.7	4.4	3.8	6.2	4.6	4.9	5.2	6.4	5.2
% in low income family (after tax)	14.7	16.5	11.4	10.8	17.7	14.6	11.9	10.1	17	25.2	17.9	10.8
Average family income (pre-tax $): all households	33006	40398	46326	42772	30256	40374	48488	47722	33003	34246	42567	46189
Unemployment rate - %	37.3	39.1	32.4	23.7	19.7	23.9	22.5	19.5	18.1	19.9	16.8	12.4

Male Occupation: % of the total experienced labour force 15 years and over

	Upper Miramichi Area				Minto Area				Drummond-Denmark Area			
	1991	1996	2001	2006	1991	1996	2001	2006	1991	1996	2001	2006
management/administration/clerical	7.4	4.7	5.9	9.6	14.6	8.3	8.1	14.7	9.3	9.9	9.5	10
sales/service	10.2	12.5	9.6	7.9	7.5	8.3	8.1	13.6	7.7	11.4	9.5	9.1
trades/transport/machining	31.4	34.3	30.1	34.6	37.7	39.2	47	45.8	34.3	32.4	41.2	47.9
manufacturing/processing/utilities	9.1	11.9	15.8	12	13.7	14.7	17.8	10.2	14.3	10.2	9.5	11.8
agriculture	2.5	0.6	0.9	2.1	0.9	1.5	3.2	0	16.7	19.1	16.9	12.6
forestry/mining/oil and gas/fishing	26.4	19.7	19.9	13.4	12.3	7.8	6.5	6.8	5.3	2.8	2.4	1.5

Female Occupation: % of the total experienced labour force 15 years and over

	Upper Miramichi Area				Minto Area				Drummond-Denmark Area			
	1991	1996	2001	2006	1991	1996	2001	2006	1991	1996	2001	2006
medicine/health	4.4	5.4	2.8	8.1	4.2	8	5	8.8	11.2	9.3	7.8	8.9
management/administration/clerical	31.6	28.3	27.1	22.7	46.5	32	30.2	35.6	30.7	25.7	27.9	18.9
sales/service	38.7	36.8	42.2	43.8	27.5	22.7	39	36.3	23.3	30	32.6	41.3
social science/teaching/government	9.8	9.3	6.8	9.2	4.9	10	8.2	5	6	4.3	7.4	11.7
agriculture	0.9	2.7	0	0.8	6.3	0	1.3	0	11.2	6.2	7	4.6
forestry/mining/oil and gas/fishing	4.9	0	1.6	0	4.9	0	0	0	1.9	0.8	0	0

Data Source: Statistics Canada Community Profiles for 1991, 1996, 2001 and 2006.

Appendix A. Social and economic profiles for 14 urban and rural areas in New Brunswick for 1991, 1996, 2001, and 2006.

	Harvey Area				Base Gagetown Area			
	1991	1996	2001	2006	1991	1996	2001	2006
Land area in square km	586.69	586.69	527.87	527.93	1700.45	1700.45	1687.5	1687.3
Total population	2113	2213	2231	2215	6901	7695	8112	7919
New immigrants - % of total population	0	0	0	0	0.1	0.4	0	0.1
% lived at same address in last 5 years	76.7	74.1	79.4	79.2	69.3	65.3	68.4	68.9
% with university degree	7	9.9	8.7	4.8	3	4.7	5.6	5.2
% in low income family (after tax)	9.2	9	5.8	7.7	10.8	14.9	3.1	10.4
Average family income (pre-tax $): all households	34082	46007	45100	50121	35286	38654	51773	50272
Unemployment rate - %	14.9	15	15.1	8	13.7	14.5	10.3	6.8

Male Occupation: % of the total experienced labour force 15 years and over

	Harvey Area				Base Gagetown Area			
	1991	1996	2001	2006	1991	1996	2001	2006
management/administration/clerical	13.9	14.4	16.9	10.3	8.5	6.3	12.8	10
sales/service	10.4	7.2	5.9	6.5	26.4	32.8	30.8	36.5
trades/transport/machining	30.4	34.2	44.9	42.1	34.1	37.3	32.7	30.6
manufacturing/processing/utilities	20	7.2	5.9	7.5	13.6	3.5	4.5	4.5
agriculture	2.6	2.7	7.6	1.9	4.4	2.8	3.8	3.8
forestry/mining/oil and gas/fishing	7.8	17.1	7.6	11.2	3.1	4.8	4.3	2.8

Female Occupation: % of the total experienced labour force 15 years and over

	Harvey Area				Base Gagetown Area			
	1991	1996	2001	2006	1991	1996	2001	2006
medicine/health	11.1	3.9	5.6	10.4	6.7	7.9	9	10.1
management/administration/clerical	19.8	28.4	36.4	29.2	37.7	34.5	33	31.6
sales/service	32.1	38.2	34.6	25.5	30.6	38.5	42.2	38.1
social science/teaching/government	13.6	10.8	6.5	16	7.1	3.3	7.9	9.1
agriculture	0	3.9	2.8	1.9	2.6	3	1.9	0.5
forestry/mining/oil and gas/fishing	2.5	0	0	0	0.7	0	0	0.5

Data Source: Statistics Canada Community Profiles for 1991, 1996, 2001 and 2006.

Appendix B.

Appendix B. Cancer counts (N) and unadjusted incidence rates (IR) per 100,000 population for males in 14 urban and rural areas in New Brunswick (1989-2005).

MALES	Province		Saint John		Fredericton		Moncton		Dalhousie		Miramichi		Bathurst		Caraquet	
	N	IR	N	IR	N	IR	N	IR	N	IR	N	IR	N	IR	N	IR
Colorectal	3934	62.5	451	79.5	294	76.6	337	69.4	41	120.4	114	77.0	85	77.6	19	51.5
Lung (and bronchus)	6121	97.2	825	145.4	338	88.0	478	98.5	50	146.8	163	110.1	130	118.7	28	75.9
Prostate	8385	133.2	977	172.2	582	151.6	688	141.7	73	214.3	193	130.4	197	179.9	44	119.2
Non-Hodgkin's Lymphoma	1271	20.2	140	24.7	79	20.6	118	24.3	15	44.0	26	17.6	28	25.6	7	19.0
Bladder	2082	33.1	248	43.7	142	37.0	177	36.5	17	49.9	51	34.5	42	38.4	10	27.1
Kidney	1081	17.2	134	23.6	66	17.2	97	20.0	10	29.4	34	23.0	24	21.9	7	19.0
Pancreas	755	12	90	15.9	46	12.0	78	16.1	7	20.5	14	9.5	17	15.5	9	24.4
Brain (and central nervous system)	499	8	47	8.3	39	10.2	45	9.3	<6	N/A	12	8.1	11	10.0	<6	N/A
Bone (and joints)	N/A	N/A	8	24.0	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A
Leukemia	N/A	N/A	27	4.8	10	2.6	13	2.7	<6	N/A	<6	N/A	<6	N/A	<6	N/A
Hodgkin's Disease	N/A	N/A	18	3.2	13	3.4	18	3.7	<6	N/A	6	4.1	<6	N/A	<6	N/A
Thyroid	N/A	N/A	19	3.3	10	2.6	11	2.3	<6	N/A	6	4.1	<6	N/A	<6	N/A

	Edmundston		Belledune Area		Upper Miramichi Area		Minto Area		Drummond / Denmark Area		Base Gagetown Area		Harvey Area	
	N	IR	N	IR	N	IR	N	IR	N	IR	N	IR	N	IR
Colorectal	114	82.6	17	71.2	46	77.4	33	102.6	24	45.2	33	50.1	16	86.9
Lung (and bronchus)	193	139.9	34	142.3	69	116.1	59	183.4	47	88.6	64	97.1	21	114.1
Prostate	188	136.3	53	221.9	97	163.2	64	198.9	47	88.6	79	119.8	39	211.9
Non-Hodgkin's Lymphoma	29	21.0	<6	N/A	10	16.8	9	28.0	9	17.0	11	16.7	6	32.6
Bladder	46	33.3	8	33.5	29	48.8	16	49.7	11	20.7	25	37.9	9	48.9
Kidney	21	15.2	8	33.5	17	28.6	<6	N/A	6	11.3	7	10.6	<6	N/A
Pancreas	18	13.0	<6	N/A	<6	N/A	7	21.8	7	13.2	9	13.7	<6	N/A
Brain (and central nervous system)	12	8.7	<6	N/A	6	10.1	<6	N/A	<6	N/A	<6	N/A	<6	N/A
Bone (and joints)	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A
Leukemia	8	5.8	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A
Hodgkin's Disease	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A
Thyroid	8	5.8	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A

N/A - Data not available

Data Source: New Brunswick Cancer Registry Database

Appendix B. Cancer counts (N) and unadjusted incidence rates (IR) per 100,000 population for females in 14 urban and rural areas in New Brunswick (1989-2005).

FEMALES	Province		Saint John		Fredericton		Moncton		Dalhousie		Miramichi		Bathurst		Caraquet	
	N	IR	N	IR	N	IR	N	IR	N	IR	N	IR	N	IR	N	IR
Colorectal	3610	56.2	462	71.7	294	68.7	364	67.3	27	71.3	104	66.1	98	82.1	22	56.7
Lung (and bronchus)	3378	52.6	579	89.8	213	49.8	346	64.0	35	92.5	121	76.9	84	70.3	13	33.5
Breast	7419	115.5	942	146.2	685	160.0	710	131.2	56	148.0	221	140.5	175	146.6	42	108.2
Non-Hodgkin's Lymphoma	1128	17.6	134	20.8	85	19.9	123	22.7	10	26.4	36	22.9	26	21.8	9	23.2
Bladder	699	10.9	112	17.4	53	12.4	84	15.5	7	18.5	20	12.7	11	9.2	<6	N/A
Kidney	756	11.8	94	14.6	49	11.4	66	12.2	8	21.1	29	18.4	24	20.1	<6	N/A
Pancreas	746	11.6	96	14.9	43	10.0	78	14.4	8	21.1	27	17.2	27	22.6	7	18.0
Brain (and central nervous system)	383	6.0	41	6.4	35	8.2	37	6.8	<6	N/A	11	7.0	6	5.0	<6	N/A
Bone (and joints)	N/A	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A
Leukemia	N/A	N/A	13	2.0	9	2.1	12	2.2	<6	N/A	<6	N/A	<6	N/A	<6	N/A
Hodgkin's Disease	N/A	N/A	14	2.2	14	3.3	14	2.6	<6	N/A	<6	N/A	<6	N/A	<6	N/A
Ovarian	756	13.5	107	16.6	76	17.8	85	15.7	16	42.3	28	17.8	16	13.4	<6	N/A
Thyroid	N/A	N/A	57	8.8	36	8.4	45	8.3	<6	N/A	16	10.2	20	16.7	<6	N/A

	Edmundston		Belledune Area		Upper Miramichi Area		Minto Area		Drummond / Denmark Area		Base Gagetown Area		Harvey Area	
	N	IR	N	IR	N	IR	N	IR	N	IR	N	IR	N	IR
Colorectal	100	64.1	20	81.6	47	85.1	33	99.2	20	38.9	23	35.8	14	74.1
Lung (and bronchus)	97	62.2	14	57.1	25	45.3	32	96.2	14	27.2	23	35.8	10	52.9
Breast	199	127.6	27	110.1	86	155.7	42	126.3	35	68.0	69	107.3	29	153.5
Non-Hodgkin's Lymphoma	25	16.0	<6	N/A	18	32.6	8	24.0	9	17.5	<6	N/A	<6	N/A
Bladder	7	4.5	<6	N/A	<6	N/A	6	18.0	7	13.6	7	10.9	<6	N/A
Kidney	16	10.3	<6	N/A	<6	N/A	<6	N/A	7	13.6	<6	N/A	<6	N/A
Pancreas	18	11.5	<6	N/A	8	14.5	<6	N/A	7	13.6	8	12.4	<6	N/A
Brain (and central nervous system)	6	3.8	<6	N/A	6	10.9	<6	N/A	<6	N/A	7	10.9	<6	N/A
Bone (and joints)	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A
Leukemia	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A
Hodgkin's Disease	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A	<6	N/A
Ovarian	23	14.7	<6	N/A	10	18.1	<6	N/A	<6	N/A	<6	N/A	<6	N/A
Thyroid	35	22.4	<6	N/A	<6	N/A	<6	N/A	<6	N/A	6	9.3	<6	N/A

N/A - Data not available

Data Source: New Brunswick Cancer Registry Database