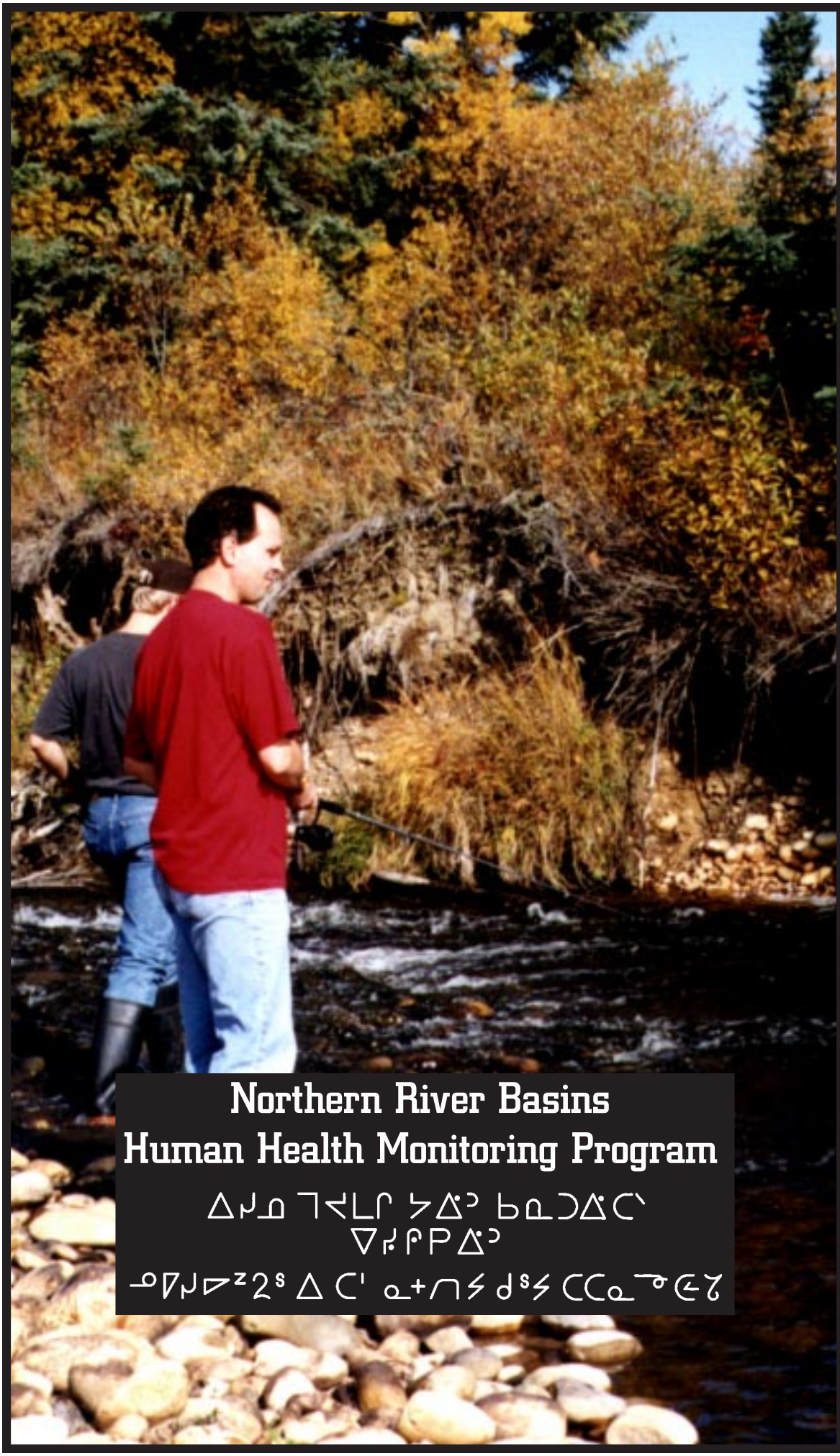

Northern River Basins Human Health Monitoring Program

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REPORT

March 1999

Northern River Basins
Human Health Monitoring Program

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Acknowledgements

This report is the result of the efforts of a number of individuals who collaborated to identify potential sources of information in available data sources, and to develop new approaches to analysis of that data. The process of analysis inevitably generated more questions than answers, but resulted also in new methods of comparing health care utilization across the province.

The study was led by Dr. Stephan Gabos, Health Surveillance and coordinated by Susan Shaw, Health Surveillance. The analysis was carried out by a team of analysts including Health Surveillance staff: Fu-Lin Wang, Thu Ha Nguyen, Yan Jin, Xinjie Cui, and Jonathan Robb; and consultants Erik Ellehoj (Ellehoj-Redmond Consulting) and Dennis Prince (WaterWest Consulting). Desktop publishing provided by Drager Communications Services.

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- Sally Ulfsten (Vice-Chair), Non-Governmental Organizations
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- Betty Collicut
- Lucille Partington

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- Mistahia Regional Health Authority

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Executive Summary

Objective

This report examines the differences in health outcomes across the province and compares the Northern River Basin Study area with the other areas of the province and examines possible relationships between health outcomes and environmental contaminants. The report includes a series of regional and local maps and graphs that identify the prevalence of certain diseases and disorders within the Peace and Athabasca river basins. The focus is on reproductive health, congenital anomalies, respiratory ailments, circulatory diseases, gastrointestinal disorders, endocrine and metabolic disorders, and neurocognitive disorders.

Methodology and Analysis

The data used for the analysis were limited to existing administrative health and environmental sources. The analysis followed an epidemiological approach: the first step was to determine if there was a difference in rates; the next step was to evaluate for a correlation between elevated rates and measures of environmental sources of contaminants

The conclusions that can be drawn from the analysis are severely limited, because this study was a first pase screening study, population sizes were ofen very small, and environmental data were often unsuitable, incomplete or non-existent. However, the analysis does identify areas where follow-up investigations are relevant and warranted. These studies should evaluate the impact of environmental factors, genetic endowment and socio-cultural factors on individual diagnoses.

Significant Findings

The diagnosis groups examined included reproductive health, infant mortality and congenital anomalies, respiratory ailments, circulatory diseases, gastrointestinal disorders, endocrine and metabolic disorders, and neurocognitive disorders. Of these, only six diagnoses were found to be higher in the NRBS area compared to other areas of the province:

- endometriosis
- selected congenital anomalies
- bronchitis
- pneumonia
- peptic ulcers
- epilepsy

Further analysis for these diagnoses — comparing variations in the rate of health care utilization with existing sources of environmental contaminants — did not yield any conclusive information.

- In general, the population of the NRBS area is younger, family sizes are larger, and residents have their children at a younger age than do people in other areas of Alberta.

- Overall, the people living in the Northern River Basins area have less education, but comparable income levels to other parts of the province. However, the income levels calculated for the large areas mask sub-regional variations.

- The Northern Lights Health Region had a very high level of income, skewing the distribution and raising the average for the whole NRBS area.

- Aboriginal people account for a much larger proportion of the population in the Northwestern and Keeweetinok Lakes Health Regions than other regions in the NRBS area.

  In addition, these two health regions have the highest fertility rates, particularly among young mothers, as well as the most crowded living conditions.

  They also stand out as having more socioeconomic disadvantages than other regions in the province, with lower education, income, and employment levels.

  These factors suggest that there are likely to be more poverty-related health problems in the population of these two regions; notably respiratory health problems and peptic ulcers related to dietary deficiencies, smoking and alcohol consumption.

  We can also expect to find more frequent health problems associated with childbirth complications due to the young age of the mother, for instance low birth weight and congenital anomalies.

  The analysis of health care utilization supports these expectations — babies born in the Keeweetinok Lakes Health Region are more likely to be underweight at birth, and people in both regions are more likely to be diagnosed with a peptic ulcer.

  Women in the Northwestern Health Region are more likely to be diagnosed with endometriosis, and residents of the Keeweetinok Lakes Health Region are more likely to be diagnosed with bronchitis or pneumonia, but less likely to be diagnosed with asthma or upper respiratory infection. (For all health regions in the NRBS area, where the rate of utilization for bronchitis and pneumonia was higher than the other regions, the rate of utilization for asthma or upper respiratory infection was lower.)

  Further, the potential years of life lost (PYLL) is higher for males living in the Keeweetinok Lakes Health Region than other regions in the NRBS area.

- The Peace Health Region has a somewhat elevated teen birth rate, and lower education compared to the other regions.

  Infant mortality was somewhat elevated above the rates for the other regions in the NRBS area, but the rate was much lower than other areas of the province.

  The rate of diagnosis of urological system anomalies is also somewhat higher than other areas of the NRBS and the rest of the province.

  Residents of the Peace Health Region are more likely to be diagnosed with endometriosis, bronchitis, pneumonia, and peptic ulcer than in some other health regions in the NRBS area and also compared to other parts of the province.

- Mistahia health region does not have elevated levels of poverty, teen birth rates, or other factors that might affect health outcomes, but the rate of health care utilization is somewhat higher in this region for some diagnoses.

For example, women living in the Mistahia health region are more likely to be diagnosed with endometriosis. Residents of Histahia are not more likely to be diagnosed with pneumonia or bronchitis.

Residents of MD19, a small portion in the north-western corner of the region, are slightly more likely to be diagnosed with a peptic ulcer.

Babies born in this region are also more likely to be diagnosed with urological system and cardiovascular system anomalies, although the rates are very small.

- Residents of the Northern Lights health region are more likely to be diagnosed with bronchitis, pneumonia, peptic ulcer, and epilepsy compared to some other health regions.

- Babies born in the Westview health region are more likely to be underweight at birth.

For the NRBS area in general, comparisons with existing information on potential environmental causes did not yield any strong conclusions.

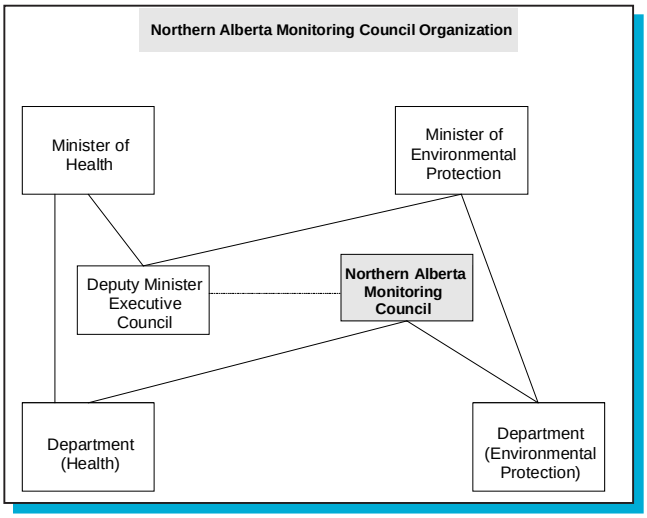
Disparity in community socioeconomic status, and birth complications such as low weight babies or teen birth rate, were the most significant predictors of variations in rates of health outcomes such as endometriosis, congenital anomalies and peptic ulcer.

Physician practices likely account for much of the difference in utilization rates for respiratory health: high rates of bronchitis and pneumonia are balanced by low rates of asthma and upper respiratory infection.

Recommendations

General Recommendations

1. The committee recommends that a Northern Alberta Monitoring Council (NAMC) be established using the following to ensure co-ordination of future ecological and health monitoring programs.



   - The Deputy Minister of Executive Council co-ordinates between ministers and ensures that a legislative mandate, a budget and the necessary authority are provided to the NAMC.

   - The federal government must participate in this process.

2. The committee recommends that the implementation of Northern River Basin Study (NRBS) recommendations relevant to human health be continued.

3. The committee strongly recommends that prioritization of future health studies be conducted using the following set of consistent principles.

- **Short-listing contaminants of concern:** A systematic prioritization of the contaminants of concern that are present in the Northern River Basins is required to ensure that monitoring effort is focussed on the contaminants that pose the greatest potential risk to human health. This prioritization should be based on monitored levels of these contaminants and on potential for human toxicity, and should include evaluation of uncertainties. The prioritization should be balanced by other health concerns in the area, such as nutrition, tobacco and alcohol use, as well as accidental death and injury. Applicable comparative risk assessment and risk ranking methodologies can be found in a report from the Resources for the Future (RFF 1996).

- **Well-designed exposure assessments:** If an exposure does not exist in a population, then associated disease does not exist. Disease rates are not useful by themselves. Community and individual level exposure assessments could be conducted on the COPCs identified earlier. This type of exposure assessment has been conducted in the form of the Alberta Oil Sands Community Exposure and Health Effects Assessment Program (AOSCEHEAP 1997). This type of exposure assessment program could be conducted on a broader scale to include the rest of the Northern River Basins.

- **Alternative study designs:** Environmental epidemiology studies are difficult to conduct properly and interpretation is problematic. Even a large-scale cohort study would likely have

insufficient power to detect associations in the Northern River Basins, due to the small population size. Alternatives to "traditional" epidemiological designs, based on health services methodologies, may be useful in establishing populations at risk of disease. For example, methodologies have been developed for examining community-based interventions. These studies may be prospective (following people through time) or cross-sectional (at one point in time) in design (Diehr et al. 1995). For example, prospective studies have been performed on rates of teenage substance abuse between rural American Indian communities with and without substance abuse prevention programs (Cheadle et al. 1995).

It may be possible to design such studies for health outcomes of interest in the Northern River Basins. For example, rates of disease in communities that are downwind of potential air pollution sources could be compared with similar communities without such sources or with communities where sources have been removed. Of course, potentially confounding factors such as smoking, alcohol use, and diet should be statistically addressed in the analyses to the extent possible.

4. The committee recommends that a Memorandum of Understanding be created between federal, provincial and First Nations governments to ensure the co-ordination of programs dealing with First Nations health issues (such as diabetes, water-borne diseases).

5. The committee recommends the continued involvement of the Nunee Health Authority in environmental health studies, due to their unique interest in environmental contaminants resulting from their geographic location and consumption of foods from local sources.

Monitoring Recommendations

Agricultural:

Due to the significant expansion of agriculture in northern Alberta, the committee specifically recommends that:

1. Baseline, province-wide monitoring for cryptosporidia and giardia be undertaken with the participation of all agencies.

2. Co-ordinated province-wide monitoring programs be undertaken for the impact of agricultural practices on surface water, ground water and air quality.

Air Quality:

The committee recommends that monitoring be improved where there is evidence of data gaps.

Science And Technological Recommendations

The committee's recommendations are:

1. Develop the capacity to monitor environmental inputs and health outcomes more effectively through the development of data and monitoring systems, with participation of governments, universities, industries, research organizations, and health authorities.

2. Make better and more effective use of the routinely collected administrative health data. Ensure the timely collection of high quality, valid and appropriate data throughout the health systems.

3. Expand the monitoring of illnesses and health conditions beyond the common communicable diseases.

4. Identify contaminants of concern in the local environment and monitor exposures, early biological changes and health outcomes.

5. Establish a process to regularly monitor selected contaminants in animals and fish used for human consumption to assess variations and detect changes over time.

6. Ensure current regulations and guidelines support continuous improvement and reduction of industry emissions.

7. Initiate action to better understand the higher incidence of congenital anomalies in the Mistahia and Peace Health regions.

Operational Recommendations

The committee's recommendations are:

1. Manage and operate future monitoring activities at arm's length from government. The management committee should be consist of representatives from a wide range of groups and interests.

2. Ensure that future management committees include appropriate technical and scientific expertise.

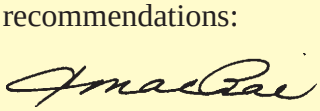
3. Have members of future management committees select their own chairpersons.

4. Ensure that RHAs continue to provide a leadership role in the planning and management of future monitoring activities.

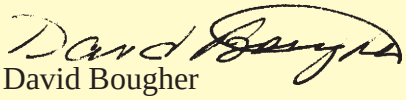
5. Communicate results and ongoing progress of future studies in an open and timely manner, given that the practice of providing timely and open communications proved successful for the HHMP.

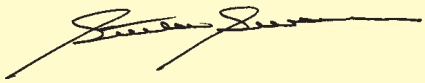
6. Communicate the results and ongoing progress of future studies in a manner that is culturally sensitive to aboriginal communities and other unique groups (given that the practice of developing culturally sensitive communications materials proved successful for the HHMP).

The following committee members endorse the recommendations:

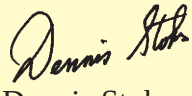

Connie MacRae


Lucille Polukoshko


David Bougher


Stella Swanson


Lucille Partington


Dennis Stokes

Introduction

This report presents the initial analysis supporting the Human Health Monitoring Program, developed as follow-up to the Northern River Basins Study. It provides baseline information and analysis only, because the scope of Phase 1 of the Northern River Basins Human Health Monitoring Program did not include collection of new information.

The report examines the differences in health outcomes across the province and compares the Northern River Basin Study area with the other areas of the province. The report includes a series of regional and local maps and graphs identifying the prevalence of certain diseases and disorders within the Peace and Athabasca river basins, focusing on reproductive health, congenital anomalies, respiratory ailments, circulatory diseases, gastrointestinal disorders, endocrine and metabolic disorders, and neurocognitive disorders. The diagnoses included in the analysis were identified by the Science Advisory Committee as potentially influenced by exposure to environmental contaminants.

The data used for the analysis were limited to existing administrative sources of health and environmental data. Data used to determine health outcomes were obtained from sources collected for administrative purposes, such as records used for physician billing, hospitalization records, and records of births and deaths. Data describing the environment were obtained from existing sources, where available, but were typically inappropriate for the evaluation.

An epidemiological approach to analysis was used: identification of differences in rates, followed by evaluation of the correlation of elevated rates with measures of environmental sources of contaminants. The conclusions that can be drawn from the analysis are severely limited, due to lack of or poor quality data. However, the analysis does identify areas where follow-up investigations to evaluate the impact of environmental factors, genetic endowment and socio-cultural factors on individual diagnosis are relevant and warranted.

In addition to the analysis, the report is intended to provide a basic understanding of the complicated relationships between exposure and health outcomes, and the variety of potential external and internal causes for each diagnosis.

Organization

Similar to other reports of this type, this document is organized into two main sections: the environment and health outcomes. The report begins with an overview of the physical environment, drawn from a variety of reports generated for the Northern River Basins Study. Potential sources of contaminants to which people might be exposed are also discussed.

The human environment is then described, including demographic variation and socioeconomic differences across the province. It is well documented that the human and socioeconomic environments have a key role in the health of the population.[1]

The third section of the report focuses on regional differences in health outcomes, as measured by individual contact with the health care system. Each of the diagnostic categories are discussed in turn, beginning with an overview of the known causes for the disorder and discussion of the provincial rates, followed by presentation of

hospitalization rates, the rates of visits to a physician, and rates of mortality for four geographic areas of the province (NRBS area, Edmonton, Calgary and the rest of the province). Further analysis was conducted only where the rates of both hospitalization and visits to a physician were higher in the NRBS than other areas of the province.

Limitations Of The Study

The limitations of this type of analysis are, in many ways, as great as the benefits. The data used for the analysis were originally intended for a different purpose, and seldom meet the requirements of adequacy for the current purpose. In addition, the type of analysis possible with administrative data supports correlations only, and cannot be interpreted as identifying a causal relationship.

Background

A 1991 joint agreement between the federal government, and the provincial governments of Alberta and the Northwest Territories established the Northern River Basins Study, a $12.3 million ecosystem research project. The purpose of the project was to clarify how the Peace, Athabasca and Slave River basins have been affected by human development. The Northern River Basins Study (NRBS) was divided into eight research components:

- hydrology and hydraulics;
- contaminant distribution, fate and effects;
- nutrients;
- the food chain;
- drinking water quality;
- traditional knowledge;
- other uses of aquatic resources; and
- synthesis and modeling.

The eight components collected and evaluated information on the main and tributary aquatic ecosystems in the northern river basins, including the water quality, contaminant distribution, fate and effects, benthic sediments, fish and fish habitat, riparian vegetation and wildlife, hydrology and hydraulics, nutrients and dissolved oxygen in the water, traditional knowledge, and other uses of the aquatic resources in the area.

The NRBS produced over 100 reports detailing the evaluation of the information collected in the region. After the analysis was completed, it became clear that there was one component not specifically included, and that needed to be addressed - human health. A variety of interest groups including aboriginal groups, environmental organizations, municipal representatives and members of the public expressed the need for an additional study to examine how the development in the North is associated with human health at public meetings held by the Northern River Basins Study.

Both the Alberta Minister of Health and the Alberta Minister of the Environment agreed that the environment is of fundamental importance as a determinant of human health. They requested the NRBS board to advise the Government of Alberta on the feasibility of a human health study. The NRBS Study Board developed a proposal for an environmental epidemiological study that was fully endorsed by the Board and its Science Advisory Committee.

This report is the final deliverable from the environmental epidemiological study. The report examines the differences in health outcomes across the province and compares the Northern River Basin Study area with the other areas of the province. The report includes a series of regional and local maps and graphs identifying the prevalence of certain diseases and disorders within the Peace and Athabasca river basins, focusing on cancer, neurological disorders, birth defects, and respiratory ailments. The study also attempted to find correlations between human health outcomes and measures of environmental sources of contaminants.

This study is an initial screening study and, the analysis was limited to existing sources. Specifically, this report examines the variations in health outcomes and the evidence of trends in human health in the north; differences between the population health outcomes for residents of the Northern River Basins Study area and other regions of the province; and the correlations between human health outcomes and contaminants from industrial, municipal and, agricultural development where information was available.

Other Health Studies

A number of other studies evaluating the impact of the environment on human health outcomes have been conducted in conjunction with this study, including an evaluation of the biomarkers of exposure to PCBs, dioxins and furans in people living in the vicinity of the Swan Hills waste treatment facility, a study of dioxins and furans in cow's milk in Alberta, the impact of sour gas flaring activity on human health, and the development and implementation of a study of the impact of oil sands development on air quality in the north. A brief description of the results of each of these studies is included below.

Exposure To PCDD/F In Swan Hills[2]

A mechanical failure of a transformer furnace was identified on October 16, 1996, at the Swan Hills Special Waste Treatment Centre, operated by Chem-Security (Alberta) Ltd., a subsidiary of Bovar Waste Management. The result of the mechanical failure was the release of an unknown quantity of polychlorinated biphenyls (PCBs), dioxins, and furans into the air. Bovar conducted an independent review of the potential effects of the mechanical failure that indicated that there was no immediate threat to the environment or to human health. A follow-up analysis of tissue samples from local wildlife indicated that PCB levels for most of the samples were within the guidelines developed by Health Canada. However, the results were somewhat higher in the case of one deer. As a follow-up, Alberta Health conducted a detailed health risk assessment that included an estimation of population exposure and the associated potential health risks through wildlife and human biological testing.

As a result of the assessment, Alberta Health issued a health advisory that recommended limiting the amount of local wild game consumption. The assessment determined that only animals that live in the near vicinity of the Swan Hills Treatment Centre would potentially be affected by the emission, because the emission was localized and would not affect any of the surrounding towns or populations. The analysis of human blood samples for biomarkers of exposure did not provide any evidence of unusual exposure to dioxins and furans.

Exposure To PCDD/F In Fort Saskatchewan[3]

Milk consumption is a significant source of exposure to dioxins and furans. Samples of cow's milk obtained from farms in the Fort Saskatchewan area were analyzed to determine the level of dioxins and furans in the milk and compared to samples taken from reference farms elsewhere in the province, as well as samples obtained from a grocery store.
There were four main conclusions from the study:

1. the range of values of toxic equivalent for whole weight was within or lower than measured amount reported in the literature;

2. concentrations in cow's milk are greater in the urban areas than at the rural sites, a relationship commonly found in such comparisons;

3. concentrations were well below the levels defined by models developed for the purposes of environmental impact analysis; and

4. estimated daily intake does not exceed the Health Canada Tolerable Daily Intake for PCDD/F.

Solution Gas Flaring And Human Health[4]

The Canadian Association of Petroleum Producers commissioned the Alberta Research Council to evaluate flare gas emissions. The study showed that the actual efficiency of some flares was found to be 60% to 70% compared with previous estimates of over 90%. The study

also identified compounds in the flare emissions that are included on the priority substance list (i.e. benzene). As a result of the study findings, the Clean Air Strategic Alliance (CASA) established a Flaring Working Group to address the issue. Their investigation included a comparison between the rates of visits to a physician for some respiratory disorders and flaring activities by postal code areas of the province. The study used administrative data and compared rates with data on flaring activities obtained from the Alberta Energy and Utilities Board (AEUB). The study found no evidence of flaring impacts on respiratory health disorders.

The Alberta Oil Sands Community Exposure And Health Effects Assessment Program[5]

The Alberta Oil Sands Community Exposure and Health Effects Assessment Program was established following public hearings conducted by the Energy Resources Conservation Board in relation to Syncrude's Mildred Lake development Project (1994). Human health concerns related to air quality were raised by various participants including aboriginal groups, environmental associations, and Alberta Health. The Program was designed to include both the direct measurement of personal and population exposure to environmental factors and the epidemiologic surveillance of health outcomes in the population. The Program was developed under co-sponsorship of Alberta Health, Syncrude Canada Ltd., Suncor Inc., Fort McMurray Environmental Association, and the Fort MacKay First Nations. A pilot study to determine the feasibility of the study and the measurement techniques was successfully completed in 1997, and the implementation of the main study began in July of the same year. The final results of the study are expected to be available by the spring of 1999.

Related Health Activities

There are several activities sponsored by Alberta Health and other agencies that are already underway. These activities arose from the results of this study and/or are relevant to the issues identified in this study.

- Mistahia and Peace Health Regions congenital anomalies study
- Dioxins, furans and PCBs in food and environmental media: the University of Alberta Eco-Research Chair is developing a laboratory to analyze dioxins, furans and PCBs in food and environmental media. The laboratory is currently conducting analysis speciating metals.
- Reproductive Outcomes: The Centre for Toxicology is developing the capacity to detect phyto-estrogens compounds and trihalomethanes in water, and is currently involved in a variety of studies of personal exposure monitoring, and biological markers of exposure.
- Trihalomethanes and cancer incidence: A Cancer Board project using an enhanced cancer surveillance system for bladder and colon cancer incidence compared to trihalomethane concentrations in municipal water supplies
- Fish contaminants and consumption advisories: Alberta Health is participating in the development and review of a new process for review of fish contaminant data and the establishment and lifting of fish consumption advisories in the Basins.

Related Environmental Activities

There are several important environmental monitoring activities and research programs that are either currently underway or planned for the near future. These activities will provide

additional evidence for the health of the river ecosystems and the health status of the Basins human population, as well as information that can be used to plan and prioritize any future human health studies.

Environmental Effects Monitoring

All pulp mills in Canada are required to conduct Environmental Effects Monitoring (EEM) every three years; this includes all of the mills located in the Northern River Basins. The first EEM cycle was completed in 1996 and provided data that supplemented and complimented data from the NRBS. For example, both EEM studies and the NRBS observed declining levels of dioxins and furans in the Basins. Furthermore, neither the EEM studies nor the NRBS found population-level changes in the fish; rather, there were some physiological changes that could either be in response to exposure to effluents and/or a reflection of natural variability. The second EEM cycle is now underway. All of the pulp mills on the Athabasca are cooperating in a Basin-wide EEM study that includes water and sediment quality, bottom-dwelling invertebrate studies and fish studies. Pulp mills on the Peace system are conducting similar studies, but on an individual basis. The new EEM data will provide valuable, updated information on the health of the river ecosystem and will record any further changes in contaminant levels and ecosystem health since the first EEM cycle and the NRBS.

Oil Sands Assessments And Monitoring

There has been considerable activity in the oil sands area since the completion of the NRBS, with several new oil sands operations announced. Four projects have submitted Environmental Impact Assessments (EIAs): Syncrude Aurora Mine Project; Shell Musket River Mine Project; Suncor Project Millenium; and, Suncrude Mildred Lake Upgrader Expansion. The Mobil Kearl Oil Sands Project EIA is still in preparation. These EIAs provide information on predicted impacts of each new operation. The EIAs address both ecosystem and human health, and can be used to help prioritize future monitoring and research. Furthermore, the oil sands operators are cooperating in a Regional Aquatic Monitoring Program (RAMP) that is examining water quality, invertebrates and fish populations, as well as fish habitat. The RAMP, together with special studies commissioned by individual operators (such as laboratory studies of the effects of exposure to oil sands reclamation waters on fish) will provide ongoing data on the health of the ecosystem in the oil sands area. The Wood Buffalo Environmental Association has implemented a Terrestrial Environmental Effects Monitoring (TEAM) program to ensure that all aspects of the environment are monitored.

Sustainable Development Strategy for the Athabasca Oil Sands

This is a recently-announced program of Alberta Environmental Protection. The goals and objectives of the program are still under development.

Canadian Oilsands Network for Research and Development (CONRAD)

This is an industry-led initiative that coordinates research related to oil sands developments, including environmental research. Academic institutions, government agencies, industry and consulting firms are part of the network.

Wood Buffalo Environmental Association

The WBEA was formerly called the Regional Air Quality Coordination Committee. The WBEA is a collaboration among communities, industry and government who share common interests in ensuring the continued quality of air, the health of residents and the protection of the environment.

The WBEA has established an air monitoring network in northeast Alberta. The stations continually analyze air quality and the data are reported to AEP. There are seven air monitoring stations in the Fort McMurray and Fort McKay areas and on station at Fort Chipewyan. They continuously monitor for: hydrogen sulphide, sulphur dioxide, oxides of nitrogen, carbon monoxide, ozone, total hydrocarbons, 0 to 2.5 micron particulate (PM 2.5), wind speed, wind direction, relative humidity, temperature and acid deposition, Periodic sampling for 0 to 10 micron particulate (PM 10), volatile organic compounds, polycyclic aromatic compounds and metals is also done. Data are available through an internet website www.wbea.org.

All of the above programs offer opportunities for providing input to human health studies. These programs can also be used to help prioritize future work in human health; for example, good overall ecosystem health is a sign that concerns for human health may be less urgent than if components of the ecosystem show definite contaminant-related effects.

Study Questions And Objectives

The objective of the Human Health Monitoring Program is to gather and present baseline information on human health and environmental factors in the Alberta portion of the Peace-Athabasca-Slave river basins, also known as the Northern River Basins area. The information will be used to evaluate trends over time, the geographic distribution of selected diseases and the potential environmental determinants of human health in the study area. The report will maintain a focus on water quality and water-borne pollutants but ambient air, food and other pathways of exposure will also be considered where information is available.

The objectives of this report are to:

- estimate the rate of selected health outcomes in the Northern River Basin Study area and compare this with rates for the other parts of the province;
- determine the most common health problems for the people living in the Northern River Basins Study area;
- examine the relationships between selected health outcomes and environmental determinants where data are available ; and
- explore possible contributing factors for the selected health problems in the Northern River Basins Study area.

In order to address these objectives, several questions were used to guide the analysis. The questions used for this report are:

1. What is the health status of the population and the more common diagnoses for the residents of the Northern River Basins area? What are the trends over time and what is the geographic distribution of various diseases?

2. What specific diagnoses are more common for people living in the Northern River Basins Study area compared to people living elsewhere in Alberta?

3. What are the potential ambient chemical, physical and biological agents related to these selected diagnoses?

4. What associations and correlations exist between the environmental determinants and these diagnoses?

Because the study did not include collection of new information, but sought only to compare the rate of disease or diagnosis with potential environmental sources with information already available, the report can provide baseline information and analysis only.

Methods

The evaluation of population health status, and particularly the examination of the impact from human development and its consequences in terms of social and environmental changes, is complex. The health of a human population depends on many factors: social and economic conditions, physical, chemical, and biological agents in the environment and the unique characteristics of the individual human body. Additional factors influencing health include living and working conditions; the physical environment; personal health attributes; practices and coping skills; and the availability of health services.

Interactions among these factors make the evaluation even more challenging. It is often difficult to isolate and assess the impact that the physical environment has on humans. Environment-related health effects are often weak and they may not appear in a population until several years after exposure. It is also difficult to determine when and where people were exposed to an environmental risk factor, because people move from place to place during their lifetimes.

Lack of appropriate information on environmental exposures adds another level of difficulty to the evaluation of the health impact of environmental contaminants. Information on environmental contaminants is collected and analyzed by different agencies and organizations and for different purposes using a variety of methods of data collection and analysis. As a result, it is difficult to compare the results and the level of pollution or contamination across geographic areas or time periods. Furthermore, information to assess the spatial and temporal variations is often not available.

The relationship between the environment and human health may also be masked by the fact that humans are extremely adaptable and may take active measures to mediate environmental effects on their health. For example, sun screen and protective sun glasses can mediate the effects of exposure to the sun and exercising frequently can reduce susceptibility to certain diseases.

The variety of physical reactions to contaminants in the environment is a further complicating factor. Exposure to one contaminant may result in a wide variety of symptoms of varying degrees of severity.

To evaluate the overall population health status in the NRBS area and to examine the potential health impact from changes in the environment, the NRBS Science Advisory Team recommended an evaluation of the following health outcomes:

- reproductive outcomes;
- congenital anomalies;
- respiratory diseases;
- circulatory diseases;
- cancers of selected sites;
- gastrointestinal diseases;
- endocrine, metabolic and nutritional disorders; and
- neurological diseases.

Evaluation of existing information on population health and the environment was chosen as the initial method of analysis by the NRBS Science Advisory Team. Evidence gathered during the initial phase will facilitate targeting of resources in future evaluations.

Because the list of potential health impacts was long, the issues are complex, and there are few data to support the analysis, a standard approach to evaluation was adopted. Each group of diagnoses was first considered at the chapter level (for example, all cardiovascular diseases were grouped together and evaluated), then evaluated at the level of specific diagnosis.

The rate of hospitalization, visits to a physician and mortality for each diagnosis were compared between the residents of the NRBS area and the other areas of the province. If the rate of health care service use was consistently high in the NRBS area compared to the other areas of the province for a particular diagnosis, the evaluation proceeded to the next step.

The second step of the evaluation identified possible known causes for those diagnoses, and sought other sources of data to support analysis at a greater detail. If measures of environmental contaminants or possible exposure were available, rates of health care utilization were developed for each relevant diagnosis at the appropriate geographic breakdown, and these rates were compared with the measures of known causal factors, including environmental contaminants, and lifestyle determinants.

Discussion of the geographic distribution of diagnoses will vary, depending upon the availability of the data. The data are generally available at large geographic groupings, such as the four areas (NRBS, Edmonton, Calgary, rest of province) or the health regions. Detailed analysis at smaller geographic units was only conducted when the data suggested that the diagnosis was more frequent in the NRBS area.

The evaluation of the geographic distribution of rates of cancers of selected sites was not included in the current study, because it was being conducted concurrently by the Alberta Cancer Board, and published elsewhere.[6]

The analyses included in this report use a variety of existing sources of data. Data sources include routine ambient monitoring data collected by Alberta Environmental Protection, demographic data collected by Statistics Canada, and administrative health care data collected by Alberta Health and Vital Statistics. Detailed discussion of each data source used for this study is outlined below.

Exposure Data

There are three potential pathways for exposure to environmental contaminants: through ingestion (the water we drink and the food we eat), inhalation (the air we breathe) and through dermal exposure. Although the latter route of exposure may be significant on an individual or occupational basis, it is not a significant source of exposure for consideration when analyzing information at a population level.

Drinking Water Quality

The information available about the sources of drinking water being used is very general and there is no accurate method of determining the source of drinking water at the individual level. These factors limited the analysis that could be conducted of water quality on health outcomes. However, information about the quality of treated water from water treatment facilities was obtained from Alberta Environmental Protection (AEP) and was used to conduct the detailed analysis comparing microbial content and incidence of food- and water-borne diseases at the community level. A more complete discussion of the methods and limitations can be found in Prince et al., 1995(b).[7]

The information used to provide an indication of drinking water quality was obtained from Alberta Environmental Protection (AEP). AEP requires all drinking water facilities in Alberta to carry out regular tests for microbial content, and the results are submitted to AEP on a regular basis. Small communities are required to provide four samples per month, and larger communities are required to sample more frequently. The database used for this study covers seven years (1987-1994) of testing and contains the results of 270,000 microbial test samples. The database stores information taken from microbial analysis records in the form of either affirmative or negative indications of the following categories:

- satisfactory samples;
- total coliform (TC) >0;
- TC > 10;
- fecal coliform (FC) >0;
- too numerous to count (TNTC);
- confluent growth (overgrown);
- samples late for analysis;
- broken bottles; and
- incorrectly labeled samples.

No actual bacterial counts were available and only the month and year of the sample date were recorded. The samples that were identified as being late, broken bottles or improperly labeled were excluded from the analysis.

To determine microbial quality of the water supplies in each community, the total number of samples from each community that were either coliform positive, too numerous to count, or overgrown was divided by the total number of samples for that community. The communities were identified as having poor quality water (more than 2% of the samples were poor), and good quality water (less than 2% of the samples were poor).

Microbial Sampling Limitations

The use of microbial sampling results as an indicator of the microbial health risks of a source of drinking water has limitations. The coliform is the traditional indicator organism used for assessing drinking water quality.

However, individual exposure to pathogens from drinking water depends upon both a compromised treatment system and pathogens in the water (originating in the raw water or the distribution system). The microbial water quality samples used here are only an indicator or a compromised treatment system and not the presence of pathogens. The limitations of the coliform indicator adequately predicting health implications of water are documented elsewhere (Payment et al., 1993).[8]

Given the limitations of the data, the analysis results must be interpreted cautiously, providing insight but not definitive results.

Air Quality

Environment Canada produces an inventory that compares estimates of emissions in the provinces and territories by industry sector. Data from the publication Canadian Emissions Inventory of Criteria Air Contaminants (1990)[9] were used to characterize the amount of contaminants entering the environment from industrial and other human sources at a provincial level. However, data on emissions were not available at a smaller geographic unit than the province.

Ambient air quality in Alberta has been monitored and evaluated by Alberta Environmental Protection (AEP) since the early 1960's. In 1994, AEP monitored air quality in 11 locations where continuous (hourly) readings were obtained, 8 locations where data were collected on an intermittent basis (daily), 31 static (monthly and tri-monthly) locations and 12 locations that collected weekly precipitation data. AEP monitors the air quality to determine the status, changes, and trends in selected measures of air quality in the province. Levels of 12 substances are monitored and compared to guidelines that were developed to prevent observable effects on the most sensitive receptor. The substances measured at 10 monitoring stations are ammonia (NH_3), carbon monoxide (CO), carbon dioxide (CO_2), coefficient of haze (COH), hydrogen sulphide (H_2S), nitrogen oxides (NO_x), including nitrogen dioxide (NO_2) and nitric oxide (NO), ozone (O_3), sulfur dioxide (SO_2), and total hydrocarbons (THC). Wind speed and direction are also measured at the continuous monitoring stations. Intermittent monitoring stations measure total suspended particles (TSP), benzo(a)pyrene (BaP), sulfates, nitrates, inhalable particulates (PM_{10}), and volatile organic compounds (VOCs). The static monitoring stations measure dustfall, calcium, total sulfation, hydrogen sulphide, and fluorides. Air quality instrumentation and data are subject to a stringent quality control and quality assurance program.

Ambient monitoring data from 1994 were used for the purposes of comparison. Although more recent data are available from these monitoring sites, the measures of potential exposure reflect the same time period as the health outcomes data. There are very few ambient air quality monitoring stations in the Northern River Basins area, and those that exist provide very limited data that were not available at a small enough geographic unit to support the analysis for the current study. Therefore, the analysis uses a model of emissions rather than the actual measured ambient levels.

To determine if there was a correlation between diagnosis rates and environmental exposure at the regional level, diagnosis rates were compared to modeled levels of emissions of SO_2 and NO_x at the census subdivision (CSD) level. The model of levels of emissions was developed by Cheng[10] for Alberta Environmental Protection using the RELAD model, a modified version of the United States Environmental Protection Agency's Lagrangian model. According to Cheng, the model "simulates the transport, dispersion, chemical transformation, and wet and dry removal processes in the atmosphere to predict ground level ambient concentration, as well as wet and dry deposition of SO_2 ... and NO_x."

Although the model has not been formally validated, it provided estimates for both contaminants at the greatest level of specificity and covered the entire province. Furthermore, the predicted levels of SO_2 in the north-east part of the province (Fort McMurray and Fort McKay) correlate with the concentrations measured at the ambient stations during the same time period.[11]

Dietary Sources

Although dietary sources of contaminants are a concern, the majority of food is obtained from sources outside the Northern River Basins area. However, a proportion of the population consumes food obtained from local sources through hunting, fishing, gathering, and through home-grown garden produce. It is difficult to determine the proportion of the diet obtained from local sources, or the potential intake of contaminants from this source because very little information has been systematically collected to address this issue. The Northern River Basins Study conducted a Traditional Knowledge survey among communities in the basins in Alberta and the NWT. The survey asked respondents which animals and what vegetation they used. However the survey did not identify what proportion of this was used as food, as dye, for ceremonial purposes, or for fur, so it is not possible to develop estimates of the proportion of the diet that is obtained from local sources.

Population Data

Population figures come from two sources: census-based data from Statistics Canada and Alberta Health Care Insurance Plan (AHCIP) registration-based data from Alberta Health. Statistics Canada conducts a census across Canada every five years. Population is estimated for each census subdivision (CSD), and sometimes for each enumeration area and community type. Populations for rural and urban areas are also estimated. In addition to population counts, Statistics Canada collects a variety of demographic data - such as age, sex, race, and ethnicity - and socio-economic information. This type of information is also available at both census subdivision and regional health authority levels.

Because census information is only available once every five years and annual population estimates were required for the calculation of annual incidence rates, population estimates for intercensal years was interpolated using a formula developed by the Alberta Cancer Board. The formula is based on population trends from the census information collected over the past twenty years. However, the formula does not apply to the calculation of population estimates since the last census and the figures from the 1996 census were not yet available, so the 1991 population figures were used for the years since 1991.

Another source of population data is the Alberta Health Care Insurance Plan (AHCIP) registration database, which includes all permanent residents of Alberta. Population estimates for the years 1986 to 1995 by gender and age group were calculated for each regional health authority region and postal code area. Population estimates generated using this approach do not have any errors due to rounding, because the figures are actual counts of people.

There are about 265,000 people living in the NRBS area. The population estimates from the census and the registration are slightly different. In 1991, for instance, the estimated population of the NRBS area was 271,520 from the census but was 275,844 according to the Alberta Health Care Insurance Plan registration database. The population estimates from the two approaches were used for different parts of the analysis, as appropriate. All rates described in the Health Outcomes section for descriptive purposes were estimated using the census-based population. In the evaluation of the relationship between

socioeconomic and environmental factors and health outcomes, rates were estimated using the registration-based population.

Socioeconomic Indicators Data

The census conducted by Statistics Canada every five years collects a variety of information in addition to the population counts. Information about income, education, language, and household characteristics is collected and provided at the census sub-division level. The grouping of data may result in some errors due to rounding, but the errors will likely be very small.

In 1996, Alberta Health contracted the Population Research Laboratory at the University of Alberta to conduct a survey of a sample of Albertans to assess a variety of performance measures from the point of view of the public. The study surveyed the opinions of 4000 people older than 18 years of age across the 17 health regions, ensuring that a minimum of 100 people were included from each region. A random-digit telephone dialing technique was used to contact residents, and a screening process was then used to identify the individual in the household who would be asked to complete the survey. Weights based on the population of the health region where the respondent resided were then applied to the responses to create a representative sample. Data from this survey were used to characterize self-reported health status.

Health Outcomes Data

Health outcomes refers to the eventual health status of the population under consideration. A totally positive outcome where everyone in the population remained healthy following exposure to all potential health stressors, including viral, bacterial, chemical, and genetic, is unlikely. A more realistic expectation is that the population will not be any more unhealthy than a comparable population - in this case, the population of the other areas of the province. Measures of poor health or illness are typically used to evaluate the relative health of a population and these measures are considered negative outcomes.

Most of the sources of data used for the health outcomes analysis are collections of records used for administrative purposes such as hospital funding, physician billing and payment, or the monitoring of contagious diseases. All of the systems use the ICD-9-CM for recording the diagnosis and procedures performed. The ICD-9-CM is a detailed numeric coding system that is used internationally to define diagnosis and procedures. The administrative data sources used for the analysis are described in further detail in Appendix A.

Each of the sources of health outcomes data have a number of potential sources of error. For example, differences in the rate of hospitalization for a particular diagnosis may reflect physician practices more than any real difference in the actual number of people with that diagnosis in the area. The greater distances in rural areas between the physician or the hospital and the home of a sick child may suggest that hospitalization is the preferred option, even if the child is not ill enough to require the comprehensive, 24-hour supervision available in a hospital. Alternatively, the urban areas offer easy access to a variety of services and short distances to travel to obtain those services, so that a physician in an urban area may prefer to allow the sick child to stay at home. Further, each physician may indicate a different diagnosis as the primary reason for admission to a hospital or office visit, depending on whether or not lab results have been obtained prior to billing, previous experience with the disease or the client, or familiarity with the ICD-9-CM system.

In addition to differences in physician practices, billing procedures and random errors in coding, there will also be random differences in rates from one area or time period to another. In order to determine whether a difference in rates across areas were due to chance or could be interpreted as a real difference in health outcomes, several methods of measuring statistical significance were applied.

Selection of the measurements was based on the purpose of the analysis, the information available, and the nature of the data. In an attempt to represent the overall picture of population health status and to reflect the potential impact from environmental sources, three groups of measures were used:

1. classical indicators for general population health status, such as life expectancy, overall mortality, potential years of life lost, and infant mortality;
2. epidemiologic measures of health outcomes, including the incidence rate of food and waterborne diseases, hospitalization rate, physician visit rate, combined rate of physician visit and/or hospitalization, and cause-specific mortality rate; and
3. specific measures for perinatal, neonatal and reproductive health, including the rates of fetal death, perinatal death, early neonatal deaths, post-neonatal deaths, rate of infertility, abortion, low birth weight, preterm delivery, and congenital anomalies at birth.

The definitions of these measurements are attached in Appendix B.

Mortality and hospital morbidity have long been used for regular provincial and national statistics reporting. The use of billing information from physician visits has recently been added to this list. Although it is difficult to estimate incidence rates (the number of NEW cases each year in a given population), it is possible to estimate the prevalence rate (the number of EXISTING cases as a proportion of the population). Prevalence rates of several diseases have been estimated using these data.[12] Comparison of geographic variations in the rate of encounters with a particular sector of the health care system can provide only a very general evaluation of the impact of environmental factors on human health outcomes.

The rates of physician visits, hospitalization, and mortality were estimated for each CSD, region, and for the province as a whole. In order to make rates comparable across areas and regions, the rates were adjusted to the 1991 Canadian population. The direct method that was used controls for potential sources of bias that might result from variations in the population age structure across regions. Carriere's method[13] was used to compute the standard error and 95% confidence intervals for the standardized rates. In addition, the age-specific rate was also calculated for selected health outcomes to determine the risk for each population age group. Comparison of the 95% confidence intervals for five-year rates across areas was used to determine statistically significance differences.

However, using any single data source may introduce some constraints on the validity of the conclusions. The three measures discussed above (visits to a physician, hospitalization, and mortality) were used initially to characterize geographic variations. For those diagnoses where all three indicators suggested that a larger proportion of residents might be diagnosed with a particular disorder than expected, further analysis was conducted using the rate of health care utilization.

Rate Of Hospital Admissions

The hospitalization rate measures the number of hospitalizations for a specific diagnosis in the population. For the majority of health outcomes studied, each individual is hospitalized only once. The rate, in general, reflects the severity of the disease in the population, as well the burden on health care system. However, as discussed above, the rate of hospitalization can be affected by practice patterns of physicians and the admitting hospital, and accessibility to health care services. The rates were calculated for each year from 1990 to 1994.

Rate Of Visits To A Physician

The rate of visits to a physician is a measure of the number of individuals in a population who visited a physician for a specific diagnosis. The rate used for this analysis focuses on the number of individuals, rather than the total number of visits for a specific disorder in a population. The number of visits may be affected by any of a number of factors including satisfaction with the physician; severity of the symptoms or the disorder, and the patient's perception of the severity of the disorder; or physician practices. The number of individuals visiting a physician for a disorder is an indicator of the number of prevalent cases, although an annual rate will be a low estimate because it excludes diagnoses made the previous year. The rate of visits to a physician may differ across areas or regions, depending upon the impact of the local environment, but may also be affected by a variety of other factors.

The graphical presentation of the mean and 95% confidence interval of the rate of visits to a physician for each diagnosis are shown for two calendar year periods for each area. The red horizontal line shows the rate for that area each year, and the I-shaped bar shows the size of the confidence interval for the rate.

Cause-Specific Mortality Rate

The mortality rate is a measure of the worst outcome in the natural history of disease. Although the cause of death is one of the most reliable pieces of information collected by Alberta Vital Statistics, there are some inconsistencies with this measure as well, due to such problems as missclassification of diagnosis, changing practices in coding, and data entry error.

Rate Of Health Care Utilization

The rate of health care utilization measures the number of individuals in a given population who visited a physician or were hospitalized for a specific diagnosis. Any individual who visited a physician or was hospitalized in a particular year for a given diagnosis was counted only once. Although there are a number of individuals who visited a physician and were also hospitalized in the same year, the purpose of the measure is to gauge the prevalence of the diagnosis in the population, rather than the relative acuity of the individual's diagnosis. It is important to remember that the measure will underestimate the actual prevalence of a diagnosis in the population, because many individuals who have been diagnosed with the disorder in the past may not require health care services during the year under investigation. However, this measure is considered a better indicator for health outcomes than either the rate of physician visits or the rate of hospitalization considered in isolation.

Throughout the discussion of diagnoses, the statistical significance of differences in hospitalization, or mortality across areas, was determined by comparing the five-year rate and the associated 95% confidence interval for each area. Any comparison where the 95% confidence intervals did not overlap was considered statistically significant at $p<.05$. Differences are not discussed if not statistically significant. Five year rates and associated confidence intervals are included in Appendix C.

Univariate and multivariate analyses were conducted to examine the relationships between study variables. Differences in means, medians, and proportions defined by geographic area or time period were compared. Relative risk, the most frequently used measure of association in epidemiological studies (calculated as a ratio of two rates), was also used for the analysis. Correlation analysis, linear regression, and variance analysis were applied for comparisons among continuous variables. A combination of these statistical analyses enabled a more complete evaluation and interpretation of the findings. Student t-test was used to evaluate differences in the means and the least square means between comparison groups; chi^2 test, Fisher's exact test, and Mendal-Hansel methods were used for comparisons among categorical variables. In addition, Cohen's kappa was used to assess the linkage across data sets. A natural log transformation was performed to approximate a normal distribution when appropriate. Categorization of continuous variables was used to reduce the likelihood that the distribution of data had multiple modes or was extremely skewed. The categorization method used existing standards (such as the Guidelines for Canadian Drinking Water Quality), or was based on the distribution of the data (such as quartiles).

Throughout the analyses, standardization, stratification, and multiple regression techniques were used for assessing the potential impact from several factors, such as geographic variations in age structure, community socioeconomic status, and the proportion of the population in a community who are aboriginal. The role of these factors varies, depending upon the hypothesis and the method of analysis.

The goals of the Northern River Basins Human Health Monitoring Program focus on the use of existing administrative data as a source of information about the relative health of the residents of the Northern River Basins area, compared to the health of Albertans who live in other areas of the province. Due to the emphasis on the use of existing administrative data as the main source of information, there are a number of limitations in the analysis that result in potential errors in interpretation.

Rate Estimation

The most frequently used measure of a health outcome is the rate. In order to ensure that the rate estimation process is reliable and accurate, the two components used, the numerator and the denominator, must be accurate and reasonably large. That is, if a rate is based on only a few cases, or if the estimate is attempted for a very small population, the reliability of the rate is compromised. Dividing the population into the four geographic areas introduces a degree of uncertainty into the rate estimation, although the population of each of the four areas is still relatively large. Estimating a rate for the health regions introduces somewhat more error because the population of the regions is smaller, particularly in the northern health regions.

The potential for error in the estimation process is compounded by the small number of cases diagnosed for some diseases (the numerator). The potential for error is further exacerbated by the potential misclassification of diagnosis.

To improve the accuracy and reliability of the estimated rates, data were restricted to diagnoses

made by a physician - about 80% of the records. The rates estimated for smaller geographic units, such as CSD, were estimated for longer time periods such as three or five year periods, when appropriate. Furthermore, only those rates based on five or more cases are considered reliable for the purposes of interpretation, unless the likelihood of the misclassification of the diagnosis is remote, as is the case for diagnoses such as congenital anomalies and infant mortality.

The accuracy of the estimate of the population size and composition is another key factor in the estimation of rates. The census collects information about the population using a consistent method, and includes the record of the actual physical address of the resident. This suggests that the population count is likely accurate for each census subdivision. However, some communities may not participate in a census, and population counts for the years between census years must be estimated, so the population counts are always less accurate.

An alternative population figure can be obtained from the registration file of all Alberta residents eligible for coverage under the Alberta Health Care Insurance Plan. This source of population figures is also deficient, because the recorded postal codes may not represent the real physical location of the registrants, and because there is currently no mechanism to ensure that the information is current and accurate.

Comparison of the population estimates from the two sources indicates that there are some marked differences, particularly for some small CSDs. Furthermore, a study was undertaken by Alberta Health to contact a random sample of residents of a particular health region by telephone using a list generated from the registration database. The study indicated that a large proportion of the numbers or addresses were out of date and inaccurate.

However, the estimates of population obtained from the registration database was used for the estimation of rates of health care utilization in the analysis below for two main reasons. First, the identification of the home location of a client is defined through an electronic link to the registration database for all physician claims. Using the registration database to generate the population estimates (and therefore the denominator) will reduce any potential bias that might arise from using different methods to assign the home location for the numerator and the denominator. Second, the registration database includes all permanent residents of the province.

To evaluate the potential impact from different methods of assigning home location, the analysis of some health outcomes included estimation of the rates using the population estimates obtained from both sources. The rates estimated using the two population sources at the CSD level were highly correlated.

The census sub-division boundaries are used for all cartographic presentation of health data in accordance with the analysis component of the study. This level of information results in the task of displaying data for over 400 CSD's in the province in a page-size map. The larger CSD's are easily visible because they correspond to counties, municipal districts, improvement districts, and national parks. The majority of the CSD's correspond to cities, towns, and reserves, most of which are not visible in a page-size map. In order to deal with this visibility issue an alternative method was devised to represent these CSD regions.

A data set was obtained from Statistics Canada which lists the permanent population on a township basis. A program was developed to translate legal land descriptions into latitude/ longitude coordinates. This information was used to create a rural population point data set. These points were buffered to a distance of 10 km to correspond to the size of most townships in Alberta. The region associated with the point was used to create a mask which separates populated from unpopulated areas. This mask covers areas which have no permanent population.

Two sets of points were merged to generate a grid of points which represents all populated portions of the province. The first point set used the centre point of each of the small CSD's contained within the larger areas, such as counties, municipal districts, improvement districts, and national parks. The second point set was created by selecting all populated township points within the larger CSD. This final product yielded a grid of points where each of these points was at least 10 km apart whereby ensuring that data are visible on a page-size map.

This merged point data set was linked to the appropriate rate ratios according to the CSD. The points were used to create an interpolated surface (the half-way point between two points with values 0.5 and 1.5 is assigned the value 1.0). The value of a single urban area is interpolated with the nearest populated townships. As the surface must pass through all data points, the resulting map is an accurate representation of the data.

The continuous surface generated by the interpolation process was reclassified according to the scheme listed below in order to aid in interpretation of the rates. The resulting map uses five categories, based on a logarithmic distribution of the rate ratio values. The class boundaries for each was consistent for all diseases.

A sub-division with a rate ratio of 1 has the same standardized rate as the province wide rate, a value of 10 indicates a rate 10 times higher than the provincial value, while a value of 0.1 consists of a value one tenth the provincial rate. The range of values from 10 to 0.1 was used as a basis of classification. The log of these values was calculated to create a scheme based on a normal distribution. This resulted in a scheme with values ranging from -1 to 1 (the logs of 0.1 and 10 respectively). This range was divided into 11 classes yielding a class range of 0.1818. If the centre of the scheme is 0 (log(1)) then the first class ranges from -0.0909 to 0.0909. The value 0.1818 is added or subtracted from the values above to generate the remaining 10 classes.

The highest and lowest classes were generated by amalgamating the 4 top and 4 bottom classes respectively. These create the classes "higher" and "lower" respectively.

The categories used are as follows:

Category	Rate Ratio
Lower	Minimum to 0.53
Low	0.54 to 0.81
Average	0.82 to 1.23
High	1.24 to 1.86
Higher	1.87 to Maximum

(Note 1.86 means that the standardized rate is almost 2 times the provincial rate)
This report uses an extended color family, green then yellow and finally red. These are colors which are adjacent in the visual spectrum, are easily discernible from each other, and also can be interpreted in context of traffic signals: green=go, yellow=caution, and red=stop.

Unpopulated areas and areas with no data available are clearly marked.

The same set of points was used to generate the map in the inset (the small map showing number of cases). The interpolation was performed using number of cases and put into three categories:1 to 2 cases, 3 to 5 cases, and more than 5 cases. The colors red, yellow, and green were used, respectively. This map is used in order to establish the stability of the rate in the larger map. A red area in the larger map shown in red in the smaller map may not truly be in the category “higher” because the rate is unstable. If the larger map shows red and the smaller map shows green for a specific area, then this area definitely fits into category “higher”.

The boundaries of the CSD are shown in black in both of these maps to help identify individual locations.

Analysis

A complete evaluation of the sources, pathways, exposures, doses and effects of environmental contaminants in the Northern River Basins area was not within the scope of this project. The evaluation of the effects of the contaminants in the NRBS area is limited because the study did not include collecting data about individual exposure and dose. The conclusions that can be reached from the type of analysis done for this report are therefore limited. However, assessment of the health of the population and a geographic comparison of high rates of health care utilization can indicate whether the population in the NRBS area has any different health problems than the population in the rest of Alberta. Estimates of potential exposure of the population can indicate whether environmental exposure is a potential cause or some other factors are involved.

In order to understand the potential exposure for residents in each of the areas, some consideration of how the natural environment, the agricultural and industrial sources of contaminants, and the pathways through which people are exposed is necessary before we can consider the actual evidence of health outcomes.

There are a number of chemicals that occur in the natural environment that can have an adverse effect on human health. The soil, water and weather patterns can all place undue stress on our bodies, and may cause negative health reactions. An understanding of the natural environment in the Northern River Basins area is necessary to the development of a profile of the ambient chemical, physical and biological agents of concern from a human health perspective.

Findings

Water: Overall, the quality of the drinking water in the NRBS area is good. The high volume of water in the rivers in the north, compared to the drier southern areas of the province, results in greater mixing and dilution of any contaminants that might find their way into the system. Agricultural activity is not as large a contributor of contaminants to the water in the north compared to the southern parts of the province. Natural sources of organic matter in surface sources of drinking water increase difficulties of water treatment. Smaller water treatment facilities using surface water sources other than the major fast-flowing rivers may have some difficulties with adequate water treatment, although concerns with meeting guidelines are being addressed through initiatives sponsored by Alberta Environmental Protection (AEP). As part of the follow-up to the Northern River Basins Study, AEP, in partnership with Alberta Health and the northern RHAs, Health Canada, representatives of First Nations, and owners and operators of municipal waterworks systems, has developed a process to evaluate and rectify concerns with training, certification and performance measurement.

Air: Air quality is good overall. Air quality monitoring stations report very few incidents when the guidelines are exceeded. Occupational exposure is a far greater hazard than exposure to large enough levels of contaminants in ambient air.

Soil: There are no significant sources of soil contamination in the NRBS area. Agricultural activity in the area is significantly less than the level of activity in the southern areas of the province, and does not contribute a significant amount of chemical contamination to the soil.

Food: There are a variety of local food sources, which are not monitored or evaluated for contaminants. A large portion of the aboriginal population (66%) say that they obtain at least some of their daily diet from local sources, and many of these people indicated that they were unable to get enough to eat. Restrictions of fish consumption are in place in several places in the NRBS, due to high levels of either mercury or dioxins and furans.

Water

The water systems in the NRBS area were the major subject under investigation in the Northern River Basins Study, focusing on the assessment of the consequences of human development on the aquatic ecosystems. These ecosystems were outlined in the Final Report to the Ministers, from which an excerpt is included below[14]:

The [Northern River Basins] Study area is defined as the Alberta and Northwest Territories portions of the Peace, Athabasca and Slave River basins. Residents of the Peace, Athabasca and Slave River basins live in an expansive and picturesque natural environment. Combined, the three basins cover 580,000 km^2 and extend across large portions of Alberta, the Northwest Territories, British Columbia and Saskatchewan. The following are descriptions of the Peace, Athabasca and Slave River basins.

The Peace River

The Peace River has its origin in hundreds of cold mountain streams in the Rocky Mountains of British Columbia. Each spring, water from melting snow and ice trickles down from the mountains and eventually drains into Williston Lake, the largest man-made lake in British Columbia.

Less than 30 years ago, the northern and southern ends of the reservoir would have appeared as the Finlay and Parsnip Rivers. The rivers have since been back-flooded by the creation of the W.A.C. Bennett Dam near the town of Hudson Hope, British Columbia. Williston Lake feeds the dam's hydroelectric generators, and the Peace River now flows from the reservoir's eastern arm.

The Bennett Dam has altered the flow and characteristics of the Peace River. Unrestricted, the level of the Peace River varied seasonally between high flow in the spring and low flow in the winter. The dam dampens these highs and lows to ensure peak energy generation potential during the winter months when electrical demands are high. Moreover, the water that passes through the dam is drawn from the lower portion of Williston Lake that remains unfrozen during the winter. These changes in water levels and temperature can alter many aspects of the ecosystem, such as the quantity of habitat, the movements of fish and animals, and the period to which the river remains frozen.

The reservoir is used by local pulp and paper mills as a corridor for transporting logs and as an outlet for their waste waters. There are three mills located in the general area of Williston Lake. The Fletcher Challenge and Finlay Forest Industries mills are located in the town of Mackenzie. The Louisiana-Pacific mill, which is located further east in the town of Chetwynd, does not rely on local surface water supplies and has little or no impact on water quality.

The two mills in Mackenzie, however, are licensed to discharge waste effluent into the reservoir and, ultimately, these wastes flow into the Peace River.

The flow of water past the Bennett Dam marks the beginning of the Peace River. The river flows eastward, carving a deep chasm in the undulating landscape and passes through the Peace Canyon Dam. It is joined by the Halfway River to the north and passes near Fort St. John, the oldest white settlement on mainland British Columbia and a former outpost of the fur trade. Further east, the Peace is joined by the Pine River near the town of Taylor, where it encounters the Fibreco pulp mill.

The river then crosses the border into Alberta's northern agricultural region (see "1" on Map 1), an area that stretches south to the city of Grande Prairie and north along the river to the town of Fort Vermilion. Much of the soil in this area once lay at the bottom of ancient glacial-meltwater lakes. Today, the gently rolling plains surrounding the river are a patchwork of fields and forests. Canola, alfalfa, clover and oats are a few of the region's main crops. Aspen and balsam poplar dominate the forests, often interspersed with white spruce and jack pine.

The river passes south of the town of Fairview, traversing a high, walled canyon-like reach that was studied during the mid-1980s as a possible site for the Dunvegan Dam and Reservoir. The Peace is later joined by the Smoky River from the south. Together with its tributaries, the Smoky River drains roughly 20 per cent of the Peace River basin and extends as far south as Jasper National Park. As with any tributary, the Smoky brings with it the history of its journey, written in the nutrient and chemical contents of its waters. The areas that the river drains are developed extensively for forestry, agriculture, coal, oil and gas. The river also receives effluent from the Weyerhaeuser Canada pulp mill through one of

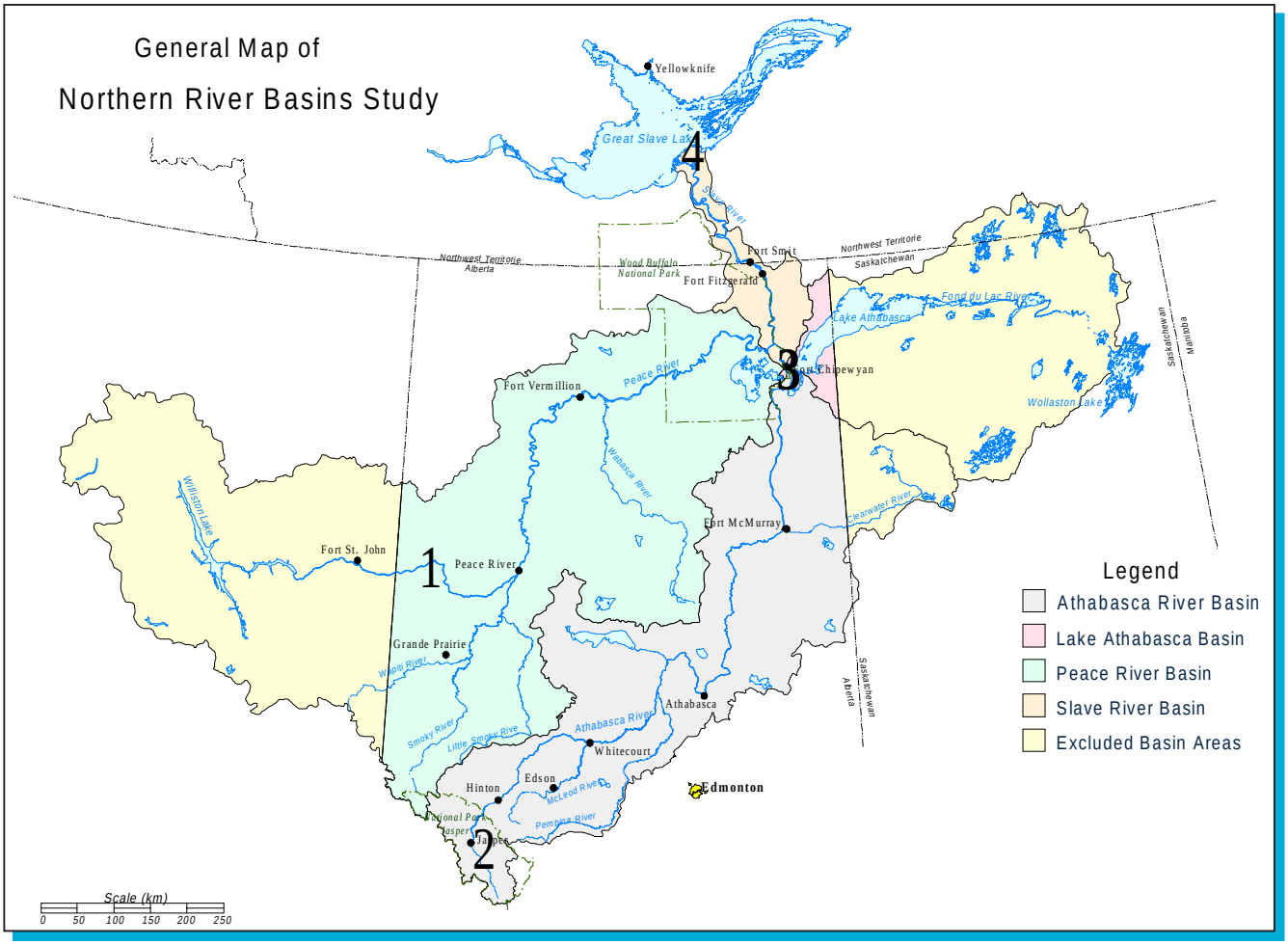
its major tributaries, the Wapiti River. Just past its picturesque confluence with the Smoky River, the Peace flows past the town of Peace River. Here the river cuts deep into the surrounding grasslands to form a green valley surrounded by high, steep bluffs.

The Daishowa-Marubeni pulp mill is located roughly 25 km north of the town. A little further north, the Cadotte River joins with the Peace River. The Cadotte River is not a major tributary to the Peace, but it drains an area that is underlain by a relatively large oil sands deposit. Commercial-scale operations are currently underway to extract and refine this non-conventional source of oil. The extraction process involves injecting pressurized steam into the deposit to melt the tar and places demand on local surface water supplies. The mixture of tar and water is then pumped out of the ground and refined.

The agricultural corridor surrounding the Peace River continues as the river travels north past the Métis Settlement of Paddle Prairie. Further on, the river veers east, passing near various native settlements representing Dene Tha', Cree and Beaver Nations. Agricultural development along the Peace River slowly phases out east of Fort Vermilion, a town that is over 200 years old and a former outpost of the fur trade.

Outside the town of Fort Vermilion, the Peace is joined by one of its major tributaries, the Wabasca River. Each year, cobble and other materials are washed down the Wabasca, forming

Map 1 The Natural Environment



a fan-shaped bank of material at the river's mouth. Historically, spring floods on the Peace River have stripped away these banks of material and washed them towards the Peace-Athabasca Delta. Many speculate that the Bennett Dam has reduced the Peace River's ability to "scour" away these deposits, resulting in a growing bank of material.

East of the Wabasca, the Peace River passes through the Vermilion Chutes rapids. During certain times of the year, these rapids have drops of three to five metres posing a major obstacle for river travel and fish movements. The Caribou Mountains lie to the north, an area of peat, lichen, black spruce and permafrost.

Further to the east, the Peace passes the Jean D'or Prairie and Fox Lake Indian Reserves before entering Wood Buffalo National Park.
The park is noted for one of the world's largest free-roaming herds of bison and is recognized as a world heritage site. Finally, the Peace River finishes its 2000 km trek as it joins with outflow from the Peace-Athabasca Delta to form the Slave River.

The Athabasca River

The Athabasca River headwaters are formed by the melting snow and glaciers of the Columbia Ice Field on the continental divide (see '2' on Map 1). Finely ground particles of rock (or "rock flour") formed by glacial action lend a silty gray color to the water.

White spruce grows near to the waters' edge. Further back, forests of Douglas fir, limber and lodgepole pine, and aspen provide habitat for elk, mule deer and many species of birds.

As the river leaves the park, the rugged topography softens into rolling foothills. Coal underlies much of these foothills, covering a broad diagonal swath across the province that parallels the Rocky Mountains. Some of western Canada's largest active open-pit coal mines are found in this region.

Further on, the Athabasca River passes the Weldwood pulp mill at Hinton, the oldest of the five mills in the Athabasca River basin. The mill relies completely on the region's softwoods: white and black spruce, lodgepole pine and alpine fir.

The river continues north and swings eastward towards the town of Whitecourt, where it encounters the Millar Western pulp mill and the Alberta Newsprint Company. At Whitecourt, the river is joined by the McLeod River that drains areas with open-pit coal mines and limestone quarries to the south. Oil and natural gas deposits are found to the north of the river, near Fox Creek and Swan Hills. In fact, one of the largest producing gas fields in the country is located in the Fox Creek area.

Leaving Whitecourt, the Athabasca River swings north again and is joined by the Pembina River that drains through prime agricultural lands to the south. By now the waters of the Athabasca are brown from the soil and other materials that it has picked up along its course. As the physical environment changes, so too do the numbers and kinds of organisms in the river. These changes continue along the length of the river, corresponding to specific habitat and nutrient requirements of different fish and aquatic organisms.

The Athabasca is joined by the Lesser Slave River, which drains the agricultural and forested areas surrounding Lesser Slave Lake. Another pulp mill, Slave Lake Pulp, is located along the banks of the Lesser Slave River. Beyond Lesser Slave River, the Athabasca dips southward toward the town of Athabasca. Prior to 1904, the

town of Athabasca was known as Athabasca Landing and was a site of great importance in northern development. Goods were moved from Edmonton to Athabasca Landing, where they could be barged to northern outposts. The Athabasca Landing Trail, created in the 1870s, was a portage that linked the North Saskatchewan River to the Mackenzie River system, allowing access to the fur trade. With the decline of the fur trade, agriculture, forestry and natural gas rose as the dominant regional industries. Barge traffic along the river declined after the railway was extended to Fort McMurray in the early 1900s.

Turning northeast once again, the Athabasca River passes by a newer feature to the land, the pulp mill owned by Alberta-Pacific (AlPac) Forest Industries Inc. The river runs through the middle of the AlPac Forest Management Agreement (FMA) boundaries, the area that defines the potential timber supply for the mill. Covering an area of roughly 61,000 km^2, AlPac's FMA is much larger than that of other pulp mills in the province. The pulp mill was constructed to make use of both the hardwood (e.g., aspen and balsam poplar) and softwood (e.g., white spruce, black spruce and jack pine) resources within the FMA area.

The Athabasca River continues northward through the boreal mixed wood forest and evolves into a series of major rapids. The influence of these rapids on the rest of the Athabasca River is quite significant. Not only do they pose an obstacle to river travel, they also serve as a major spawning area for fish, such as lake whitefish and walleye. The turbulence of the water also replenishes levels of dissolved oxygen needed for fish and other aquatic organisms. This aeration takes on an added significance during the winter months, when ice cover blocks contact with the air and dissolved oxygen levels dwindle.

Beyond the rapids, the Athabasca River encounters the city of Fort McMurray. Historically, Fort McMurray was another outpost of the fur trade and a major site for the transport of goods north along the Athabasca River. Here, the river cuts through shallow oil sands deposits and its waters are tinged with natural hydrocarbons. Bitumen (the raw hydrocarbon of the oil sands) is visible as an asphalt-like substance along the banks of the river. Indians once used bitumen to patch their canoes. Today, the Athabasca oil sands provide a non-conventional source of oil that is currently mined by two companies (Suncor and Syncrude) located just north of the city of Fort McMurray.

At Fort McMurray, the Athabasca River is joined by the Clearwater River that flows across the border from Saskatchewan. The Clearwater River's major tributary, the Christina River, drains an area with extensive oil and gas development. The Athabasca continues north past Fort McKay and Bitumont, where the abandoned facilities of Alberta's first pilot oil sands operation can be found. The river then becomes the eastern border of Wood Buffalo National Park, where the terrain becomes wetter and dominated by black spruce and boggy areas. The main portion of the Athabasca and its tributary (the Embarras River) continue on to Lake Athabasca.

Lake Athabasca marks the end of the Athabasca River's 1,231 km trek from the Rocky Mountains. With an area of 7,936 km^2, it is the fourth largest lake entirely in Canada. The lake is shared by Alberta and Saskatchewan, and is a valuable local resource for fishing. It is surrounded by areas that are naturally rich in uranium.

The Peace-Athabasca Delta

The Peace-Athabasca Delta is a unique environmental feature (see "3" on Map 1). Athabasca is Cree for "where there are reeds," describing the delta's marshes and grasslands. The flat terrain is a patchwork of marshes, lakes, mud flats, sedge meadows, willow and shrub thickets and forests of white spruce and balsam poplar, interwoven by numerous winding channels. With its variety of landforms and lush vegetation, the delta has the capacity to support a diverse mixture of animal species. In 1985, the Canadian Wildlife Service counted 220 species of birds, mammals and fish that inhabit the delta during some part of their life cycle. Well over half of these species are birds. Twice each year, millions of birds follow established routes (or "flyways") on their north or south migrations. All of the four major flyways in North America converge on the Peace-Athabasca Delta. Many birds use the delta as a pit stop to "fuel up" for the rest of their long trek, while others stay on to nest. Among these are tundra swans; snow, white-fronted and Canada geese; Ross' goose and a variety of ducks. In 1982, the delta was recognized by the Convention on the Conservation of Wetlands of International Importance.

The characteristics of the delta that contributed to the Ramsar designation have been significantly altered. The complex water flows in the Peace-Athabasca Delta are fundamental to its environmental characteristics. Since the landscape of the delta is relatively flat, many of its waterways can flow in two directions. The direction of the flow depends upon the relative water levels in different parts of the delta. When the water level in Lake Athabasca is higher than Claire and Mamawi lakes, water flows westward into the delta. When Lake Athabasca is low, water flows east out of the delta lakes and into Lake Athabasca.

The reversing concept holds true for the channels that drain the delta: Chenal des Quatre Fourches, Revillon Coupé and Riviére des Rochers. Usually, these three channels flow north to meet with the Peace River and then continue north as the Slave River. However, when the flooding of the Peace River rises higher than the water level of Lake Athabasca, water flows south into Lake Athabasca and the delta.

The back flooding of the three channels by the Peace plays an important role in maintaining the delta wetlands. Many of the small lakes of the delta exist as "perched basins" that are only replenished through the periodic, spring ice jam flooding by the Peace River. However, since the construction of the Bennett Dam, these floods have been rare and less extensive. As a result, many of the marshy areas of the delta are transforming into terrestrial landforms dominated by willows and sedges.

The transformation is of concern to both ecologists and local residents. Residents of Fort Chipewyan, located on the shores of Lake Athabasca, rely on the delta for fishing, hunting and recreation. Fort Chipewyan is one of the oldest communities in Alberta. During the heyday of the fur trade, Fort Chipewyan was an important outpost for the Hudson's Bay Company and the delta was renowned for the quantity and quality of its muskrat pelts. However, many of the marshes are now too shallow for muskrats to overwinter. Falling water levels have also decreased habitat for waterfowl and fish.

During the 1970s, a considerable amount of effort went into stabilizing the water levels of the delta through the construction of control weirs along the three channels. The weirs were intended to reduce the outward flow of water while still allowing the Peace River floods to wash into the delta. The weirs proved effective in retaining

water, but they could not mimic the natural fluctuations in water levels that are integral to the unique environmental characteristics of the delta. The Quatre Fourches dam was later removed because it kept waters artificially high year-round.

The Slave River And Delta

The Slave River drains north (see "2" on Map 1), still serving as the eastern border of Wood Buffalo National Park. As it travels towards the Northwest Territories, the river passes by the town of Fitzgerald. Fitzgerald is the last stop before a major series of rapids that culminate in the Rapids of the Drowned just north of the town of Fort Smith. The rapids impede travel and form a natural barrier to the upstream movement of fish, such as arctic lamprey and inconnu. The scenic beauty of the area attracts a growing number of tourists each year and the rapids have become a popular site for white water kayaking and rafting.

The town of Fort Smith marks the crossover of the Slave River into the Northwest Territories. The volume of water flowing across this border is enormous, with an annual flow estimated at 107 billion m^3. Due to the high volume of water, the rapids along this stretch of river possess enormous hydroelectric potential and a large-scale hydroelectric development was proposed for the area. Alberta Environment conducted the Slave River Hydro Feasibility Study during the early 1980s to investigate the economic benefit and environmental impacts of the proposed dam. The monetary and environmental costs were deemed too high for the power demand, and the project was put on hold indefinitely.

The Slave Delta lies on the southeast portion of Great Slave Lake, at the end of the river's 434 km course. Covering an area of 640 km^2, the Slave Delta is considerably smaller than its southerly counterpart, but is still a valuable environment for fish and waterfowl habitat. In 1985, the Canadian Wildlife Service reported that 212 species of birds, mammals and fish frequented or live in the Slave Delta.

Fort Resolution on the southern shore of Great Slave Lake marks the northernmost limit of the northern river basins. From there, the waters become part of the Mackenzie River system that eventually drains into the Beaufort Sea.

Human Uses Of Water

Human settlements invariably have an impact on the natural environment and this impact is particularly detrimental to the water systems. There are five distinct uses of water for which guidelines of cleanliness and purity have been developed: drinking, recreation, freshwater aquatic life, agricultural uses and industrial water supply.

Public Drinking Water

Safe drinking water is a common concern to Albertans, particularly in areas where municipalities, agriculture or industry deposits waste into the streams and rivers that become the source of drinking water for those further downstream. People in the NRBS area, like those in the rest of the province, obtain drinking water from a variety of sources. Those people who live in a large enough settlement have their water provided to them by the municipality, who are responsible for ensuring that the water is safe to drink. Other people get their drinking water from a well, a dugout, or a stream. Water from these sources is seldom treated to ensure that it is safe to drink.

The Environmental Protection and Enhancement Act and associated Potable Water Regulations require anyone (including municipalities, corporations or individuals) providing water for public consumption to ensure that the water is

potable (that is, safe to drink). The provincial government requires the treatment facilities to adhere to a set of standards and guidelines for treatment of drinking water. Alberta uses the Guidelines for Canadian Drinking Water Quality which establish drinking water quality limits. In Alberta, the 'Standards and Guidelines for Municipal Water Supply, Wastewater, and Storm Drainage Facilities' outline the acceptable methods of treating water to ensure that water-borne diseases, harmful chemicals, and other standards can be met. Municipalities are required to monitor the quality of the water they are supplying to their residents on a continual basis, and to take action if there is evidence of a problem. Map 2 shows the source of water for municipalities across the province.

Approximately 50% of the communities obtain their water from surface sources, 45% from ground sources, and 5% of the areas obtain their water supply from a combination of both ground and surface sources.

Albertans who obtain their drinking water from a well or dugout can have their water tested to ensure that the water is potable and doesn't contain any harmful chemicals, bacteria or organisms. The water is tested free of charge by the provincial laboratory (although there may be a small fee for shipping and handling of time-sensitive samples in some regions).

Many of the contaminants that pose a health concern are naturally occurring microscopic organisms, or chemicals that come from the rocks and soil surrounding the water. Water that is safe for recreational purposes (such as boating, swimming or fishing) may be unsafe for drinking. Water can also absorb contaminants from the pipes leading to and inside the home.

The drinking water quality guidelines define maximum allowable concentrations of more than 70 contaminants, as well as aesthetic guidelines such as temperature, taste and smell.

Water can taste and smell bad without the presence of any harmful contaminants, or may be completely odorless and tasteless while containing a variety of harmful chemicals and bacteria. Chlorination is the most common method for disinfecting water (reducing the presence of pathogenic bacteria, protozoa or viruses to levels which will not cause waterborne disease). However, chlorine reacts with organic matter which is naturally present in water to varying degrees (negligible levels in a mountain stream vs. high levels in a stream draining muskeg) to produce a variety of by-product chemicals called disinfection by-products. The most common of these disinfection by-products are the trihalomethanes (THMs) which, once formed, are difficult to remove in water treatment systems. Larger water utilities often select raw water supplies which have low levels of natural organic matter or they practice treatment steps to minimize disinfection by-product formation. Smaller communities may be constrained to using water supplies with high natural organic matter and will be unable to undertake more sophisticated treatment processes to minimize disinfection by-product formation. As a result, residents of smaller communities may be exposed to much higher levels of THMs than residents of larger communities.

The majority of people living in the NRBS area obtain their drinking water from municipal water sources. Survey data suggest that 55% of households use municipal sources while 31%, especially farm households, take their water from wells or springs. About 5% of households use water from various surface water sources and four percent take their water from dug-outs. Another 4% of households use bottled water for drinking.

The work completed by the Drinking Water Component of the NRB Study estimates that, based on the design capacity of the 214 licensed drinking water facilities in the basin, about 75% of the basin population use municipal water systems.[15]

The same report also estimates that about 60% of the basin population may actually be served by these drinking water facilities. In contrast, data from the Traditional Knowledge Component of the NRB Study found that only 5% of the 221 traditional resource users from nine native communities use municipal water supplies.[16] Based on the inconsistencies among data sources, we can only estimate that between 55% and 75% of basin residents draw their water from municipal water systems. The remaining residents not using municipal water sources are obtaining their water from other, less reliable sources.

According to survey results, the vast majority of municipalities believe that their treatment facilities are producing water that meets drinking water standards. The perception that water treatment plants are meeting drinking water standards is inconsistent with the results of assessments by the Drinking Water Component of the Northern River Basins Water Quality Study. Testing shows that as many as 60% of samples taken from towns and hamlets exceeded the Guidelines for Canadian Drinking Water Quality[17] for trihalomethanes (Guidelines based on an annual average of 4 samples). In addition, tests for microbial contamination show a high proportion of poor samples, especially for communities with a population of less than 500.

Disinfection by-products (DBPs) are formed when the oxidizing agent used to inactivate micro-organisms combines with other compounds present in the water. Some DBPs have been identified as a health concern by toxicological and epidemiological studies that link DBPs with reproductive disorders or some types of cancers, although these results are not conclusive. There are a wide variety of DBP compounds, but trihalomethanes (THMs) are the most widely documented and the only one that is regulated in Canada. The Guidelines for Drinking Water Quality in Canada limits the amount of THMs allowable in drinking water to 100(g/L as an average of four annual samples. THMs are currently considered a surrogate measure of the DBPs in chlorinated drinking water.

The studies conducted by the drinking water component of the NRBS found elevated levels of THMs in some communities, based on historical data and on data collected specifically for the study (NRBS reports # 55 and #115).

Table 1 shows the THM data from NRBS report #115 sorted by THM level. The table shows THM levels are generally lower at sites that take water from the Athabasca and Peace Rivers while communities that obtain water from other surface water bodies had higher levels. The data show the results of one sample and cannot be compared directly to the guideline value of 100ug/L, however, it seems evident that some communities may not meet the guidelines.

This information demonstrates that disinfection by-products are at levels of concern at several communities in the NRBS area. There is need for further study of the occurrence of disinfection by-products and associated health effects and efforts should be focused on the communities most impacted. The initial indications are that communities that do not get their raw water from the Peace or Athabasca Rivers have higher levels of disinfection by-products.

Although the levels of disinfection by-products in drinking water are elevated in several communities in the NRBS area, the rate of cancers associated with drinking high levels of these contaminants was not correspondingly elevated.

Table 1 THM Levels In Select NRBS communities

Location	Date Sampled	Population*	Source Water	THMs (µg/L)
Edson	11-Aug-94	7323	Ground Water	24
Cadotte Lake	24-Aug-94	241	Cadotte Lake	27**
Jasper National Park	16-Aug-94	4475	Cabin Lake	29
Hinto	18-Aug-94	9893	Athabasca River	34
Athabasca	10-Aug-94	1975	Athabasca River	42
Fort McMurray	29-Aug-94	33698	Athabasca River	45
Grimshaw	20-Jul-94	2812	Ground Water	47
Peerless Lake	24-Aug-94	253	Peerless Lake	54**
Fairview	18-Jul-94	3281	Peace River	61
Peace River	21-Jul-94	6696	Peace River	65
Fort Vermilion	29-Jun-94	823	Peace River	74
Smith	14-Jul-94	323	Athabasca River	84
Fort Chipewyan	31-Aug-94	1200	Lake Athabasca	85
Gift Lak	23-Aug-94	424	Gift Lak	88**
Slave Lake	13-Jul-94	5607	Lesser Slave Lake	107
Wandering River	9-Aug-94	43	Wandering River	141
Whitecourt	12-Jul-94	6692	Macleod River	142
Grande Cache	17-Aug-94	3842	Victor Lake	143
Westlock	23-Jun-94	4463	Pembina River	169
Desmarais	23-Aug-94	350	South Wabasca Lake	174
Manning	27-Jun-94	1144	Notikiwin River	183
High Level	28-Jun-94	2921	Footner Lake	185
Colinto	25-Jul-94	126	Ground Water	223
Tangent	20-Jul-94	60	Surface Runoff	230
Janvier	1-Sep-94	435	Christina River	269
Worsley	19-Jul-94	51	Eureka River	290
Fort McKay	30-Aug-94	267	Ells River	317

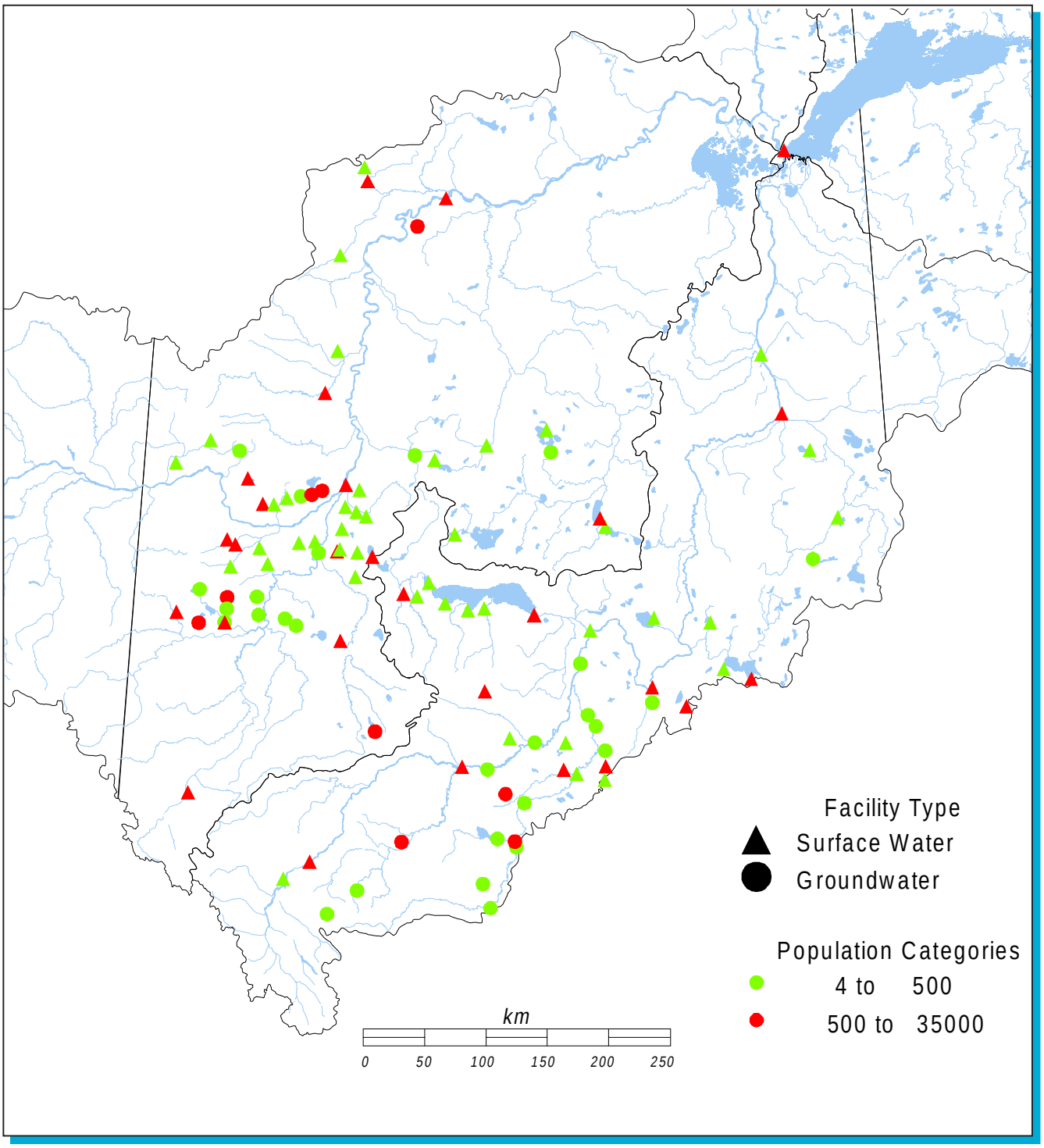
This information is taken from the Northern River Basins Study report No. 115
* population does not include people receiving trucked water
** low free chlorine residual in these samples means the levels of THMs may not be representative

As noted earlier, between 25% and 45% of the population in the basin use water from sources other than a municipal water supply. The treatment methods and problems faced by these people vary according to the source of water used. About 31% of the households in the NRBS area use ground water from wells.

Ground water use is especially important in areas with a high agricultural population. The most frequent use of ground water as a source for drinking water is reported in the Middle Athabasca, Pembina/Macleod and Wabasca regions.

Only about 30% of the households that rely on ground water use some form of treatment. The most common treatments for ground water include distillation (29%), filtration (26%), mineral removal (23%) and chlorination (10%).

Map 2 Drinking Water Facilities In The Northern River Basin



A large study of farmstead drinking water quality was conducted under the Canada-Alberta Environmentally Sustainable Agriculture Agreement (CAESA).[18] Results from the survey of 857 farm sites across the province indicated that 32% of the wells supplying drinking water to farm families exceeded the Guidelines for Canadian Drinking Water Quality maximum acceptable concentrations (MACs) and 93% exceeded one or more aesthetic objectives outlined in the Guidelines. Three percent had measurable levels of herbicides and 14% had measurable levels of coliforms.

Just over 4% of the households in the NRBS area get their drinking water from dug-outs. Dug-outs are used in 6 of the 12 regions and are the usual source of drinking water for between 10% and 30% of the households in the Peace River basin. Forty percent of the households that rely on dug-outs treat this water before using it. Common forms of treatment include filtration (33%), distillation (8%), or some type of chemical treatment (chlorine, copper sulfate) to control vegetation and bacterial growth (59%). About 15% of households using dugouts have water quantity problems. These problems include low water levels, winter freeze-up, and poor water during spring run-off. Of households that use dug-outs, nearly 44% are concerned about water quality. Problems with bad taste or smell are common (65% of concerns), and this applies to people using other unconventional water sources, as well. Problems associated with vegetation and bacteria in dug-outs are also fairly common - 29% of people expressing concerns with their water raised this as an issue.

During the pilot study conducted for CAESA, a number of farm sites obtaining drinking water from surface water sources were sampled, and the quality of that source was demonstrably poorer than ground water sources.[19] For example, 48% of the dugouts sampled had detectable levels of herbicides, and 68% were found to contain measurable levels of fecal coliforms.

Nearly 3% of households in the NRBS area draw their drinking water directly from the rivers. This practice occurs throughout the basins. River water is treated by 42% of the households using this as a source for drinking water. Treatment typically involves either filtration (55%) or boiling (45%). Only 4% of the households using river water said that they had water quantity problems, and these were related mostly to summer droughts. The quality of river water is of concern to 47% of the households that use it. In many cases (41%), the problem is a bad taste or smell, either during spring run-off (41%) or throughout the year (26%). However, 24% of quality concerns associated with use of river water are that the water has a chlorine taste. The source of this chlorine is unknown because none of these people report using chlorine to treat their water.

Only 2% of basin households draw their water from lakes. This practice is most common in the Lac la Biche portion of the basin. Over half (57%) of the respondents indicated that they use some form of water treatment, most commonly distillation (37%), filtration (31%), chlorination (19%) or boiling (17%). Less than 5% of respondents reported water quantity problems, and these were usually associated with winter freeze-up. The quality of lake water concerned 29% of households that use it. The respondents were concerned about the taste or smell of the water (49%), especially in the spring (31%). About 20% of respondents were concerned about algae growth or microbial or bacterial contamination of lake water.

Air

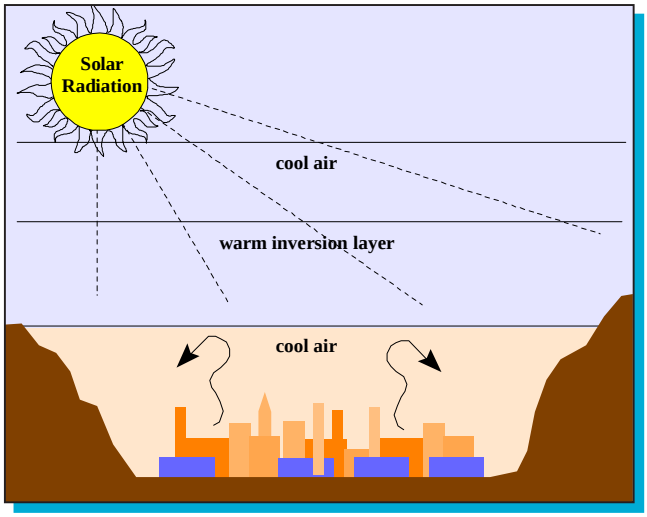
The air is another major pathway (or source of transportation) of contaminants. The amount of contaminant to which an individual might be exposed is a function of a variety of factors, including the amount of emissions that each local industry is licensed to produce, the local weather

patterns, and the topography of the area (the hills, valleys, trees, and other natural obstacles that force the wind to precipitate its load).

Climate, Weather And Pollution

The climate and weather have an effect on the direction and dispersion of the contaminants that are put into the air by human industry. Wind speed and direction, temperature, turbulence, and solar radiation all have an effect on where air pollutants go, the amount of area over which pollutants are spread, and what the concentration is at ground level.

Figure 1 Temperature Inversion



Wind is movement of the air caused by changes of pressure and temperature in the atmosphere. Wind direction will indicate the trajectory, or path, of air pollutants from source to receptor. Wind speed and distance from the source will determine the time it will take pollutants to travel from source to receptor. At high wind speeds, the air will contain more mechanical turbulence and, therefore will enable more rapid dispersion of air pollutants released near ground level. However, air pollutants emitted by elevated stack sources may actually transport more rapidly to the ground during high wind speeds and, therefore, lead to higher ground level pollutant concentrations. At low wind speeds, pollutants emitted from sources near ground level, such as vehicle exhaust, will disperse at a slower rate.

Air temperature gradient also has an effect on the dispersion of air pollutants from the source. Temperature inversions, when the temperature close to the ground is colder than the air above, limit the height that plumes from emission sources can reach (see Figure 1). Temperature inversions are common in Alberta during the winter, when radiation from the sun is minimal. Air pollutants, including vehicle exhaust, build up at ground level, and may reach high levels of concentration if the temperature inversion lasts for a long period of time.

Topography also has an impact on the local weather patterns. Small hills and trees may alter wind speed and direction while also enhancing mechanical turbulence. Larger mountains, hills and valleys may be a governing factor in the control of wind speeds and wind direction. For example, wind may be diverted around large hills and mountains and channeled through valleys. Important daily variations of wind may also be caused by terrain features. A common cause for air pollution episodes in a valley which contains numerous pollutant sources, is the occurrence of a persistent temperature inversion.

Climate Of The NRBS Area

Terrain differences greatly influence climate variations throughout the Northern River Basins. The area consists of river valleys, sloping uplands and mountains. The Caribou and Birch Mountains rise about 600 metres above the surrounding area, while the areas in the Rocky Mountains rise to over 2,000 metres. These terrain variations result in microclimates which may only be representative of a small area.

Drainage areas within the mountainous regions of the Study area will generally receive less precipitation than higher elevations. Although

temperature will not vary as much as precipitation over a given area or elevation, in winter, low lying valleys will have colder temperatures than higher elevations, due to radiative cooling. During summer, low lying valleys can have warmer temperatures than the surrounding higher elevations.

Table 2 Climate In The NRBS

Temperature	Mid latitude, polar
Annual Precipitation	Between >25 cm to 100 cm
Precipitation/Evaporation	Semi-arid
Natural Vegetation	Boreal forest, mountains and foothills, parkland, subarctic
Air-mass meteorology	Continenta

The Northern River Basins Study area has a continental climate with warm summers and cold winters. Continental aArctic air - dry and very stable - creates pronounced temperature inversions over the area for extended periods. Winds aloft flow into the area from the northwest although air occasionally flows from a northerly, northeasterly or easterly direction.

Westerly flows aloft bring maritime Arctic air (very unstable, clouds, and flurries) from the northern Gulf of Alaska across the mountains of British Columbia into the Northern River Basins. At the surface, areas to the lee of the mountains will experience snow conditions.

Chinook winds occasionally occur in the winter in the Northern River Basins area, although chinook conditions primarily occur in southwestern Alberta. Occasionally, westerly flows bring air with above-freezing temperatures at higher altitudes into the region where upper and lower air is mixed. As the air ascends over the Rockies, precipitation forms on the windward slopes. Dry, warm, chinook winds occur on the east side of the Rockies.

The maritime Arctic air mass is the most common air mass over the Northern River Basins during the summer. The path of low pressure systems moving across the northern Pacific is further north, resulting in weaker and few disturbances. Wet summer weather comes from showers and thundershowers caused by daytime heating or cooling aloft. Disturbances become more frequent and intense as the path of low pressure systems moving across the Pacific slips south from the summer into fall.

Convection refers to the upward lift in the air mass by daytime heating or cooling aloft. This process forms clouds which in turn develop into showers or thundershowers. Hence, a common daily cycle over the Northern River Basins is clear morning skies developing into midday cloudiness and showers by mid afternoon. The Northern River Basins area receives moisture throughout the year, although between 50 to 65% falls during the convective season - May to August. Fort Resolution, Uranium City, and the western half of the British Columbia section of the Northern River Basins experience less precipitation during the May to August period. July is the month of greatest average precipitation for almost all localities.

These meteorological features can result in forest fires due to lightning. A prolonged upper ridge over an area will cause high daily temperatures and low relative humidity. Due to the convection process, the forests are extremely vulnerable to fire and can be ignited by lightning. Northern forests experience the most forest fires and a high percentage of these fires occur because of lightning. The percent of fires that are ignited by lightning strikes in the Northern River Basins area range from 44.6% in the Slave Lake Forests to 81.6% across the Athabasca Forest.

Airborne Contaminants

Compared to other areas of Canada and the United States, Alberta has very clean air. Since the 1970's, federal and provincial standards for emissions have been gradually reducing the amount of emissions that can be deposited in the atmosphere. However, there are several sources of contaminants that are deposited in the atmosphere by human activities which may have an effect on the health of those people breathing the contaminated air. Contaminants that may have an effect on human and environment health can come from a variety of sources, both natural and man-made.

Natural sources, such as forest fires or the interaction between the sun and the chemical processes of decay, create contaminants with potential health effects such as ozone, toluene, dioxins and furans. Dust is another natural airborne contaminant that may cause adverse health effects.

Indoor sources of natural contaminants, to which we are exposed for a much greater portion of each day, include air borne particles from cooking food, moisture from humidifiers, chemicals used for cleaning and hobbies, and the dust and dander from our own bodies and those of our pets. In addition, tobacco smoking and fireplaces are important sources of indoor air pollution.

Man-made sources of contaminants come from agricultural and industrial activity, and from daily human activities, such as house cleaning, home heating, smoking, using personal care products such as deodorant or hair spray, hobbies, gardening and driving to the local store for groceries. In addition, man-made contaminants generated from indoor sources come from the gradual disintegration of the materials that were used in the construction of the home and the furniture.

Whether the source of the contaminant is natural or man-made, airborne contaminants can cause a number of adverse health effects. Respiratory diseases such as asthma, emphysema, and pulmonary fibrosis are all affected by breathing contaminant in the air. Normally, the human body can filter out most of the dust and other chemical contaminants in the air, so that the lung tissue can remain unobstructed. The body's natural mechanisms are able to filter the small amounts naturally found in the environment, and occasional exposure to large amounts do not normally cause any damage. Some occupations (e.g. bakers) and some lifestyle habits (e.g. smoking) may lead to exposure to very large amounts of contaminants that the body is unable to filter out, and damage to the respiratory tract is the resulting health outcome.

One of the most important sources of exposure to airborne contaminants is primarily self-inflicted, or inflicted by those around us: cigarette smoke. According to a recent report[20], 25% of the population in Alberta aged 15 years and older reported that they smoke cigarettes either daily or occasionally, and the proportion is even higher among the Metis and First Nations populations: 59% of Metis and 58% of other Aboriginal people reported that they smoke cigarettes either daily or occasionally.

Most of the air quality monitoring that takes place in Alberta is conducted close to the source. Alberta Environmental Protection is responsible for licensing industries, and controlling the amount of emissions that each source is allowed to produce. Estimates of the amount of emissions for the province by industry sector are included in Appendix B. The estimates are calculated by Environment Canada and attempt to quantify the amount of emissions from vehicles and non-licensed sources, as well as licensed amounts.

The largest amount of airborne pollutants comes from cars and trucks, electric power generation, upstream oil and gas operations, oil sands processing, and natural gas processing. The pulp and paper industry is a comparatively low contributor to airborne pollution. Although information was available at the provincial level, it was not available at the level of detail required to support analysis of the potential health impacts of airborne contaminants.

A number of contaminants are routinely monitored in the ambient air by Alberta Environmental Protection, including carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_x, NO, NO_2), ozone (O_3), total hydrocarbons (THC), coefficient of haze (COH), total suspended particulates (TSP), benzo(a)pyrene (BaP), volatile organic compounds (VOC_s), particulate matter less than 10 microns in diameter (PM_{10}), sulfur dioxide (SO_2) and hydrogen sulphide (H_2S). Ambient stations are located in populated areas to determine population exposure to the chemicals. However, the ambient stations do not all measure all the above contaminants; only a selection of contaminants are monitored at any given site.[21]

A description of some of these contaminants, the guidelines for maximum allowable concentrations, used by Alberta Environmental Protection and the health implications from prolonged exposure are included below[22]:

CO: Carbon monoxide is a colorless, odorless gas that results from incomplete burning of fuel. The majority of carbon monoxide in the air comes from vehicle exhaust. Some types of industry also produce CO, as do forest and man-made fires. Although the amount of atmospheric CO produced by gas furnaces is very small, these are a major source of poisoning in homes where the furnace is not functioning properly. CO quickly reacts in the atmosphere with oxygen to become carbon dioxide or is reduced to methane by microorganisms. The stable weather patterns and low wind speeds typical during Alberta winters can result in an increase in the concentration of CO. Maximum permissible CO concentrations are:

- < 13.0 ppm as a one hour average concentration; and
- < 5.0 ppm as an eight hour average concentration.

Those at greatest risk from the negative health effects of CO are firefighters, those people who work in poorly ventilated areas where they are exposed to combustion fumes, and people who have malfunctioning furnaces or fireplaces. The effects of severe CO poisoning include heart problems such as myocardial infarction, and neurologic and psychiatric deterioration with symptoms such as Parkinsonism, memory impairment, and cognitive functioning deficits. CO poisoning frequently occurs with smoke inhalation.

NO_x: Oxides of nitrogen are primarily composed of NO_2 and NO that result from burning products such as natural gas, coal, oil and gas at very high temperatures. NO_2 is formed when NO combines with oxygen in the atmosphere. NO_2 is a reddish brown gas with a pungent odor, frequently visible as a brown haze hanging over large cities. NO_2 is primarily formed from the oxidation of NO, which is emitted during high temperature combustion of fuels. Maximum permissible NO_2 concentrations are:

- <0.21 ppm as a one hour average concentration;
- <0.11 ppm as a twenty-four hour average concentration; and
- <0.03 ppm as an annual average concentration.

NO_2 is not readily soluble in water, which means that it is not filtered by the upper respiratory tract, and can penetrate deep into the lungs where it can cause injury to the lung tissue. Inhalation of large amounts of NO_2 can also lead to methemoglobin.

THC: Total hydrocarbons refers to a group of chemicals that come from a variety of sources, both natural and man-made. Natural sources of hydrocarbons include trees, vegetation, and decaying plant or animal material. Man-made sources include motor vehicles, the petroleum and chemical industries, drycleaners, and gas fireplaces. There are no ambient air quality guidelines for hydrocarbons. Normal background levels of THC range from 1.5 to 2.0 ppm. Hydrocarbons can react with nitrogen oxides in the presence of sunlight to form ozone.

O_3: Ozone is a chemical that is found in various concentrations at all levels of the atmosphere. Most people are familiar with the term ozone and the effect it has in protecting us from harmful radiation from the sun. However, few people are as familiar with the effects of ozone at ground level. At ground level, a reaction between solar UV radiation, volatile organic compounds and O_2 produces a new compound called ozone (O_3) that is very unstable. Contact with almost any other molecule can cause an ozone molecule to release the third oxygen atom, returning it to the more stable molecule O_2. Because of the reaction between nitric oxide emitted in vehicle exhaust with background ozone that produces NO_2 and O_2, concentrations of ozone at urban locations are generally lower than those at rural locations. Maximum permissible O_3 concentrations are:

- <0.082 ppm as a one hour average concentration; and
- <0.025 ppm as a twenty-four hour average concentration.

Although ozone is a naturally occurring substance, it can cause an irritation to mucous membranes that are exposed to large concentrations. People who are exposed to large amounts of ozone may also experience lung or eye irritation.

COH: The coefficient of haze is a measure of the amount of dust and smoke in the atmosphere. The particles may be from dust or smoke and may come from car exhaust, industrial emissions, wind-blown soil, smoke from fireplaces, forest fires or camp fires, and agricultural activities. Maximum permissible COH is defined as:

- <90% of the COH readings per month shall be less than 1.0 COH unit.

The particles that interfere with vision can also affect breathing and may even damage the lung tissue.

SO_2: Sulfur dioxide is a heavy colorless gas with a pungent odor. SO_2 has been designated as a major atmospheric pollutant around the globe. Combustion of fossil fuels, kraft and sulfite wood pulp processing, and sour gas processing are all sources of SO_2. Maximum permissible SO_2 concentrations are:

- <0.17 ppm as a one hour average concentration;
- <0.06 ppm as a twenty-four hour average concentration; and
- <0.01 ppm as an annual average concentration.

On contact with water, sulfur dioxide forms sulfurous acid, which can burn the eyes, mucous membranes and skin of anyone in contact with it. Long term exposure to elevated levels of SO_2 (concentrations over 20 ppm) can cause chronic bronchitis and other forms of chronic obstructive pulmonary disease.

H_2S: Hydrogen sulphide is a colorless gas that smells strongly of rotten eggs. H_2S occurs naturally in coal, natural gas, swamps, marshes, and sewers. The smell in swamps, marshes and sewers comes from decomposing bacteria that contain sulfur; as the dead bacteria decomposes, the sulfur in the bacteria reacts with the water to form H_2S. Industries contributing to atmospheric H_2S include the petroleum refining industry, natural gas plants, coke oven plants, and pulp and paper mills using the kraft process. Maximum permissible H_2S concentrations are:

- <0.010 ppm as a one hour average concentration; and
- <0.003 ppm as a twenty-four hour average concentration.

Exposure to small concentrations has little effect on the human body, although long term exposure to moderate amounts (below 50 ppm) may cause a form of poisoning. Exposure to large concentrations of H_2S can cause eye irritation and respiratory tract irritation, olfactory nerve paralysis, and high concentrations can cause dizziness and central nervous system damage.

Fort McMurray and Fort McKay both have continuous monitoring stations. The Fort McMurray monitoring station monitors CO, NO_x, NO, NO_2, O_3, THC, COH, SO_2 and H_2S. The monitoring station at Fort McKay only monitors SO_2, H_2S and THC. The concentrations of the individual contaminants are summarized on a monthly basis.

Fort McMurray:
The wind directions recorded most frequently at the Fort McMurray monitoring station in 1993 were southeast to south-southeast (28% of the time) and north (14% of the time). This reflects the local topography and the location of the monitoring station, which is at the confluence of two large rivers, the Athabasca and the Clearwater. The winds were calm for over 10% of the year. The maximum one-hour value for CO was not exceeded in either 1993 or 1994. The annual average concentration of CO in 1994 was 0.40 ppm. The guideline for COH was also not exceeded; the annual average in 1994 was only 0.11 COH units. The one-hour guideline for NO_2 was exceeded once during 1994, and was attributed to construction near the monitoring station. The 24-hour guideline for SO_2 was exceeded once in 1994. The average annual SO_2 concentration was 0.003 ppm. The H_2S guidelines were exceeded in 1994 for both one-hour concentrations (5 hours) and 24-hour concentrations (once). The oil sands plants were responsible for the high concentrations of both SO_2 and H_2S. Concentrations of total hydrocarbons were also high in 1994: the average hydrocarbon concentration in Fort McMurray in 1994 was 2.2 ppm, an increase from the average of the previous 10-year period of 1.9 ppm.

Fort McKay:
The wind directions recorded most frequently at the Fort McKay monitoring station in 1993 were from the north to northeast (35% of the time) and south to southwest (22% of the time). The winds were calm for over 11% of the year. The one-hour guideline for SO_2 was exceeded twice in 1994; the average annual concentration was 0.004 ppm. The H_2S guidelines were not exceeded in 1994. The average annual concentration of hydrocarbons was 1.7 ppm, lower than the average for the previous 7 years.

Until 1995, tri-monthly monitoring stations were located at Bigstone, Blue Ridge, Edson, Kaybob, Kaybob south, Mayerthorpe, Simonette, Valleyview, and Windfall. These stations monitored total sulfation and hydrogen sulphide (H_2S). The guidelines for H_2S and total sulphation were not exceeded at any of these stations during 1994.

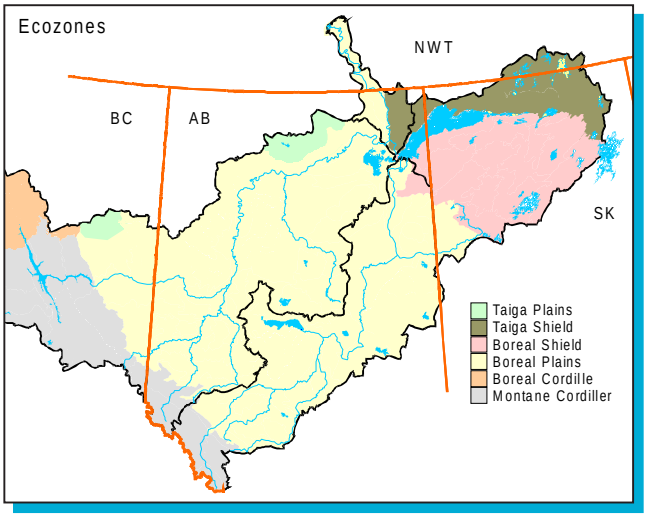
A number of monitoring stations have been added in the NRBS area, and the list of contaminants and frequency of measurement has been expanded to support ongoing evaluation of air quality and health effects.

Soil

The types of vegetation and soil can be classified into different regions called ecozones.[23] The Northern River Basins region is primarily classified as boreal forest. Map 3 shows the difference ecozones of the province.

Boreal - Mixedwood
This is the most widespread ecozone within the Northern River Basin area. The Boreal Mixedwood ecozone extends over a variety of landforms and topography. The vegetation consists of aspen and balsam poplar, with some white spruce and balsam fir.

Map 3 Ecozones Of The NRBS Area



Boreal - Foothills
The ecoregion occurs at higher elevation than the Boreal-Mixed Wood ecoregion. It is a transitional zone, containing a wide range of trees: aspen, balsam poplar, paper birch, lodgepole pine, white spruce, black spruce and fir.

Boreal - Uplands
This region occurs primarily along the Rocky Mountains, and in the Swan and Clear Hills. The topography associated with this area is both mountains and foothills. White and black spruce are the dominate vegetation.

Boreal - Subarctic
The Cameron Hills, Caribou Mountains, and Buffalo Heads comprises the Boreal Subarctic Ecoregion. This area is distinguished by the presence of discontinuous permafrost and a sparse overstory. Widely spaced black spruce and moss ground cover are common.

Boreal - Northland
This region is located in the northern extreme of the Boreal climate zone. Small sections are found at the upper elevations of the Buffalo Head Hills and Birch Mountains. Mixed deciduous and coniferous forest dominate moderately well drained sites, while black spruce is found in poorly drained sites.

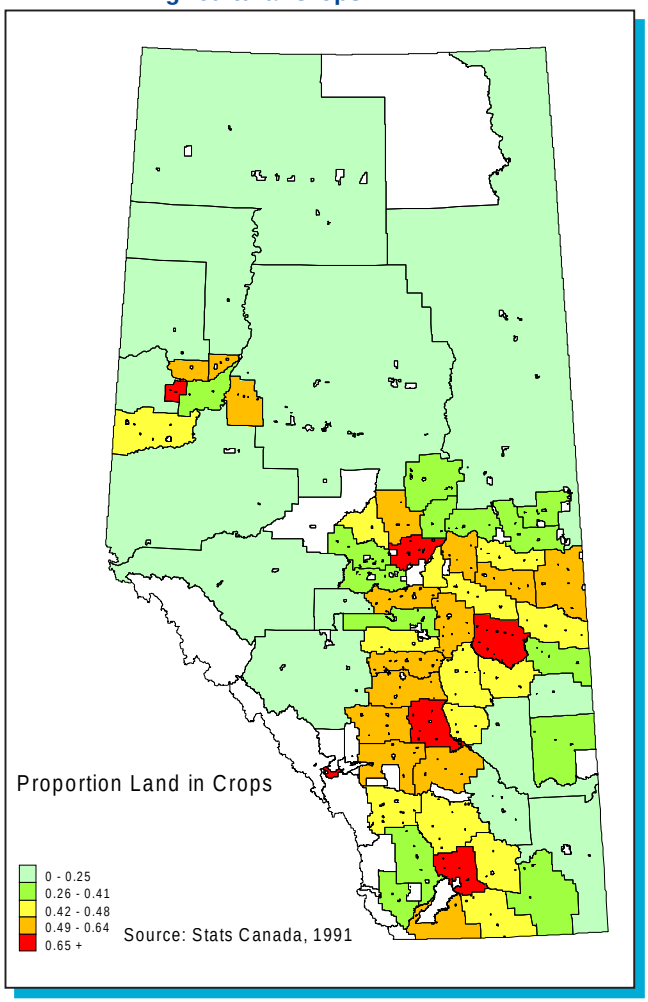
Human Uses Of The Soil--Agriculture

One of the most important economic forces in the province is farming. Map 4 shows the proportion of land used for crops in 1991. As one might expect, the majority of agricultural activity occurs in the south-central areas of the province, where the climate and soil are best suited for that type of activity. Compared to the other areas of the province, very little of the land in the NRBS area is cultivated.

There are two major areas where agricultural activities take place within the Northern River Basins Study area. The first is found in the northwest portion of Alberta. Encompassing the most northerly agricultural lands in Canada, this area includes the Peace River country and stretches from Grande Prairie and Valleyview to Fort Vermilion. Crops in this area include oats,

fescue, wheat, canola, peas, barley, tame hay, alfalfa, timothy, clover, and beekeeping. Livestock farming, such as cattle, bison, elk, and some sheep are in limited production.

Map 4 Percentage Of Land In Use For Agricultural Crops



The second area, the central zone, includes agricultural lands along the Pembina River basin to Lac La Biche River. Barley, canola, peas, oats and forage crops dominate this area, although some wheat is grown. Beef cattle, with some hogs, elk and bison are raised here.

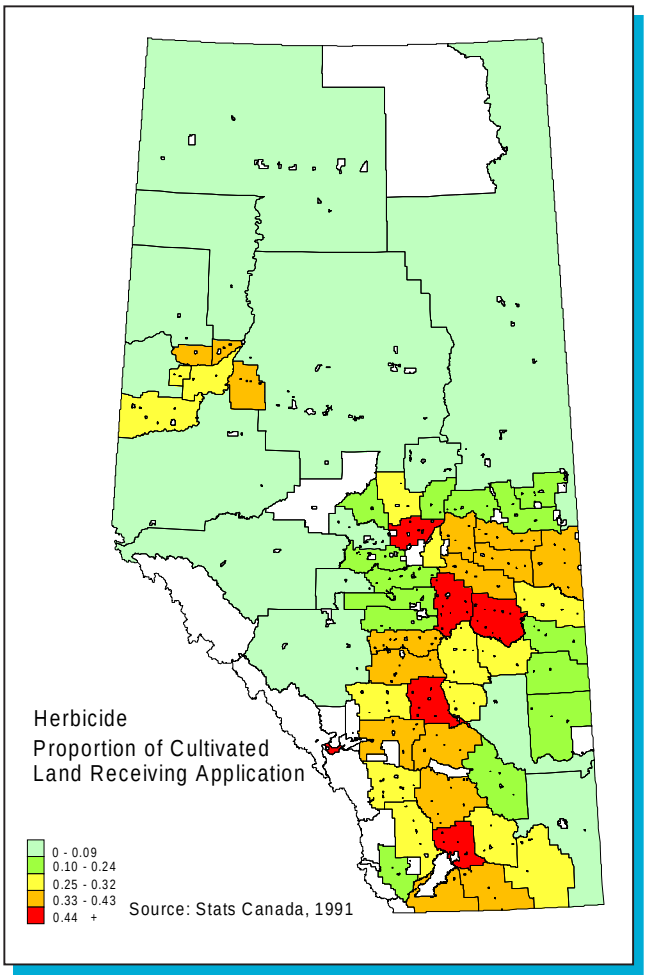
The quality of soil, combined with poor drainage, limits agricultural expansion. Nearly all of the economically viable agricultural land in the basin is in use. Agricultural activities in the Northern River Basins area present two environmental concerns: 1) soil erosion and 2) agricultural runoff in the form of chemicals and sediments. The soils native to this region, called solonetz and luvisol, are naturally susceptible to erosion. Farming practices, such as land clearing and drainage, can expose the soil to the erosive forces of water and wind. Pesticides, herbicides, soils and nutrients can enter the local water as a result of water erosion. Furthermore, the practice of summer-fallowing, where the soil is tilled and left uncultivated, can also promote erosion.

The application intensity of fertilizers and herbicides follows a similar pattern to the intensity of agricultural crops in the basin - application rates are higher in the crop-growing areas. The two regions described above have larger application rates than other surrounding areas. The impact of these farming practices in the Peace River country affects mostly the waters of the Smoky-Wapiti systems, and therefore the Peace River itself. The effect of farming in the central region is felt in the Pembina and Athabasca systems and parts of the McLeod River basin.

Farm use of herbicides and pesticides varies by farm type. About 85% of grain and oilseed farms use herbicides and pesticides. These chemicals are also used by 60% of mixed farms. Round-Up, MCPA Amine, Poast, Lontrel and 2,4-D are the most common brands of herbicides used. According to Alberta Agriculture, Food and Rural Development, farmers in the region apply these herbicides at rates equal to, or just below, the recommended rates.[24]

The use of herbicides and pesticides is greatest in those regions where grain and oilseed farms are predominant, such as the Upper and Middle Peace regions. Map 5 shows the rate of application of herbicides across the province by CSD, and Map 6 shows the rate of application of insecticides and fungicides across the province by CSD.

Map 5 Herbicide Application Rates

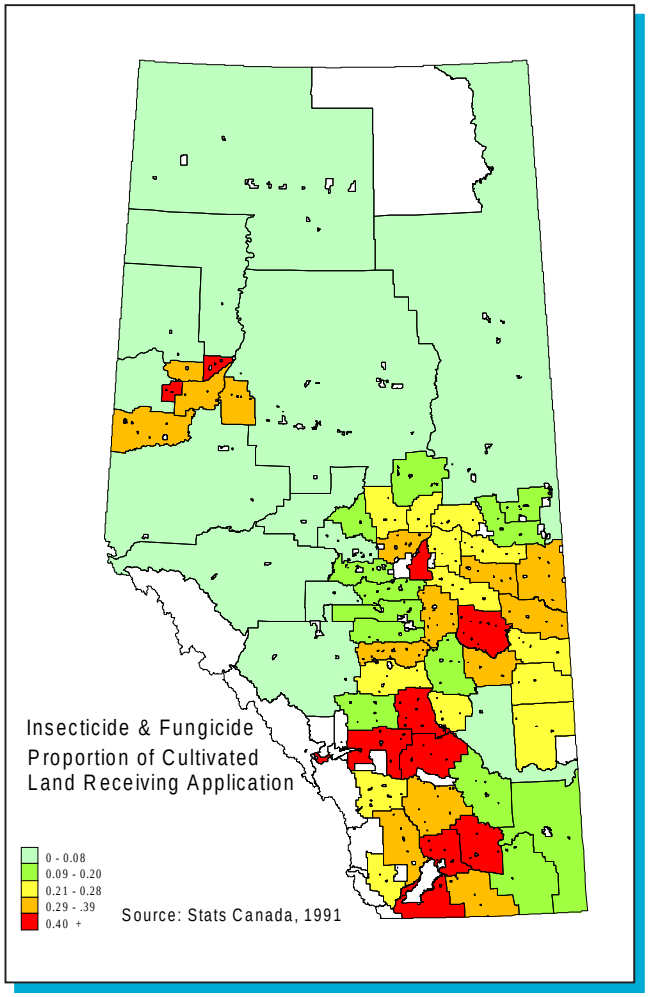


The majority of farms (56%) use fertilizers. The greatest use of fertilizer is reported in the upper Peace River region and on grain and oilseed farms. In nearly half of the cases, farmers report using a general nitrogen-based fertilizer. Survey respondents also identified 27 different types of fertilizers, with the most common being combinations of nitrogen, phosphorous, potassium and sulfur in blends (based on proportions) of 27-14-0-0, 11-52-0-0 and 82-0-0-0 (anhydrous ammonia)

Livestock farms use three different methods for disposing of manure. About 85% of mixed and livestock farms spread their manure back on to their fields. Composting of manure is the most popular manure disposal practice on grain and oilseed farms, but is relatively unusual on other types of farms. The third method of manure disposal is to sell it. This is reported by only two to three percent of mixed and livestock farms.

Over the next decade, the status of agriculture in the northern river basins is not expected to change dramatically. A review of recent trends suggests that the amount of farmland in the basins is not expected to grow by more than five percent.[25] Furthermore, there may be a shift toward increased cattle production, due to changing world markets and changes in grain transportation subsidies (elimination of the Crow Rate). It is expected that fertilizer use may increase in the future, depending on grain prices, but farmers are becoming increasingly sensitive to the environmental effects of their activities. Compared to the rest of the province, the application of fertilizers, manure and commercial products is relatively low in the Northern River Basins area. County 24 (Vermilion River) and County 29 (Flagstaff) display the greatest use per area of fertilizers in Alberta. The quantity of nitrogen and phosphorus from manure is the greatest the County 26 (Lethbridge), followed by County 23 (Red Deer). The application of commercial fertilizers is the greatest in the County of Strathcona (20), MDs 14 and 90, (Taber and Sturgeon respectively), and County 4 (Newell).

Map 6 Insecticide And Fungicide Application Rates



In general, the impact of fertilizers and herbicides on water quality is greater in southern Alberta than in the Northern River Basins area for two reasons: the level of agricultural activity is greater in the south, and there is a greater amount of water to dilute any chemicals that do find their way into the surface water system. The Peace/ Athabasca river systems represent a far greater flow of water than the water systems in southern Alberta, therefore the effects of agriculture on water quality are relatively smaller.

Food

The sources of the food we eat, how it was grown, and the chemicals it was treated with during growth and shipping, are important to our health. Food that is intended for public consumption (for example, food purchased in the grocery store) is required to pass tests to ensure that amounts of contaminants in the food are within acceptable guidelines. Agriculture Canada conducts periodic tests of a variety of foods, and issues warnings or, in the case of a large amount of either chemical or microbial contamination, removes the product from the shelves.

Although the products that we purchase are monitored for both chemical and microbial contaminants, the food that we obtain from other sources is not. People who eat food products that grow for their own consumption; obtained from other growers, such as food at farmer's markets; or local wild fruit, vegetables and meat are not assured of the quality of the product. If a large part of the diet is obtained from such sources, the likelihood of adverse health outcomes is increased.

Local Food Sources For The Aboriginal Population

According to the 1991 Aboriginal Peoples Survey (APS) conducted by Statistics Canada[26], 66% of the aboriginal population in Alberta obtain at least some of their daily diet, such as meat, fish and poultry, through hunting.

The Northern River Basins Study conducted a Traditional Knowledge survey of 10 native communities in the basins in Alberta and the NWT, asking what animals and vegetation are used. Over half of the residents identified meat food sources from moose, beaver, and lynx.

These were followed closely by caribou, fish, rabbit, ptarmigan, grouse, and waterfowl. Many individuals mentioned that the number of wild animals available for hunting has been declining. Some also mentioned that the appearance of some of these animals when skinned was unappetizing, although many indicated that they preferred, whenever possible, traditional foods over store-bought foods. Many respondents mentioned that the poor quality of fish meant that much of it was used as food for dogs.

The list below summarizes the foods that these communities used, according to category:

Plants and Trees:
Wild rose, wild raspberry, saskatoon berry, strawberry, low bush cranberry, high bush cranberry, choke cherry, blueberry, gooseberry, bear berry, pin cherry, labrador tea, mint, sweet grass, rat root, jack pine, birch, black spruce, and willow.

Animals:
Moose, beaver, lynx, caribou, rabbit, black bear, coyotes, mink, red fox, mule and white tail deer, weasel, wolf, bison, red squirrel, fisher, and river otter.

Birds:
Canada goose, ptarmigan, mallard, prairie chicken, grouse, teal, shoveller, and other water fowl. Some respondents also mentioned consuming mallard and coot eggs.

Fish:
Goldeye, northern pike, walleye, burbot, mountain whitefish, arctic grayling, and trout. According to the APS, 10% of the aboriginal population in Alberta do not get enough food to eat, and 41% of these respondents indicated that it happens on a regular basis.

The amount of nutrition available from local wild sources is generally higher than the amount of nutrition from an equivalent amount of food from a cultivated source. However, as concern over the quality and toxicity of the local sources increases, many people who formerly relied on local sources are turning to cultivated sources of food, and are therefore not getting the same quality of nutrition as they obtained from the local food sources. This change in diet may result in more people developing diseases associated with nutritional deficiencies.

Local Food Sources For The Non-Aboriginal Population

The NRBS area is also a popular source of wild meat for non-aboriginal hunters. Many people travel across the province, or from places outside of Alberta, to hunt animals in the NRBS area. There is no way of identifying those people who have consumed wild meat or natural vegetation from the NRBS area to determine if there is any impact on their health.

A survey of a random sample of the population in the Swan Hills and surrounding area indicated that approximately 36% of the general population eat wild game, most of whom (70%) eat wild game at least once a month. Thirty-seven percent of the general population eat locally caught fish, and 52% of people who eat wild fish eat it at least once a month. Only 23% of the general population eat both wild game and wild fish on a regular basis. Respondents in the survey indicated that the wild game eaten most frequently is moose. Respondents also indicated that they ate deer, grouse, elk, duck, goose, partridge, bear, rabbit, and muskrat. The wild fish eaten most frequently was walleye or pickerel. Respondents also indicated that they frequently ate pike, perch, trout, whitefish, and grayling.

Evaluation of samples of wild game taken from the area indicate that those people living in the Swan Hills area who don't limit their consumption of wild game according to the published guidelines may be consuming more dioxins and furans than advisable.

Human Exposure To Contaminants Through Food

Mercury

Human exposure to mercury is primarily through consumption of mercury-contaminated food. Organic mercury or methyl mercury is more toxic than inorganic mercury (metallic mercury). Organic mercury can be found naturally in the environment and comes from both natural and industrial sources.

Mercury is rapidly absorbed by the bloodstream and tends to accumulate in organs such as the liver and kidneys. The slow accumulation of mercury in the brain affects the brain's sensory, visual, auditory and coordinating function. Fetal development is also adversely affected by the accumulation of mercury. Physical and mental retardation, coordination, cerebral palsy, and behaviour patterns are affected by mercury. For these reasons, pregnant women and children under the age of 15 should not consume mercury-tainted fish. Health Canada and Alberta Health publish guidelines about how much fish may be eaten safely.

Dioxins and Furans

Dioxins and furans can originate from both natural and human sources, and are classified as 'toxic' to health and the environment under the Canadian Environmental Protection Act. Dioxins and furans are released into the environment by pulp and paper mills which use chlorine bleaching, combustion sources such as incinerators, burning wood and motor vehicles. Large forest fires can also deposit significant amounts of dioxins and furans into local water systems, particularly during the spring. Air, soil, and water contamination, however, are minimal contributors to human exposure to these compounds. Exposure to dioxins and furans is mainly due to consumption of contaminated food, such as fish meat, poultry, eggs, and dairy products.

It is difficult to assess the effects of dioxins and furans on humans. Many of the health concerns surrounding these compounds stem from the results of animal toxicity tests. Animals exposed to 2,3,7,8-TCDD (a dioxin), experience weight loss, skin disorders, impaired liver function, cancer and birth defects. The most consistent observation of the effects of occupational exposure in humans are skin ailments, liver and immune system impairment and behaviour changes.

In general, levels of dioxins and furans have declined substantially relative to the levels recorded in the late 1980's. The highest levels of dioxins and furans were recorded on the Athabasca, Peace, and Wapiti Rivers in 1992. A fish consumption restriction was put in place for the upper reaches of the Peace and Athabasca Rivers due to evidence of unacceptably high levels of these compounds. The advisory recommends that only the fillet portions should be eaten and the organs should be discarded.

In addition, all kraft pulp mills in Alberta must convert from elemental chlorine to chlorine dioxide (which doesn't produce dioxins and furans) by January 1, 2000. Only one mill is currently using elemental chlorine.

Demographic characteristics, such as the number of men and women in each age group, marital status or race can indicate whether the NRBS area has a population that is similar to the rest of the province or markedly different in some way. A larger percentage of women of childbearing years, for example, could account for a higher birthrate or more women diagnosed with those diseases associated with that age group.

Findings

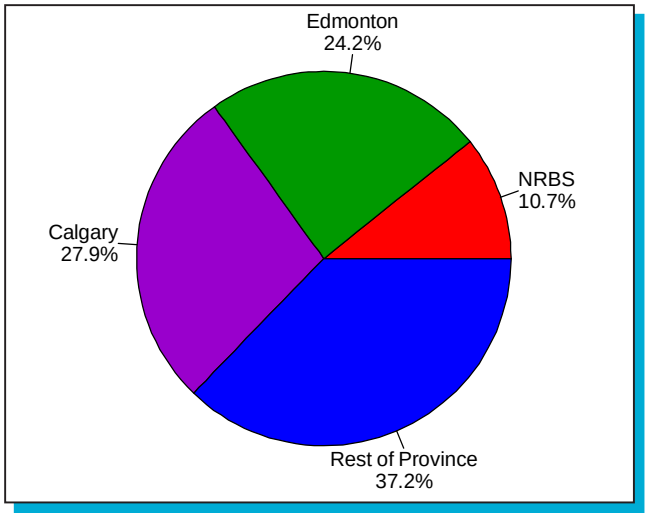
The discussion of the human environment reflects some of lifestyle factors, although the measurable indicators are of limited value. Overall, the analysis found that the population of the NRBS area is younger, has more children, and has their children at a younger age than people in other areas of Alberta.

The Northwestern and Keeweetinok Lakes Health Regions have the highest fertility rates, particularly among young mothers, as well as the most crowded living conditions. These indicators suggest that we can expect to find more frequent health problems with childbirth (complications due to the young age of the mother) and those diagnoses which are found more frequently in an aboriginal population, such as diabetes.

Population Distribution

Approximately 52% of the population of the province lives in the two largest urban centres (see Figure 2). Even in comparison with the other rural area (the rest of the province), the Northern River Basin area is very sparsely populated and accounts for only 11% of the total provincial population. Map 8 shows the Regional Health Authority boundaries, and the population size for each region. It is important to note that large expanses of the Northern River Basins area are unpopulated.

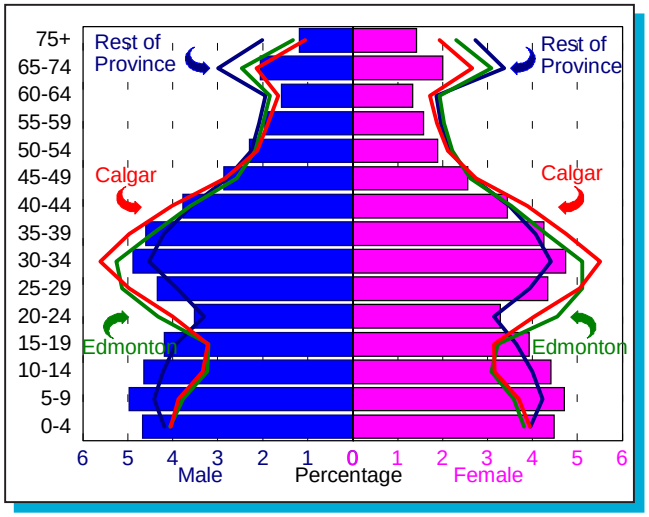
Figure 2 Population Distribution Across Areas



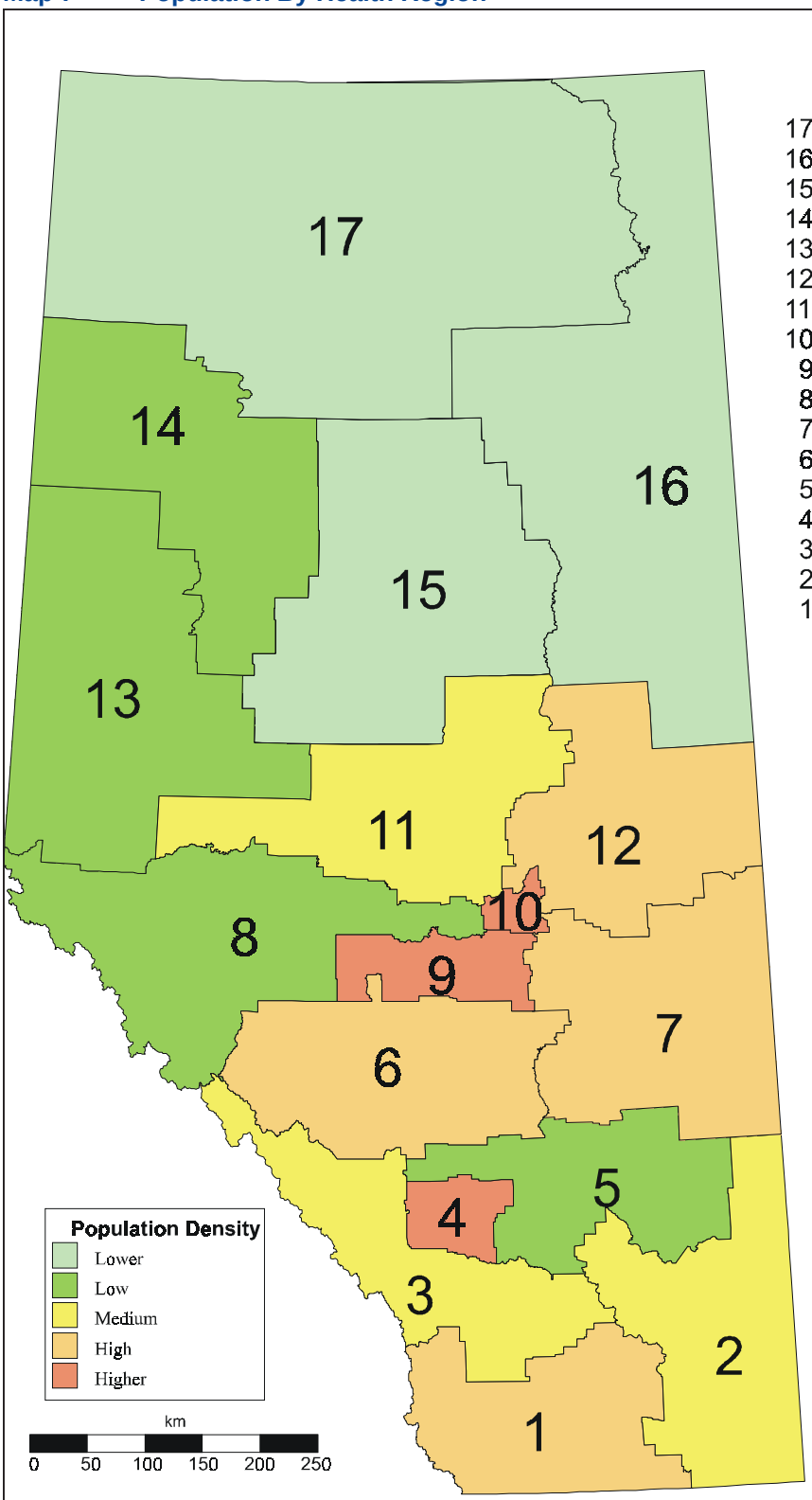
Age And Gender Distribution

Figure 3 shows the percentage of people in the NRBS area by gender and age group. Although the index of dissimilarity (7.5 for Calgary, 8.4 for Edmonton, and 6.1 for the rest of the province) indicates that the population structure in the NRBS area is similar to that in each of the other areas, larger differences exist at both younger and older age groups. More specifically, the NRBS area has a fairly large proportion in the younger age groups and a fairly small proportion in the older age groups, and hence a younger population than the other areas.

Figure 3 Age And Gender



Map 7 Population By Health Region



Health Region	Population
17. Northwestern	14,992
16. Northern Lights	37,379
15. Keeweetinok Lakes	18,726
14. Peace	20,584
13. Mistahia	77,069
12. Lakeland	100,206
11. Aspen	81,116
10. Capital	715,460
9. Crossroads	69,786
8. Westview	79,006
7. East Central	98,276
6. David Thompson	158,449
5. RHA #5	46,682
4. Calgary	754,033
3. Headwaters	58,266
2. Palliser	79,193
1. Chinook	136,330

Marital Status

Marital status has been found to have a relationship with health. Married people tend to be healthier and happier than people who are single, separated, widowed or divorced. This relationship is likely due to the social and emotional support provided by a spouse, as well as the potential financial contributions from a second income.

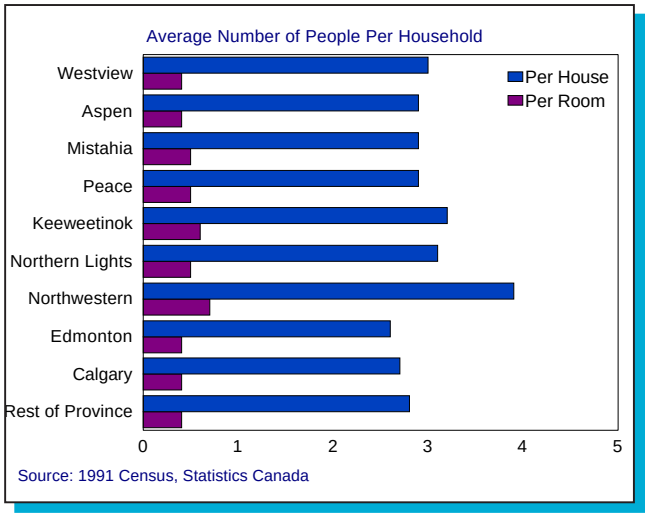
Table 3 compares marital status across areas. A larger percentage of the population in the NRBS area is married compared to the two large urban centres, but not compared to the rest of the province, which is also predominantly rural. The NRBS area also has a smaller percentage of the population who are widowed or divorced, compared to the two large urban centres.

Size Of Household

Although research has shown that social support is important to create good health, a crowded living environment can contribute to poor health through increased stress. The size of the household - that is, the average number of people living in each house, and the average number of people per room - is an indicator of poverty, and also indicates the potential health stressors from overcrowding.

Figure 4 compares the average number of people living in private households, and the average number of people per room across the Health Regions in the NRBS area with the other areas of the province. The average number of people in each house and each room is greater in the Keeweetinok Lakes and the Northwestern Health Regions. The average number of people in each household is also greater for each of the Health Regions in the NRBS area than it is in any of the other areas of the province.

Figure 4 Average Number Of People Per Household



Fertility Rate

The total fertility rate is a way of determining the average number of children that are born to the women living in the area under evaluation. Total fertility rate is calculated as the sum of the age-specific birth rates over all ages of the childbearing period (usually considered to be from age 15 to 49). Table 4 shows the total fertility rate for each of the areas of the province. The two rural areas have a higher total fertility rate than the two urban areas, and the total fertility rate is higher in the NRBS area than any other area of the province.

Table 3 Marital Status By Area

Region	Single	Married	Separated	Widowed	Divorced
NRBA	29.	58.	2.69	4.13	5.37
Edmonton	33.	50.	3.08	5.39	7.40
Calgary	31.	54.	2.77	4.46	7.37
Rest of Province	26.	60.	2.18	5.97	5.37
Alberta	29.	55.	2.66	5.13	6.51

Table 4 Total Fertility Rate By Area

Area	Total Fertility Rate
NRB	2269.5
Edmonton	1824.7
Calgary	1710.7
Rest of Province	2116.6

The age-specific fertility rate is the number of births to women of a given age group for every 1,000 women in that age group. High fertility is frequently associated with high infant mortality and maternal mortality, particularly the teenage fertility rate. The age-specific birth rate indicates whether an area has a high teenage fertility rate.

Figure 5 compares the age-specific fertility rate in the NRBS area with the other areas of the province. The rate of births to young women is highest in the NRBS area, and lower than the other areas for older women. Women living in the NRBS area tend to have children at a younger age, and complete their childbearing at a younger age, compared to women living in other areas of the province.

Figure 5 Age-Specific Fertility Rate By Area

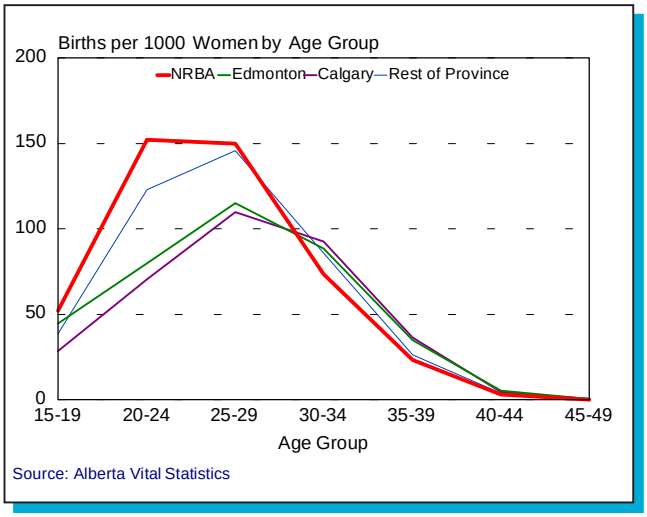
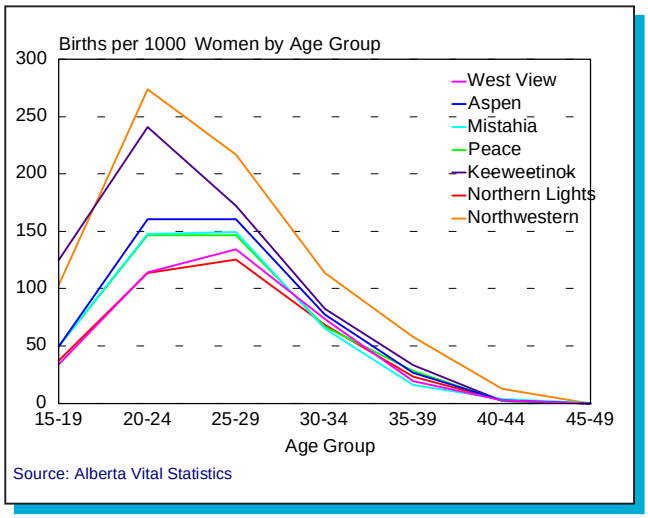


Figure 6 compares the fertility rate across the Health Regions in the NRBS area. The Northwestern Health Region has the highest fertility rate for all age groups, with the exception of the youngest age group (ages 15 to 19); Keeweetinok Health Region has the highest fertility rate for women younger than 20 and the second highest fertility rate for women in the next age group (ages 20 to 24). The Northwestern health region has the highest fertility rate and the highest teenage fertility rate, followed closely by the Keeweetinok Lakes health region.

Figure 6 Age-Specific Fertility Rate By Region

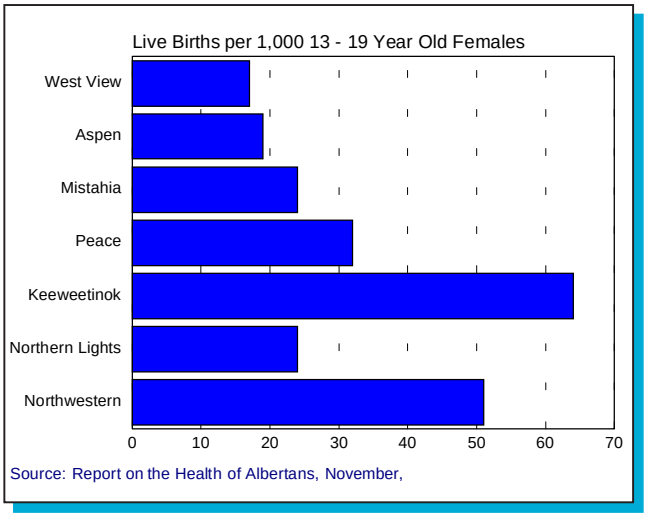


The teen birth rate is defined as the number of births to women under the age of 20 per 1000 females between the ages of 13 and 19 years. Babies born to a young mothers are typically smaller and have the health problems associated with low birth weight. In addition, teen mothers face a number of social and economic disadvantages that can have a negative impact on the health of both the mother and the baby because they are less likely to finish high school, less likely to find employment, and more likely to live in poverty.

Figure 7 compares the teen birth rate across Health Regions. The teen birth rate for the province as a whole was 20 in 1993/94. This figure can be considered the average rate for the province, and the rates for each of the regions can be compared to this average. Keeweetinok Lakes and Northwestern Health Regions have a significantly higher teen birth rate compared to

the other health regions in the NRBS area as well as to all the other health regions in the province. The difference in teen birth rate between these

Figure 7 Teen Birth Rate By Health Region

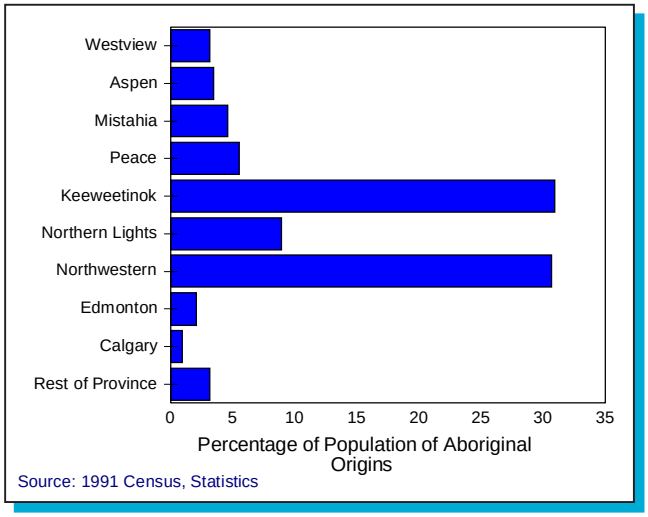


two regions and the rest of the province is an indicator of a number of potential health and social problems in these two regions, because, as we saw earlier, babies born to young mothers are more likely to be underweight, and typically begin life with physical disadvantages. Teenage mothers are also more likely to be single parents and live in poverty and therefore are less likely to be able to provide adequate care for their infants.

Race

According to the 1991 census, the percentage of the population in the NRBS area that claim single origins as aboriginal (including Inuit, Métis, and North American Indian) is very high - more than 7% - compared to the other areas of the province. Figure 8 shows the proportion of the population who have aboriginal origins for each region in the NRBS area, as well as the other areas of the province. A very high percentage of the population in both the Keeweetinok Lakes and the Northwestern health regions are of aboriginal origins. The other regions in the NRBS area also have somewhat larger proportions of the population who are of aboriginal origins than the other areas of the province.

Figure 8 Aboriginal Origin By Region



Research has shown that the socioeconomic environment can have an effect on the health of the population. The socioeconomic environment includes factors such as education, income and poverty, employment, and the number of people living in each household. People who have more education typically have a higher income, and these two measures are typically associated with better health. Two parent families also are more likely to have access to larger income than single parent families, and also benefit from the social and emotional support provided by the spouse.

Findings

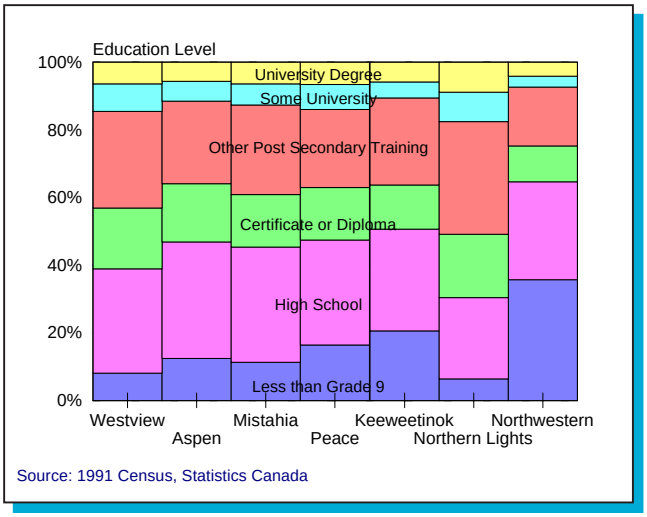
The socioeconomic environment also has a very great impact on health outcomes that is difficult to measure without detailed individual assessments. However, it is well recognized that underemployment, low education level and poverty are contributors to poor health through lifestyle factors. Two Health Regions stand out as having more socioeconomic disadvantages than other regions in the province: Northwestern and Keeweetinok Lakes Health Regions. The population in these two areas has lower education, lower income, and more unemployment. We can expect to see more of the poverty-related health problems in the population of these two regions ... such as nutritional deficiencies and the adverse effects on fetal development and greater susceptibility to diseases; and more people who smoke cigarettes and the negative effects of this behaviour on lung and cardiac health.[27]

Education

Education has a positive effect on health, by improving the likelihood of gaining employment and the work environment, by increasing income and by improving the individual's access and understanding of information about healthy lifestyles.

Figure 9 compares the level of education across the Health Regions in the NRBS area. With the exception of Northwestern and Keeweetinok Lakes Health Regions, almost half of the population in each of the Health Regions in the NRBS area have high school education. Compared to the other Health Regions in the area, fewer people in the Northwestern and Keeweetinok Lakes Health Regions have obtained education beyond grade nine. A comparatively large percentage of the population in the Northern Lights Health Region have advanced training of some form, and a very small percentage of the population of that region has less than high school education.

Figure 9 Education Level



Source: 1991 Census, Statistics Canada

Household Income And Poverty

Household income and the proportion of households with low income in a region or area reflects the ability of the individuals in the population to purchase adequate food and shelter. Lower income households are less likely to be able to maintain a healthy lifestyle.

Figure 10 compares average and median household income across the Health Regions in the NRBS area. The median income is less than

the average income in all cases, because the median income is not influenced by the extreme values and is therefore a better reflection of the actual income of most people in the area. Both median and average income in the Northern Lights Health Region is significantly greater than any of the other areas, including both of the large urban centres, and the difference between the median and the average income is not as pronounced as it is across the other regions. Westview Health Region reports the second largest median household income. The Northwestern and Keeweetinok Lakes Health Regions have the lowest average income of all areas of the province. As we saw above, the population of these two Health Regions is also generally less well educated than other Health Regions in the province.

Figure 10 Household Income By Region

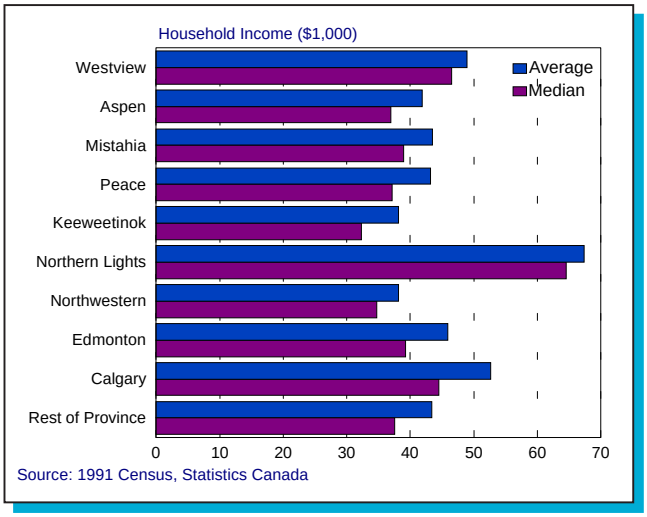
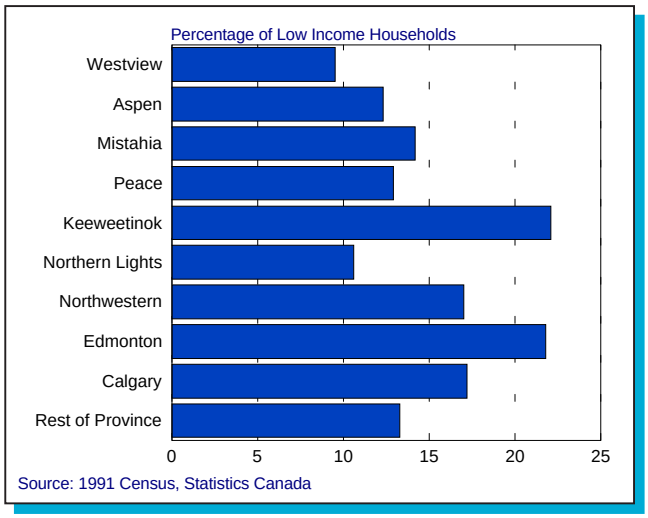


Figure 11 compares the percentage of households with low income across the Health Regions in the NRBS area with the other areas of the province. The Westview and Northern Lights Health Regions have the smallest proportion of households that report low income, and the Keeweetinok Lakes and Northwestern Health Regions have the largest proportion of households that report low income, but the percentage of households in the Northwestern Health Region is the same as Calgary, and the percentage of households in the Keeweetinok Lakes Health Region is the same as Edmonton.

Figure 11 Percentage Of Low Income Households



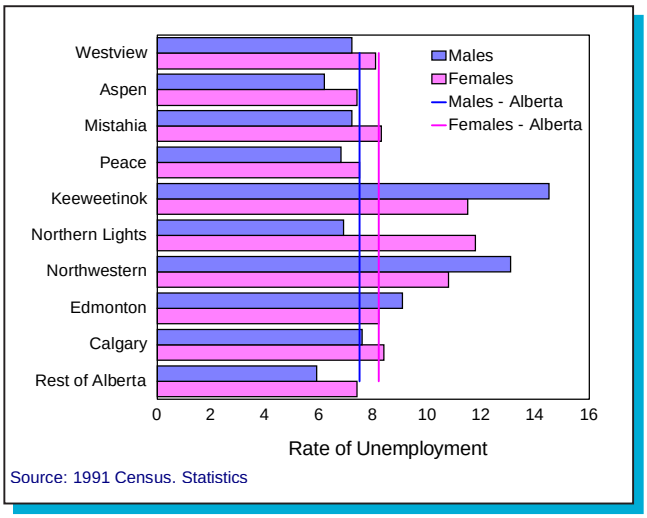
Unemployment

The rate of unemployment also reflects the ability of the individuals in the population to purchase adequate food and shelter to maintain a healthy lifestyle. A number of health complaints have been linked to unemployment, including fatigue, depression, and loss of appetite. The individual's health may also be compromised in other ways due to the lost income and reduction in social activities. Statistics Canada considers an individual unemployed if they did not have a job, but were available for work during the week preceding the census.

Figure 12 compares the rate of unemployment between males and females across the Health Regions in the NRBS area and the other areas of the province. Overall, the rate of unemployment in the NRBS area is lower than the two urban centres, but higher than the other comparable rural areas of the rest of the province. The unemployment rate for men in the NRBS area is 7.5 and the unemployment rate for women in the NRBS area is 8.6. The rate of

unemployment is very high for both men and women in the Keeweetinok Lakes and the Northwestern Health Regions, and high for women in the Northern Lights Health Region. Keeweetinok Lakes, Northwestern and Edmonton Health Regions are the only areas of the province where the unemployment rate for men exceeds the rate for women.

Figure 12 Unemployment Rate By Region



Source: 1991 Census. Statistics

Family Composition

Family composition can provide a general indicator of the socio-economic status of a family: single parent families typically have less disposable income; and couples who are in a common-law relationship are typically less likely to remain stable than are married couples, and the family is more likely to become a single parent family. In rural areas where employment typically pays less and is more scarce, single parent families are even more likely to experience health problems due poor nutrition and sub-standard living conditions than two-parent families or even single parent families in larger urban centres.

Table 5 compares family structure across areas and across regions within the NRBS area. A large percentage of the families in the Keeweetinok Lakes Health Region are headed by a single parent; only Edmonton has an equivalent concentration of single parent families. Excluding the Keeweetinok Lakes Health Region, the rest of the Health Regions in the NRBS area have a similar concentration of single parent families as the rest of the province - about 10% of the total number of families are headed by a single parent. Furthermore, a large proportion of the families in most of the regions in the NRBS area are headed by two common-law parents; Keeweetinok Lakes Health Region has the highest concentration of two parent common-law families.

Table 5 Family Composition By Region

Region	Two-Parent Family			Single-Parent Family		
	Total	Married	Common-law	Total	Male	Female
Westview	90.7	81.4	9.3	9.3	2.5	6.8
Aspen	90.9	82.3	8.6	9.0	2.2	6.8
Mistahia	88.9	78.6	10.3	11.1	2.3	8.8
Peace	89.6	79.3	10.2	10.4	2.1	8.3
Keeweetinok Lakes	83.8	64.2	19.6	16.2	3.2	13.0
Northern Lights	88.0	71.5	16.6	12.0	3.1	9.0
Northwestern	88.8	73.1	15.5	11.4	2.5	8.8
Edmonton	84.1	74.6	9.6	15.9	2.4	13.5
Calgary	87.1	77.9	9.2	12.9	2.1	10.7
Rest of Province	90.0	82.5	7.4	10.0	2.0	8.0

Dependency Ratio

The dependency ratio is a measure of the number of people who are of an employable age (that is, people between the ages of 15 and 65) compared to the number of people who require some form of financial support (that is, people younger than 15 or older than 65).

Table 6 shows the total dependency ratio, as well as the child dependency ratio and the aged dependency ratio. The child and the aged dependency ratios are the two components used to calculate the total dependency ratio.

The child dependency ratio for the province as a whole is 35. All of the Health Regions in the NRBS area have a higher child dependency ratio than the province as a whole, as well as the two large urban centres. The aged dependency ratio for the province as a whole is 13.5. With the exception of the Aspen and Peace Health Regions, all of the Health Regions in the NRBS area have a lower aged dependency ratio than the other areas of the province.

The total dependency ratio for the province as a whole is 48.5. The Northern Lights Health Region has a very low total dependency ratio compared to the provincial ratio, and the Keeweetinok Lakes and Northwestern Health Regions have higher total dependency ratios than expected.

The table also shows the index of aging which compares the number of people older than 65 with the number of children younger than 15. The index of aging can be used to compare the populations to indicate if a population is

Table 6 Dependency Ratio By Region

Region	Child Dependency Ratio	Aged Dependency Ratio	Total Dependency Ratio	Index of Aging
Westview	40.	9.2	49.	22.
Aspen	41.	14.	56.	35.
Mistahia	41.	11.	53.	26.
Peace	41.	12.	53.	31.
Keeweetinok Lake	50.	8.4	58.	16.
Northern Lights	39.	2.0	41.	5.0
Northwestern	66.	6.1	72.	9.2
Edmonton	31.	13.	44.	42.
Calgary	31.	11.	42.	35.
Rest of Province	39.	17.	56.	44.
Alberta	35.	13.	48.	38.

relatively young, intermediate or old. A population is considered young if the index of aging is under 15, intermediate if the index is between 15 and 30, and old if the index is over 30. Overall, the index of aging for Alberta indicates that Alberta has an old population.

Only the Aspen and Peace Health Regions have comparably high indices of aging. Most of the regions in the NRBS area have an intermediate-aged population, but the Northern Lights and Northwestern Health Regions have quite young populations.

Population health indicators are used to show the general health status of the population and are typically used to compare the populations of large areas. The health indicators discussed below are standard measures and are consistent with those used by the World Health Organization.

Findings

The total fertility rate is high in the NRBS, compared to the other areas of the province, and age-specific fertility was highest among young women in the NRBS areas. Because more babies born in the NRBS area are born to younger mothers, and because there are a number of additional health problems typically associated with these babies, we can expect higher rates of infant mortality, low birth weight, complications associated with childbirth, and congenital anomalies, particularly in the Keeweetinok Lakes, Northwestern and Peace health regions.

General Health Status

Respondents to the 1996 Population Health Survey were asked to rate their overall health, compared with other people their own age. Figure 13 compares the responses from the entire sample across areas. Overall, most Albertans rate their health as very good or excellent, and this is fairly consistent across areas. Slightly fewer respondents in the two rural areas (the NRBS area and the rest of the province) rated their health as excellent compared to the urban populations, but slightly more respondents in the two rural areas rated their health as very good or good. About the same percentage of the population in each area rated their health as poor. Differences in self-rated health are likely due to differences in perception between rural and urban populations, rather than reflecting any real difference in the health of these populations.

Figure 13 Self-Reported Health Status

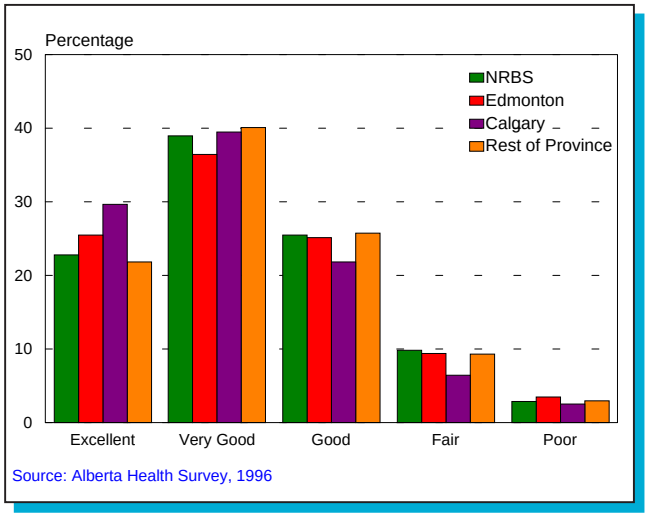
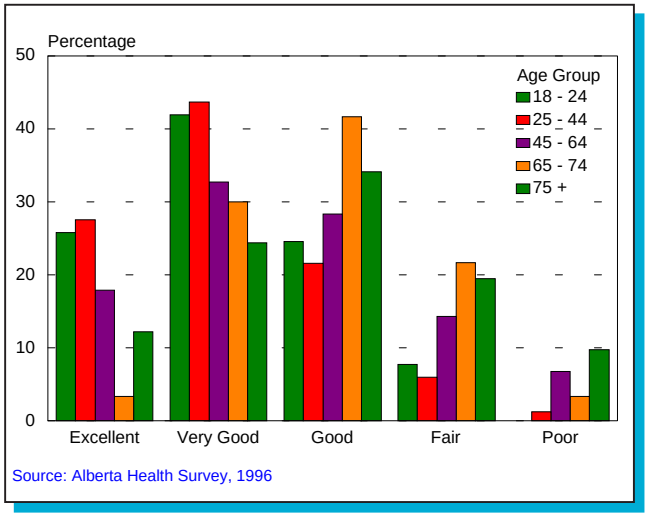


Figure 14 compares the responses from the respondents in the NRBS area by age group. Overall, most young respondents reported their health as excellent or very good, and very few reported poor health. Older respondents were more likely to rate their health lower - good, fair or poor - than were younger respondents. The difference in reporting self-rated health status across age groups is consistent with the responses from the other areas of the province.

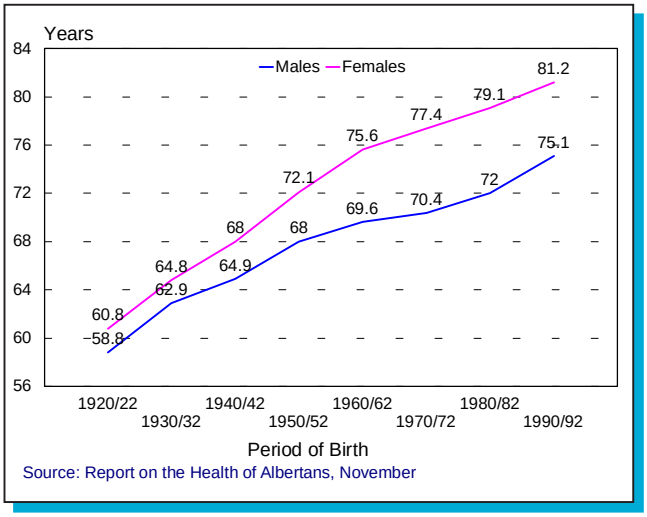
Figure 14 Self-Reported Health Status In NRBS Area



Life Expectancy

Life expectancy is an internationally recognized indicator of general population health because it reflects the ability of the country's health care system to overcome preventable deaths. Life expectancy in developing countries is affected primarily by infant mortality, but infant mortality no longer plays as great a role in developed countries like Canada.

Figure 15 Life Expectancy In Alberta By Year



Source: Report on the Health of Albertans, November

Life expectancy is typically greater for women than it is for men. Furthermore, people who are wealthy and people who are married can expect to live longer than people who are poor and people who are not married. Albertans have one of the highest life expectancies in Canada and in the world. Over the past century, the life expectancy has increased steadily (see Figure 15), primarily due to improvements in infant health and reductions in infant mortality. A girl born in 1922 could expect to live to the age of 61, and a boy born in 1922 could only expect to live to be 59 year of age. A girl born in 1992 can expect to live to the age of 81, and a boy born in 1992 can expect to live to be 75.

Table 7 compares life expectancy at birth across the health regions in the NRBS area with the other areas of the province. The life expectancy at birth is slightly lower for the NRBS area than it is for the other areas of the province.[28]

Table 7 Life Expectancy At Birth By Gender, 1998-1993

Region	Female	Male	Total
NRBS	80.67	74.38	77.25
Edmonton	81.32	74.76	78.08
Calgary	81.70	76.15	79.04
Rest of Province	81.01	74.79	77.75
Alberta	81.27	75.13	78.15

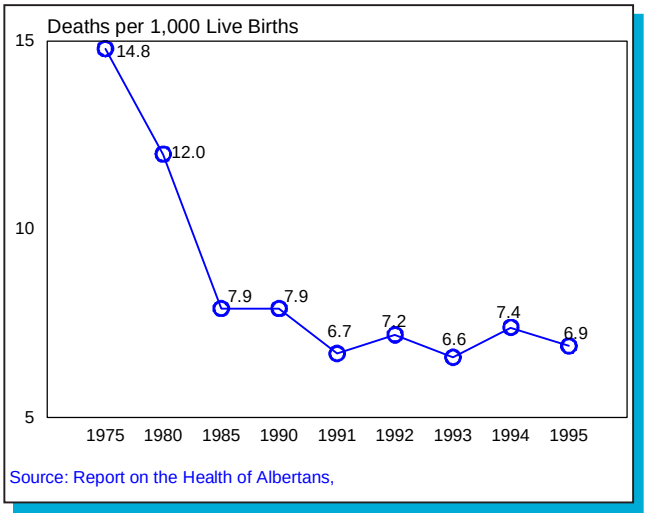
Infant Mortality

Infant mortality is frequently used as an internationally comparable measure of population health. Infant mortality is affected by prenatal care, the mother's health, the social environment, the natural environment, and the ability of the health care system to deal with problems that arise during that first year, such as birth complications, congenital anomalies, or childhood disease.

Figure 16 presents an historical perspective of the decrease in infant mortality rates in Alberta. There was a fairly drastic decline in infant mortality during the ten year period between 1975 and 1985. Since that time, infant mortality in Alberta has remained relatively stable at around 7 deaths per thousand live births. This means that, of the 38,523 babies born in Alberta in 1995, 266 babies died before their first birthday.

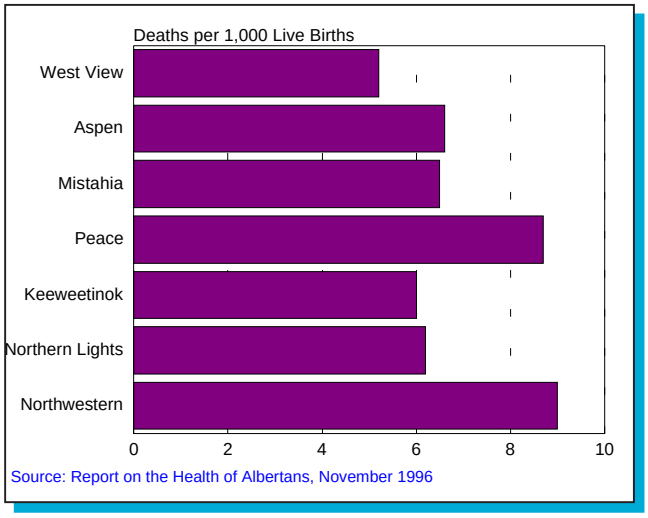
The infant mortality rate in Alberta is still slightly higher than it is for Canada as a whole - the infant mortality rate for Canada was only 6.3 in 1993, low compared to Alberta's rate of 6.6 for that year.

Figure 16 Infant Mortality In Alberta



Source: Report on the Health of Albertans,

Figure 17 Infant Mortality By Region



Source: Report on the Health of Albertans, November 1996

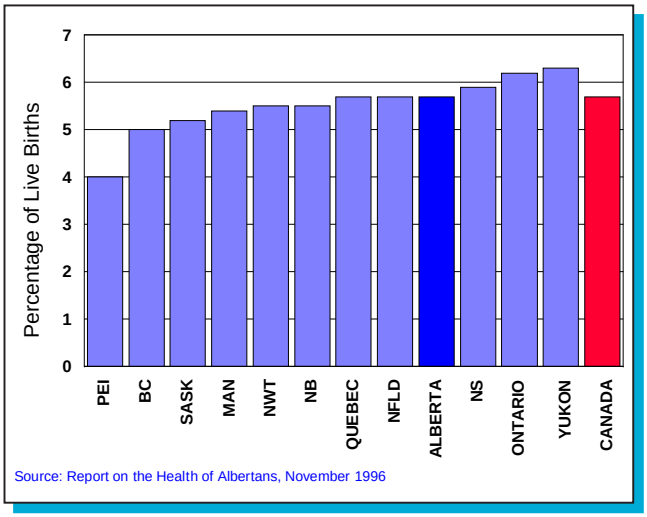
Figure 17 shows the infant mortality rates for each of the health regions in the NRBS area. Despite the high birth rate in the Keeweetinok Lakes region that we saw above, that region does not have a correspondingly high infant mortality rate, and in fact, has one of the lowest rates of infant mortality in the province, second only to the Westview health region. The two regions with a high infant mortality rate are the Northwestern and the Peace health regions. Only two other health regions in the province - the David Thompson and Health Authority 5 regions - had a higher infant mortality rate than the Northwestern and Peace health regions. The infant mortality rates of the other regions in the NRBS area were about the same as the provincial figure.

Low Birth Weight

Birth weight is another indicator that measures the health of the newborn. Babies who have a very low weight at birth are more likely to have complications related to the birth, developmental delays, and other long term health problems, and are more likely to die at an early age. Low birth weight is defined as weighing under 2500 grams or 5.5 pounds, and very low birth weight is defined as under 1500 grams or 3.5 pounds. The average weight of all girl babies born in Alberta in 1994 was 3,318 grams, and the average weight of boy babies born in Alberta that year was 3,426 grams. Compared to the other provinces and Canada as a whole, Alberta has a high percentage of low weight births. Six percent of the babies born in 1993 weighed less than 2,500 grams, and .9% weighed less than 1,500 grams at birth. Calgary, Capital, David Thompson and Westview Health Regions had the largest proportions of low birth weight babies.[29]

Figure 18 compares the low birth weight rates for Alberta with the other provinces and Canada as a whole for 1993. The rate of low weight births is calculated as a percentage of the total number of live births. The rate of low weight births in Alberta was typical of the rest of Canada, with the exception of Prince Edward Island, where the low weight birth rate was only 4% of all live births. A total of 2,231 newborn babies (5.7% of all babies born in Alberta that year) weighed less than 2,500 grams at birth.

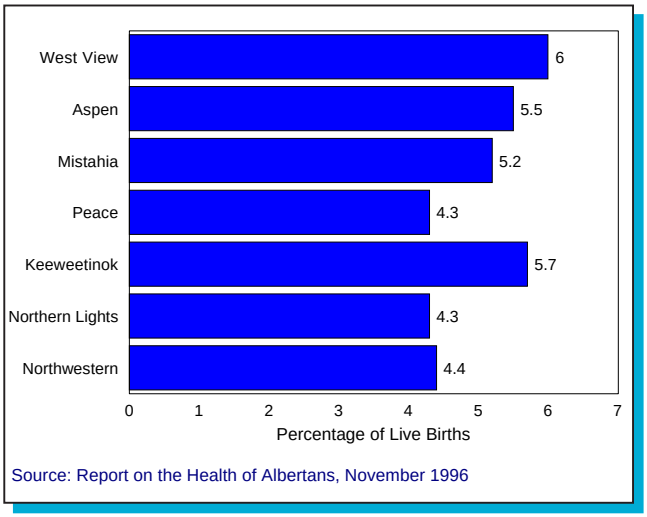
Figure 18 Low Birth Weight Rates In Canada



Source: Report on the Health of Albertans, November 1996

Figure 19 compares the low birth weight rates for each of the health regions in the NRBS area with the other areas of the province. With the exception of Westview Health Region, the NRBS area has fewer low weight births than the other areas of Alberta. As mentioned above, Capital, Calgary, David Thompson and Westview Health Regions have the highest rates of low weight births in the province. The Northern Lights, Peace, and Northwestern health regions have lower rates of low weight births than average. This means that the babies born in the Westview health region are generally smaller than babies born the Northern Lights, Peace or Northwestern health regions. Overall, however, the babies born in the NRBS area are larger than babies born in some of the other health regions.

Figure 19 Low Weight Birth Rate By Region



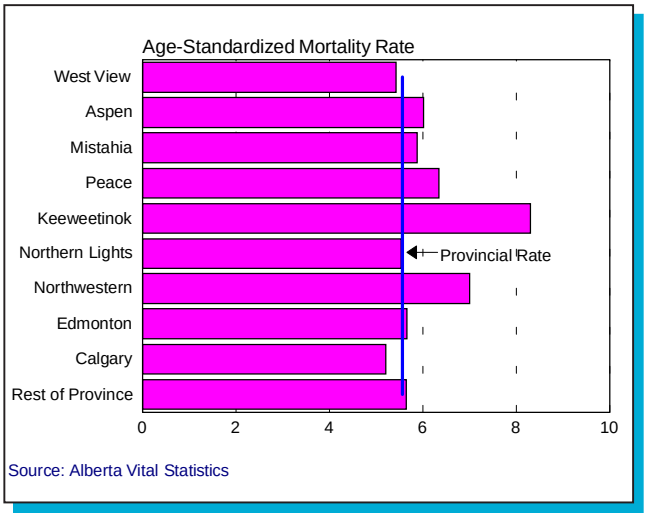
Source: Report on the Health of Albertans, November 1996

Mortality Rate

The mortality rate is the number of deaths in each area for every 1,000 people. The mortality rate was age-standardized because an age-standardized rate can account for differences in population structure in the areas and is the more appropriate measure to evaluate differences across regions.

Figure 20 shows the mortality rate for each of health regions in the NRBS area and compares those regions with the other areas and with the mortality rate for the province as a whole. The rate of mortality is higher in the NRBS area (5.99) than the other areas of the province, and is highest in the Keeweetinok Lakes and Northwestern health regions.

Figure 20 Mortality Rate By Region



Potential Years Of Life Lost

Potential Years of Life Lost is another general indicator of the health of a population and reflects the rate of premature death. Premature death refers to death from any cause that occurs before the normal life expectancy is reached. A lower rate of potential years of life lost indicates a healthier, safer environment and better health of the population. Potential Years of Life Lost is defined as a death that occurs before the age of 70, and does not include infant mortality or deaths that occur in the first year of life.

Figure 21 shows the decrease in the rate of Potential Years of Life Lost (PYLL) over time and compares Alberta to Canada. The decrease in PYLL between 1977 and 1982 for Canadian males was slightly more dramatic than for Alberta males, but the PYLL for males in 1992 was the same for an Alberta man as it was for a man living elsewhere in Canada.

The PYLL for Alberta women was the same as for a woman living elsewhere in Canada in 1977. The decrease in PYLL for women was not as great in Alberta as it was for women living elsewhere in Canada, and remained slightly higher in Alberta in 1992.

Figure 21 Potential Years Of Life Lost In Alberta And Canada

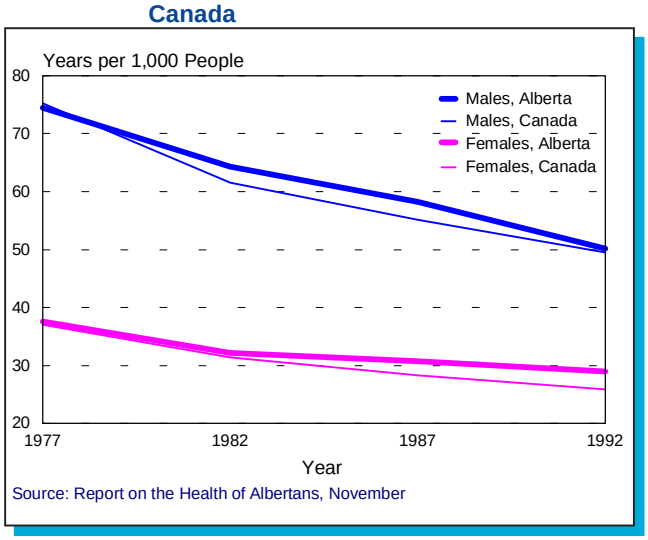
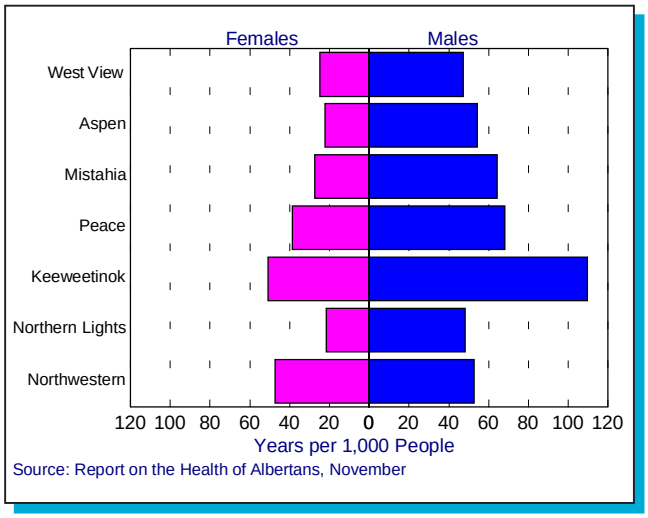


Figure 22 compares the rate of potential years of life lost for men and women in each of the health regions in the NRBS area. The Potential Years of Life Lost is high for both men and women in the Keeweetinok Lakes health region and overall it is higher for men than for women. This gender difference is consistent with the other areas of Alberta and Canada.

Figure 22 Potential Years Of Life Lost By Region



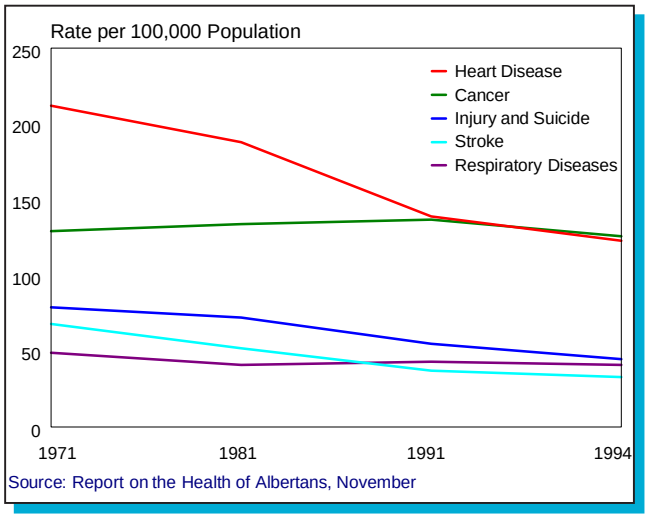
A health outcome refers to the actual health of the population, or in other words, the outcome of an individual's exposure to daily stressors, such as pollutants, viruses and bacteria. Health outcomes are typically measured in terms of poor health, because the information collected focuses on peoples' contacts with the health care system for problems with their health, rather than measuring positive or good health. Although this study did not undertake to measure personal exposure and dose, an evaluation of the health outcomes of the whole population of the Northern River Basins area, compared to the other areas of the province, will provide an estimate of the potential health impacts of human activity in the north. As discussed above, each diagnosis is discussed in turn, comparing the rates of hospitalization, visits to a physician, and mortality across areas. Significant differences across areas are determined using 95% confidence intervals for the five-year adjusted rate; discussion of differences occurs only where the differences were statistically significant. Further analysis of the relationship between outcomes and the environmental impact was undertaken only where there was a consistent significant difference in rates across areas.

Major Causes Of Death

Comparison of the mortality rate by cause of death can indicate trends in causes of death, and can be used to identify the priority health problems of an area.

Figure 23 compares the mortality rate for the five major causes of death over time for all Albertans. Heart disease was the major cause of death prior to 1991, but decreased steadily and, by 1991, the rate of mortality from this group of diseases was equivalent to the rate of mortality from all cancers. Injury and suicide, stroke and respiratory diseases are the other major causes of death in Alberta.

Figure 23 Mortality Rate By Cause Of Death



Although these disease categories are an important focus for evaluation of the health of Albertans, the purpose of this study is to focus on those diseases or diagnoses that may be relevant to the NRBS area. The evaluation below focuses on comparing the rates for those diseases or diagnoses that might be affected by exposure to contaminants in the environment. Some additional diagnoses that might be caused by lifestyle are also included.

Reproductive System Diseases

Reproductive system disorders are receiving attention in environmental epidemiology in recent years.[30] This attention is, in part, because of the relatively short latent period between exposure to environmental contaminants and adverse outcomes. In fact, it has been suggested that reproductive outcomes should be used as sentinel diagnoses for identifying environmental hazards.[31] Conditions included in this section of the report are menstrual cycle disorders, infertility, spontaneous abortion, and endometriosis. These conditions, sometimes associated with each other, may result from a variety of factors, including nutrition, alcohol intake during pregnancy, and exposure to

environmental contaminants, such as exposure to organic solvents, lead, ethylene glycol ethers, pesticides, or dioxins. Looking at the geographic distribution of these diseases may help understand the potential impact from human development.

Findings

Of the four groups of reproductive disorders that were evaluated, endometriosis was the only diagnosis for which the rate of both physician visits and hospitalizations was consistently higher in the NRBS area.

As mentioned in the methods section, the rate of hospitalization was combined for a five year period to improve the stability of the rate to determine whether the rate in the NRBS area was statistically different from the rate in the other areas. The five-year combined rate of hospitalization for endometriosis in the NRBS area was 224.9 (14.8), which was significantly higher than the rates of the other three areas ($p<.05$). Five-year rates and 95% confidence interval limits for all diagnoses are listed in Appendix D.

Consistently higher rates of both physician visits and hospitalization suggest that the incidence rate of endometriosis is likely higher in the NRBS area than it is anywhere else in the province. As has been discussed elsewhere, there are differences in accessibility to health care services, in perception and awareness of diseases by health providers, in behaviour of both physicians and clients, and in hospital admissions policies across areas. These differences may partly explain the differences in the rates of physician visits and hospital admissions. However, the high rates of both visits to a physician and hospitalization suggested that further analysis of the geographic distribution of endometriosis and selected environmental factors was required.

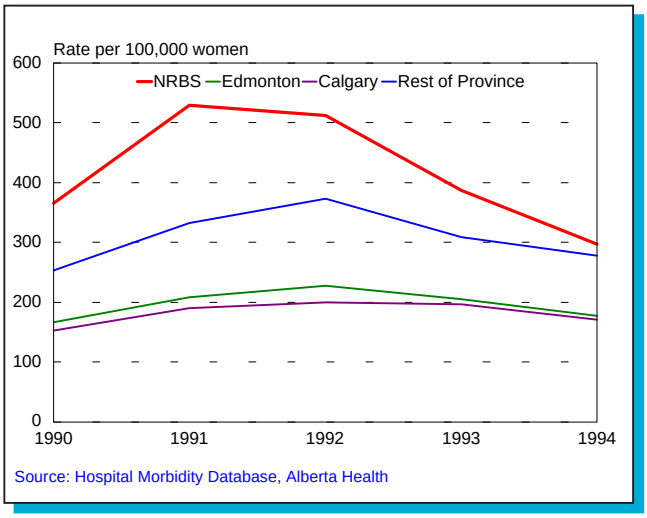
Preliminary analysis comparing rates of health care utilization at the CSD level with several sources of data on potential environmental toxicants did not yield any significant causal factors. There was some evidence to suggest that socio-economic factors are related to diagnosis of endometriosis, although the relationship may be spurious, and may result from different practices and procedures in smaller communities. Comparison of the number of First Nations women diagnosed with endometriosis with other women living in the area indicates that there is no significant difference in the two population groups.

Menstrual Cycle Disorders

Menstrual cycle disorders represent a group of clinical conditions, such as amenorrhea, oligomenorrhea, irregular menstrual cycle, menopausal and postmenopausal disorders. This group of disorders may co-exist with endometriosis and/or infertility, and was used as, together with other conditions, indicators of measurements for potential environmental impact. Overall, the rate of visits to a physician for menstrual cycle disorders in Alberta is approximately 18,300 per 100,000 women of 10-49 years. In other words, about 1/5 of women in the childbearing age groups visit a physician for this condition each year.

Figure 24 shows the rate of hospitalization for menstrual cycle disorders by area. The rate of hospitalization increased in all areas between 1990 and 1992, but the increase was the most dramatic in the NRBS area. The rate in the two predominantly rural areas is significantly higher than the rate in the two urban areas, and the rate in the NRBS area is significantly higher than the rate in the rest of the province ($p<0.05$ - see Appendix D for more detail). The rate of hospitalization for these disorders decreased in all areas since 1992, but the rate of hospitalization in the two rural areas remains higher than the rate in the two urban areas.

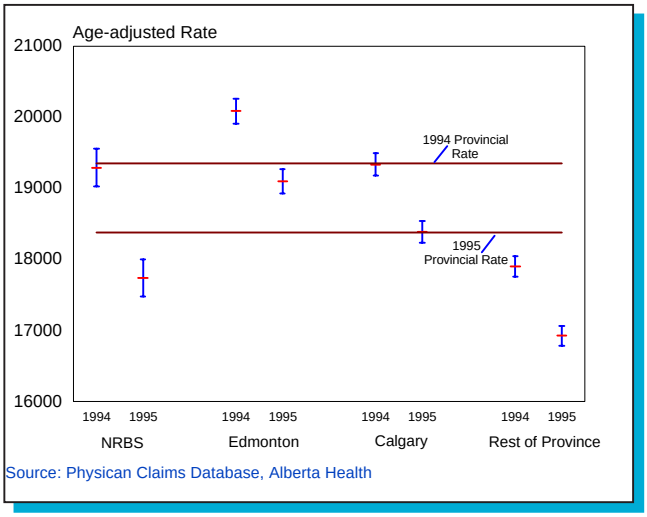
Figure 24 Hospitalization For Menstrual Cycle Disorders By Area



Source: Hospital Morbidity Database, Alberta Health

Figure 25 shows the rate of individuals visiting a physician for menstrual cycle disorders by area. The red horizontal line indicates the rate for that area that year, and the blue I-shaped line represents the confidence limits for the rate. The 1995 rate of visits to a physician was lower than the 1994 rate in each of the four areas. The rate in the NRBS area was significantly lower than Edmonton ($p<0.05$), and not statistically different from Calgary each year. The lowest rate of visits to a physician for menstrual cycle disorders occurred in the rest of the province in both 1994 and again in 1995.

Figure 25 Physician Visits For Menstrual Cycle Disorders By Area



Source: Physican Claims Database, Alberta Health

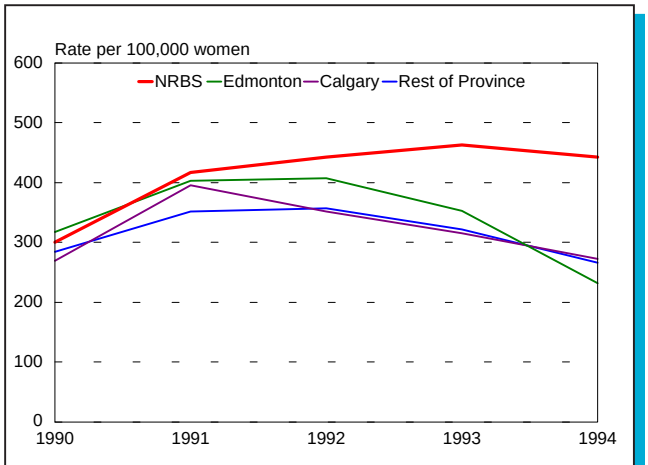
There is a marked difference in the pattern of hospitalization compared to visits to a physician across the areas. The rate of hospitalization suggests that menstrual cycle disorders are a significant problem in the NRBS area, but the rate of visits to a physician does not provide supporting evidence.

Abortion

Abortion includes any early termination of pregnancy, and usually refers to an abortion that happens before the twentieth week of gestation has completed. Spontaneous abortion is the most frequent cause of abortion. Spontaneous abortion has been linked to genetic factors, but may also be caused by environmental exposure. The provincial rate of individuals visiting a physician visit because of a spontaneous abortion was 1,700 per 100,000 women of childbearing age. The average number of visits was 1.4 per woman.

Figure 26 shows the rate of hospitalization for spontaneous abortion. The rate of hospitalization for spontaneous abortion increased in all areas between 1990 and 1991. The rate of hospitalization decreased after 1992 in all areas except the NRBS area, where the rate continued to increase. Differences across areas were not statistically significant.

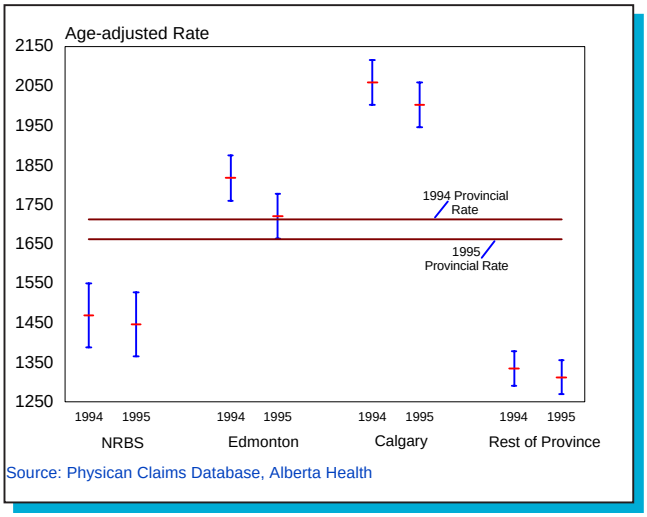
Figure 26 Hospitalization Rate for Spontaneous Abortion By Area



Source: Hospital Morbidity Database, Alberta Health

Figure 27 shows the rate of women of childbearing years visiting a physician for an abortion by area. The rate in the NRBS area was significantly lower than the rate in the two urban areas for both 1994 and 1995, and not significantly different from the rest of the province either year ($p<0.05$).

Figure 27 Physician Visits For Abortion By Area



Source: Physican Claims Database, Alberta Health

Overall, the rate of hospitalization for spontaneous abortion is consistent with the rates in the other areas, with the exception of the rates for 1993 and 1994, but the rate of visits to a physician for this condition is significantly lower than the rates of the two urban areas for the same time period. This indicates that spontaneous abortion is not a greater problem for residents of the NRBS area than for residents of the other areas of the province.

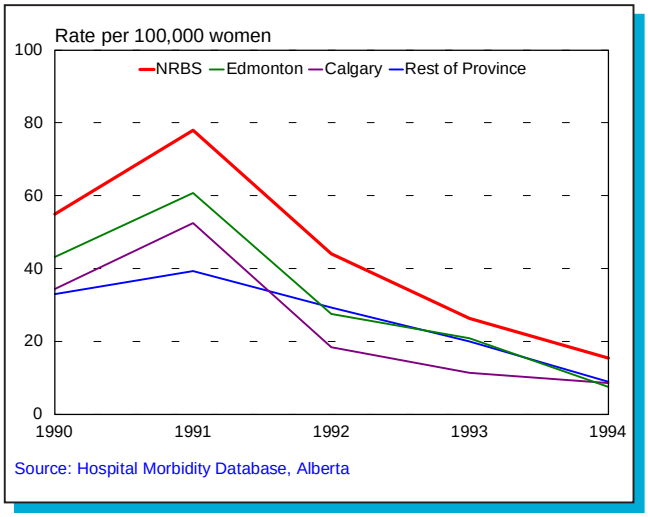
Infertility

Infertility is defined as the inability to conceive. Studies have linked infertility with sexually transmitted diseases, genetics and exposure to environmental contaminants.

Figure 28 shows the rate of hospitalization for infertility for females by area. The rate of hospitalization decreased in all areas after 1991.

There was no significant difference in the 1994 rate of hospitalization across areas, although the rate in the NRBS area was slightly higher than the rate of hospitalization in the other areas.

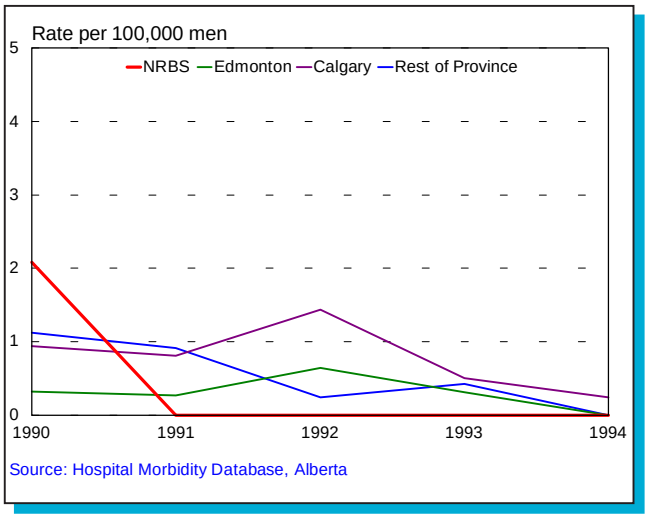
Figure 28 Hospitalization Rate For Female Infertility By Area



Source: Hospital Morbidity Database, Alberta

Figure 29 compares the rate of hospitalization for infertility among males by area. The actual number of males admitted to a hospital in the NRBS area for infertility was so small that the rate was lower than all other areas since 1991. Overall, the rate of hospitalization for males for infertility is very low in each of the areas, and there is no significant difference across areas.

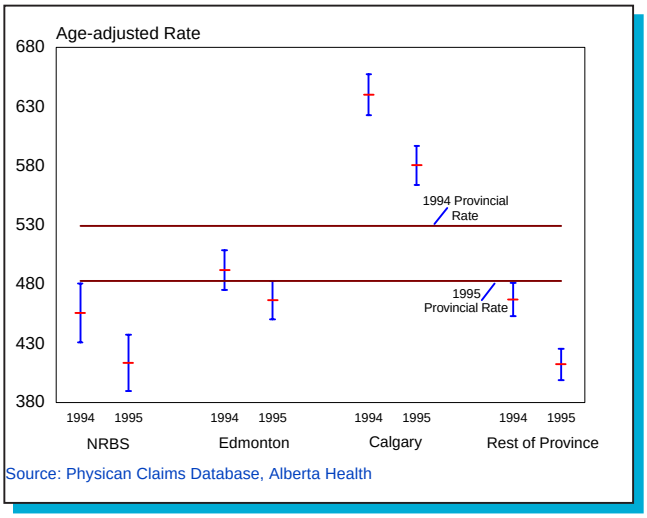
Figure 29 Hospitalization Rate For Male Infertility By Area



Source: Hospital Morbidity Database, Alberta

Figure 30 shows the rate of individuals visiting a physician for infertility by area. The rate of visits in the NRBS area was the same as the other rural area (the rest of the province) in both 1994 and 1995. The rate in the NRBS area was slightly lower than the rate in Edmonton, and significantly lower than the rate in Calgary both years ($p<0.05$).

Figure 30 Physician Visits For Infertility By Area



Source: Physican Claims Database, Alberta Health

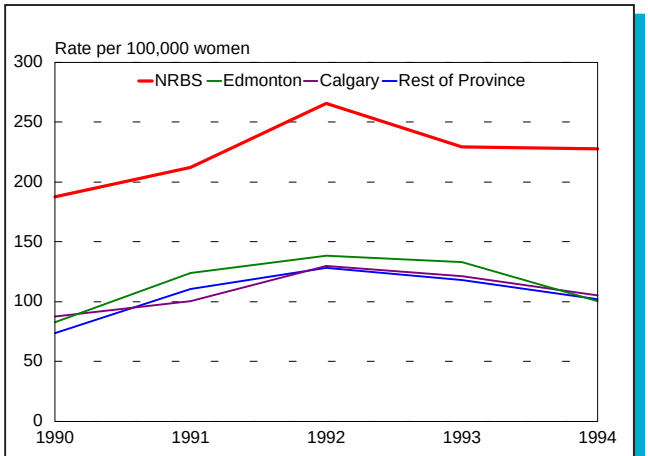
Overall, the slightly higher rate of hospitalization for females living in the NRBS area is balanced by the lower rate of visits to a physician for infertility by residents of the NRBS area. There is no evidence to suggest that the rate of infertility is higher in the NRBS area than it is in any other area of the province, although there is some evidence to suggest that infertility is a greater problem in the Calgary area than any other area of the province.

Endometriosis

Endometriosis is defined as a condition of an ectopic location of endometrial tissue, including both endometrial glands and stroma. In other words, endometriosis is a condition that affects many women (about 12% to 15%[32]), usually, although not strictly, during childbearing years. It results in the growth of endometrial tissue - the type of tissue that forms the lining of the uterus - in other locations within the pelvic cavity, such as the bowel or bladder. The endometrial tissue may penetrate the surrounding tissue, and cause damage to the area. Clinical manifestations of this disease vary significantly by patient, although pain is the most common symptom. Although the causes of endometriosis are not well understood, factors associated with this disease may include genetic background, alcohol use, socioeconomic conditions and may be related to environmental exposure to dioxins.

Figure 31 compares the rate of hospitalization for endometriosis in women across areas over time. Similar to the pattern we have seen for other diagnoses, the rate of hospitalization for endometriosis is significantly higher in the NRBS area than any other area of the province ($p<0.05$). However, the rate of hospitalization in the rest of the province does not follow the typical pattern, but is comparable to the rate in the two urban areas.

Figure 31 Hospitalization Rate For Endometriosis By Area

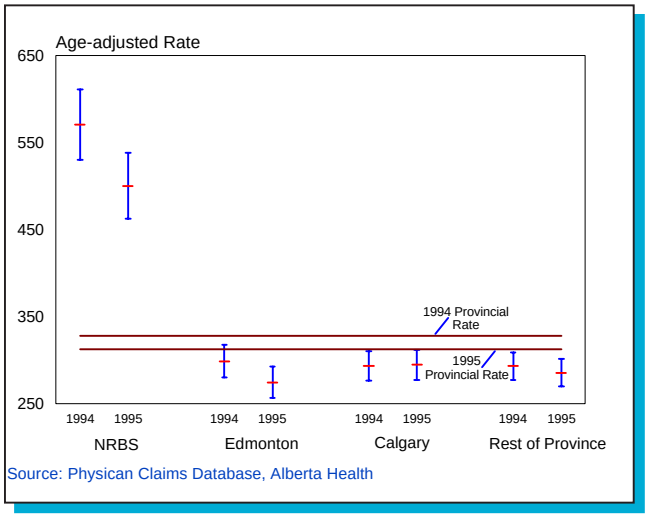


Source: Hospital Morbidity Database, Alberta Health

Figure 32 compares the rate of women visiting a physician for endometriosis by area in 1994 and in 1995. Although the rate decreased in the Edmonton area and the NRBS area from 1994 to 1995, the rate in the NRBS area is significantly higher than any other area of the province

($p<0.05$). The rate of visits for endometriosis was almost identical in the other three areas (Edmonton, Calgary, and the rest of the province). The rate in the NRBS area was high enough that the extreme values skewed the distribution, and increased the provincial average to a level that was greater than the rate in Edmonton, Calgary and the rest of the province.

Figure 32 Physician Visits For Endometriosis By Area



Source: Physican Claims Database, Alberta Health

Further analysis of the combined rate of women accessing the health care system for endometriosis was undertaken to compare rates across the province, and to see if there was any relationship between this diagnosis and the measures of environmental contaminants available. Measures of agricultural activity, source of drinking water, and dioxin and furan levels in fish obtained for the NRBS were used to define the level of contaminants that potentially cause endometriosis.

In 1994, 4,500 women aged 15 years and over visited a physician or were hospitalized for endometriosis in the province, resulting in a rate of 327 per 100,000 female population. A strong pattern of geographic variations in diagnosis of this condition is evident. Several census subdivisions in northwest Alberta, particularly in census divisions 11 & 13 (RHAs 14 & 17), had a higher rate ratio in 1994 (Map 8). Although some census subdivisions in central and southern Alberta also show higher rates, the small number of cases in these areas make it difficult to draw firm conclusions. The rate ratio was higher in rural communities than in urban areas.

Agricultural Activities

Agricultural activities, particularly the widespread application of certain pesticides and herbicides, have been related to the incidence of endometriosis.[33] Health care services utilization rates for endometriosis were compared to four measures of agricultural activity to determine if a relationship could be identified. The four measures of agricultural activity were:

1. the proportion of the land in a given geographic area used for crops;
2. the rate of application of herbicides;
3. the rate of application of insecticide and fungicide; and
4. the rate of application of fertilizer.

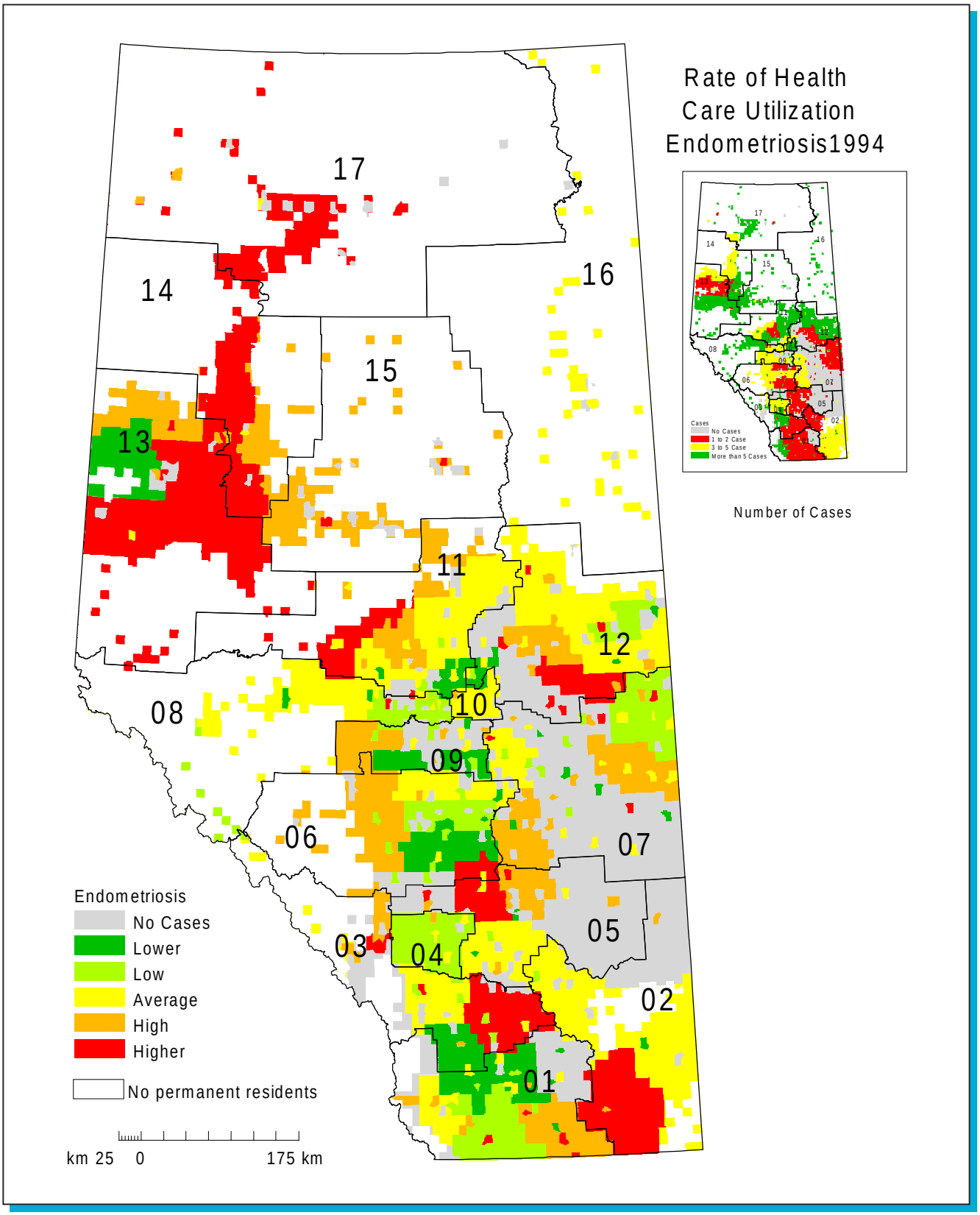
The correlation of each of these measures with the rate of health care service utilization for endometriosis was evaluated with a chi^2 test of significance at both the county and the CSD level.

Table 8 Correlation Between Endometriosis And Agricultural Activities

Area		% Crop Land	Herbicide Application Rate	Insecticide Application Rate	Fertilizer Application Rate
Rural	r	-0.060	-0.050	-0.040	-0.060
	p	.0488	0.529	0.671	0.442
County	r	-0.070	-0.060	-0.040	-0.100
	p	0.651	0.691	0.793	0.496

r = correlation coefficient
p = p-value for correlation coefficient

Map 8 **Rate Of Health Care Utilization For Endometriosis**



No significant correlations were found between any of the measures of agricultural activity and the rate of health care utilization for endometriosis.

Drinking Water

As mentioned previously, drinking water is a potential source of exposure to a variety of possibly harmful chemicals, both natural and those introduced into the environment through human activity. The source of drinking water is important to understanding the potential health impact. For example, ground water may contain levels of some naturally occurring chemicals that may have an impact on the health of those people who drink it, but in most cases won't contain contaminants introduced by human industrial activity. Surface water has many potential sources of contaminants and always requires treatment to make it safe to drink.

There is no information about the source of drinking water available to each individual Albertan, so any analysis of the impact of water quality on human health must be based on proxy measures of water source. The main source of drinking water was compared to the rate of health care service utilization for endometriosis at the CSD level. The analysis did not indicate that the source of drinking water has an impact on health care services utilization for endometriosis ($p=0.442$).

Dioxins and Furans

Some researchers have indicated that dioxins and furans may be related to endometriosis however the evidence is weak.[34] Dioxins and furans come from both man-made and natural sources. Food is the most significant source of human exposure to these contaminants, and is likely consistent throughout the province because most people obtain their food from commercial sources. Furthermore, there is very little information about the potential exposure to these chemicals through non-commercial sources.

Nonetheless, many people are concerned about potential exposure to these contaminants through their drinking water and food. Comparison of the rate of endometriosis by CSD indicates that the two areas where highest levels of dioxins and furans were measured in fish and sediment samples have relatively low rates of endometriosis. The rate of endometriosis for residents living in Hinton is very low, compared to the rates for other areas of the province. The rate of endometriosis in Grande Prairie is somewhat higher, but was only half the rate measured in several other areas of the province, including Bow Island, Milk River, Myrnam, and Fort Saskatchewan. Also, the source for drinking water in Grande Praire is upstream of any potential sources.

Socio-Economic Factors

Two socio-economic factors appear to be correlated with health care services utilization for endometriosis. Analysis of several indicators at the CSD level suggests that endometriosis is more common in CSDs with smaller populations and is also more common in the northern communities.

Initial correlational analyses found a correlation between the rate of endometriosis and community socioeconomic index ($r=-0.30$, $p<0.001$), population size ($r=-0.31$, $p< 0.001$), population density ($r=-0.14$, $p=0.027$), and the proportion of the population of aboriginal origin ($r=0.18$, $p=0.003$). However, the correlation coefficient is less than 0.4 for all correlations (meaning that even though the correlations are statistically significant, the socioeconomic factors explain very little of the variation in the rates of health care utilization for endometriosis), and all indicators, with the exception of the proportion of population who are of aboriginal origin, are positive. Correlation with latitude is also positive ($r=0.26$, $p<0.001$).

Multiple variate analysis was used to evaluate whether there is a relationship between the rate of endometriosis and the area of the province where

the individual lives. The rate of health care utilization for endometriosis was found to be higher in the NRBS area than the rest of the province, after adjusting for the effects of community socioeconomic index, population size, and population density. There is no significant relationship between the proportion of the population who are aboriginal and the rate of endometriosis.

Further analysis was conducted using only the population of the NRBS area. Latitude is the only significant predictive factor, and explains about 9% of the geographic variation of the rate of health care utilization for endometriosis in the NRBS area.

The analysis indicates that communities with lower socioeconomic status (low income, less education, low fertility), or small populations, are associated with increased risk for diagnosis of endometriosis. Women living in the northern parts of the province also have increased risk for endometriosis although this may be a result of lower community socioeconomic status and smaller population size in northern communities. Further studies at the individual level are required to clarify these relationships.

Aboriginal Differences

Many First Nations people continue to obtain a variety of staple foods from local sources, and may be exposed to more environmental contaminants than other people living in the same location. Consequently, the relationship between aboriginal status and health care utilization for endometriosis was explored further.

Table 9 compares the rate of First Nations women using health care services for endometriosis with the rate of health care utilization for the rest of women living in each area during the 1995/96 fiscal year.

The table shows that there is no difference in the rate of health care utilization for First Nations women and the rest of women living in the NRBS area. Although there are some differences in the rate by age group, there is little difference overall. It is important to note that the actual number of women seeking health care services for this diagnosis is quite small, particularly among First Nations women.

The rate of health care utilization for First Nations women in the rest of Alberta is higher than the rate of health care utilization by the rest of the women living in that area. In contrast, the rate of health care utilization by First Nations women living in Calgary is lower than the rate for the rest of the women living in Calgary.

Although the rates vary somewhat by area, there is little difference overall between First Nations women and the rest of women in Alberta. It was

Table 9 Age-Standardized Rate Of Endometriosis Per 100,000 Women By Area

Area	First Nations Women						Rest of Women in Area					
	#	< 20	20-29	30-44	45 +	Total	#	< 20	20 to 29	30 to 44	45 +	Total
NRB	53	57.7	179.8	249.5	63.3	550.3	629	39.7	205.2	270.1	38.9	553.9
Edmonton	20	10.3	73.9	115.5	89.3	289.0	863	5.3	87.9	161.8	32.7	287.6
Calgary	11	.	93.5	133.2	0	226.7	1163	11.3	86.3	158.9	43.4	299.8
Rest of Province	73	30.8	141.6	214.5	35.3	422.2	1210	10.0	100.0	161.6	33.6	305.1
Unknown Location	9	0	307.3	230.5	86.5	624.4	104	19.4	89.8	160.9	39.5	309.6

difficult to determine if the differences are significant, because of the large number of women for whom no home location is identified.

Stillbirth And Infant Death

Stillbirth refers to births of babies with no signs of life, delivered after 20 weeks of gestation or after attaining a weight of 500 grams. Infant mortality is defined as the death of a baby within the first year of life.

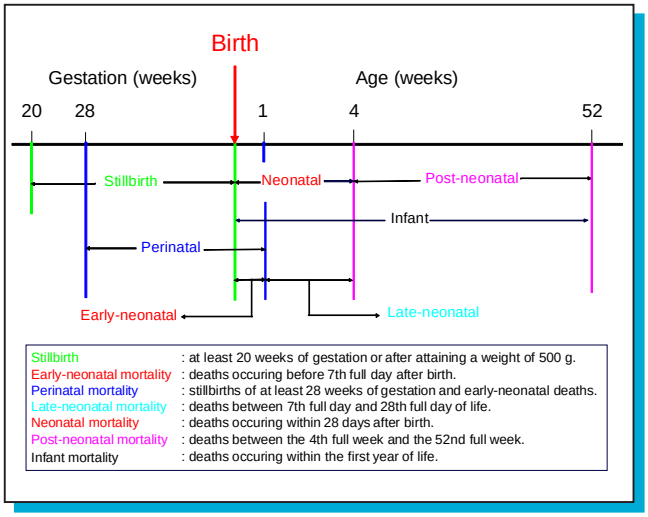
Stillbirths and infant deaths are major public health concerns. Research has indicated that infant mortality accounts for the majority of deaths in children younger than 18 years old, and is higher than the mortality rate among any other age group younger than 55.[35] Stillbirths and infant deaths are related to socio-economic status, life style, maternal health, and biological, genetic as well as reproductive conditions. Studies have shown that poverty, low education attainment, inadequate prenatal care, smoking and alcohol consumption during pregnancy, very young or old maternal age (younger than 16 years or older than 35 years of age), and maternal medical problems are associated with adverse pregnancy outcomes such as premature birth, low birth weight, and birth defects. These adverse outcomes are in turn the most important determinants of stillbirth and infant mortality.

Findings

Although the infant mortality rates for the NRBS area (7.95 deaths per 1000 live births) were higher than the provincial average (7.26), they were not as high as the rates for Edmonton (8.05). Comparison of the leading causes of infant death between the NRBS area and the rest of Alberta did not indicate any significant reasons for the differences. The leading cause of infant death in both the NRBS area as well as in the rest of Alberta was sudden infant death syndrome (SIDS).

Figure 33 illustrates how the definitions of mortality are different, depending upon the period of gestation or the age of the infant. These definitions were derived based on the potential effects of prevention and the causes of death at different stages of development.

Figure 33 Definition Of Stillbirth And Infant Death



Trends in Perinatal and Neonatal Mortality Rates and Stillbirth Rates

The perinatal mortality rate (PMR) for Alberta is decreasing over time. In 1993, the overall PMR for Alberta reached a record low of 10.1 deaths for every 1000 live births. The rate of early neonatal mortality (NMR) in 1993 was 3.4 deaths for every 1000 live births, which was a dramatic decrease from the 1992 rate of 17 deaths for every 1000 live births. Another Alberta record was broken in 1993 with a rate of 6.7 stillbirths for every 1000 live births.

The time trend of the PMR for Alberta between 1955 and 1993 is very positive. The rate of mortality for babies who weigh 1000 grams or more decreased steadily from 23 deaths for every 1000 births in 1955 to 5.2 deaths for every 1000 births in 1993. Similarly, the rate of mortality for babies who weigh 500 grams or more decreased from 26 deaths for every 1000 births in 1955 to 7.5 deaths for every 1000 births by 1993. These

trends are largely the result of improvements in technology and the ability of the health care system to assist babies in distress. These effects on trends are less dramatic after 1983, which corresponds to a leveling off of improvements in technology and in the health care system.

Birth weight has a very significant impact on perinatal and neonatal deaths. The PMR for babies less than 2500 grams was 120 per 1000 live births in 1993, a rate almost 12 times higher than the 1993 average, while the NMR for babies less than 2500 grams was 51 per 1000 live births, a rate 15 times higher than the 1993 average. For very low birth weight babies (less than 1500 grams), the PMR worsens to a rate of 491 per 1000 live births (almost half of babies born in this weight category perish), while the NMR suddenly becomes 286 per 1000 live births. The birth weight trend continues for extremely low birth weight babies (less than 1000 grams), when the PMR jumps to 699 and the NMR to 500 per 1000 live births in 1993.

Factors Associated with Perinatal and Neonatal Mortality

Smoking has long been known to cause complications with pregnancy and fetal development. The smoking history for women who delivered in 1993 was available and reported by hospitals for 28,967 women. Of these women, 24% had a history of smoking in pregnancy. In 1993, smoking was reported as a risk factor in 34% of stillbirths and neonatal deaths. Maternal age is also a factor in perinatal and neonatal mortality rates. The age range of mothers giving birth in Alberta in 1993 was 13-45 years. The PMR (13.9 deaths per 1000 births) and NMR (6.1 deaths per 1000 births) was the highest when the mother was 17 years or younger. Mothers aged 35 years or older accounted for 10.2% of total births. This group had the second highest PMR (13.1 deaths per 1000 births) and NMR (4.9 deaths per 1000 births) when compared to other age groups of mothers. Intrauterine growth restriction (birth weight less than tenth percentile) was a factor in 25% of perinatal deaths and 18% of neonatal singleton deaths in 1993. Major congenital anomalies accounted for 26% of stillbirth and neonatal deaths in 1993. Gestational age of less than 37 weeks accounted for 72% of neonatal deaths in 1993. Extreme immaturity (less than 1000 grams) was a factor in 48% of neonatal deaths in 1993. Infection was a factor in 15% of all stillbirths and neonatal deaths in 1993. Hemolytic group B streptococcus, herpes, and E. coli were reported in the neonatal deaths.

Studies have found higher mortality rates among infants born to mothers who were exposed to methyl isocyanate (MIC) or pesticides during pregnancy.[36] Paternal exposure to lead and organic solvents was shown to be associated with elevated risk of preterm birth and perinatal deaths.[37] Consumption of PCB-contaminated cooking oil during early pregnancy was found to result in certain congenital anomalies.[38] However, there are also studies that have shown no indication of adverse reproductive results originating from chemical exposures.[39] Thus, the epidemiologic evidence on the relationship between environmental toxicants and infant mortality is inconclusive.

Infant Mortality

Table 10 compares the three year average infant mortality rates across regions for the years 1990 to 1992 by age at death. All of the mortality rates for Edmonton and the NRBS area are consistently higher than the provincial average, especially for the post-neonatal period. Mortality rates at different stages in the first year of life reflect different aspects of risks that are associated with these deaths. For instance, perinatal deaths are caused mostly by complications of the cord and placenta, problems associated with immaturity and low birth weight, birth defects, and maternal

health conditions such as hypertension, while the major causes of post-neonatal deaths are sudden infant death syndrome (SIDS), birth defects, respiratory disorders, and injury. It is believed that post-neonatal mortality is more closely linked to socio-economic disadvantages, and perinatal mortality is more likely due to biologic vulnerabilities of the mother.[40]

Table 10 Infant Mortality Rates (Per 1000 Live Births) By Area

Region	Perinatal Mortality	Early Neonatal Mortality	Neonatal Mortality	Post-Neonatal Mortality	Infant Mortality
NRBS Area	7.97	3.55	4.45	3.49	7.95
Edmonton	7.96	3.74	4.52	3.53	8.05
Calgary	7.10	3.66	4.69	2.36	7.05
Rest of Province	7.18	3.11	3.91	2.57	6.48
All Alberta	7.47	3.50	4.37	2.89	7.26

* May be an unstable rate because the number of deaths is less than 5.

Causes of Death

Tables 11 through 14 compare the leading causes of deaths for different periods of infant life for the NRBS area with the rest of Alberta. Table 11 shows that the NRBS area and the rest of Alberta share the same leading cause of stillbirth, (i.e., conditions originating in perinatal periods), although the ranking of the other leading causes varies between areas. For example, the NRBS rates for morphological and functional abnormalities of the placenta, anoxia and asphyxia, and maternal hypertension disorder, are higher than the percentages for the rest of Alberta. Conversely, the rates for compression of the umbilical cord, other forms of placental separation and hemorrhage, and other conditions of the umbilical cord are higher in the rest of Alberta than the NRBS area.

Table 11 Leading Causes Of Stillbirth For The NRBS Area And The Rest Of Alberta (1990-1992)

Leading Causes	NRBS		Rest of Alberta	
	Rank	Percentage	Rank	Percentage
Condition originating in perinatal period	1	21.5	1	19.6
Morphological & functional abnormalities of placenta	2	15.2	6	4.0
Anoxia, asphyxia	3	11.4	5	6.3
Maternal hypertension disorder	4	8.9	7	3.3
Compression of umbilical cord	5	8.9	2	14.3
Other forms of placental separation & hemorrhage	6	7.6	3	12.9
Other conditions of umbilical cord	7	*2.5	4	11.0

* May be an unstable rate because the number of deaths is less than 5.

Table 12 shows that the leading causes of neonatal deaths are identical in ranking. Respiratory distress syndrome is the leading cause of neonatal death, followed by under-development of the lung, extreme immaturity, and heart defects.

Table 12 Causes Of Neonatal Death In NRBS Area And Other Areas In Alberta (1990-92)

Leading Causes	NRBS		Rest of Alberta	
	Rank	Percentage	Rank	Percentage
Respiratory distress syndrome	1	12.7	1	13.3
Agenesis, hypoplasia, dysplagia of lung	2	8.9	2	6.3
Extreme immaturity (<1000 grams, or <28 weeks)	3	7.6	3	4.4
Hypoplastic left heart syndrome	4	6.3	4	4.4

* May be an unstable rate because the number of deaths is less than 5.

Table 13 shows that the most prominent cause of post-neonatal deaths across Alberta is due to sudden infant death syndrome (SIDS). SIDS seems to cause a slightly higher proportion of post-neonatal deaths in the NRBS region than in the rest of the province (45% vs. 42%). The remaining causes of post-neonatal deaths account for a very small proportion of cases in Alberta.

Table 13 Leading Causes Of Post-neonatal Death In The NRBS Area And The Rest Of Alberta (1990-1992)

Leading Cause	NRBS		Rest of Alberta	
	Rank	Percentage	Rank	Percentage
Sudden infant death syndrome (SIDS)	1	45.2	1	42.1
Unspecified anomaly of heart	2	*6.5	3	2.6
Convulsions	3	*3.2	-	-
Chronic respiratory disease arising in the perinatal period	4	*1.6	2	3.9

* May be an unstable rate because the number of deaths is less than 5.

Table 14 gives the leading eight causes of deaths among infants under one year of age. As is true for post-neonatal deaths, the leading cause of infant death is SIDS, and also similar to post-neonatal rates, the NRBS rate is slightly higher than the rate for the rest of Alberta (19.9% compared to 16.8%). Respiratory distress syndrome is a distant second for both regions. Extreme immaturity is the third leading cause of infant deaths for the NRBS region, but ranks only sixth for the rest of Alberta, with a rate almost half of the NRBS rate. Anomalies of the heart fall in the same position for each area, ranked fourth, while under-development of the lung follows, with both regions having almost identical rates. Anencephalus appears to occur twice as often in the NRBS area compared to the rest of Alberta, but is likely the result of only a few additional cases in the NRBS region.

Table 14 Leading Causes Of Infant Death In The NRBS Area And The Rest Of Alberta (1990-1992)

Leading Causes	NRBS		Rest of Alberta	
	Rank	Percentage	Rank	Percentage
Sudden infant death syndrome (SIDS)	1	19.9	1	16.8
Respiratory distress syndrome	2	7.1	2	8.6
Extreme immaturity (<1000 grams, or <28 weeks)	3	5.0	6	2.7
Unspecified anomaly of heart	4	4.3	4	3.0
Agenesis, hypoplasia, dysplagia of lung	5	4.3	3	4.1
Anencephalus	6	3.5	13	1.7
Hypoplastic left heart syndrome	7	3.5	5	2.8
Other forms of placental separation & hemorrhage	22	*0.7	7	2.4

Congenital Anomalies

Congenital anomalies include structural defects, chromosomal and monogenic syndromes, and inborn errors of metabolism. A congenital anomaly is a condition that is present at birth, although it may not be diagnosed until months or years later. Prenatal exposure to a teratogen of the (parental) environment, genetic alterations, or a combination of both may cause the anomaly. A variety of factors have been linked to congenital anomalies, including smoking; alcohol use; social drugs; therapeutic drugs such as anticoagulants, anticonvulsants, diethylstilbestrol, and thalidomide; nutritional deficiencies; infectious agents such as rubella, cytomegalovirus, herpes simplex, and toxoplasmosis; and other maternal health conditions, such as diabetes and other metabolic disorders.

It has been estimated that the exact cause of the anomaly is unknown for 65 to 70% of all cases, may be attributed to genetic defects such as sickle cell anemia in 20% of all cases, and is attributable to drugs and environmental causes in only 4 to 6% of all cases.[41]

There are several groups of congenital anomalies, depending upon which system of the body the anomaly has affected. The results of a review of the literature[42] and some preliminary analysis suggest that there may be geographic variations in the incidence of some types of anomalies across the province. Geographic variations may be due to environmental factors, or may be combined with differences in genetic predisposition.[43] The three groups of congenital anomalies that were examined for this report were neural tube and other nervous system anomalies, cardiovascular defect, and urological defect.

Although the frequency of congenital anomalies has decreased since 1990, the frequency of urinary system anomalies increased slightly. Every year in Alberta about 40 babies out of every 1,000 babies born have some type of congenital anomaly. About 767 people in every 100,000 visited a physician in 1994 for a congenital anomaly, with an average of about two visits per patient. In addition, about 133 people for every 100,000 Albertans were hospitalized each year between 1990 and 1994, and stayed an average of 10 days. Over 63% of physician visits and 80% of hospitalizations for congenital anomalies in Alberta are children under 15 years.

Findings

The incidence rate of neural tube defects and other anomalies of the nervous system was somewhat higher in the Westview and Palliser health regions compared to the other health regions in the province; the incidence rate of heart defects and other anomalies of the cardiovascular system was somewhat higher in the Mistahia health region than other health regions; and the incidence of urinary system defects was somewhat higher in the Peace River health region than other health regions in the province.

As discussed earlier, prenatal exposure to some chemicals or metals (such as methyl mercury, lead, and dioxins), and to drugs or alcohol is associated with increased risk for neural tube defects and other anomalies of the nervous system. Low birth weight is also associated with neural tube defects and other anomalies of the nervous system. There are numerous risk factors for cardiovascular system defects, including low birth weight, premature birth, maternal use of drugs, medications or sex hormones during pregnancy, and infections during pregnancy.

It is unclear why these regions have higher rates of these congenital anomalies compared to the other health regions in the province. The comparison of incidence rates for congenital anomalies with the measures of environmental contaminants could be used to indicate correlations in geographic distribution, but any relationship identified using this method would likely be spurious. Furthermore, lifestyle behaviours have been identified as key factors in prenatal health, and must be considered as a major part of the equation. Further study of the individual babies born with congenital anomalies, the mother's lifestyle, diet and prenatal care habits, and biomarkers of exposure is required before any valid conclusion can be reached.

Figure 34 presents the incidence rate of congenital anomalies in Alberta between 1985 and 1994. Overall, the rate decreased slightly from 37.6 anomalies for every 1,000 live births in 1985 to 32.5 in 1994. Similarly, the rate of cardiovascular system defects decreased from 7.7 anomalies for every 1,000 live births in 1985 to 6.1 in 1994. The rate of neural tube defects and other defects of nervous system dropped sharply from 1985 (2.0) to 1987 (1.2), then increased to a high of 1.8 in 1990, and decreased to 1.4 in 1994. In contrast, defects of the urinary system increased from 1.0 anomaly for every 1,000 live births in 1985 to a maximum rate of 2.2 in 1992. This represents an increase of 120% over the eight year period. Although the rate decreased again after 1992, the 1994 rate was still 50% higher than the 1985 rate.

Figure 34 Incidence Of Selected Congenital Anomalies

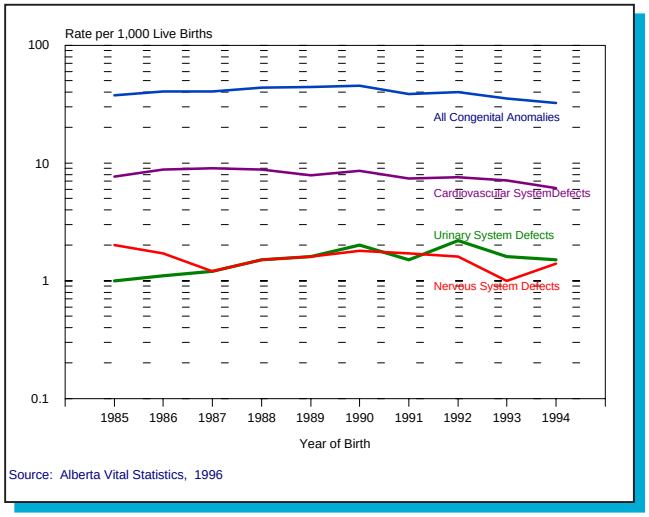


Figure 35 compares the average (three-year combined) incidence rate of congenital anomalies by region for the period between 1991 and 1993. The rate of congenital anomalies was lower for all of the regions in the NRBS area than it was for the rest of the regions and for the province as a whole. The rate of congenital anomalies was highest in the Palliser region.

Figure 35 Incidence Rate For Congenital Anomalies By Region

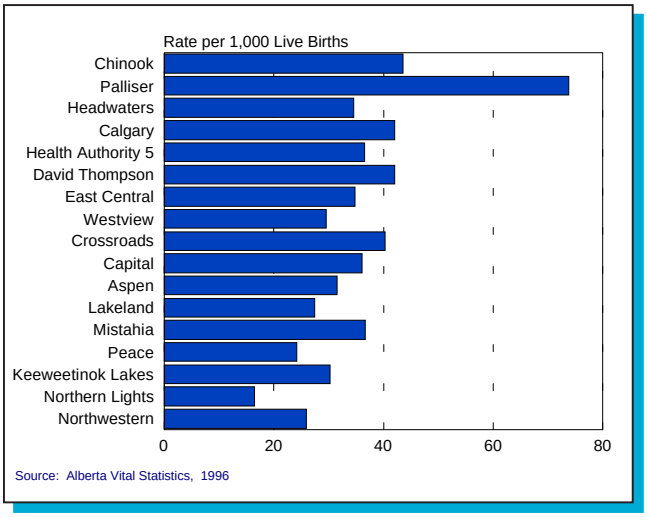


Figure 36 compares the rate of hospitalization for congenital anomalies across areas by year. The rate of hospitalization for congenital anomalies in the NRBS area is similar to the rate in the other areas, and has declined slightly since 1991. Calgary has the highest rate of hospitalization for congenital anomalies, although overall the rate of hospitalization for this diagnosis is very small.

Figure 36 Hospitalization for Congenital Anomalies By Area

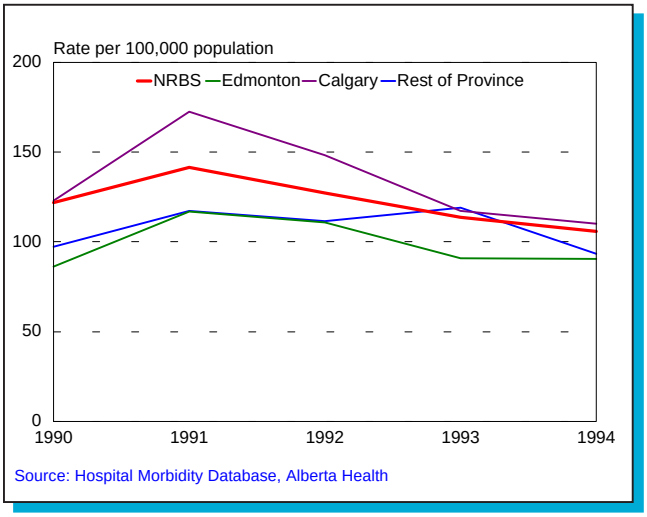
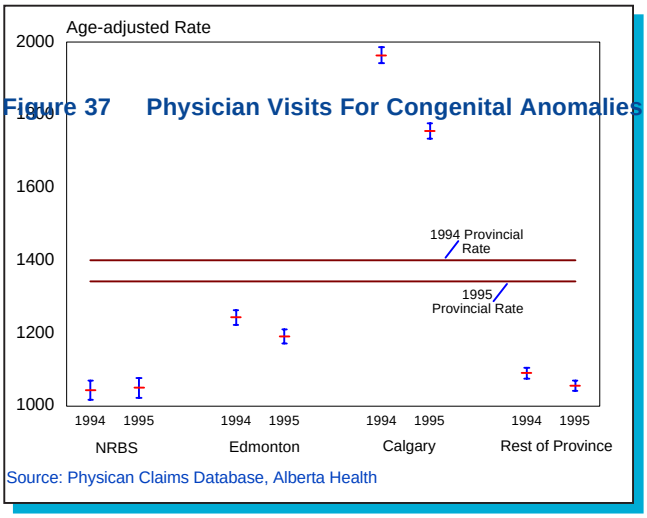


Figure 37 shows the rate of individuals visiting a physician for all congenital anomalies in each of the areas and compares the rates for 1994 with 1995. The rate of visits to a physician for congenital anomalies was lower in the NRBS area than any other are in the province in 1994. In 1995, the rate of visits to a physician by residents of the other rural area - the rest of the province - was as low as the rate of visits by the residents of the NRBS area. The rate of individuals visiting a physician because of a congenital anomaly in Calgary was significantly higher both years ($p<0.05$).

Figure 37 Physician Visits For Congenital Anomalies

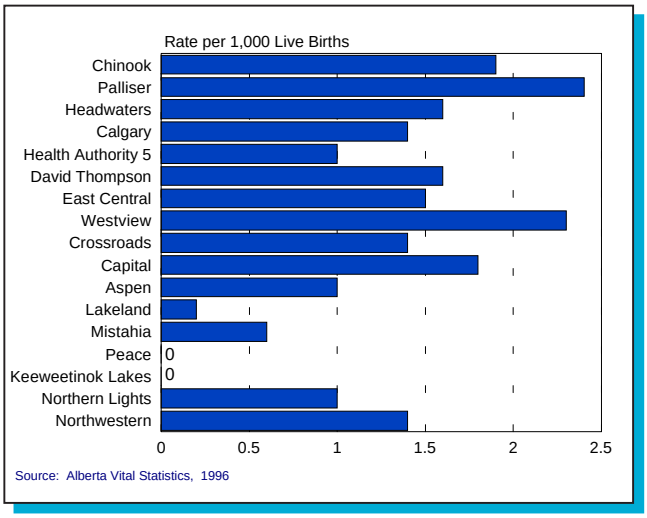


Nervous System Anomalies

Nervous system anomalies include spina bifida, anencephalus, hydrocephalus, and other anomalies of the brain, spinal cord and nervous system. During its development, the nervous system is very susceptible to the toxic effects of chemicals, alcohol or drugs and other teratogens, as well as a lack of folic acid in the diet.

Figure 38 the average (three-year combined) incidence rate of nervous system anomalies by region for the period between 1991 and 1993. The rate of nervous system anomalies was lower in most of the regions in the NRBS area than it was for the rest of the regions and for the province as a whole. The differences across regions are not statistically significant

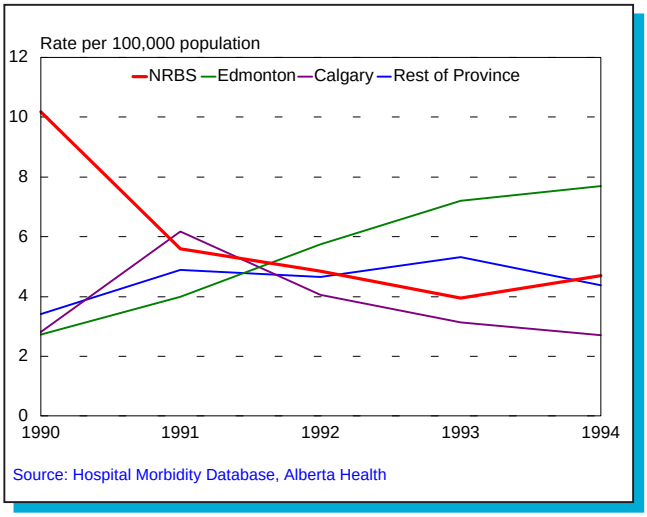
Figure 38 Incidence Of Nervous System Anomalies By Region



Source: Alberta Vital Statistics, 1996

Figure 39 compares the rate of hospitalization for nervous system anomalies across areas by year. The rate of hospitalization is very low overall. The rate of hospitalization for nervous system anomalies was higher in the NRBS area than the rate in the other areas in 1990, but declined sharply in 1991 to a level comparable to the other areas where the rate remained until 1994. The rate in the Edmonton area has increased steadily since 1991, and by 1994, Edmonton area had the highest rate of hospitalization for nervous system anomalies.

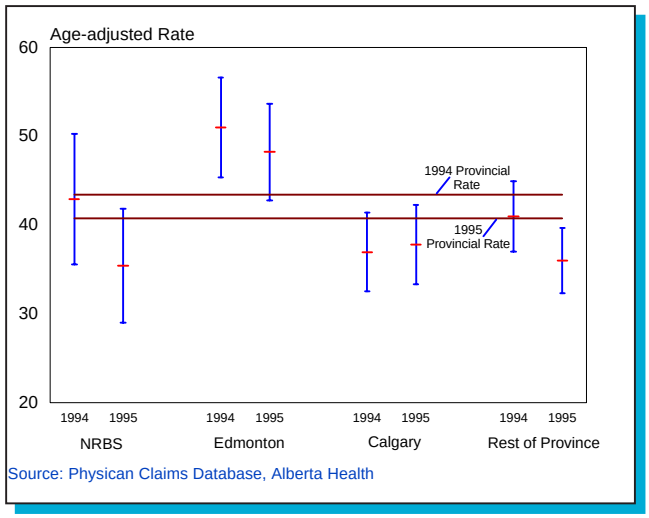
Figure 39 Hospitalization For Nervous System Anomalies By Area



Source: Hospital Morbidity Database, Alberta Health

Figure 40 shows the rate of individuals visiting a physician for neural tube defects. The confidence interval for this rate is very wide because the actual number of babies born with this diagnosis is very small. Although the average number of visits to a physician (indicated by the short red horizontal line) by residents of the NRBS area is much lower that the provincial average in 1995, the confidence interval for that mean includes the mean. This indicates that the rate is not significantly different than the average for the province. The rate of visits of residents in the Edmonton area was higher than the provincial average, and significantly higher than the rate of visits of residents of any other region in both 1994 and 1995 ($p<0.05$). The rate of visits by residents of the rest of the province was similar to that of the residents of the NRBS area.

Figure 40 Physician Visits For Neural Tube Defects



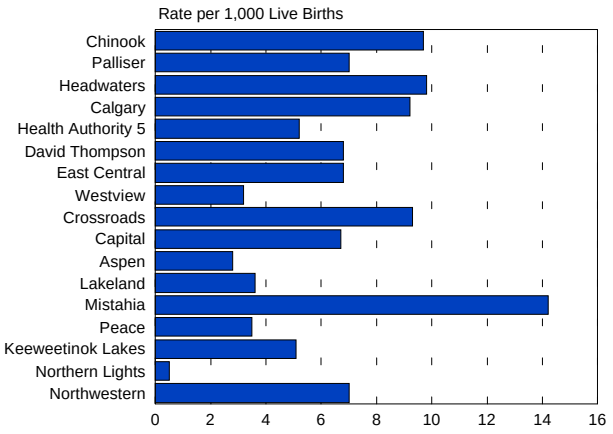
Source: Physican Claims Database, Alberta Health

Cardiovascular System Anomalies

Cardiovascular system anomalies include ventricular/atrial septal defect, valve stenosis, and other forms of anomalies of the cardiovascular system. During its development (at between 6 and 12 weeks of gestation), the cardiovascular system is susceptible to the effects of drugs, sex hormones, rubella infection, and other similar risk factors.

Figure 41 compares the average (three-year combined) incidence rate of cardiovascular system anomalies by health region for the period between 1991 and 1993. Once again we see that the rate of congenital anomalies in the NRBS regions is low compared to the other regions of the province, with one notable exception: Mistahia health region. The rate of cardiovascular system anomalies in the Mistahia region was higher than any other health region in the province.

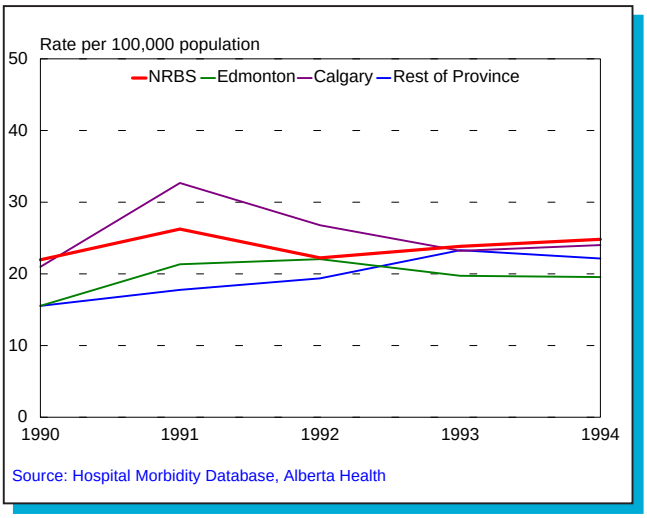
Figure 41 Incidence Of Cardiovascular System Anomalies By Region



Source: Alberta Vital Statistics, 1996

Figure 42 compares the rate of hospitalization for nervous system anomalies across areas by year. The hospitalization rate is very low, and there is no difference in rates across the areas. The highest hospitalization rate occurred in the Calgary area in 1991, but the rate in Calgary decreased to a comparable level by 1992.

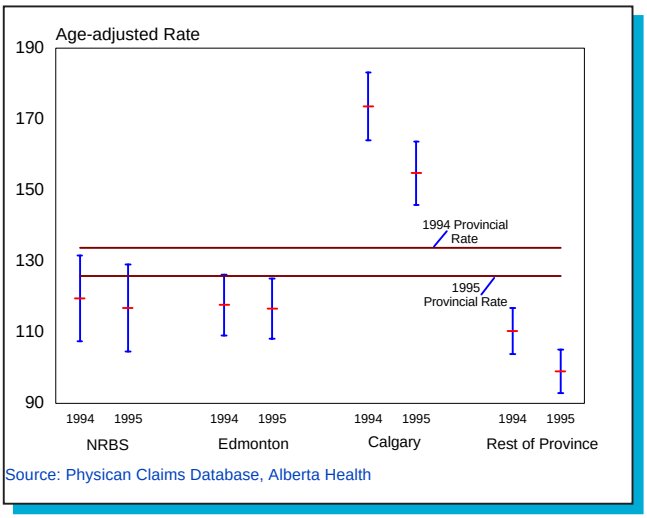
Figure 42 Hospitalization For Cardiovascular System Anomalies By Area



Source: Hospital Morbidity Database, Alberta Health

Figure 43 shows the rate of people visiting a physician for cardiovascular system anomalies. The rate of visits to a physician for cardiovascular system anomalies by residents of the NRBS area was lower than the provincial rate, and equivalent to the rate of visits by residents of the Edmonton area. The lowest rate of visits in both years occurred in the rest of the province; significantly more Calgary area residents visited their physicians for these anomalies than any other area ($p<0.05$).

Figure 43 Physician Visits For Cardiovascular System Anomalies



Source: Physican Claims Database, Alberta Health

Urinary System Anomalies

Urinary system anomalies include obstructive defects of renal pelvis and ureter, renal agenesis and dysgenesis, cystic kidney disease, and other anomalies of the development of the urinary system. Prenatal exposure to diethylstilboestrol (DES) or some organic solvents, overuse of vitamins D and A, and other factors may be, in part, responsible for these anomalies.

Figure 44 compares the average (three-year combined) incidence rate of urinary system anomalies by health region for the period between 1991 and 1993. The rate of urinary anomalies is high in some of the regions in the NRBS area, and very low in others. The rate in both Mistahia and Northern Lights health regions is zero, and the rate in Westview is also one of the lowest in the province. However, the rate of urinary system anomalies in the Peace health region was the highest in the province, and the rate in the Keeweetinok Lakes health region was also higher than most health regions in the province.

Figure 44 Incidence of Urological System Anomalies By Region

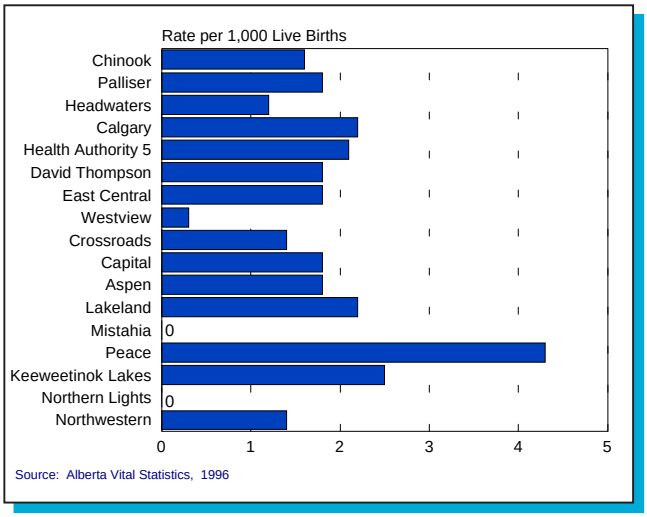


Figure 45 compares the rate of hospitalization for urological system anomalies across areas by year. There is no significant difference in hospitalization for urological system anomalies across the four areas ($p<0.05$).

Figure 45 Hospitalization for Urological System Anomalies By Area

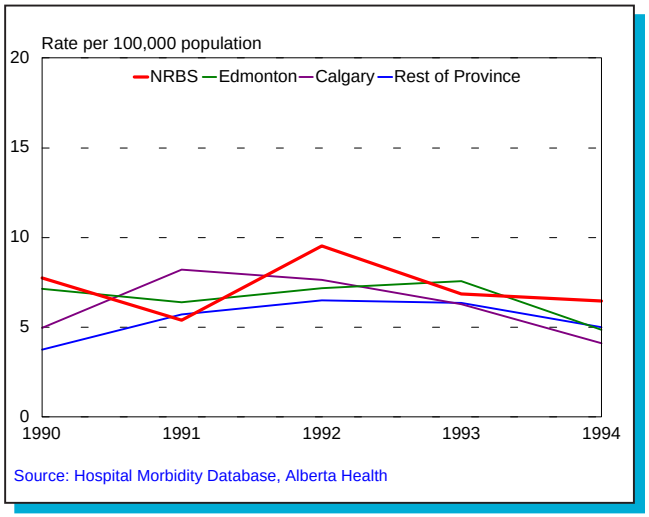
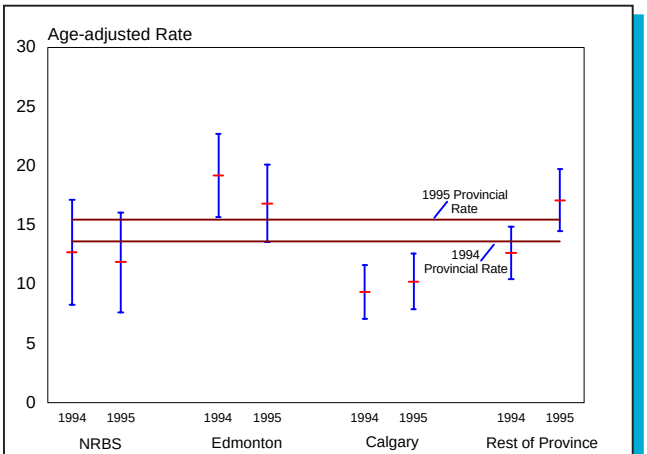


Figure 46 shows the rate of people visiting a physician for urinary system anomalies. There was very little difference between the rate of visits to a physician for urinary system anomalies by residents of the NRBS area and the rate of visits by residents of the other areas of the province. The rate of visits decreased slightly between 1994 and 1995 in the two northern areas (Edmonton and the NRBS area), and increased slightly in the two southern areas of the province (Calgary and the rest of the province). The differences in rates across years and across areas are not statistically significant.

Figure 46 Physician Visits For Urinary System Anomalies



Source: Physican Claims Database, Alberta Health

Respiratory Diseases

Respiratory diseases include asthma, bronchitis, emphysema, and lung ailments caused by external agents, as well as other diseases associated with the respiratory system. Respiratory diseases have been related to gender (more men are diagnosed with respiratory diseases than women), to genetic inheritance and to lifestyle factors such as smoking, income and education. Research has also found relationships between respiratory diseases and air pollution,[44] including indoor air pollutants such as dust and dander, and occupational exposure to a number of airborne contaminants such as dust (flour, wood, cotton), isocyanates, moldy grain, or bird droppings. Airborne pollutants found in the home environment include cigarette smoke, humidifier water, carbon monoxide, smoke from cooking, barbeques or fires, and chlorine (bleach). Other significant factors identified are ammonia, ozone, and hydrogen sulphide.

The specific diagnosis determined by the physician reflects the location of the condition in the lungs, although all the diagnoses indicate respiratory health problems. Some diagnoses may also be recorded by the physician on the first visit, and reevaluated following further testing or evidence, although that change is not recorded in the data used for the analysis below.

Findings

Asthma, bronchitis, emphysema, pneumonia, acute respiratory infection, and other chronic respiratory infections were evaluated to determine if any of these conditions are more frequently diagnosed for residents of the NRBS area than the other areas of the province.

High rates of hospitalization for asthma, emphysema and upper respiratory infections found in the NRBS area are balanced by very low rates of visits to a physician for these conditions whereas the rates of hospitalization and visits to a physician for bronchitis and pneumonia are consistently higher in the NRBS area than other areas of the province.

The geographic distribution of the rates of health care utilization for the various respiratory diseases, and the difficulty of accurately diagnosing any of these health conditions without consideration of further testing, suggests that some diagnostic differences among physicians might be the reason for higher rates of some respiratory diseases, and lower rates of others. Four diagnostic groups, asthma, bronchitis, pneumonia, and upper respiratory infection, were analyzed in greater detail, including an evaluation of the correlation between these diagnoses and airborne contaminants such as sulfur dioxide (SO_2) or oxides of nitrogen (NO_x) and several other indicators representing the socioeconomic environment.

The predicted levels of exposure to SO_2 and NO_x were lower for residents of the northern areas of the province with the exception of the residents of the north eastern part of the province around Fort McMurray. However, differences in the rate of diagnosis of bronchitis do not correspond to the predicted levels of exposure.

Analysis of the total population of the province indicated a small relationship between predicted levels of airborne contaminants and some respiratory diseases. The consistency of findings using different methods supports the argument that ambient SO_2 may impose an increased risk for asthma, pneumonia, and infections of the upper respiratory system for Albertans. However, this effect is likely very small. The largest difference in the rate of diagnosis of asthma between the SO_2 comparison groups is less than 2 people per 100,000 population. Latitude, socioeconomic status, population density, and the proportion of the population who are aboriginal appear to be important predictive factors for the geographic variations of respiratory conditions at the community level.

The models explain very little of the variation in the rate of diagnosis (only 20 - 60%). A number of other factors, such as tobacco use, exposure to smoke from fireplaces and barbeques, and other sources of indoor air pollution likely have a far more direct impact on respiratory health.

Figure 47 compares the five year average provincial rate of hospitalization for all respiratory diseases in the province by gender. More male babies are hospitalized for respiratory diseases than female babies, but this relationship reverses for children between the ages of 5 and 15, when more girls than boys are hospitalized for this type of ailment. The rate of hospitalization for respiratory diseases is quite low for both males and females between the ages of 20 and 50. Among the older age groups, more males than females are hospitalized for respiratory ailments.

Figure 47 Provincial Rate of Hospitalization for Respiratory Disease

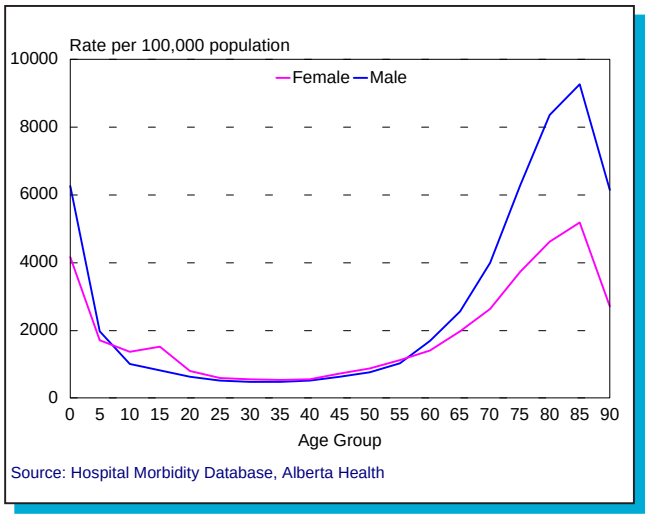
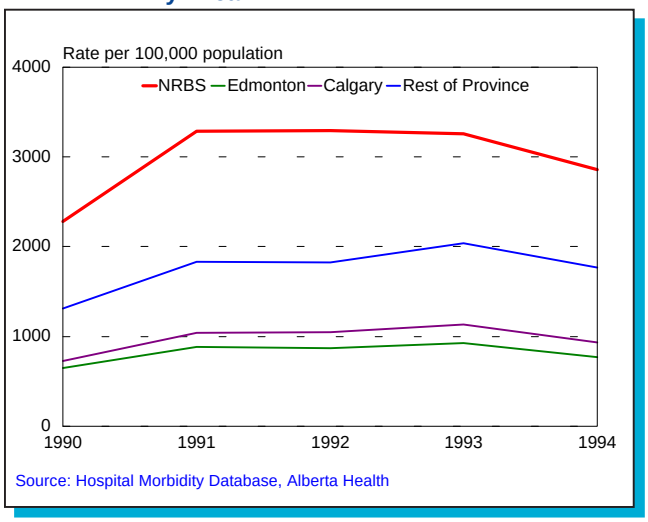


Figure 48 compares the rate of hospitalization for all respiratory diseases by area and year. The rate of hospitalization for respiratory diseases is consistently higher in the two rural areas than it is in the two urban areas, although the rate of hospitalization in the NRBS area is much higher than the rate in the rest of the province (differences are statistically significant, $p<0.05$). The pattern of hospitalization over time is similar across all regions: rates increased between 1990 and 1991, where they remained until 1993. Hospitalization rates decreased again by 1994, although the 1994 rate was greater than the 1990 rate in all areas.

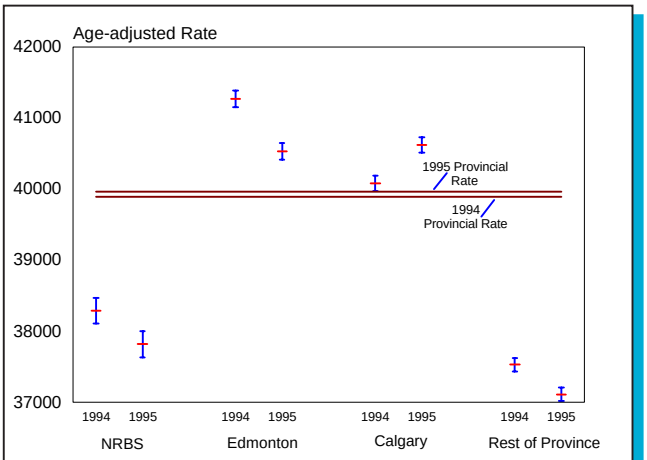
Figure 48 Hospitalization For Respiratory Diseases By Area



Source: Hospital Morbidity Database, Alberta Health

Figure 49 compares the rate of individuals visiting a physician for all respiratory diseases in 1994 with the rate for 1995 in each of the four areas. The rate of visits to a physician for a respiratory disease by residents of the NRBS area was significantly lower than the rate of visits by residents of either urban area, but was significantly higher than the rate of visits for these diagnoses by residents of the other rural area, the rest of the province ($p<0.05$). The rate decreased between 1994 and 1995 in all areas of the province except Calgary, where the 1995 rate of visits was significantly greater than the 1994 rate ($p<0.05$).

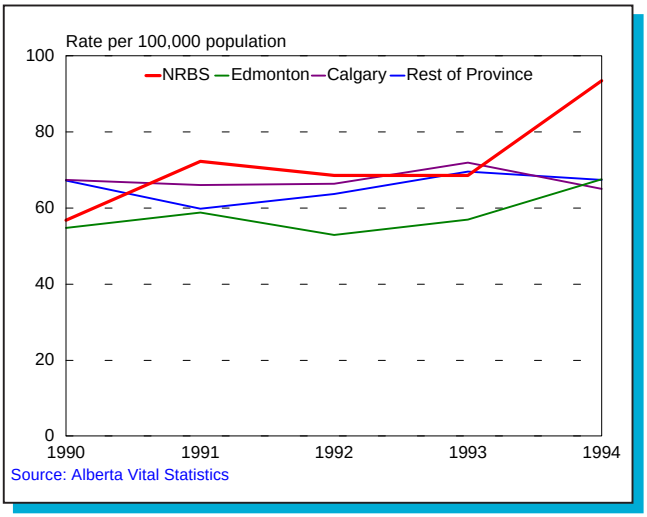
Figure 49 Rate of Individuals Visiting a Physician for Respiratory Diseases



Source: Physican Claims Database, Alberta Health

Figure 50 shows the rate of mortality from all respiratory diseases over time. The rate in the NRBS area was similar to the rate in each of the other areas for most years, but increased somewhat in 1994. The differences between the areas are not statistically significant. The apparent increase in mortality rate in 1995 in the NRBS area compared to the other areas of the province corresponds to low rates of visits to a physician, and a decrease in the rate of hospitalization that year.

Figure 50 Rate of Mortality from Respiratory Diseases



Source: Alberta Vital Statistics

Although the rate of mortality and the rate of visits to a physician were both slightly higher in 1994, this corresponded to a decrease in hospitalization rates, indicating that there is no difference between the NRBS area and the other areas of the province for respiratory diseases.

Asthma

Asthma is a condition that results in periodic breathing difficulty, caused by a spasm or swelling of the membranes of the bronchial tubes. Asthma occurs more frequently in children than in adults and may be caused by allergic reaction to contaminants in the air, such as pollen, dust or dander, or may be caused by an infection of the respiratory tract. Some people may be allergic to some types of food or some drugs, and may get an asthmatic attack from eating these foods.

Figure 51 shows the five year average provincial rate of hospitalization for asthma in the province by gender. The distribution shows that asthma is a more acute problem (requiring hospitalization) among the very young. This is also true for older people, but the rate of hospitalization is not as great among older people. The rate is much higher among children younger than 10, and more baby boys are hospitalized for asthma than are baby girls. Slightly more females than males between the ages of 10 and 70 are hospitalized for asthma. The hospitalization rate for males older than 75 is the same as the hospitalization rate for females older than 75.

Figure 51 Provincial Rate of Hospitalization for Asthma

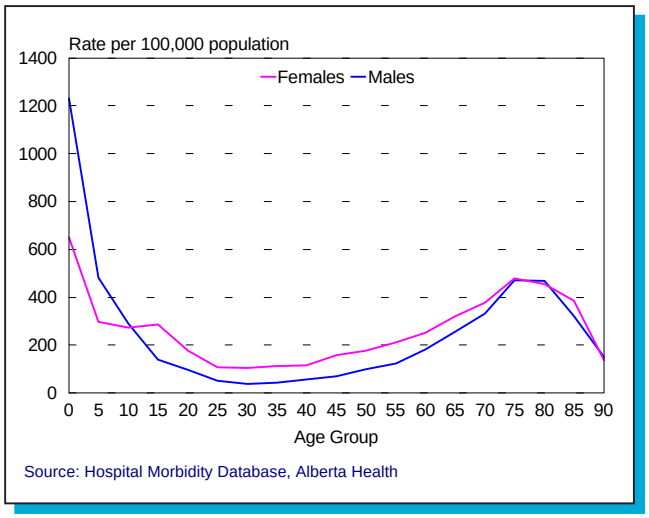
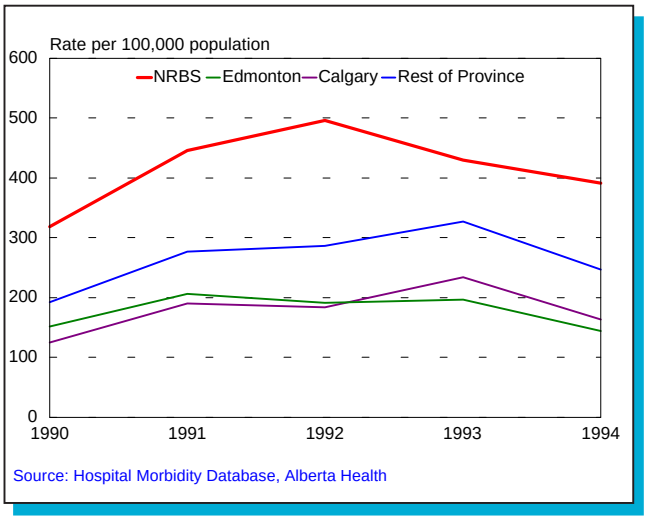


Figure 52 shows the rate of hospitalization for asthma across areas by year. The rate of hospitalization for asthma across regions reflects the rate for all respiratory diseases discussed above. Again we see that the rate of hospitalization is higher in the two rural areas than it is in the two urban areas, although the rate of hospitalization in the NRBS area is higher than the rate in the rest of the province (differences are statistically significant, $p<0.05$). The pattern of hospitalization over time in the NRBS area is slightly different than the other regions: the rate continued to increase in the NRBS area during those years when the rate remained stable in the other areas. Hospitalization rates in all areas decreased again by 1994, although the 1994 rate was greater than the 1990 rate in all areas, except Edmonton.

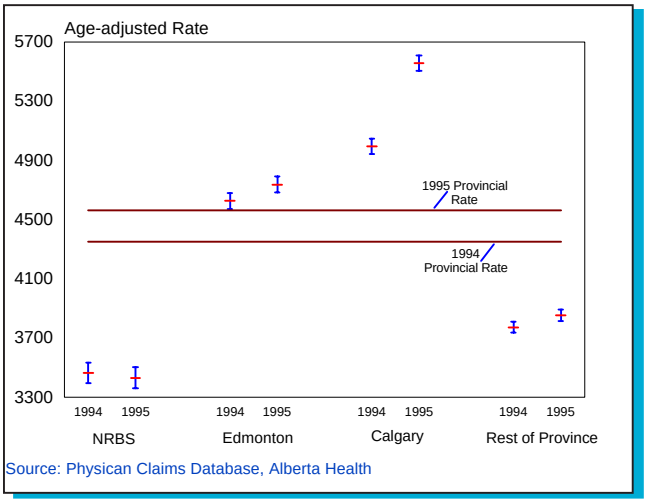
Figure 52 Hospitalization for Asthma by Area



Source: Hospital Morbidity Database, Alberta Health

Figure 53 compares the rate of individuals visiting a physician for asthma across areas in 1994 with 1995. The rate of visits to a physician for asthma by residents of the NRBS area was significantly lower than the rate of visits by residents of any other area, and remained the lowest for both 1994 and 1995 ($p<0.05$). Unlike the pattern we have seen with other diagnoses, the rate of visits by residents of the rest of the province was significantly higher than the rate in the NRBS in both years. The rate of visits to a physician for asthma by residents of the Calgary area was significantly higher than the other areas in 1994, and the rate increased significantly the following year ($p<0.05$).

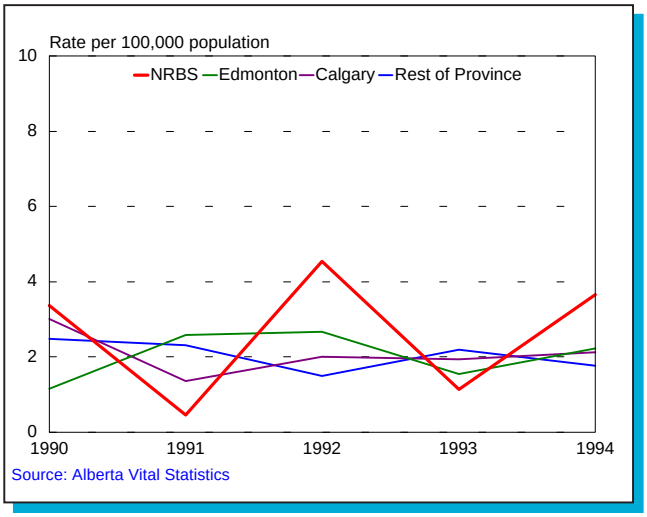
Figure 53 Rate of Individuals Visiting a Physician for Asthma



Source: Physican Claims Database, Alberta Health

Figure 54 shows the rate of mortality from asthma. The apparent fluctuations in the mortality rate in the NRBS area are due to the small number of deaths attributed to this diagnosis. The actual number of deaths due to asthma in the NRBS region ranged between one death in 1991, and eight deaths in 1992. The difference in the rate of mortality from asthma between residents of the NRBS and the other areas of the province were not statistically significant.

Figure 54 Rate of Mortality from Asthma



Source: Alberta Vital Statistics

Bronchitis

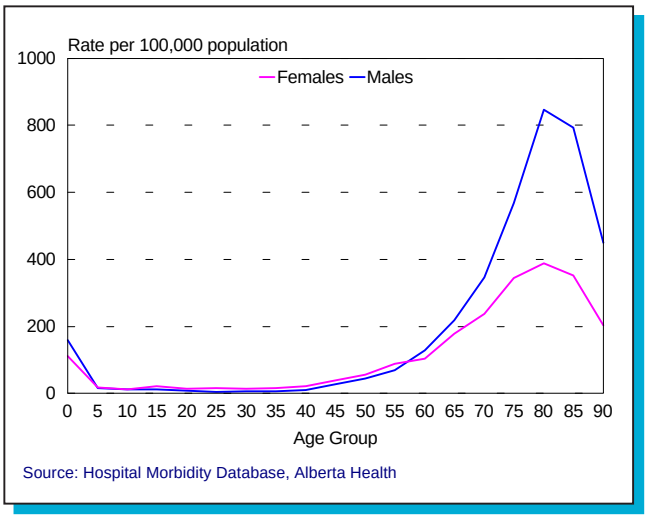
Bronchitis is an inflammation of the mucous membrane of the bronchial tubes, typically resulting from a viral infection. Poor nutrition, dust and fumes, or allergies may also reduce the individual's ability to resist the viral infection. Research has also found links between chronic bronchitis and respiratory tract injury due to occupational exposure to inhaled irritants, such as ammonia, hydrogen chloride, hydrogen sulphide, chlorine or nitrogen oxides.

According to the 1991 Aboriginal Peoples Survey,[45] aboriginal people more frequently report having been diagnosed with bronchitis than the other respiratory health conditions, and more Metis people report having a diagnosis of

bronchitis (13%) than do First Nations people (8.3%).

Figure 55 shows the five year average provincial rate of hospitalization for bronchitis by gender. The rate of hospitalization for bronchitis for males and females in each group is quite different than the rates for asthma - the hospitalization rate for asthma for babies was much higher than the rate of hospitalization for bronchitis, and the rate of hospitalization for bronchitis for older males is much higher than the rate of hospitalization for asthma for older males.

Figure 55 Provincial Rate of Hospitalization for Bronchitis

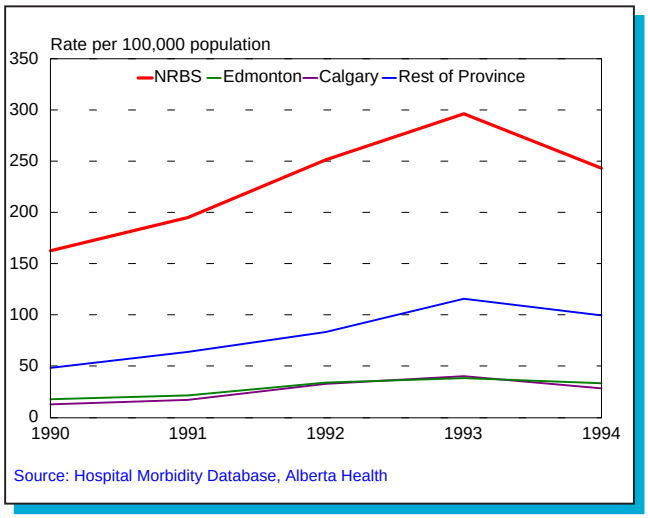


Source: Hospital Morbidity Database, Alberta Health

Overall, the rate of hospitalization for bronchitis is lower than that for asthma. Further, although the rate is higher for babies than for young adults, the differences are not great. There is no difference between the rate of hospitalization for males and females younger than 60, but there is a marked difference between the rate for males who are 65 years of age and older and females who are the same age - more older men than older women are hospitalized for bronchitis.

Figure 56 shows the rate of hospitalization for bronchitis across areas by year. The rate of hospitalization for bronchitis is higher in the two rural areas than it is in the two urban areas. The rate in the NRBS area is significantly greater than the rate in any of the other areas ($p<0.05$). Overall, the pattern of hospitalization for bronchitis was similar across the areas. The rate of hospitalization for bronchitis increased steadily in all areas between 1990 and 1993, and decreased slightly in 1994.

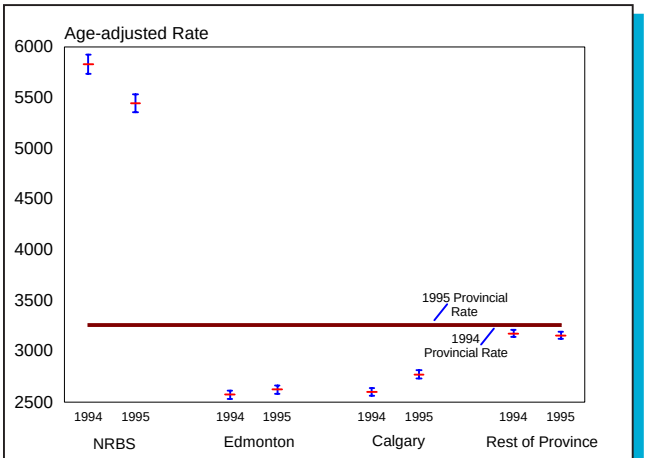
Figure 56 Hospitalization for Bronchitis by Area



Source: Hospital Morbidity Database, Alberta Health

Figure 57 compares the rate of individuals visiting a physician for chronic bronchitis in 1994 with the 1995 rate in each of the four areas. The rate of visits to a physician for bronchitis was significantly greater in the NRBS than any other area of the province. The rate of visits to a physician for bronchitis by residents of the NRBS area was twice as great as the other areas. The rate of visits was lowest in Edmonton; Calgary was comparable in 1994, but the rate of visits to a physician for bronchitis by Calgary residents increased somewhat in 1995. The rate of visits by residents of the rest of the province was significantly higher than the two urban areas, but the rate was half that of the NRBS area.

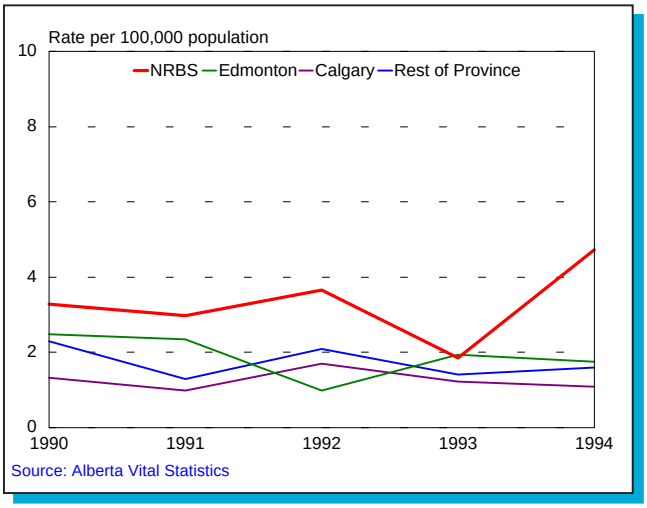
Figure 57 Rate of Individuals Visiting a Physician for Chronic Bronchitis



Source: Physican Claims Database, Alberta Health

Figure 58 shows the rate of mortality from bronchitis by area. The rate of mortality from bronchitis in the NRBS area was significantly higher than the rate in Calgary, but was not different than the rate for Edmonton or the rest of the province ($p<0.05$). The low rate of mortality corresponds to the high rate of hospitalization for the same year, and the increase in mortality in 1994 corresponds to a high rate of visits to a physician in the same year. The differences between the NRBS area and the other areas of the province suggests that bronchitis is a more frequent diagnosis for the residents of the NRBS area than other areas of the province.

Figure 58 Rate of Mortality from Bronchitis



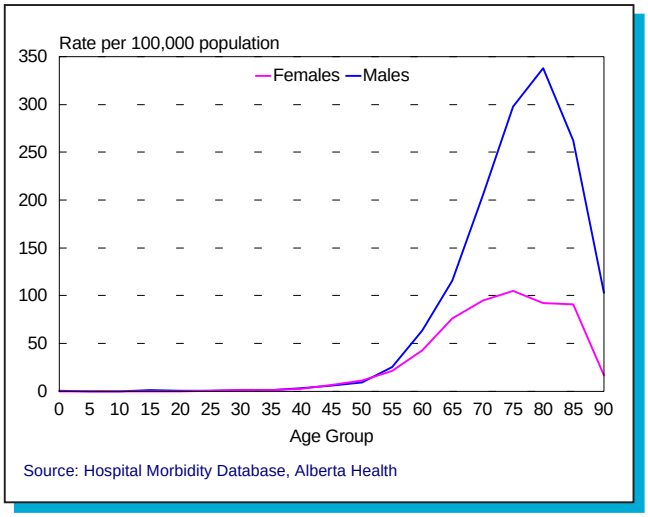
Source: Alberta Vital Statistics

Emphysema

Emphysema is a chronic pulmonary disease that causes damage to the lung tissue, and consequently results in large spaces in the tissue of the lungs. Emphysema is usually exacerbated by air pollutants, particularly cigarette smoke.

Figure 59 shows the provincial five year average rate of hospitalization for emphysema by gender for each age group. This graph shows that emphysema is a disease that affects older people, and affects men more than women. The rate of hospitalization for emphysema is very low for people younger than 55 and is the same for men as women. The difference between older men and older women is very pronounced, particularly for men and women who are between 75 and 85 years old.

Figure 59 Provincial Rate of Hospitalization for Emphysema



Source: Hospital Morbidity Database, Alberta Health

Figure 60 shows the rate of hospitalization for emphysema across area by year. The five year rate of hospitalization for emphysema in the NRBS area was significantly higher than the rate in the rest of the province ($p<0.05$). However, the rate in Calgary was much higher than the rate reported in any other area, including the NRBS area ($p<0.05$).

Figure 60 Hospitalization for Emphysema by Area

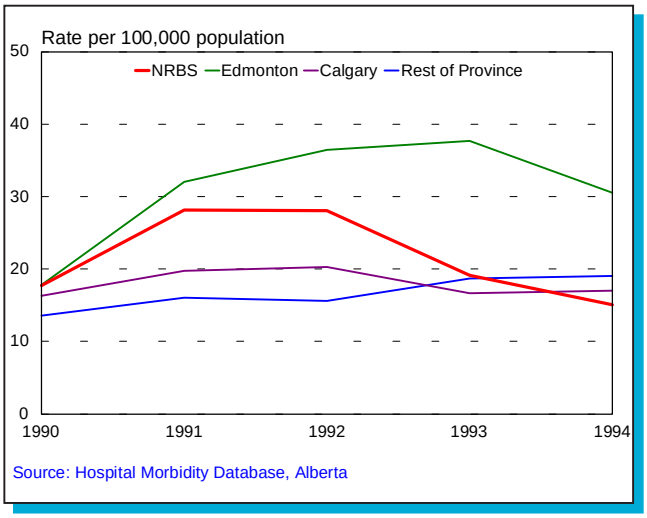


Figure 61 compares the 1994 and 1995 rates of individuals visiting a physician for emphysema in each of the four areas. The rate of visits for emphysema by residents of the NRBS area was significantly lower than the rate of visits by residents of Edmonton in both 1994 and 1995, and significantly lower than the rate of visits by Calgary residents in 1995. There was no significant difference in the rate of visits to a physician for emphysema by residents of the NRBS area and residents of the rest of the province in either year. The rate of visits by residents in the NRBS area decreased slightly from 1994 to 1995, while the rate of visits by residents of the rest of the province remained constant.

Figure 61 Rate of Individuals Visiting a Physician for Emphysema

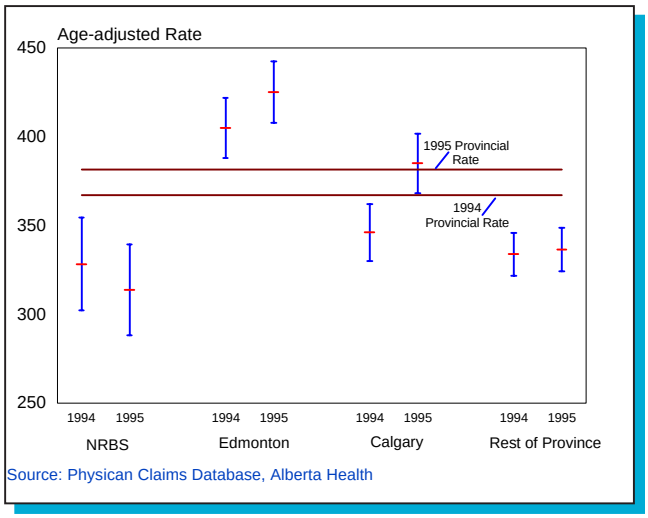
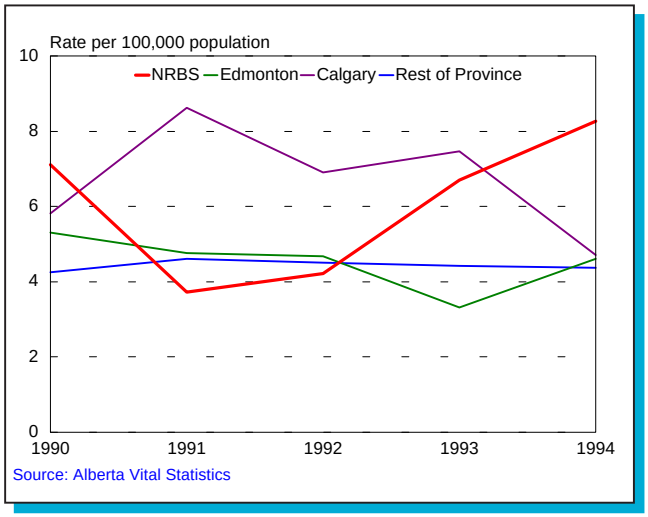


Figure 62 shows the rate of mortality from emphysema. The apparent fluctuations in the rate of mortality across time in all areas are due to the small number of deaths attributed to this diagnosis. The rate of mortality from emphysema was very similar in all areas - less than 10 deaths in every 100,000 are attributed to emphysema. Between 6 and 14 deaths in the NRBS area were attributed to emphysema.

Figure 62 Rate of Morality from Emphysema



Pneumonia

Pneumonia is an inflammation of the lung tissue, caused by bacteria or a virus. There is also some evidence from research that long term exposure, or exposure to large amounts of some airborne contaminants such as grain dust, wood pulp, wheat flour, or isocyanates, may also cause a form of pneumonia. Weakness of the lung tissue caused by long term exposure to irritants such as tobacco and wood smoke, or particulates such as dust and diesel exhaust may also increase susceptibility to the virus or bacteria that cause pneumonia.

Figure 63 compares the provincial rate of hospitalization for pneumonia in the province by gender. The rate of hospitalization among babies is greater than that for children older than 5 years, and is the same for boy babies as it is for girl babies. There is no difference in the rate of hospitalization for males and females between the ages of 5 and 60. More men who are older than 60 are hospitalized than women in the same age groups.

Figure 63 Provincial Rate of Hospitalization for Pneumonia

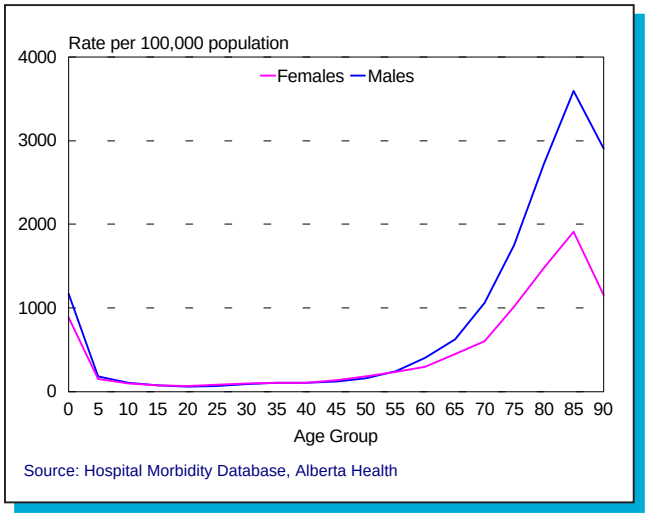


Figure 64 compares the rate of hospitalization for pneumonia across areas by year. The rate of hospitalization for pneumonia increased over time in all areas of the province, although the rate of hospitalization in the two urban areas was much lower than the rate in the two rural areas and the increase in the rate was less dramatic. The rate of hospitalization in the two rural areas was significantly higher than the rate in the two urban areas, and the rate in the NRBS area was significantly higher than any other area in the province ($p<0.05$).

Figure 64 Hospitalization for Pneumonia by Area

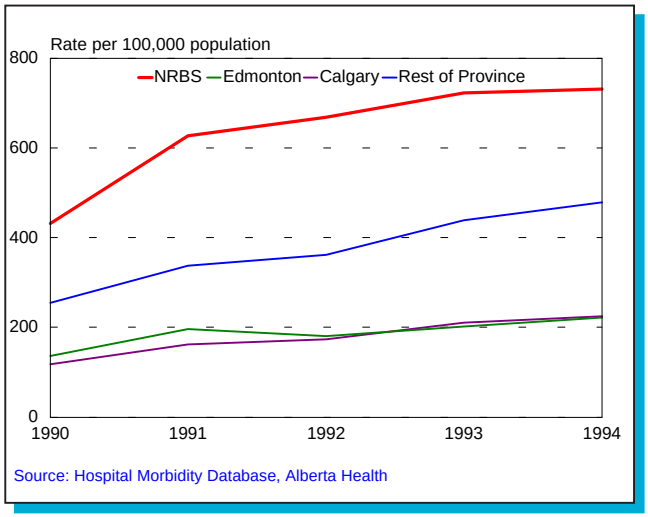
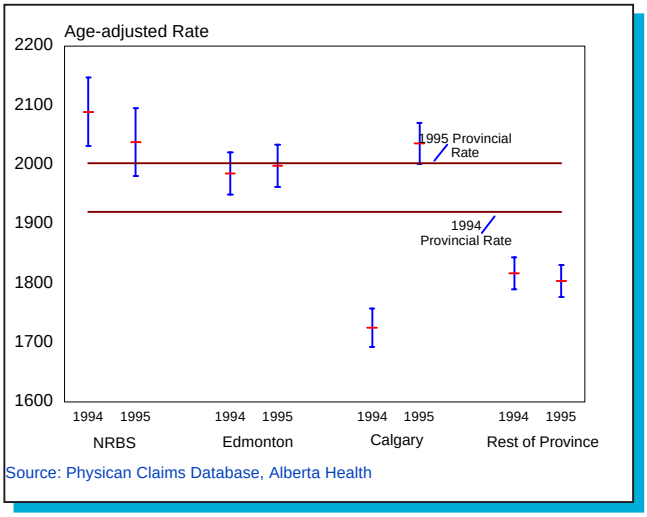


Figure 65 compares the rate of individuals visiting a physician for pneumonia in 1994 with the 1995 rate across areas. The rate of visits to a physician for pneumonia by residents of the NRBS area was significantly higher in 1994 than any of the other areas of the province, but the rate decreased in 1995 to a level comparable to the two urban areas. The rate of visits by residents of the other rural area - the rest of the province - was significantly lower than the NRBS area in both 1994 and 1995. The rate of visits to a physician for this diagnosis by residents of the Calgary area was lower than any other area in 1994 ($p<0.05$).

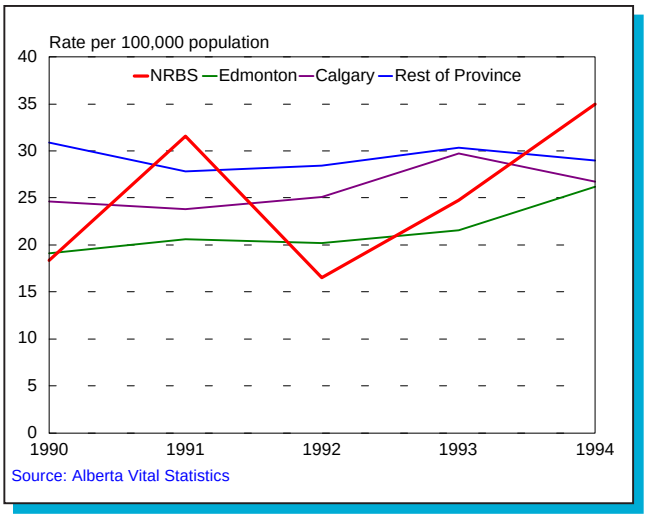
Figure 65 Rate of Individuals Visiting a Physician for Pneumonia



Source: Physican Claims Database, Alberta Health

Figure 66 compares the rate of mortality from pneumonia across areas by year. The rate of mortality from pneumonia was roughly the same for residents of the NRBS area as for residents of the other areas in the province, although the fluctuations were more pronounced in the NRBS area. Between 28 and 60 people died from pneumonia each year in the NRBS area.

Figure 66 Mortality from Pneumonia by Area



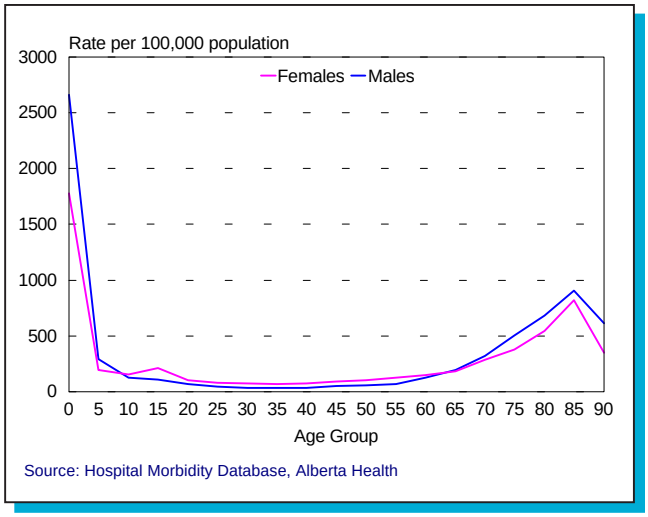
Source: Alberta Vital Statistics

Acute Respiratory Infection

Acute respiratory infection is similar to pneumonia, but is differentiated from pneumonia by location: acute respiratory infection is an inflammation of the upper respiratory tract whereas pneumonia is defined as an inflammation of the lung or lower respiratory tract. Acute respiratory infections are caused by the same types of bacteria, viruses, or irritants as pneumonia.

Figure 67 compares the rate of hospitalization for acute respiratory infection in the province by gender. There is no difference in the rate of hospitalization between men and women. Babies and older people are most susceptible to respiratory infections, and the hospitalization rate for baby boys is somewhat greater than the rate for baby girls. Compared to adults, the rate of hospitalization for babies is significantly greater.

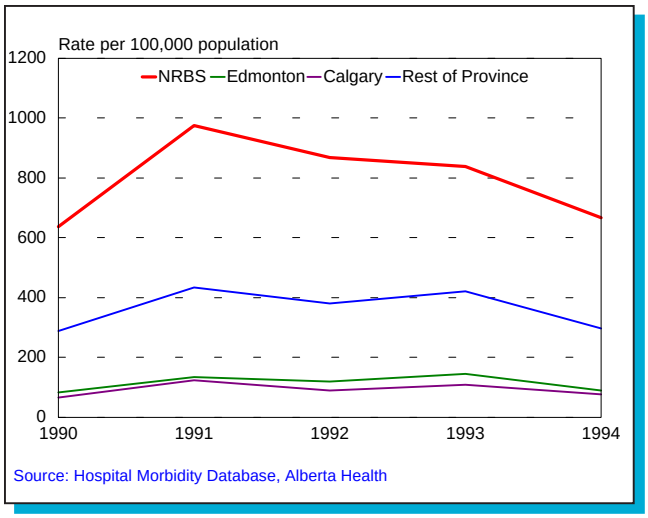
Figure 67 Provincial Rate of Hospitalization for Acute Respiratory Infection



Source: Hospital Morbidity Database, Alberta Health

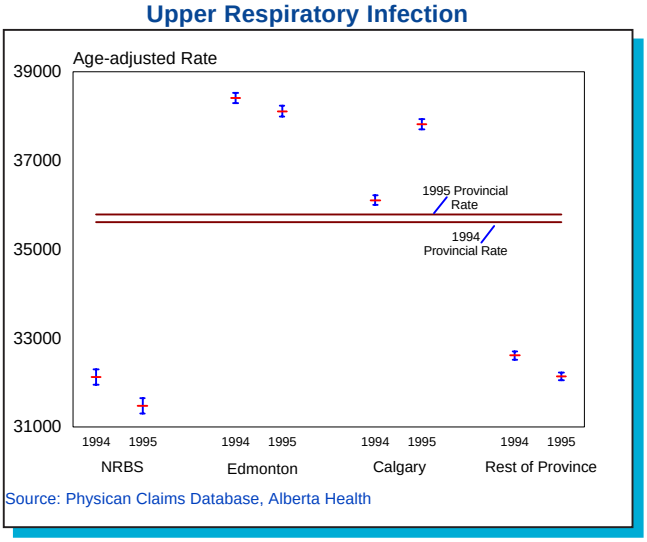
Figure 68 compares the provincial rate of hospitalization for acute respiratory infection across areas by year. The rate of hospitalization for respiratory infections is greater in the two rural areas than in the two urban areas ($p<0.05$). The rate of hospitalization for acute respiratory infection in the NRBS area increased in 1991, but by 1994, the rate had decreased again to the 1990 level. A similar pattern of increase and decrease occurred in the other rural area (the rest of the province), while the rate of hospitalization in the urban areas remained relatively constant

Figure 68 Provincial Rate of Hospitalization for Acute Respiratory Infection



Source: Hospital Morbidity Database, Alberta Health

Figure 69 Rate of Individuals Visiting a Physician for Upper Respiratory Infection

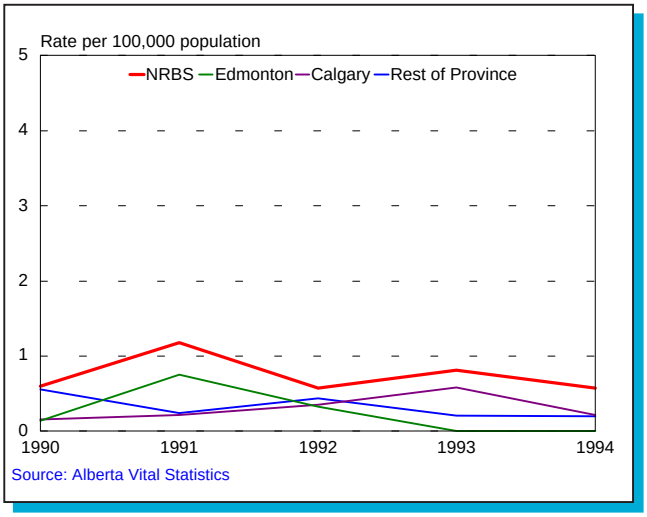


Source: Physican Claims Database, Alberta Health

Figure 69 compares the rate of individuals visiting a physician for acute respiratory infection for each of the four areas in 1994 with the rates for 1995. The rate of visits to a physician for acute respiratory infection by the residents of the NRBS area was significantly lower than any other area in the province in both 1994 and again in 1995. The rate of visits by residents of the two urban areas was much higher, and, similar to the rate of visits to a physician for pneumonia, the rate of visits by Calgary residents for acute upper respiratory infection increased dramatically between 1994 and 1995 (all differences were statistically significant at the 0.05 level).

Figure 70 compares the rate of mortality for acute respiratory infection across areas by year. Overall the rate of mortality from respiratory infections is very low. Only one or two people died each year from a respiratory infection, and the greatest number of people who died from respiratory infection in any area during the past ten years was six. The differences between the areas are not statistically significant.

Figure 70 Mortality Rate for Respiratory Infection



Source: Alberta Vital Statistics

Other Chronic Obstructive Pulmonary Disease

Other chronic obstructive pulmonary diseases (COPD) includes several diagnoses attributed specifically to exposure to a particular contaminant, such as farmer's lung (caused by exposure to grain dust and hay mold), bird-fancier's lung (attributed to exposure to bird feces), ventilation pneumonitis (caused by fungus or other organisms living in a ventilation system) and other chronic airway obstructions where the source was unspecified.

Figure 71 compares the rate of hospitalization for other chronic obstructive pulmonary disease in the province by gender. More men are hospitalized with this diagnosis than women in the same age groups, and the rate of hospitalization is greatest for people older than 55 years of age. This is likely due to the occupation-related nature of the diagnosis - it is only after years of exposure that the condition develops, and older people are more likely to develop acute effects from this chronic condition.

Figure 71 Provincial Rate of Hospitalization for Other COPD

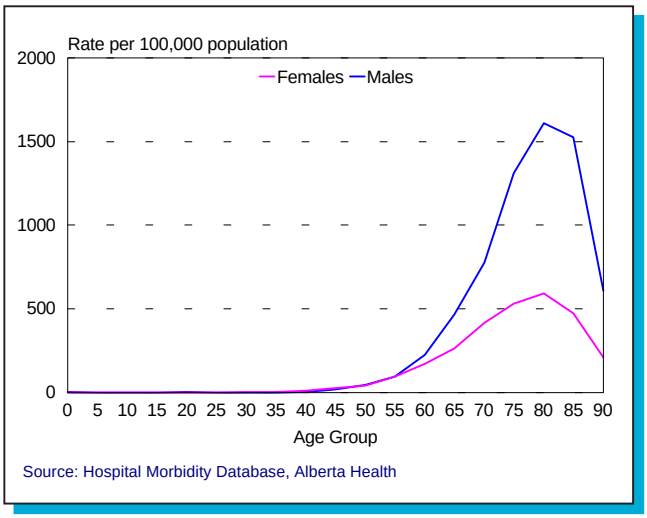


Figure 72 compares the rate of hospitalization for other chronic obstructive pulmonary disease across areas by year. The hospitalization rate was higher in the two rural areas than the two urban areas, and the rate in the NRBS area was much greater than any of the other areas ($p<0.05$). The rate of hospitalization in each of the areas were statistically different than all other areas ($p<0.05$).

Figure 72 Hospitalization for Other COPD by Area

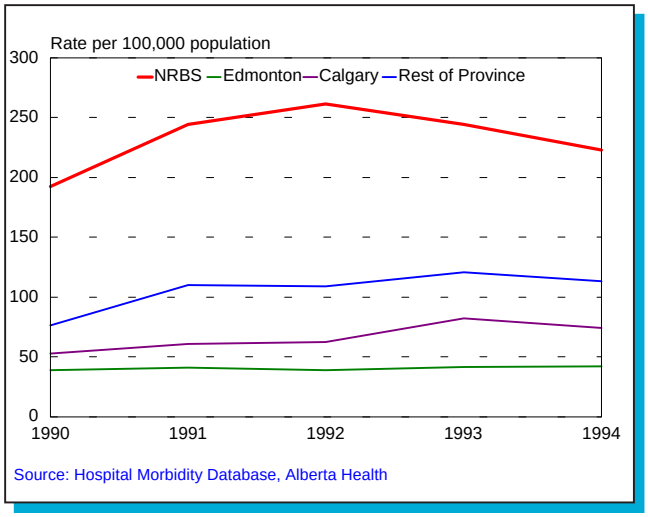
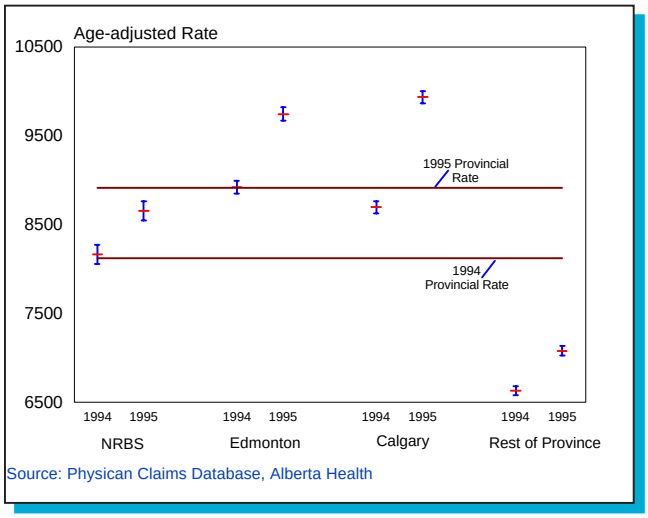


Figure 73 compares the 1994 rate of individuals visiting a physician for other chronic obstructive pulmonary diseases in each of the areas with the 1995 rate. The rate of visits to a physician for other chronic obstructive pulmonary disease by residents of the NRBS area was significantly lower than the rate of visits by residents of the two urban areas each year, but significantly higher than residents of the rest of the province ($p<0.05$). The rate of visits increased in all areas between 1994 and 1995.

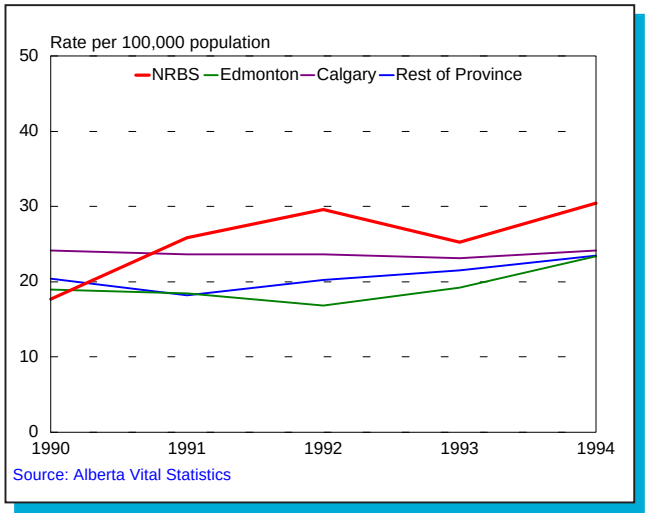
Figure 73 Rate of Individuals Visiting a Physician for Other COPD



Source: Physican Claims Database, Alberta Health

Figure 74 compares the rate of mortality for other chronic obstructive pulmonary disease across areas by year. The rate of death from other chronic obstructive pulmonary diseases is relatively low, and there is very little difference across the areas. Fifty deaths in the NRBS area were attributed to other COPD in 1994. The rate of mortality from other COPD among residents of the NRBS area was significantly greater than Edmonton and the rest of the province, but was not different from the rate of mortality for residents of the Calgary area.

Figure 74 Rate of Mortality for Other COPD by Area



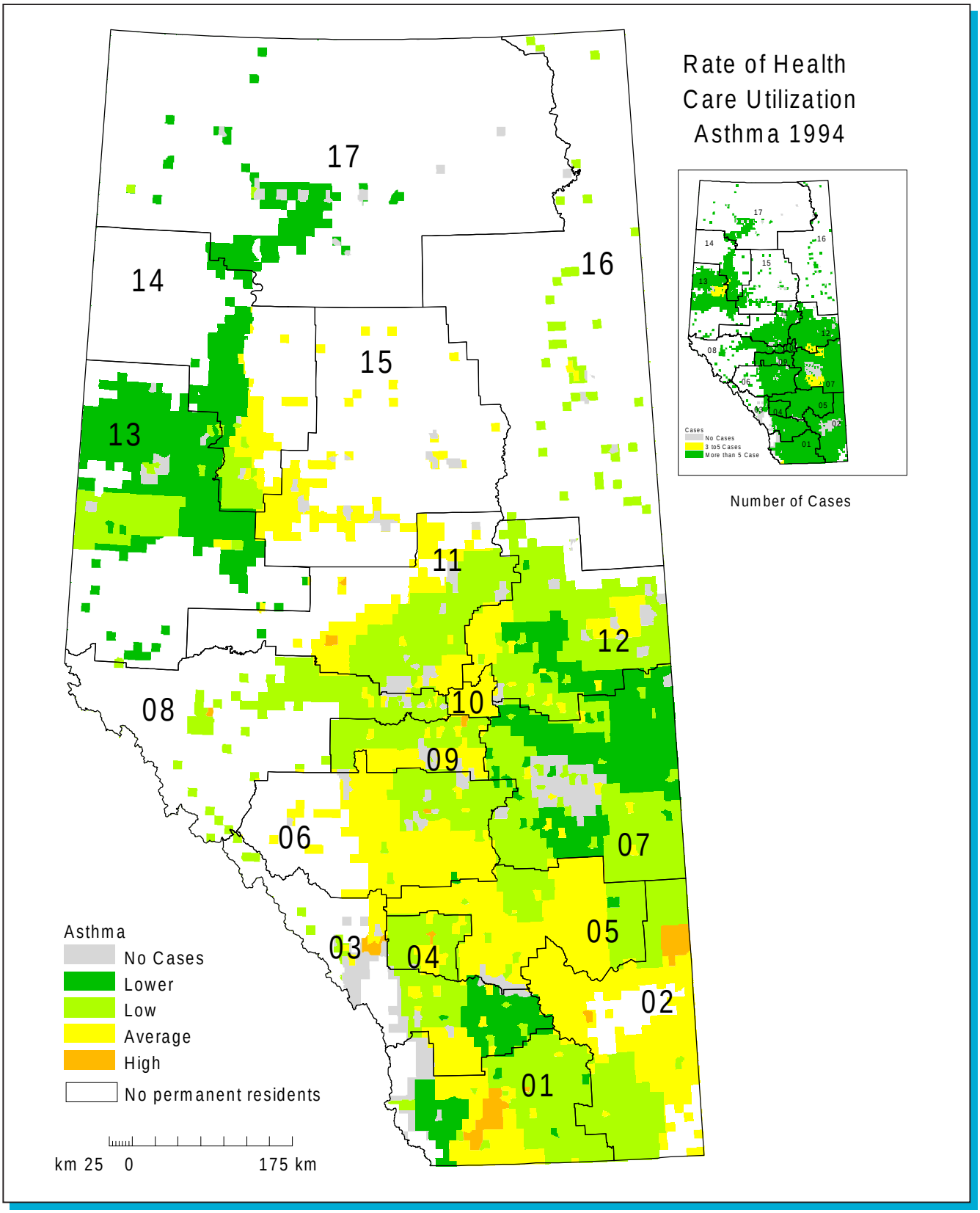
Source: Alberta Vital Statistics

Further analysis was conducted to determine if the higher rates of bronchitis and pneumonia were correlated with estimates of air quality, or other potential sources of variation could be identified. Detailed discussion about the source of air quality data is included in Appendix E.

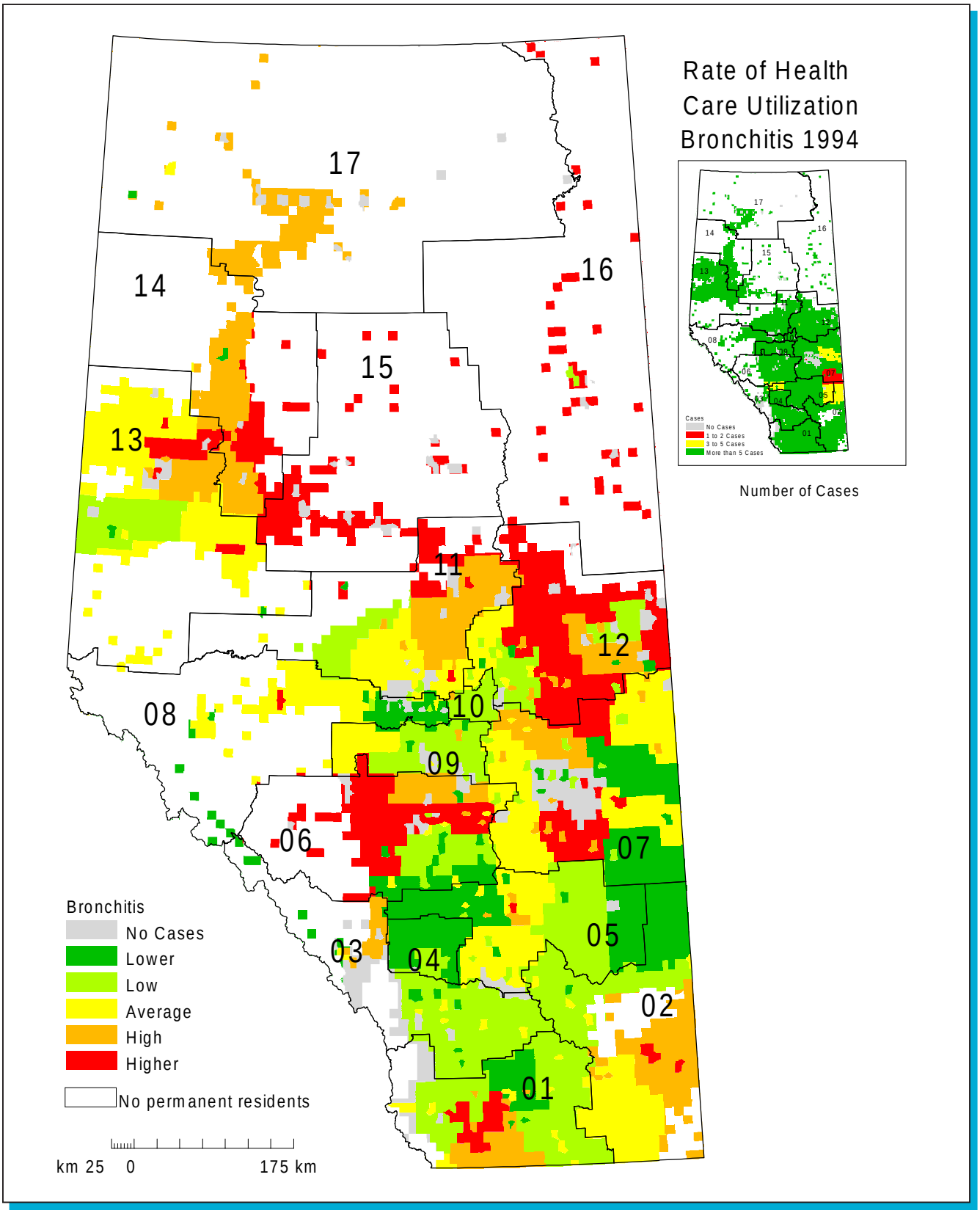
Maps 9, 10, 11 and 12 show the geographic distribution of the four respiratory diagnoses included in the analysis. The rates used for the current analysis are based on a cumulative measure of all visits to a physician and all admissions to a hospital counting each individual only once in a given year. This measure is indicative of the rate of health care utilization for an area (for further discussion of the rate of health care utilization, refer to the Methods chapter).

Table 15 shows the adjusted means of the log-transformed rate for asthma by level of SO_2 for all of Alberta and for the NRBS area. It shows that, after adjusting for the effects of other variables, the rate of health care utilization for asthma in Alberta and in the NRBS area increases with the level of SO_2 in both models. Although the comparison was made only between the level 1 and level 2 areas and between the level 1 and level 3 areas, the overall pattern suggests a positive association.

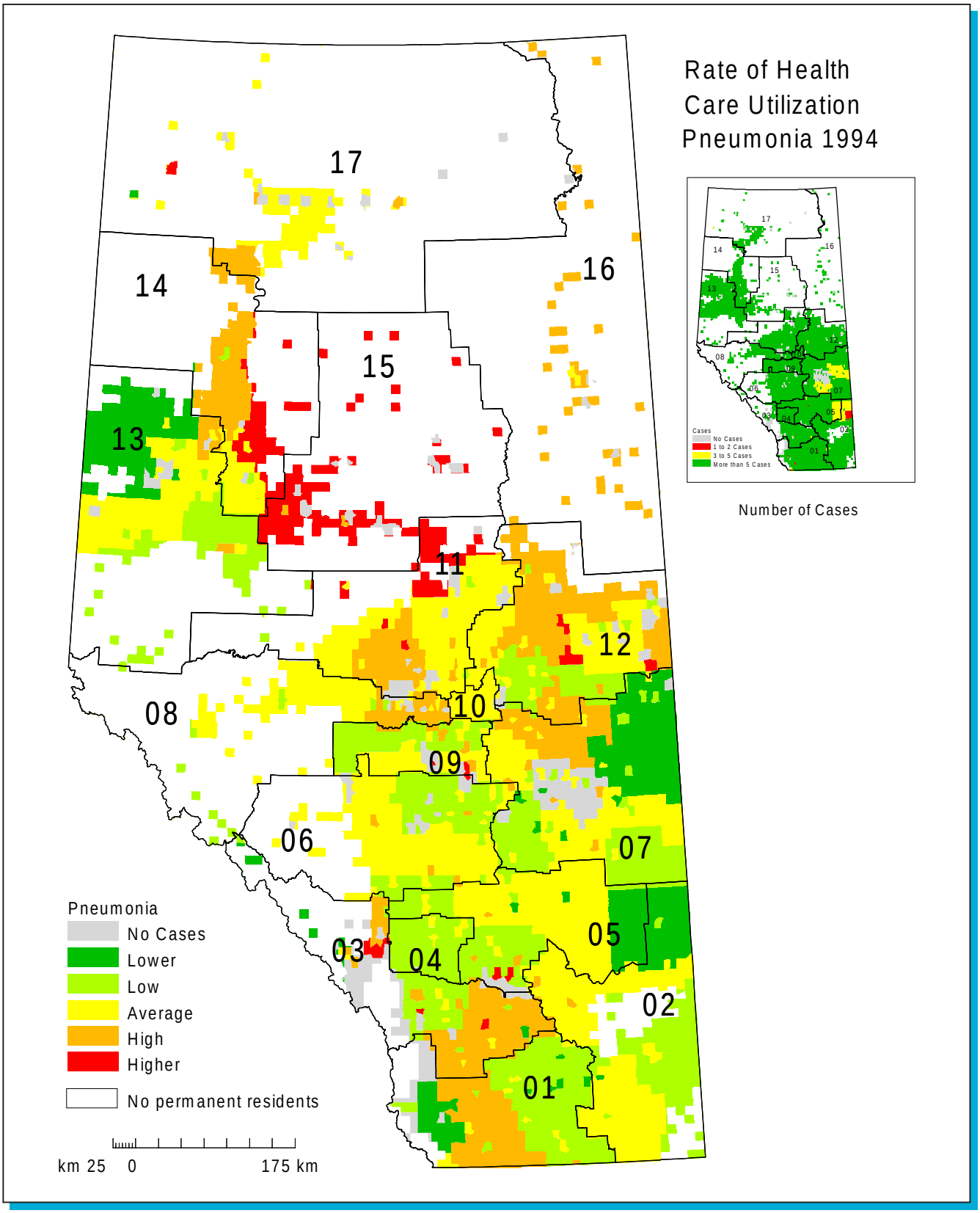
Map 9 **Rate of Health Care Utilization for Asthma, 1994**



Map 10 **Rate of Health Care Utilization for Bronchitis, 1994**



Map 11 Rate of Health Care Utilization for Pneumonia, 1994



Map 12 **Rate of Health Care Utilization for Upper Respiratory Infections, 1994**

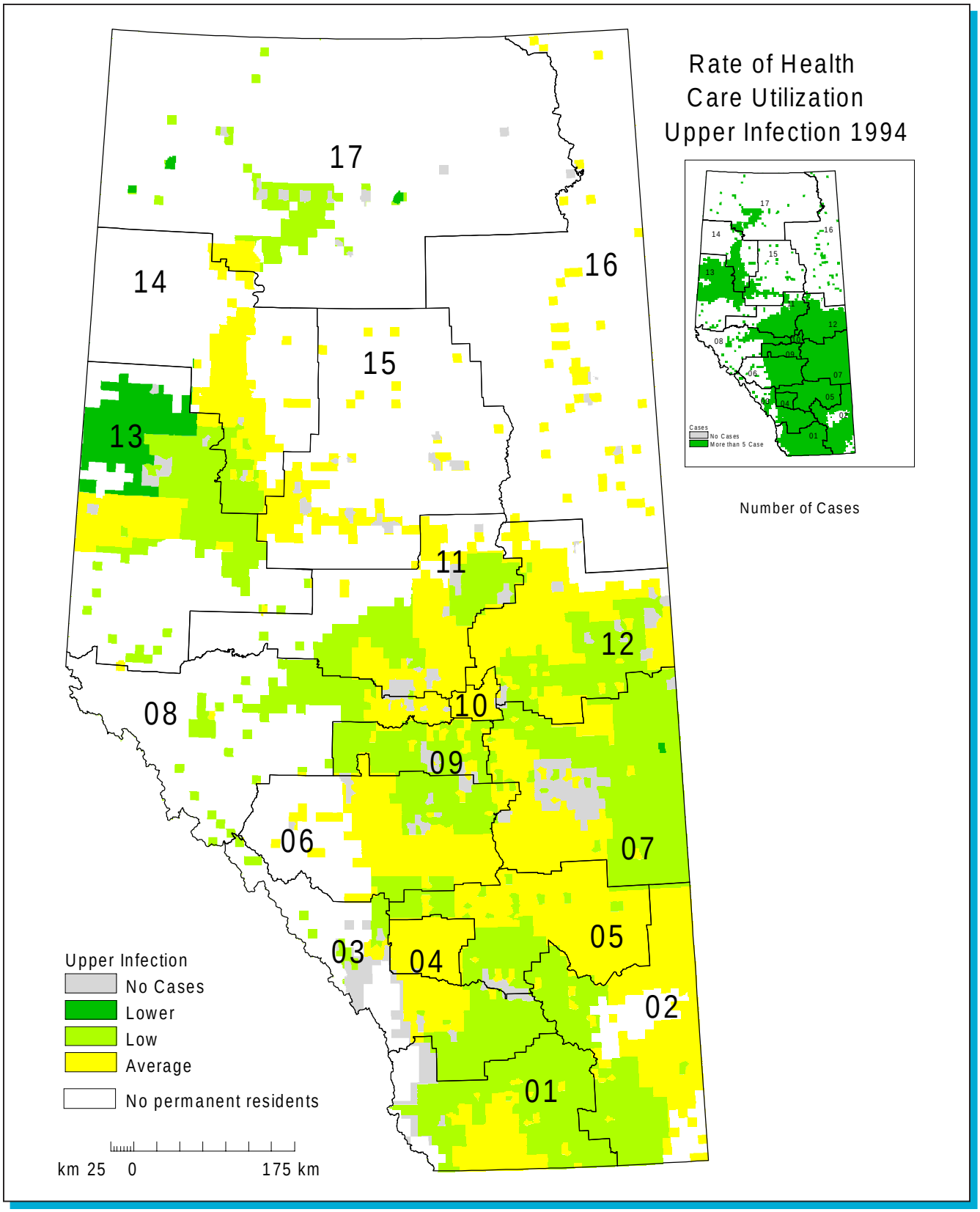


Table 15 Adjusted Means of Log Rate of Health Care Utilization for Asthma by SO_2 Level

Level		Model with All CSDs Included			Model with Partial CSD		
		LSMean[1]	t value[2]	p value[3]	LSMean	t value	p value
NRBS Area	1	7.82			7.51		
	2	7.97	1.29	.203	7.90	3.43	.001
	3	8.30	2.70	.009	8.11	2.60	.012
		N= 66 R^2 = 38.5%			N = 66 R^2 = 32.1%		
All Alberta	1	7.94			7.94		
	2	8.03	2.24	.026	8.09	2.78	.006
	3	8.12	3.66	<.001	8.25	3.65	<.001
		N= 318 R^2 = 18.7%			N= 271 R^2 = 21.3%		

1 Least square means (LSMean) of log transformed rate of disease, which is adjusted for the effects of the other variables in the model.
2 Student's t-test statistic for the hypothesis: LSMean (I) = LSMean (j). Level 1 is the reference.
3 The p-value of the t-test for the difference between level 1 and 2 or between level 1 and 3.

Tables 16, 17, 18 show the adjusted means of the log-transformed rate for bronchitis, pneumonia, and infections of the upper respiratory system by predicted level of airborne SO_2 for Alberta and for the NRBS area. A similar relationship exists with these diagnoses as we saw with asthma: after adjusting for the effects of other variables, the rate of health care utilization for pneumonia and infections of the upper respiratory system increases with the predicted level of SO_2 in both models for the province as a whole, but there is no relationship between the predicted level of SO_2 and the rate of health care utilization for pneumonia and acute infections of the upper respiratory system for residents of the NRBS area. There is no relationship between the predicted level of SO_2 and health care utilization for bronchitis by residents of the NRBS area using either model, but there is a significant relationship between the predicted level of SO2 and health care utilization for bronchitis for the province as a whole using the first model.

A variety of socioeconomic and environmental factors were analyzed to determine if any patterns consistent with the geographic distribution of the diseases were evident. The variables included in the analysis were:

- community socioeconomic status index (CSSI);
- proportion of aboriginal people;
- population density;
- population size;
- rural or urban status;
- latitude and longitude;
- level of SO_2 and NO_x; and
- the rate of health care utilization for each of the four respiratory diagnoses.

The analysis examined geographic correlations between socioeconomic and environmental factors and the rate of health care utilization. A natural log transformation was done for the health outcome measures as well as for other variables where appropriate.

Table 16 Adjusted Means of Log Rate of Health Care Utilization for Bronchitis by SO_2 Level

Level		Model with All CSDs Included			Model with Partial CSDs		
		LSMean[1]	t value[2]	p value[3]	LSMean	t value	p value
NRBS Area	1	8.52			8.77		
	2	7.92	2.35	.022	8.27	2.28	.026
	3	8.09	1.10	.274	7.92	1.93	.058
		N= 66 R^2 = 13.4%			N = 66 R^2 = 29.6%		
All Alberta	1	8.15			8.16		
	2	7.96	2.05	.041	7.85	2.52	.012
	3	7.84	2.80	.006	7.90	1.38	.168
		N= 318 ^{2} = 13.0%			N= 271 R^2 = 21.8%		

1 Least square means (LSMean) of log transformed rate of disease, which is adjusted for the effects of the other variables in the model.
2 Student's t-test statistic for the hypothesis: LSMean (I) = LSMean (j). Level 1 is the reference.
3 The p-value of the t-test for the difference between level 1 and 2 or between level 1 and 3.

Table 17 Adjusted Means of Log Rate of Health Care Utilization for Pneumonia by SO_2 Level

Level		Model with All CSDs Included			Model with Partial CSDs		
		LSMean[1]	t value[2]	p value[3]	LSMean	t value	p value
NRBS Area	1	7.45			7.39		
	2	7.50	0.32	.752	7.59	1.58	.119
	3	7.77	1.33	.188	7.50	0.42	.676
		N= 66 R^2 = 4.3%			N = 66 R^2 = 27.2%		
All Alberta	1	7.35			7.37		
	2	7.45	1.48	.140	7.48	1.41	.160
	3	7.49	1.77	<.078	7.66	2.41	<.017
		N= 318 R^2 = 4.1%			N= 271 R^2 = 12.4%		

1 Least square means (LSMean) of log transformed rate of disease, which is adjusted for the effects of the other variables in the model.
2 Student's t-test statistic for the hypothesis: LSMean (I) = LSMean (j). Level 1 is the reference.
3 The p-value of the t-test for the difference between level 1 and 2 or between level 1 and 3.

Table 18 Adjusted Means of Log Rate of Health Care Utilization for Upper Respiratory Infections by SO_2 Level

Level		Model with All CSDs Included			Model with Partial CSDs		
		LSMean[1]	t value[2]	p value[3]	LSMean	t value	p value
NRBS Area	1	10.13			9.96		
	2	10.20	0.81	.419	10.18	3.19	.002
	3	10.31	1.39	.170	10.11	1.03	.309
		N= 66 ^{2} = 24.1%			N = 66 ^{2} = 35.1%		
All Alberta	1	10.18			10.18		
	2	10.23	2.05	.041	10.26	2.60	.010
	3	10.27	3.38	<.001	10.32	2.78	.006
		N= 318 ^{2} = 17.4%			N= 271 R^2 = 17.7%		

1 Least square means (LSMean) of log transformed rate of disease, which is adjusted for the effects of the other variables in the model.
2 Student's t-test statistic for the hypothesis: LSMean (I) = LSMean (j). Level 1 is the reference.
3 The p-value of the t-test for the difference between level 1 and 2 or between level 1 and 3.

A chi^2 test was used for comparisons among categorical variables. Correlation analysis, linear regression, and variance analysis were applied for comparisons among continuous variables. The combination of these statistical analyses enables a more complete evaluation and interpretation. In addition, Cohen's kappa was used to assess the linkage among the data sets which was between 100% and 99.9% (kappa=0.94). Student's t-test was used for differences in the least square means of predicted values between comparison groups. Comparisons were made between CSDs with low and medium or low and high expected levels of SO_2.

The analysis indicates that there are several factors that have a stronger association with the four disorders studied than the predicted level of SO_2 (see Table 19). Latitude is the strongest predictor of asthma, followed by urban area, and population density. A strong south to north trend in the diagnosis of asthma may be due to relatively higher dust and pollen in southern Alberta, made airborne by the more frequent wind or may result from differences in physician diagnosis practice and preference. The higher rate of asthma in urban areas may result from combination of several factors, such as higher levels of air borne contaminants from traffic. It is important to note, however, that the predicted level of SO_2 is a statistically significant predictor of geographic variations in the rate of asthma, although the effect is very small. The effects of population density, latitude and predicted level of SO_2 follow the same pattern in the NRBS area as in the whole province.

Community socioeconomic status is the strongest predictor for variations of bronchitis and pneumonia; communities that are more economically viable are less likely to have a high rate of bronchitis or pneumonia. Latitude is positively correlated with bronchitis and pneumonia, the opposite of the relationship we saw with asthma. The difference in the impact of latitude implies two opposing factors that might be responsible: that factors associated with latitude such as temperature and socioeconomic status, are more important for bronchitis and pneumonia; alternatively, that physician diagnosis practices are different in the north than they are in the south. The proportion of the

population who are aboriginal is also a significant predictive factor for bronchitis, and the larger proportion of aboriginal people in the NRBS may be the reason for the higher rates of bronchitis. Interestingly, there is a negative relationship between the predicted level of SO_2 and the rate of bronchitis. The relationship between asthma and community socioeconomic status, percentage of the population who are aboriginal and the predicted level of SO_2 are the same in the NRBS area as they are for the entire province.

Population density and the percentage of the population who are aboriginal are positively associated with the rate of infections of the upper respiratory system, and latitude is negatively associated with infections of the upper respiratory system in both Alberta and in the NRBS area. The predicted level of SO_2 is positively associated with the rate of infections of the upper respiratory system when considering the province as a whole, but the relationship is not significant in the NRBS area.

Table 19 Summary of Analysis of the Relationship Between Socioeconomic and Environmental Factors and Selected Respiratory Disorders

Predictive Factor	Diagnosis Rate			
	Asthma	Bronchitis	Pneumonia	Upper Respiratory System Infection
Alberta:				
Population Density	positive*	n.s.	n.s.	positive**
Urban Area	positive**	n.s.	positive**	positive?
Socioeconomic Status Index	positive?	negative***	negative**	n.s.
% Aboriginal	n.s.	positive*	n.s.	positive*
Latitude	negative***	positive**	positive	negative*
Level of SO_2	positive*	negative*	positive?	positive*
NRBS Area:				
Population Density	positive*	n.s.	n.s.	positive*
Urban Area	n.s.	n.s.	n.s.	n.s.
Socioeconomic Status Index	n.s.	negative**	negative?	n.s.
% Aboriginal	n.s.	positive*	positive	positive*
Latitude	negative*	n.s.	positive?	negative*
Level of SO_2	positive*	negative	n.s.	n.s.

Note: This summary is based on the results from both variance analysis and regression analysis. The relative importance is ranked by the size of the variance and/or the regression coefficient of each predictive variable. Several models were fitted to ensure appropriate interpretation of the findings and optimal use of the data.

* statistically significant
? marginal difference or inconsistent results from different models
n.s. not statistically significant

Circulatory Diseases

Circulatory diseases include anything affecting the heart or blood vessels, but not diseases of the blood and blood-forming organs. Some of the specific diagnoses included for this study are hypertension, stroke, and coronary heart disease. Extensive research has been conducted on circulatory diseases and relationships have been found between this family of diseases and a variety of stressors including: age, stress, use of oral contraceptives, genetic factors, diabetes, hyperlipidaemia (an excessive amount of fat in the blood), and lifestyle. Lifestyle is perhaps the most important factor in the causal chain for circulatory diseases, particularly exercise, smoking and the effects of poverty.

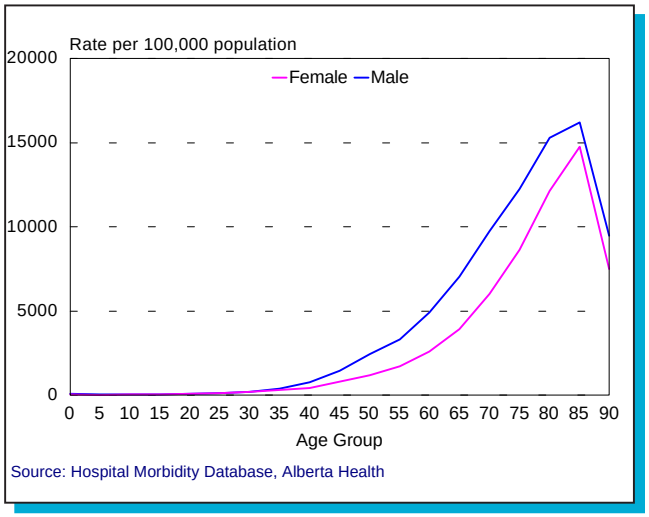
Heart disease was the major cause of death in Alberta prior to 1991 and although it remained one of the leading causes of death in 1994, it was equivalent to the rate of mortality from cancer. Circulatory diseases were included in the study because there is some evidence that exposure to some pesticides, for example DBCP (1,2-dibromo-3-chloropropane) may have an adverse effect on the human circulatory system.[46] There is also a negative correlation between hard water and heart disease. Other studies have also found a correlation between air-borne particulate matter and heart disease,[47] exposure to carbon monoxide, carbon disulfide, environmental tobacco smoke, halogenated hydrocarbons, organophosphates and hydrogen sulphide.[48]

Findings

There was no evidence of a difference in the rate of hypertension for residents of the NRBS area. Higher rates of hospitalization were balanced by lower rates of visits to a physician for this diagnosis chapter, and there was no difference in the rate of mortality between residents of the NRBS area and residents of the other areas of the province.

Figure 75 shows the five year provincial rate of hospitalization for all circulatory diseases by gender and age group. The rate of hospitalization increases steadily with age until age 85 for both men and women, but slightly more males than females are hospitalized for circulatory diseases. Overall, the pattern of hospitalization over the lifespan is similar for men and women. About 4,000 women out of every 100,000 women between the ages of 65 and 70 in Alberta are hospitalized for a circulatory disease, and about 7,000 men out of every 100,000 men between the ages of 65 and 70 in Alberta are hospitalized for a circulatory disease.

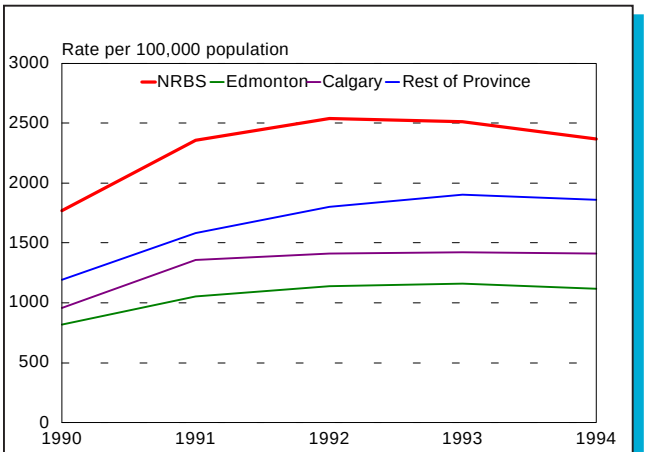
Figure 75 Provincial Rate of Hospitalization for Circulatory Diseases by Gender



Source: Hospital Morbidity Database, Alberta Health

Figure 76 shows the rate of hospitalization for all circulatory diseases for each area. The rate of hospitalization for circulatory diseases is consistently higher in the two rural areas than it is in the two urban areas. The rate of hospitalization in the NRBS area was very high compared to the other areas ($p<0.05$). Differences in the rates between each of the areas are statistically significant ($p<0.05$). Edmonton has the lowest rate of hospitalization for circulatory diseases.

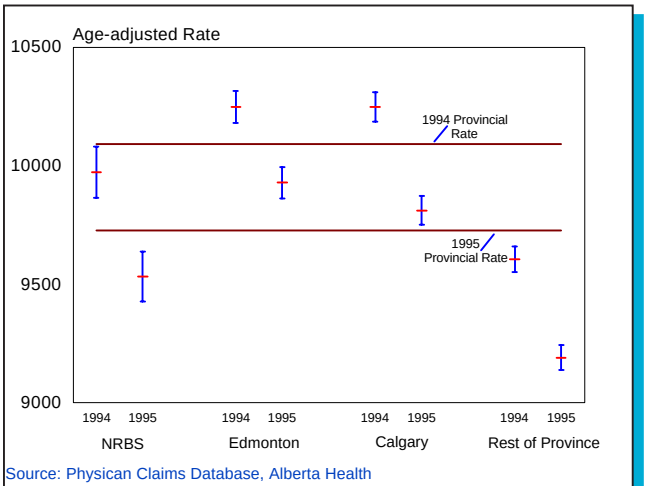
Figure 76 Hospitalization for Circulatory Diseases by Area



Source: Hospital Morbidity Database, Alberta Health

Figure 77 compares the rate of individuals visiting a physician for a circulatory disease by area in 1994 and 1995. The 1994 rate of visits to a physician for a circulatory disease by residents of the NRBS was significantly lower than the 1994 rate of visits by residents of either urban centre, but significantly higher than the rate of visits by residents of the rest of the province. The 1995 rates were significantly lower than the 1994 rates in all areas, and the cross-area pattern remained the same.

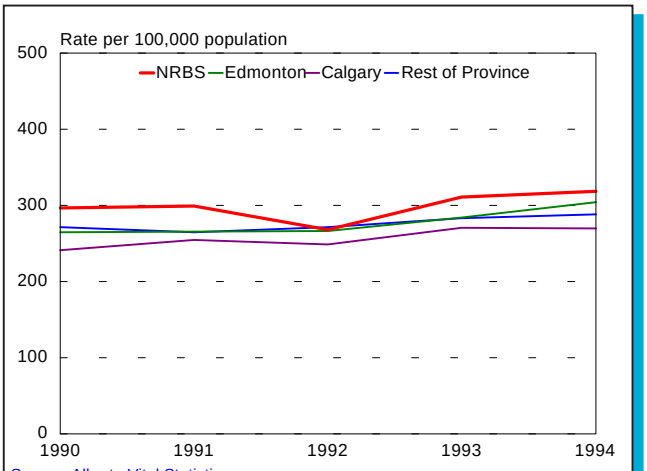
Figure 77 Individuals Visiting a Physician for a Circulatory Disease



Source: Physican Claims Database, Alberta Health

Figure 78 compares the mortality rate for all circulatory diseases in the province by area and year. The mortality rate for circulatory diseases fluctuates slightly, but remains relatively stable at about 300 deaths for every 100,000 people. The mortality rate is slightly higher in the NRBS area than it is in the other areas of the province and this difference is consistent for all years, with the exception of 1992, when the rate was the same as Edmonton and the rest of the province. However, differences across areas are not statistically significant.

Figure 78 Rate of Mortality from Circulatory Diseases



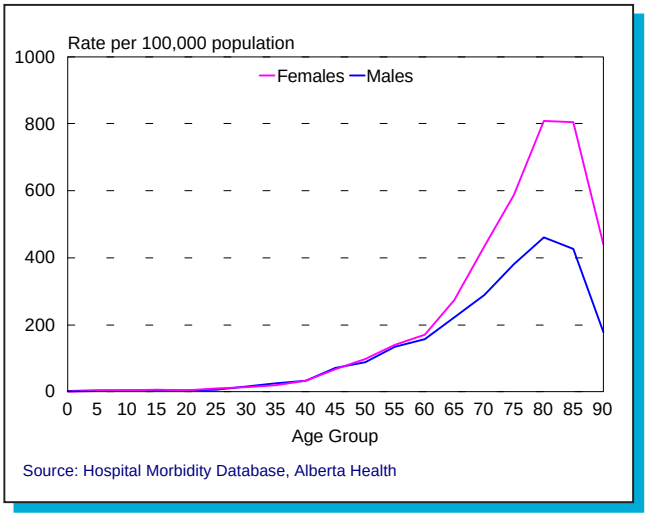
Source: Alberta Vital Statistics

Hypertension

Hypertension is defined as abnormally high blood pressure that develops without an evident cause. Hypertension is a treatable disease if it is found in the early stages of development. Research has identified a number of factors that are related to the development of hypertension, including lifestyle factors such as stress, noise, weight and lack of exercise. Exposure to some chemicals (including lead, cadmium, carbon disulfide and organic solvents), in large enough doses has also been associated with hypertension.[49]

Figure 79 shows the five year average provincial rate of hospitalization for hypertension by gender and age group. Hospitalization for hypertension follows the same pattern as we saw for all circulatory diseases, with the exception that more women are hospitalized for hypertension than men at an older age. The rate of hospitalization for hypertension increases steadily until age 85, and then decreases sharply.

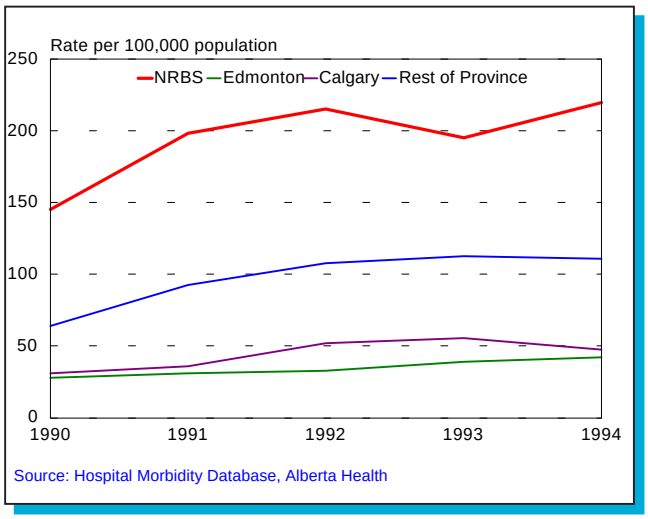
Figure 79 Provincial Rate of Hospitalization for Hypertension



Source: Hospital Morbidity Database, Alberta Health

Figure 80 compares the rate of hospitalization for hypertension by area. The two rural areas show a similar pattern of increasing rates between 1990 and 1993, and a corresponding stabilization or decrease in the rate of hospitalization for hypertension from 1993 to 1994. The rate of hospitalization in the two rural areas is very similar, and the pattern of change over time is almost identical. The rate of hospitalization for hypertension is significantly higher in the NRBS area than any other area of the province, and the rate of hospitalization in the two urban areas is significantly lower than the two rural areas ($p<0.05$).

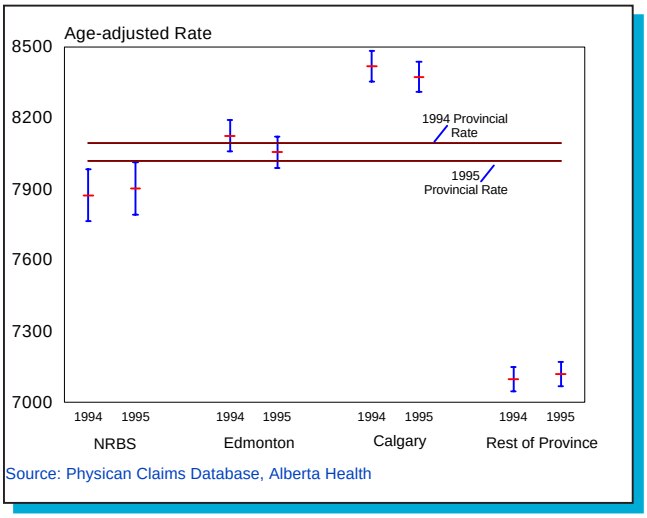
Figure 80 Hospitalization for Hypertension by Area



Source: Hospital Morbidity Database, Alberta Health

Figure 81 compares the rate of individuals visiting a physician for hypertension in the NRBS area with other areas of Alberta for both 1994 and 1995. There was very little difference between the 1994 rate of visits and the 1995 rate of visits to a physician for hypertension in each of the areas. The 1994 rate of visits by residents of the NRBS area was significantly lower than the 1994 rate of visits by residents of the two urban areas, and this difference was also evident in 1995. The rate of visits to a physician for hypertension by residents of the rest of the province was significantly lower than any other area in both 1994 and 1995.

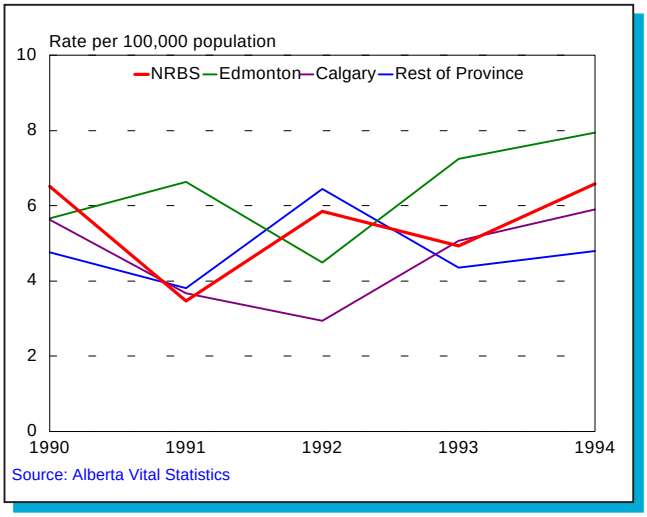
Figure 81 Rate of Individuals Visiting a Physician for Hypertension



Source: Physican Claims Database, Alberta Health

Figure 82 compares the mortality rate for hypertensive disease across areas over time. Although there are fluctuations in the rate of mortality in some areas, these fluctuations are largely due to the small number of deaths attributed to this disease. Overall, the rate of mortality from hypertension in the NRBS area is similar to that in all other areas.

Figure 82 Mortality from Hypertension by Area



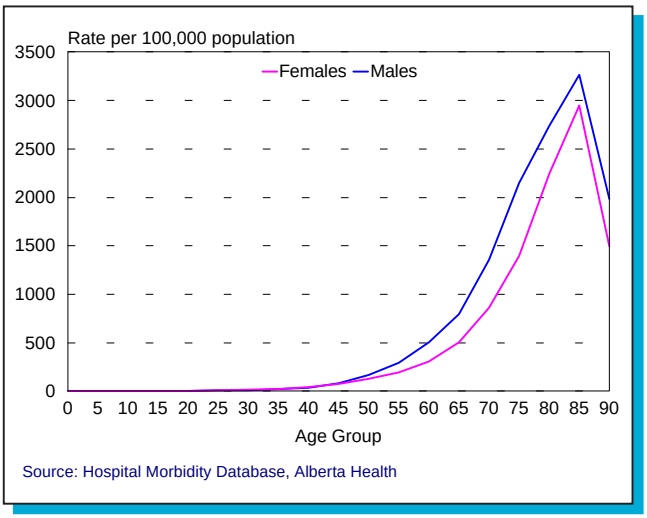
Source: Alberta Vital Statistics

Stroke

Stroke, or cerebrovascular accident, refers to a condition resulting from the formation of a blood clot that prevents the flow of blood through an artery or a rupture of an artery in the brain that disrupts the normal flow of blood through the brain. A stroke results in loss of consciousness, and frequently in paralysis. A stroke may be caused by aging, hypertension, heart disease, smoking, diabetes mellitus, or the use of oral contraceptives - particularly when combined with smoking.[50]

Figure 83 shows the five year average provincial rate of hospitalization for stroke by gender and age group. Slightly more men are hospitalized for stroke than women, and the rate of hospitalization increases exponentially from age 45 to age 85. The rate of hospitalization for stroke drops dramatically for people older than 85. This is likely due to the fact that a stroke is typically fatal for people who are older.

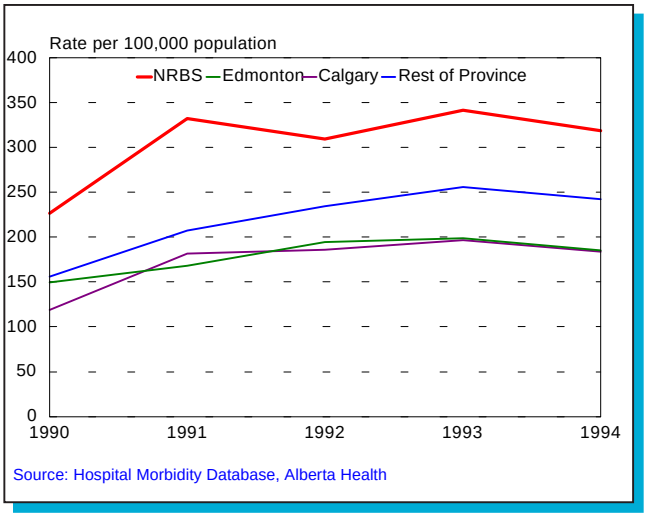
Figure 83 Provincial Rate of Hospitalization for Stroke



Source: Hospital Morbidity Database, Alberta Health

Figure 84 shows the rate of hospitalization for stroke for each area. The rate of hospitalization for stroke increased in all areas over time, but is significantly higher in the NRBS area than it is in the other areas of the province ($p<0.05$). Furthermore, the rate of hospitalization for stroke for residents of the two rural areas was significantly higher than the rate of hospitalization for residents of the two urban areas ($p<0.05$).

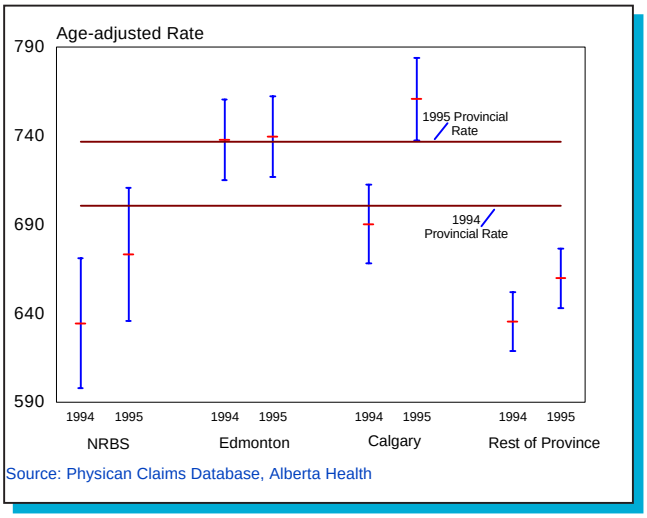
Figure 84 Hospitalization for Stroke by Area



Source: Hospital Morbidity Database, Alberta Health

Figure 85 compares the rate of individuals visiting a physician for a stroke in 1994 with the rate in 1995 for each of the four areas. The 1995 rate of visits to a physician for stroke by residents of the NRBS area was significantly lower than the rate of visits by residents of the two urban areas for this diagnosis, but there is no difference between the rate of visits in the NRBS area and the rate of visits in Calgary in 1994. There was no significant difference between the rate of visits by residents of the NRBS and residents of the rest of the province in either 1994 or 1995.

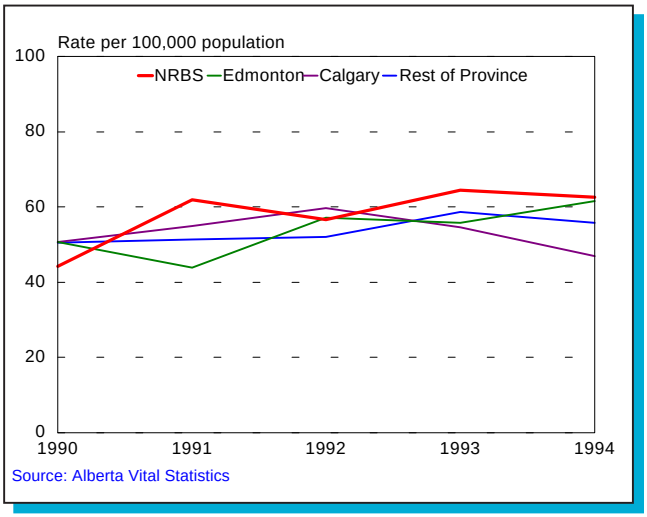
Figure 85 Rate of Individuals Visiting a Physician for Stroke



Source: Physican Claims Database, Alberta Health

Figure 86 compares the mortality rate for all circulatory diseases across areas by year. The mortality rate for stroke is about the same in the NRBS area as it is in the other areas of the province for most years. There were between 70 and 90 deaths from stroke each year in the NRBS area.

Figure 86 Rate of Mortality from Stroke



Source: Alberta Vital Statistics

Ischematic Heart Disease

Ischematic heart disease results from an obstruction in the flow of blood to the heart. The ICD-9-CM diagnosis classification categories identify whether the effects of the disease are acute and therefore immediately life-threatening, or chronic, which indicates that the effects are not as immediately life-threatening. Other forms of heart disease include dysrhythmias and congestive heart failure. As we saw with the other forms of cardiovascular disease above, ischematic heart disease is affected by lifestyle factors, including smoking, exercise, stress, high lipids, and genetic factors. Research has also indicated that there is a relationship between ischematic heart disease and exposure to environmental tobacco smoke (in other words, second-hand smoke), and occupational exposure to carbon disulfide and carbon monoxide. Cyanide and hydrogen sulphide also act as myocardial asphyxiants (blocking the flow of blood and oxygen to the heart). Exposure to high levels of cobalt, arsenic, arsine and lead has resulted in direct myocardial injury, and halogenated hydrogens, organophosphates, antimony and arsenic can cause arrhythmias (fluttering and missed heart beats). While some of these substances naturally occur in drinking water, they are seldom present at levels that would cause heart disease. The exception is sodium. In some drinking waters, the natural levels of sodium can be high enough to present a risk to people who should be on a sodium restricted diet.[51]

Figure 87 shows the five year average provincial rate of hospitalization for the acute effects of ischematic heart disease by gender and age group. Significantly more males than females are hospitalized with this diagnosis. The rate of hospitalization increases for both men and women at approximately the same degree for each age group, and is approximately equal among the oldest age groups. Two thousand five hundred men in every 100,000 men between the ages of 75 and 85 are hospitalized for acute effects of ischematic heart disease.

Figure 87 Provincial Rate of Hospitalization for Acute Ischematic Heart Disease

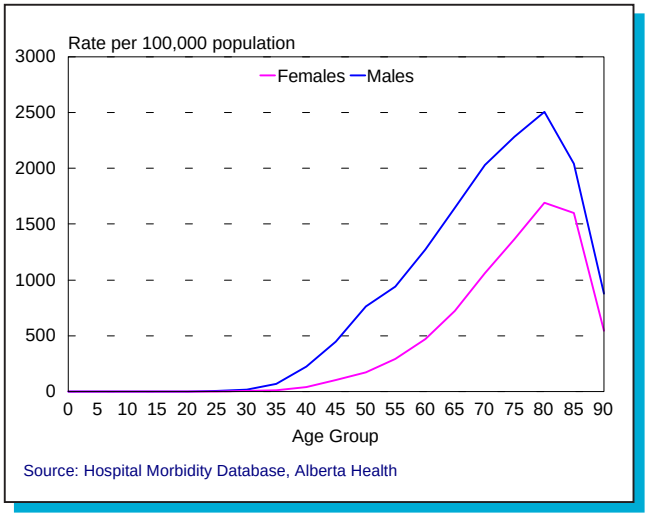
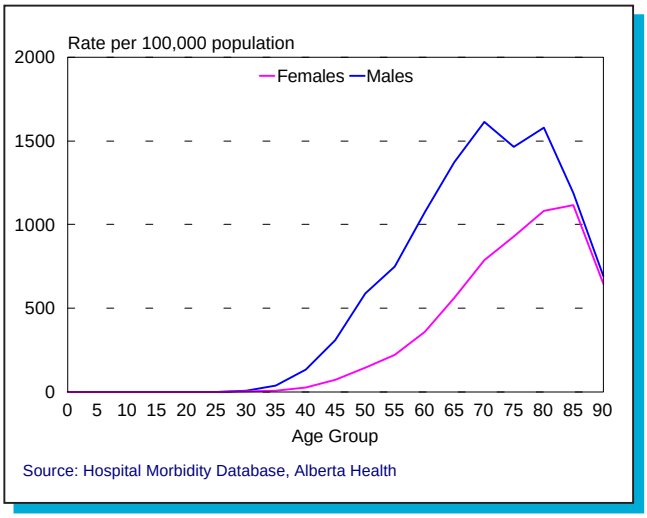


Figure 88 shows the five year average provincial rate of hospitalization for chronic effects of ischematic heart disease by gender and age group. The distribution for this diagnosis is very similar to the distribution of hospitalization for the acute effects of ischematic heart disease. Again we see that the rate of hospitalization is greater for men than for women, and the rate increases steadily with age. The rate decreases sharply for those people who are older than 80, and the rate for women aged 90 years or older is the same as the rate for men in that age group.

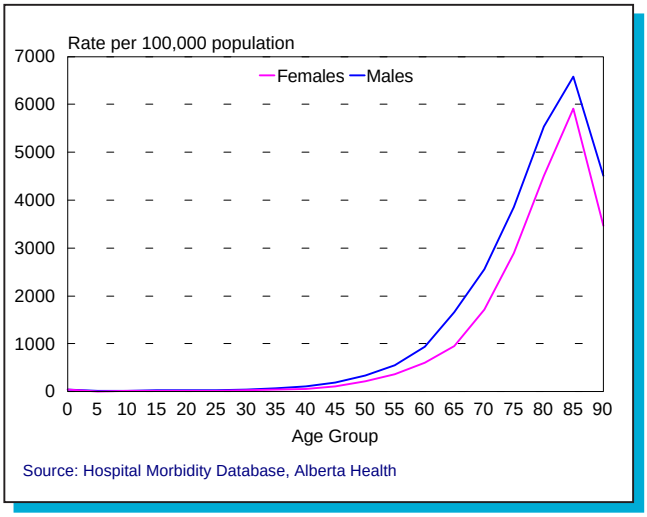
Figure 88 Provincial Rate of Hospitalization for Chronic Ischematic Heart Disease



Source: Hospital Morbidity Database, Alberta Health

Figure 89 shows the provincial rate of hospitlization for other types of heart disease by gender and age group. The hospitalization rate for other types of heart disease is almost the same for women as it is for men. The rate for men is still slightly higher than it is for women, but the difference is small. Again we see that the rate of hospitalization increases drastically with age, reaching a peak rate at age 85.

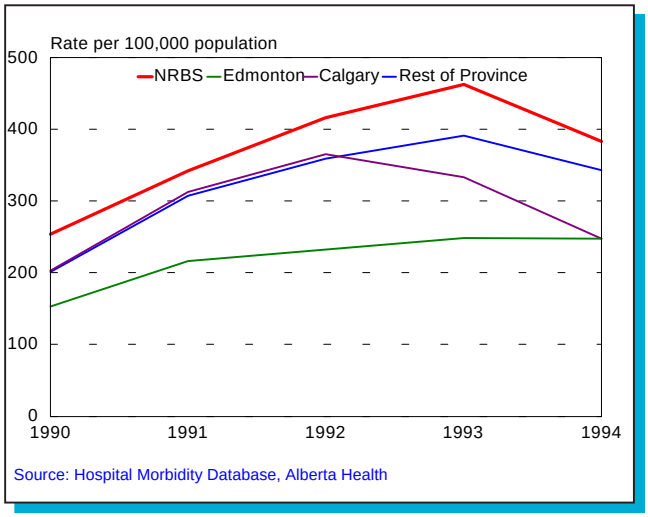
Figure 89 Provincial Rate of Hospitalization for Other Heart Disease



Source: Hospital Morbidity Database, Alberta Health

Figure 90 compares the rate of hospitalization for acute ischematic heart disease across areas by year. The hospitalization rate for heart disease increased in all areas between 1990 and 1992. In 1993, the rate of hospitalization in Calgary decreased from the previous years rate, but the rate of hospitalization in the other three areas continued to increase. The 1994 rate was lower than the 1993 rate in all areas of the province except Edmonton, where the rate of hospitalization remained constant and was significantly lower than the other areas ($p<0.05$). The rate of hospitalization for acute ischematic heart disease in the NRBS area was significantly higher than the rates in the other areas ($p<0.05$).

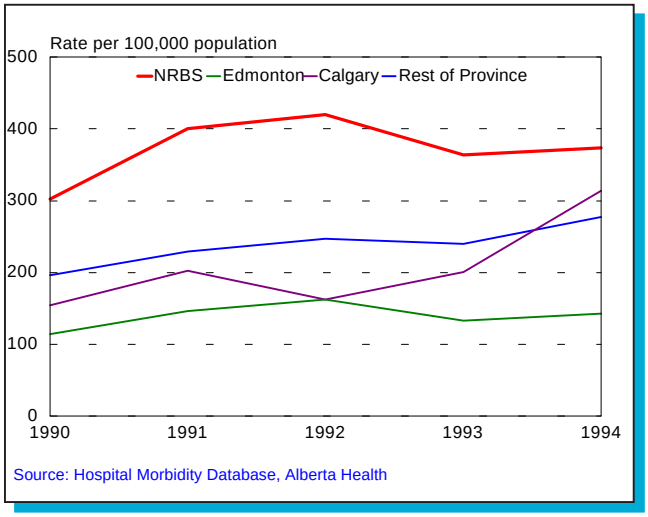
Figure 90 Hospitalization Rate for Acute Ischematic Heart Disease



Source: Hospital Morbidity Database, Alberta Health

Figure 91 shows the rate of hospitalization for chronic ischematic heart disease across areas by year. The hospitalization rate for chronic ischematic heart disease was higher in the NRBS area than the rate in each of the other areas of the province ($p<0.05$). The increase in the rate of hospitalization for chronic ischematic heart disease was not as dramatic as the rate for acute ischematic heart disease, but the 1994 rate was still higher than the 1990 rate in the two rural areas of the province.

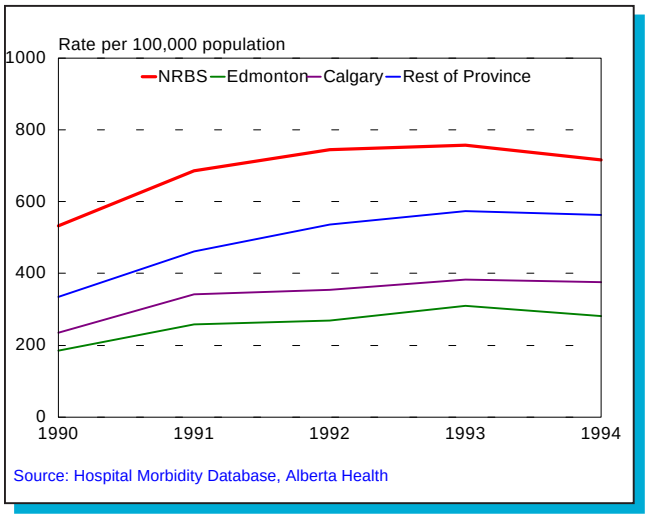
Figure 91 Hospitalization Rate For Chronic Ischematic Heart Disease



Source: Hospital Morbidity Database, Alberta Health

Figure 92 shows the rate of hospitalization for other types of heart disease across areas by year. The hospitalization rate for other types of heart disease increased in all areas of the province between 1990 and 1994. The two rural areas had the highest rate of hospitalization for heart disease, and the highest rate of hospitalization was in the NRBS area. The lowest rates of hospitalization were in the two urban areas, and the Edmonton area was the lowest in the province. Differences in rates between each of the areas were statistically significant ($p<0.05$).

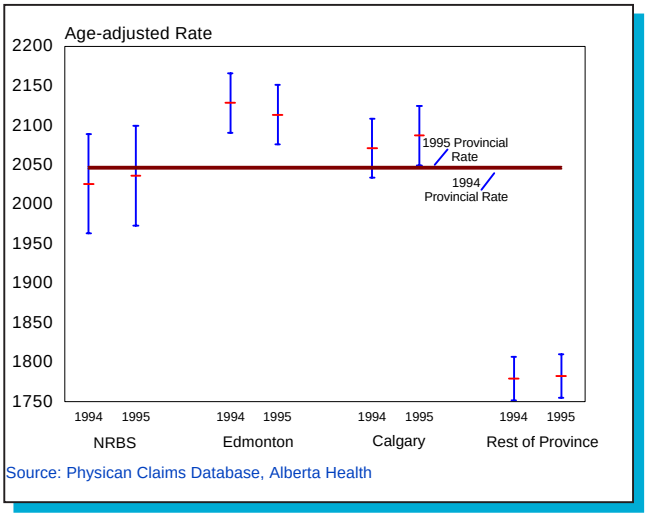
Figure 92 Hospitalization Rate For Other Heart Disease



Source: Hospital Morbidity Database, Alberta Health

Figure 93 compares the rate of individuals visiting a physician for chronic heart disease in 1994 with the rate in 1995 by area. The rate of visits to a physician for chronic heart disease by residents of the NRBS area was not significantly different than the rate of visits by residents of the two urban areas for either 1994 or 1995. The rate of visits by residents of the rest of the province was significantly lower than the rate of visits for the other three areas. The rate of visits for this complaint was consistent over time - the 1994 provincial rate was almost identical to the provincial rate for 1995.

Figure 93 Rate of Individuals Visiting A Physician For Chronic Heart Disease



Source: Physican Claims Database, Alberta Health

Figure 94 compares the mortality rate for acute ischematic heart disease across areas by year. The rate of mortality in the NRBS area is significantly higher than the rate for the other areas of the province, although the mortality rate from acute ischematic heart disease decreased over time in all areas of the province ($p<0.05$). Differences between Edmonton and Calgary were not statistically significant ($p<0.05$).

Figure 94 Rate of Mortality from Acute Ischematic Heart Disease

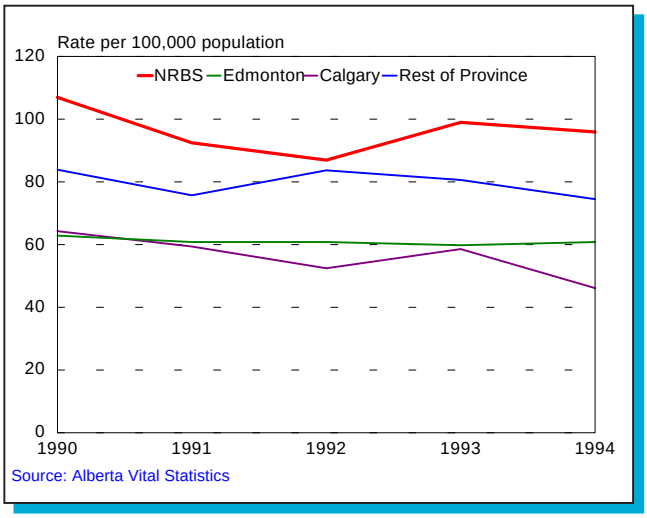
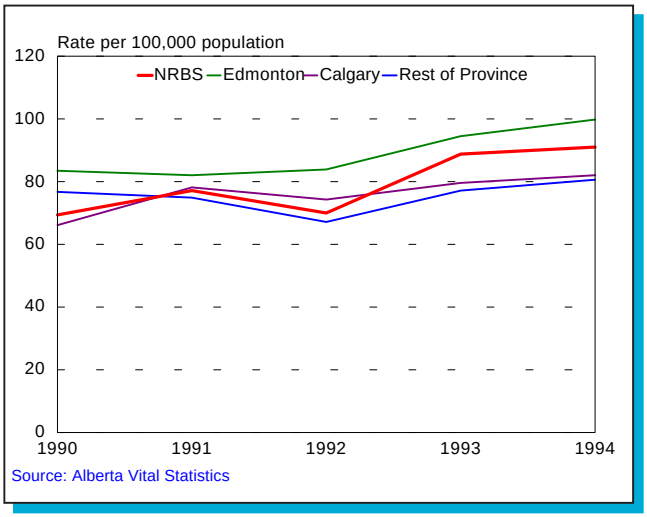


Figure 95 compares the mortality rate for chronic ischematic heart disease across areas by year. The rate is relatively stable over time, with a slight increase over all areas between 1993 and 1994. There is no difference between the NRBS area and the other areas of the province, although the rate in Edmonton was significantly higher than the rates in Calgary and the rest of the province ($p<0.05$). The rate of mortality was between 80 and 90 deaths per 100,000 population in 1994.

Figure 95 Rate of Mortality For Chronic Diseases



Gastrointestinal Diseases

Gastrointestinal diseases include all disorders of the digestive system, including the esophagus, stomach, and duodenum. These diseases may result from family history and genetic factors, but are also attributed to stress, microbial infection, alcohol and caffeine intake, or may be caused by orally ingested environmental contaminants.

Findings

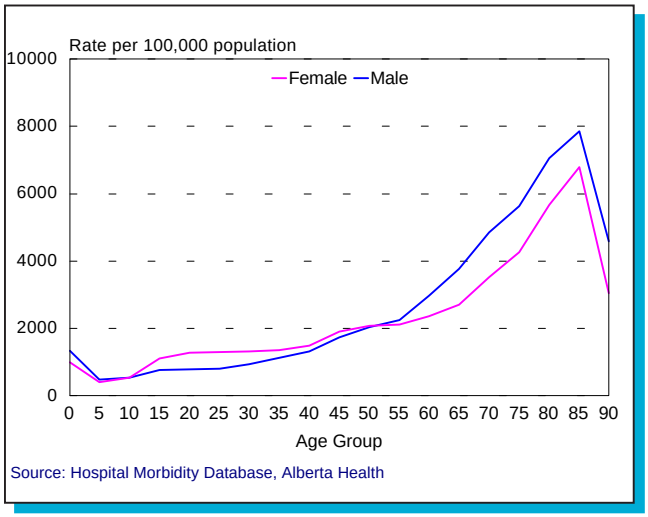
For most of the diagnoses considered below, higher rates of hospitalization are balanced by lower rates of visits to a physician, indicating that the residents of the NRBS area are not diagnosed with most gastrointestinal disorders any more frequently than residents of the other areas of the province. The one exception is peptic ulcer. Consistently high rates of hospitalization and physician visits indicates that peptic ulcer is more frequently diagnosed for residents of the NRBS area than for residents of the other areas of Alberta. The rate of health care utilization (visits to a physician plus hospitalization) decreased sharply between 1993 and 1994 but remained higher than any other area. Diagnoses evaluated for this study include gastroenteritis, hepatitis A, peptic ulcer, liver cirrhosis, and a variety of food- and water-borne diseases.

The rate of health care utilization for peptic ulcer is greater in some parts of the NRBS area than others, particularly the northern-most areas of the province. More than 26,700 Albertans visited a physician or were hospitalized for a peptic ulcer in 1994, resulting in a rate of 1,046 per 100,000 population. RHAs 15, 16 and 17 had a high rate ratio compared to the remaining regions in 1994. Similar to endometriosis, the rate ratio was higher in communities in the rural areas than urban areas.

Detailed analysis of food- and water-borne diseases indicated that shigellosis may be linked to water source (ground or surface water) and size of community, but that public drinking water does not appear to be a significant risk factor for hepatitis A, giardiasis, campylobacteriosis and salmonellosis. Follow-up responses to the Northern River Basins Study include an improved program of training for all water treatment facility operators, and improved monitoring of facilities in small communities.

Figure 96 shows the rate of hospitalization in the province for all gastrointestinal diseases by age group and gender. The rate of hospitalization for gastrointestinal disorders is about the same for men as for women, and increases gradually with age. Overall the rate of hospitalization is quite high - approximately 1,600 people in every 100,000 people are hospitalized with a gastrointestinal disease each year.

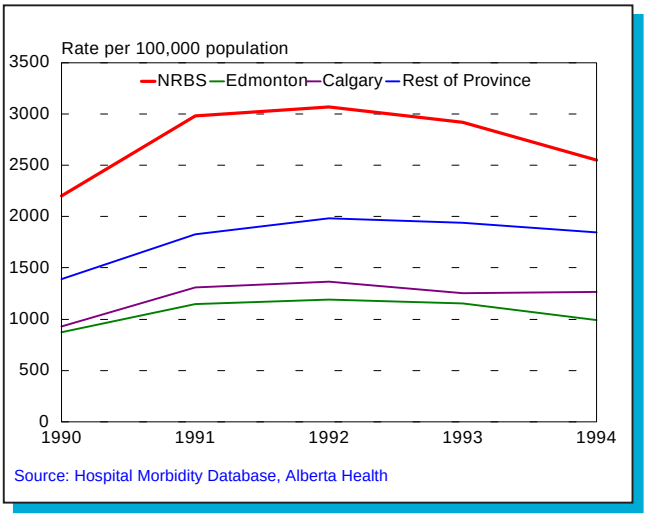
Figure 96 Provincial Rate of Hospitalization for Gastrointestinal Diseases



Source: Hospital Morbidity Database, Alberta Health

Figure 97 compares the rate of hospitalization for all gastrointestinal diseases across areas over time. The familiar pattern we have seen in previous regional comparisons is once again evident in this comparison of hospitalization rates for gastrointestinal diseases - the hospitalization rate is lowest in the two urban areas, and the rest of the province shows a similar pattern to, although lower than the pattern in the NRBS area. Differences in rates between each of the areas are significant ($p<0.05$). The rate of hospitalization in the NRBS area in 1994 was 2,551 people per 100,000 population.

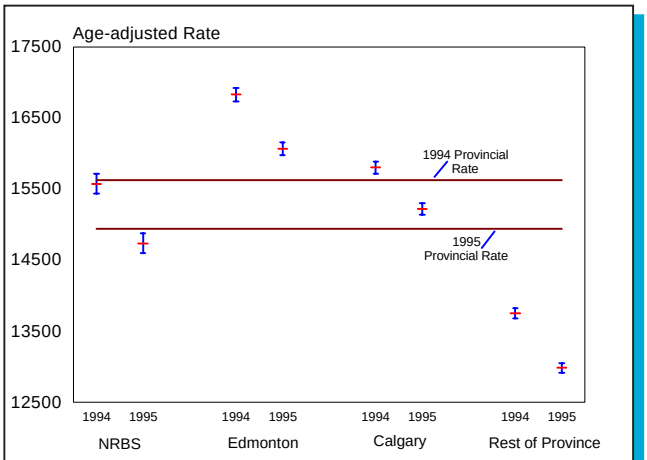
Figure 97 Hospitalization Rate for Gastrointestinal Diseases by Area



Source: Hospital Morbidity Database, Alberta Health

Figure 98 compares the rate of individuals visiting a physician for a gastrointestinal disorder in 1994 with the rate for 1995 by area. The 1995 rate of individuals visiting a physician for a gastrointestinal disorder was significantly lower than the 1994 rate in all four areas of the province. The rate in the NRBS area was lower than the rate in the two urban areas for the same year, but was much higher than the rate in the rest of the province in both 1994 and 1995.

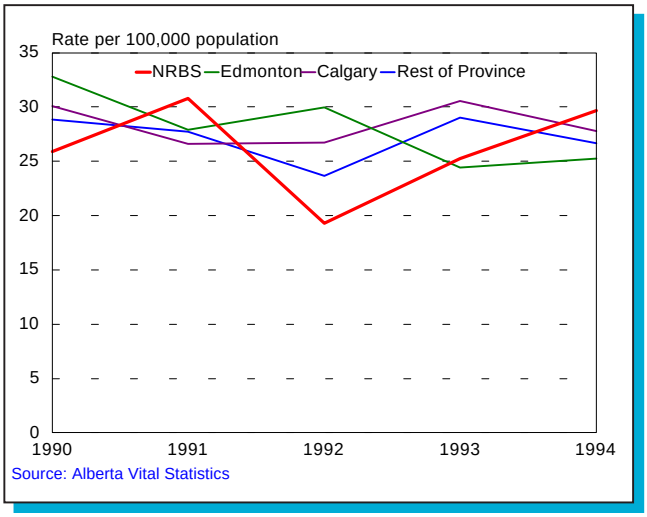
Figure 98 Rate of Individuals Visiting a Physician for Gastrointestinal Disorders



Source: Physican Claims Database, Alberta Health

Figure 99 compares the mortality rate for all gastrointestinal diseases in the province by area and year. The mortality rate for people with gastrointestinal diseases in the NRBS area was higher than the other areas of the province in 1990, but declined to a level comparable to the other areas of the province by 1994. The rate of mortality from gastrointestinal diseases in the NRBS area during 1994 was 29. Differences in the rate of mortality across areas were not statistically significant.

Figure 99 Mortality from Gastrointestinal Diseases



Source: Alberta Vital Statistics

Gastroenteritis

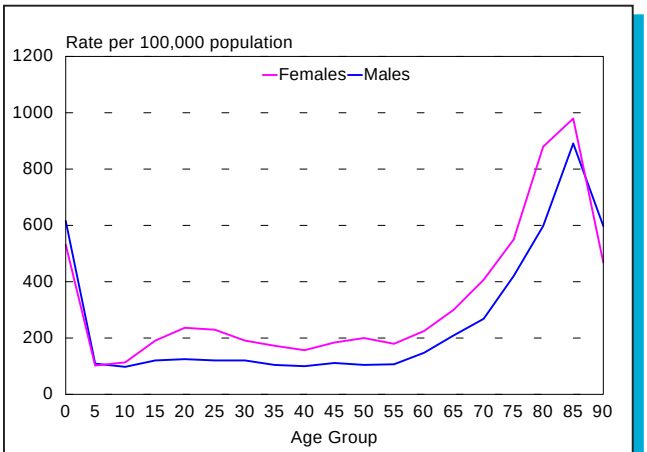
Gastroenteritis is an inflammation of the mucous and submucous tissues of the intestinal tract, and the terms enteritis and colitis identify the actual location of the inflammation - enteritis refers to inflammation of the small intestine, and colitis refers to an inflammation of the colon. This group of diagnoses also includes Crohn's disease, a chronic inflammation of a regionalised area of the intestine or colon. Colitis is the most frequently diagnosed gastrointestinal disease which causes alternating constipation and diarrhea accompanied by intestinal distress and pain. Symptoms are usually triggered by stress, although in many cases the actual cause is unknown. Symptoms may also be exacerbated by diet.

A number of contaminants commonly found in groundwater or well water, such as barium or nitrates, can cause gastrointestinal distress that may be diagnosed using a generic term such as gastroenteritis.[52] As we saw above, drinking water supplied by municipalities is checked to ensure that the levels of these contaminants are low enough that the water id safe to drink, but well water and other sources of untreated water are not always checked to ensure that they are safe.

An infestation of a bacteria (e.g. Salmonella, Shigella, or Staphylococcus), a virus (e.g. rotovirus, adenovirus, or enterovirus), or a parasite (e.g. Giardia, entamoeba or dientamoeba) may also be the cause of gastrointestinal distress.[53]

Figure 100 shows the provincial rate of hospitalization for gastroenteritis by gender and age group. Gastroenteritis primarily affects babies and people older than 65 years of age. Slightly more adult females than adult males are diagnosed with gastroenteritis, but there is no difference between boy babies and girl babies, nor among men and women older than 85.

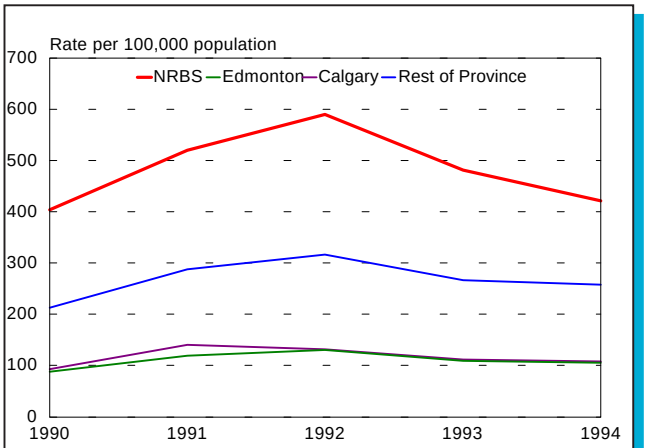
Figure 100 Provincial Rate of Hospitalization for Gastroenteritis



Source: Hospital Morbidity Database, Alberta Health

Figure 101 compares the rate of hospitalization for gastroenteritis across areas over time. The hospitalization rate for gastroenteritis was lowest in the two urban areas, and there was no difference between the urban areas ($p<0.05$). The two rural areas were significantly higher than the two urban areas, and the rate in the NRBS area was significantly higher than the rest of the province ($p<0.05$). The rate of hospitalization for gastroenteritis in the NRBS area was 421 per 100,000 population in 1994.

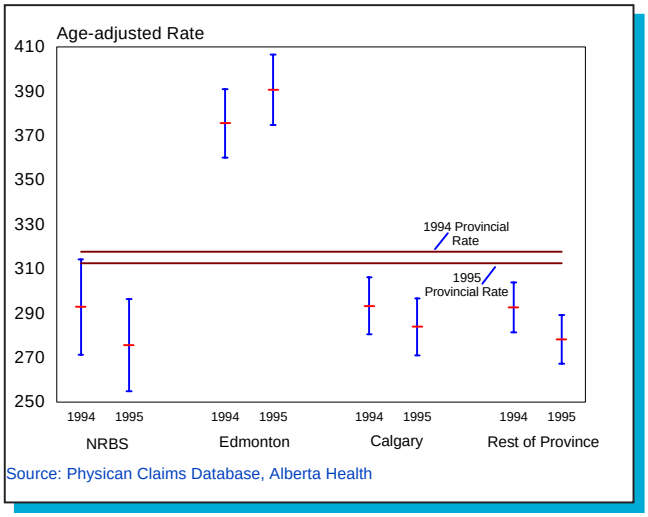
Figure 101 Hospitalization Rate for Gastroenteritis



Source: Hospital Morbidity Database, Alberta Health

Figure 102 compares the rate of individuals visiting a physician for enteritis or colitis in 1994 with the rate for 1995 by area. The rate of individuals visiting a physician in the NRBS area was no different than the rate in Calgary or the rest of the province during either 1994 or 1995. The highest rate of individuals visiting a physician for enteritis and colitis was recorded in the Edmonton area both years. The difference between the rate in the Edmonton area and the other areas of the province is statistically significant, although it is not possible to determine if the difference is due to individual behaviour (more people attend a physician for these symptoms because they are more aware of the potential problem), or due to a real difference in disease rates.

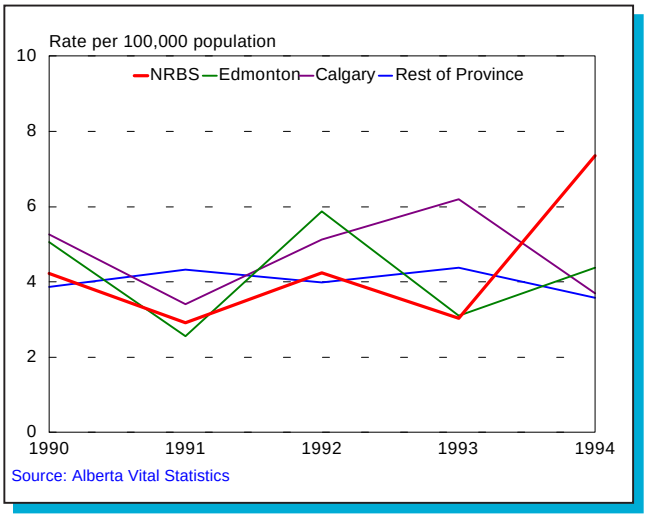
Figure 102 Rate of Individuals Visiting a Physician for Enteritis and Colitis



Source: Physican Claims Database, Alberta Health

Figure 103 compares the mortality rate for gastroenteritis by area and year. The mortality rate for people with gastroenteritis in the NRBS area was no different than the rate for any of the other areas ($p<0.05$). Overall the rate of mortality from gastroenteritis is very low.

Figure 103 Mortality from Gastroenteritis



Hepatitis

Hepatitis is an inflammation of the liver due to a virus that may be transmitted through food that has not been cooked adequately, or through unsafe drinking water, or through other means, such as through the use of unsanitary needles, or personal contact with someone infected with the virus. There are three main types of hepatitis that are all considered notifiable diseases, and are differentiated by the method of transmission of the disease: Hepatitis A is usually associated with inadequate sanitation and overcrowded living conditions, and may be transmitted through inadequately cooked food. This disease is frequently identified in child daycare centres where sanitation standards are not maintained, or in people who have contracted the disease through contact with a foreign country where sanitation standards are less than adequate. Hepatitis B is not transmitted through food or water, but can be transmitted through the use of contaminated needles (parenteral transmission). Hepatitis B is most frequently diagnosed in people who use illicit drugs, people who work or live in institutions, sexually active homosexual men, and haemodialysis patients. Hepatitis B can cause cirrhosis of the liver. Hepatitis C is also transmitted through parenteral sources.

Figure 104 shows the rate of hospitalization in the province for hepatitis A for males and females by age group. This graph supports the conclusion that susceptibility to the hepatitis A virus is not associated with age as much as it is with contact. There is a wide variation in the hospitalization rate across age groups, and no real difference between males and females. The rate of hospitalization is high for young children who are more likely to be exposed to unsanitary conditions, and more likely to transmit the disease orally. Overall the rate of hospitalization is quite low, because the sanitation standards in Alberta are very high.

Figure 104 Provincial Rate of Hospitalization for Hepatitis A

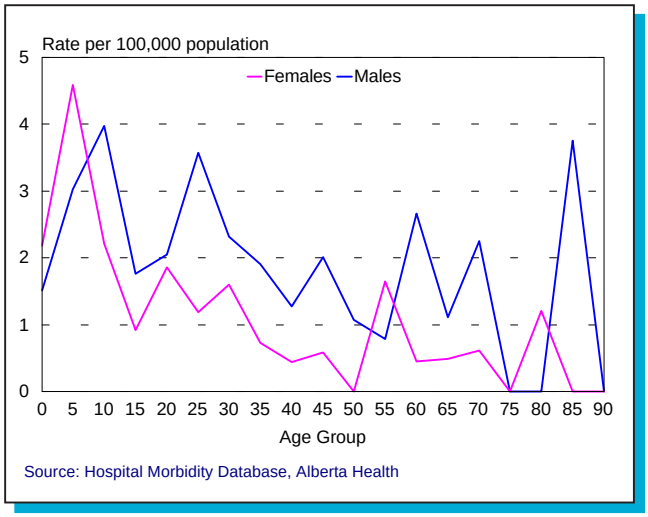


Figure 105 shows the rate of hospitalization for hepatitis A by area over time. The rate of hospitalization is very low, and fluctuates somewhat over time in all areas of the province. The fluctuations are generally associated with small epidemics that are carefully monitored by the medical officers of health in each region. The rate of hospitalization in the NRBS area was significantly greater than the rate in Edmonton.

Figure 105 Hospitalization for Hepatitis A by Area

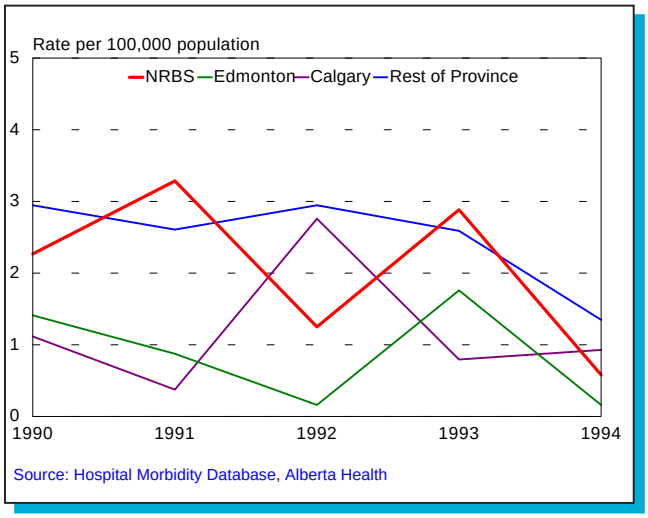


Figure 106 shows the rate of hospitalization in the province for Hepatitis B for males and females by age group. The pattern of hospitalization over the lifespan is very different than the pattern we saw for hepatitis A above - very few children are hospitalized with hepatitis B, and far more older men are hospitalized with this disease than are women

Figure 106 Provincial Rate of Hospitalization for Hepatitis B

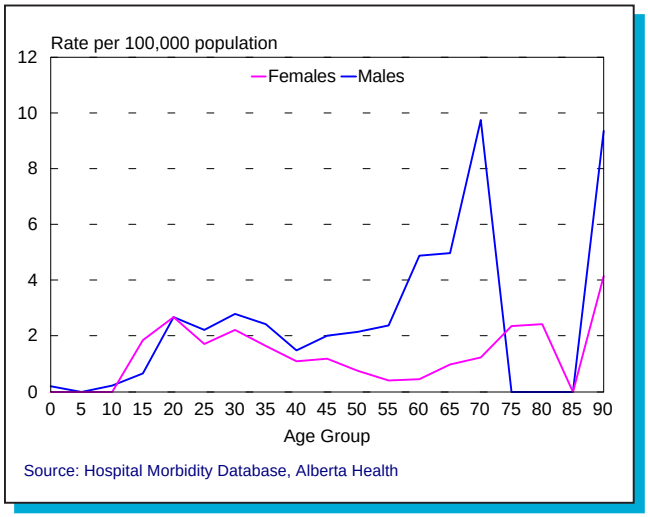


Figure 107 shows the rate of hospitalization for hepatitis B by area over time. The rate of hospitalization for hepatitis B is very low, and is no different across the areas.

Figure 107 Hospitalization for Hepatitis B by Area

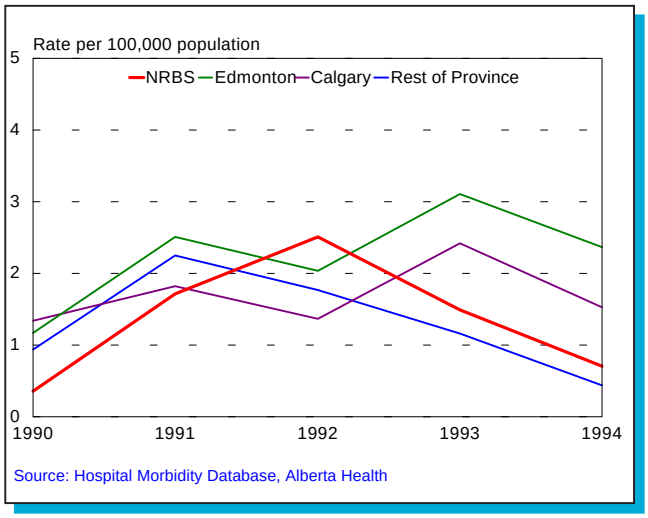
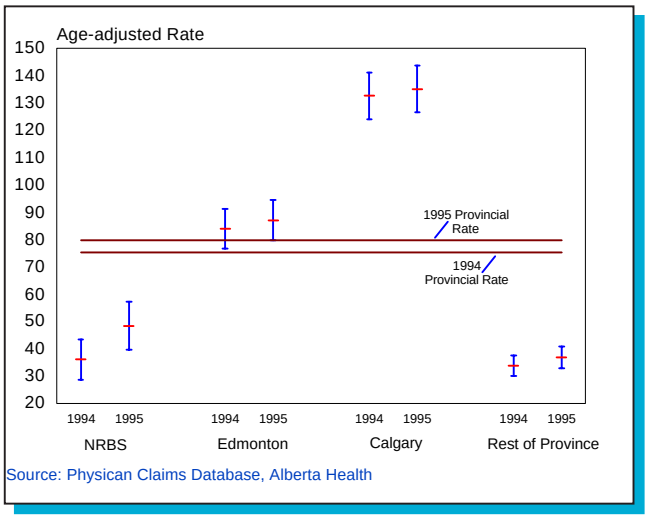


Figure 108 compares the rate of individuals visiting a physician for hepatitis A or B in 1994 with the 1995 rate across the four areas. The rate of individuals visiting a physician for hepatitis A or B was highest in the two urban areas; the rate in Calgary was significantly higher than any other area of the province for both 1994 and 1995. The rate in the NRBS area was comparable to the rate in the rest of the province. The 1995 rate of visits by residents of the NRBS area was slightly higher than the rate of visits by residents of the rest of the province. The difference was not significant.

Figure 108 Rate of Individuals Visiting a Physician for Hepatitis A or B



Peptic Ulcer

A peptic ulcer is an ulcer that forms in the esophagus, stomach, or duodenum. Peptic ulcers may be caused by genetic factors such as blood type (regardless of Rh factor, people with type O blood are more likely to develop a peptic ulcer), family history factors that influence lifestyle choices, smoking and aspirin use. Peptic ulcers are exacerbated by alcohol use and caffeine.

Figure 109 indicates the rate of hospitalization in the province for peptic ulcers by age group and gender. Slightly more males are hospitalized for peptic ulcers than females. The rate of hospitalization increases with age, particularly among men older than 60, and women older than 65.

Figure 109 Provincial Rate of Hospitalization for Peptic Ulcer

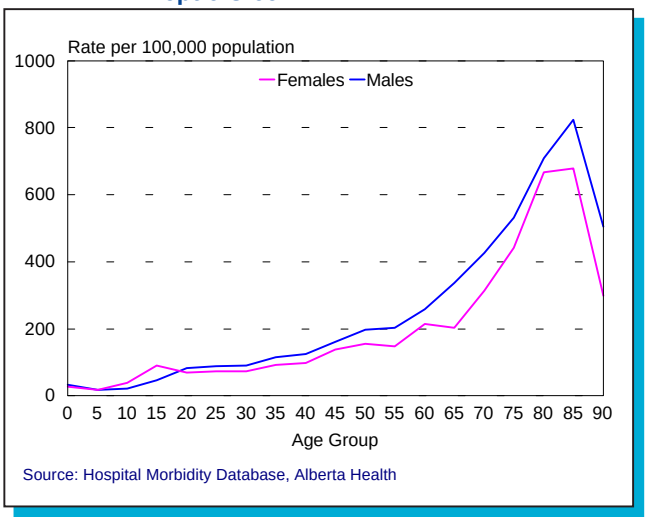


Figure 110 compares the rate of hospitalization for peptic ulcer across areas over time. The rate of hospitalization for peptic ulcer is very low in the urban areas; the rate in the rest of the province is almost double that of the two urban areas, and the rate in the NRBS area is about four times greater than the rate of hospitalization in the two urban areas ($p<0.05$).

Figure 110 Hospitalization Rate for Peptic Ulcer by Area

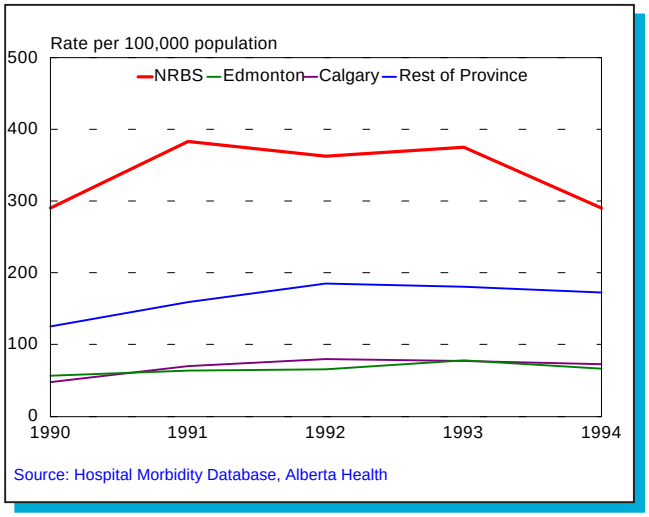
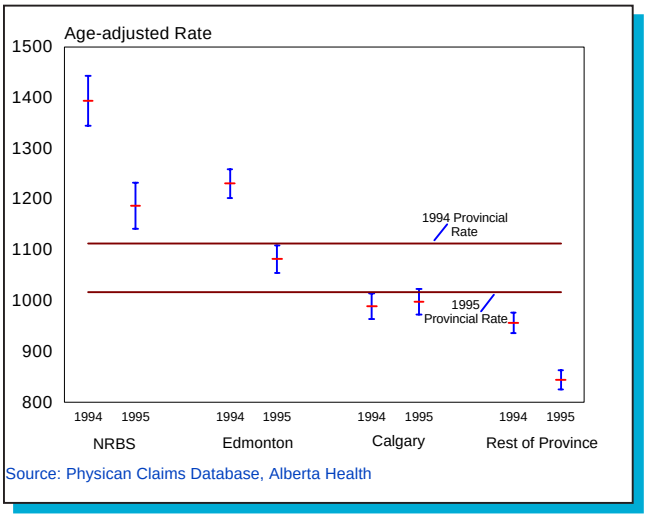


Figure 111 compares the rate of individuals visiting a physician for a peptic ulcer in 1994 with the rate for 1995 by area. The rate of visits by residents of the NRBS area was significantly higher than the rate of visits by residents of any other area for both 1994 and 1995. The 1995 rate of visits to a physician for a peptic ulcer was lower than the 1994 rate in each of the areas, including the NRBS area. The lowest rate of visits was by residents of the rest of the province. The rate of visits by residents of the NRBS area was almost double the rate of visits by residents of the rest of the province. Differences in rates across the areas are statistically significant.

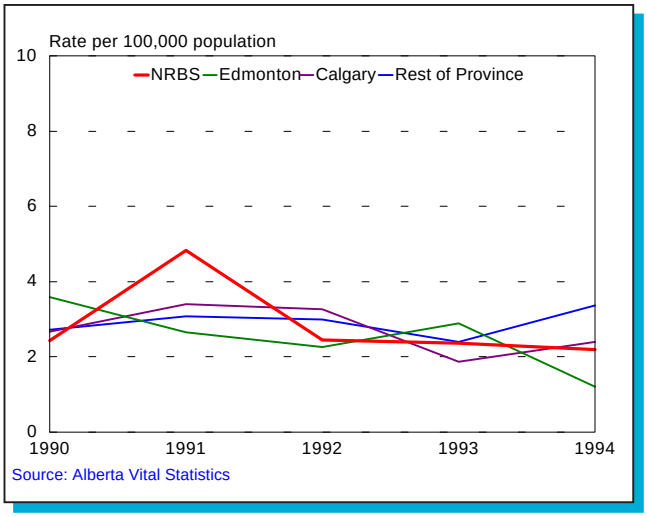
Figure 111 Rate of Individuals Visiting a Physician for Peptic Ulcer



Source: Physican Claims Database, Alberta Health

Figure 112 compares the mortality rate for peptic ulcer by area and year. Overall the rate of mortality from a peptic ulcer is very low. Although the rate of mortality in the NRBS appears to fluctuate dramatically, this is largely due to the small number of people that die each year from this disease. Differences across areas are not significant.

Figure 112 Rate of Mortality from Peptic Ulcer

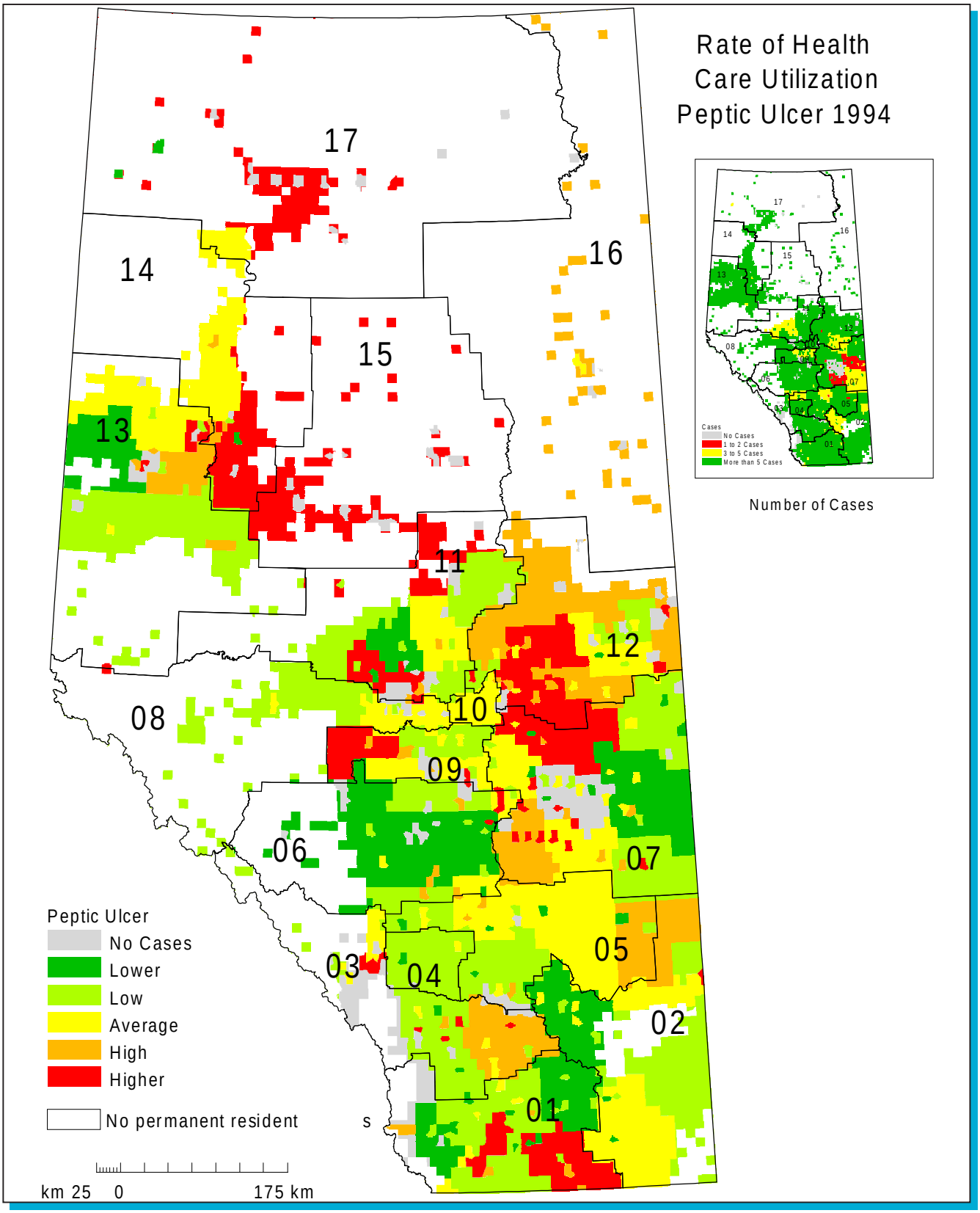


Source: Alberta Vital Statistics

Consistently high rates of hospitalization and physician visits indicates that peptic ulcer is more frequently diagnosed for residents of the NRBS area than for residents of the other areas of Alberta. The rate of health care utilization (visits to a physician plus hospitalization) decreased sharply between 1993 and 1994 but remained higher than any other area.

Map 13 shows that the rate of health care utilization for peptic ulcer is greater in some parts of the NRBS area than others, and is generally higher in the northern-most areas than it is the south and western portions of the province. More than 26,700 Albertans visited a physician or were hospitalized for a peptic ulcer in 1994, resulting in a rate of 1,046 per 100,000 population. Most census subdivisions in central, north and northeast Alberta (census divisions 11, 13 & 10 or RHAs 15, 17 and 16) had a high rate ratio compared to the remaining census subdivisions in 1994. The rate ratio was also higher for some census subdivisions in regions (RHAs) 11, 12, 9, & 1. Similar to endometriosis, the rate ratio was higher in communities in the rural areas than urban areas. As shown in the small map inset in the top right-hand corner, most CSDs had more than five individuals with this diagnosis, indicating a reasonably stable rate.

Map 13 **Rate of Health Care Utilization for Peptic Ulcer**



Liver Cirrhosis

Liver cirrhosis is a malformation and scarring of the tissue of the liver. It can be fatal, and is typically caused by excessive alcohol consumption, although chronic hepatitis can also result in cirrhosis of the liver. Alcoholism has been linked to genetic factors, as is liver cirrhosis. Gender is a complicating factor, because the amount of alcohol that can be consumed by men without permanent damage is double that for women, although the ability of the body to eliminate alcohol from the system and the relative damage to the liver varies greatly across people. Diet and nutrition is also implicated in the individual's ability to overcome the toxic effects of alcohol, because lack of protein in the diet results in depletion of hepatic amino acids and enzymes which are required by the liver for elimination of these toxins. Poverty therefore plays a very important role in the development of liver cirrhosis.[54]

Figure 113 shows the rate of hospitalization in the province for liver cirrhosis by age group and gender. The rate of hospitalization is much higher for males between the ages of 45 and 70 than it is for females of the same age group, but the rate of hospitalization is greatest for men and women between the ages of 40 and 75. The pattern of hospitalization over the life cycle reflects abuse of the body rather than a normal process of aging.

Figure 113 Provincial Rate of Hospitalization for Liver Cirrhosis

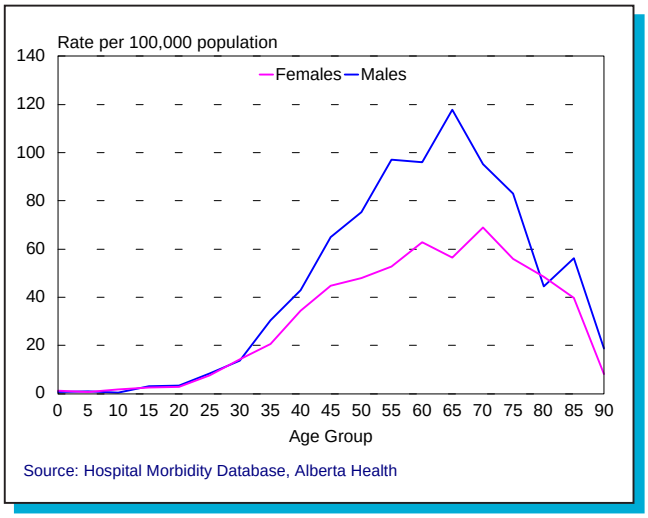


Figure 114 compares the rate of hospitalization for liver cirrhosis across areas over time. The rate of hospitalization for liver cirrhosis in the NRBS area increased over time while the rate in the Edmonton area decreased over the same time period. Overall, the rate of hospitalization for liver cirrhosis was the same in all areas (differences across areas are not statistically significant ($p<0.05$))

Figure 114 Hospitalization Rate for Liver Cirrhosis by Area

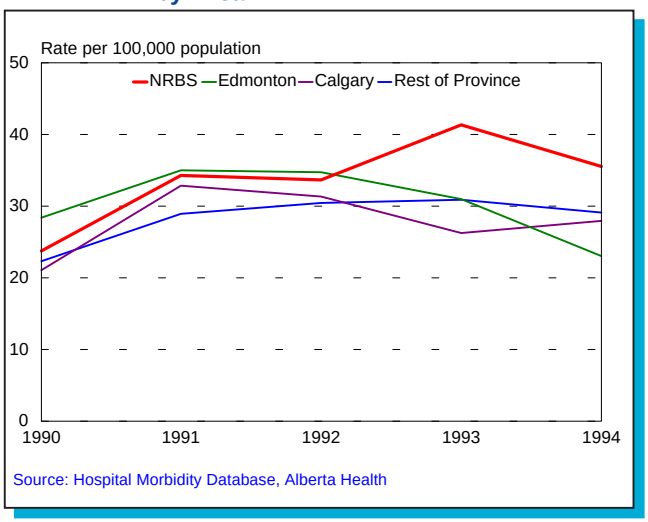
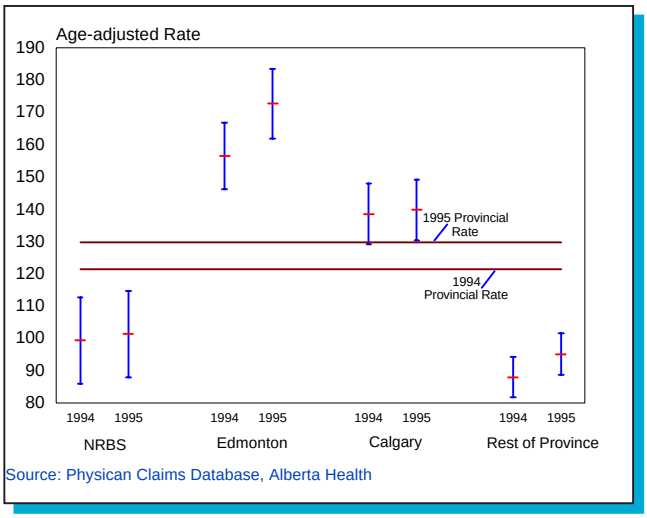


Figure 115 compares the rate of individuals visiting a physician for liver cirrhosis in 1994 with the rate for 1995 by area. The rate of visits to a physician for liver cirrhosis by residents of the NRBS area was significantly lower than the rate of visits by residents of either of the two urban areas, and no different than the rate of visits by residents of the rest of the province. There was no difference in the rate of visits from 1994 to 1995.

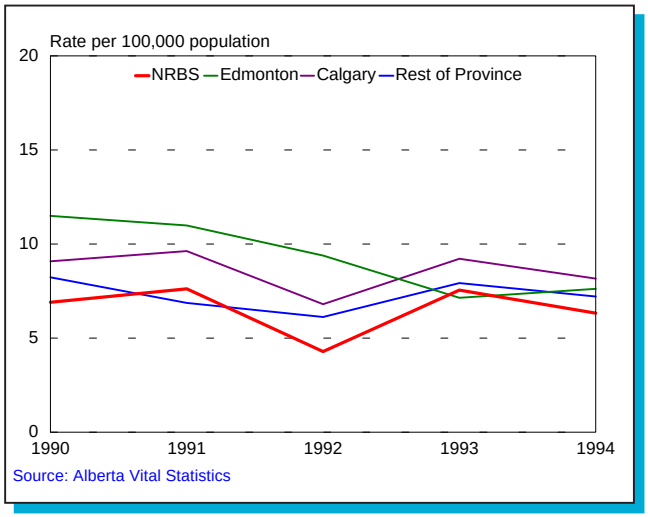
Figure 115 Rate of Individuals Visiting a Physician for Liver Cirrhosis



Source: Physican Claims Database, Alberta Health

Figure 116 compares the mortality rate from liver cirrhosis by area and year. The mortality rate for people in the NRBS area from liver cirrhosis has been lower than most other areas of the province since 1986, although the differences in rates across the areas are minor. Variations in the rate of mortality is likely due to the small number of deaths attributed to liver cirrhosis; similar to other diseases that attack the liver, the death is typically attributed to renal failure, rather than the disease that caused the liver to fail.

Figure 116 Mortality from Liver Cirrhosis



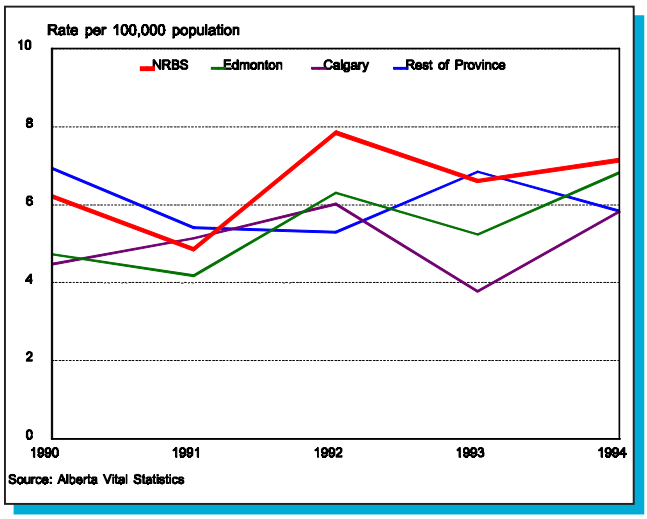
Source: Alberta Vital Statistics

Renal Failure

Renal failure occurs when the kidney fails to function properly. Renal failure has been associated with trauma, or any condition that impairs the flow of blood to the kidneys, but it has also been linked to exposure to some toxic substances, such as mercury, carbon tetrachloride, ethylene glycol, or bacterial toxins.

Figure 117 shows the rate of mortality from renal failure across areas over time. The rate of mortality from renal failure for residents of the NRBS area is not statistically different than the rate of mortality from this diagnosis for residents of any other area in the province.

Figure 117 Mortality Rate from Renal Failure



Food And Water-Borne Disease

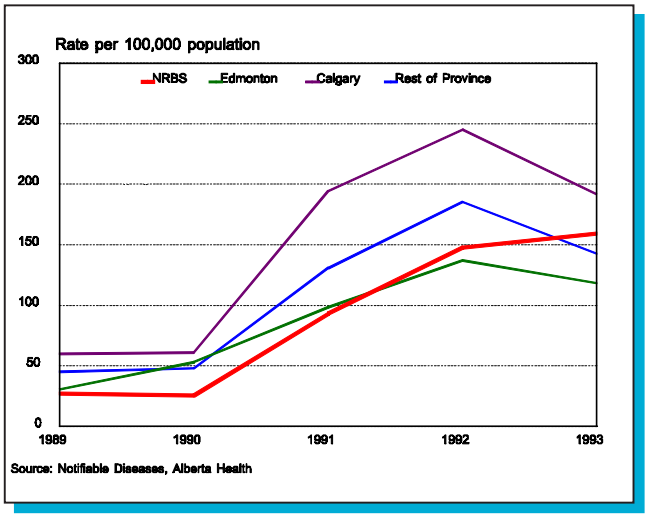
Many gastrointestinal diseases are caused by an infection of a virus, bacteria or protozoan in the stomach, small intestine and liver. Typical symptoms include fever, loss of appetite, abdominal pain, vomiting, and diarrhea.[55] The four most frequently found types of food- and water-borne communicable diseases - salmonellosis, shigella, hepatitis A, and giardiasis - were evaluated for this study.

The Communicable Diseases Regulations under the Public Health Act require anyone identifying that an individual has a communicable disease to notify the Medical Officer of Health in that region. Several of the diseases specified by that legislation are potentially water-borne diseases, such as salmonellosis, shigella, hepatitis A, and giardiasis. For example, the provincial laboratory is responsible for informing the Medical Officer of Health of each case of giardiasis that is identified through the examination of individual specimen samples. It is then the responsibility of the Medical Officer of Health to evaluate the source of contamination for each disease. Staff from the local public health unit conduct a detailed evaluation of the potential sources of contamination, and attempt to isolate the source. This evaluation is followed up with a correction plan to ensure that further contamination is avoided.

Very few people in the entire province are diagnosed with any of these food- and water-borne diseases in a given year. Occasional epidemics are monitored very closely to prevent additional people contracting the disease, and to identify and remove the potential contaminated source. The total number of people who contract a disease does not clearly indicate if the disease is common or rare, and even a small epidemic may artificially increase the number of people who contract the disease in a given year. In addition, comparison across regions is difficult without accounting for the different population sizes. For these reasons, the incidence rate of a disease is more frequently used to determine irregular or 'epidemic' years.

The incidence rate is shown in Figure 118. The incidence rate of food and water-borne diseases increased significantly between 1990 and 1992 in all areas of the province ($p<0.05$). The rate in the two urban areas and the rest of the province decreased between 1992 and 1993, but continued to increase in the NRBS area. Calgary had the highest rate of food- and water-borne diseases overall ($p<0.05$).

Figure 118 Incidence Rate for All Food and Water-Borne Diseases



Salmonellosis is a reaction to a type of bacteria called Salmonella that causes digestive problems, from mild gastroenteritis (inflammation of the digestive tract) to severe or fatal poisoning. Salmonellosis may be contracted through either a water or a food source.

Figure 119 shows the rate of hospitalization for salmonellosis for males and females by age group. Babies and older adults are more likely to be hospitalized with salmonellosis than are children older than 5 years of age and adults younger than 60 years of age. There is no significant difference in the rate of hospitalization for salmonellosis between males and females.

Figure 119 Provincial Rate of Hospitalization for Salmonellosis

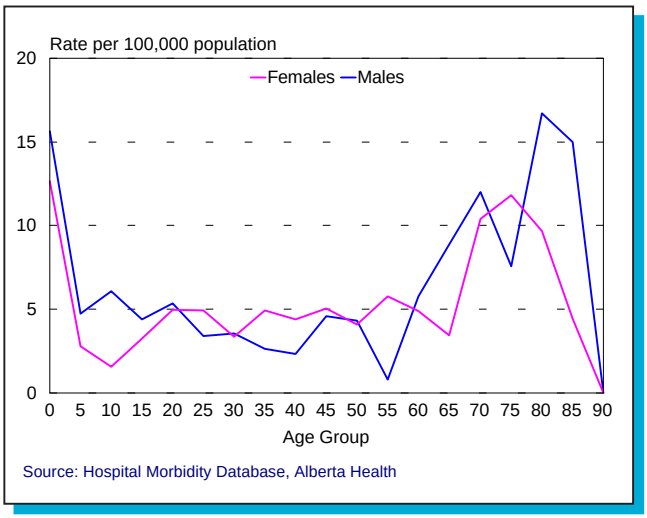
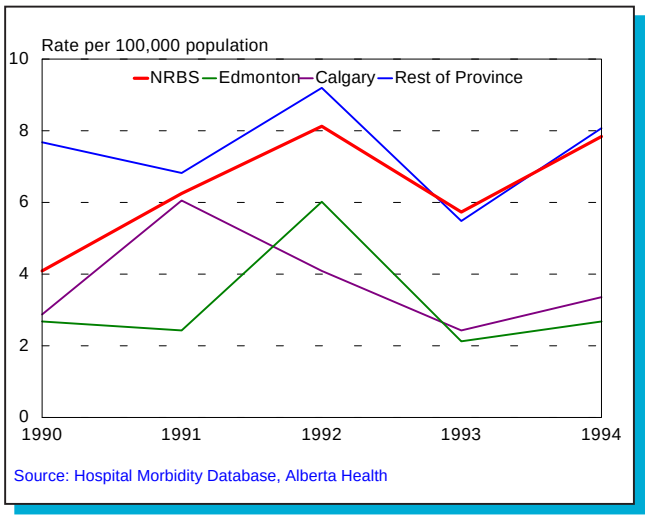


Figure 120 compares the rate of hospitalization for salmonellosis by area over time. Overall, the rate of hospitalization for salmonellosis is very low. The rate in the two rural areas is consistently higher than the rate in the two urban areas. The rate fluctuated over time in all of the areas, and reached a peak level in 1992 in all areas except Calgary. The two rural areas had higher rates of hospitalization, although we saw earlier that the incidence rates identified for all diagnoses were not higher in these two areas. This relationship suggests that physician practices are different in the two rural areas than they are in the two urban areas. For example, long distances between the hospital and the individual's home make hospitalization a safer alternative in rural areas; urban areas are not typically faced with the potentially dangerous impacts of travel distance.

Figure 120 Hospitalization Rate for Salmonellosis by Area



Shigella is another species of bacteria that affects the digestive system and causes mild to severe diarrhea. Exposure to the shigella bacteria results in a condition called shigellosis. According to the Notifiable Diseases Annual Summary, 1993, the rates of shigellosis in Alberta, Saskatchewan and Manitoba were the highest in Canada and were four to ten times higher than the other provinces. The Summary also shows a similar increase in shigellosis in the three provinces in the years 1992 and 1993. This indicates a significant increase in shigellosis cases in the prairie provinces that may have common risk factors.

The five year provincial rate of hospitalization for shigellosis is shown in Figure 121. The rate of hospitalization is about the same as the hospitalization rate for salmonellosis among children younger than 5 years old, but is lower than salmonellosis for all other age groups. Also unlike salmonellosis, the rate does not increase among people older than 60, but remains

relatively low and stable, with some smaller increases among the very old (older than 80 years). This pattern is consistent with the incidence rate, indicating that there is a higher risk of infection for children younger than ten year of age.

Figure 121 Provincial Rate of Hospitalization for Shigellosis

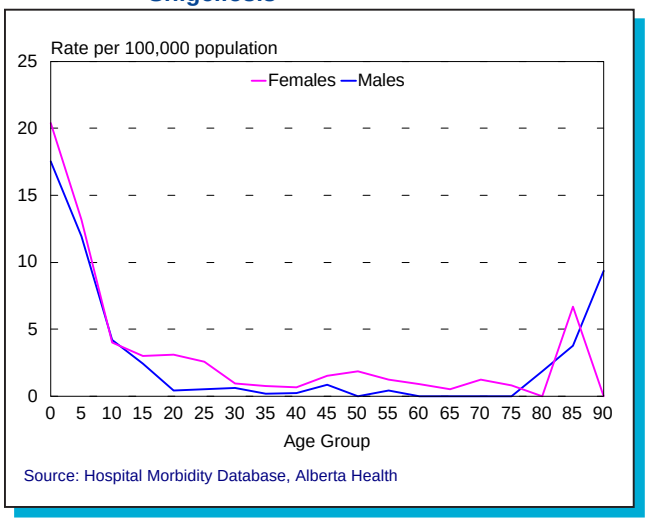


Figure 122 compares the rate of hospitalization for shigellosis across areas over time. There was a small outbreak of shigellosis in the NRBS area in 1993, indicated by the sharp increase in the hospitalization rate during that year. There was also a smaller outbreak in the rest of the province during 1992. Both outbreaks have an impact on the five-year combined rate, so the rates for both areas are statistically higher than the two urban areas.

Giardia lamblia is a species of internal parasitic protozoa which are sometimes found in untreated or improperly treated water. When an individual drinks enough of the water containing the parasite, they may be infected with the parasite - a condition called Giardiasis. Giardia lamblia attaches itself to the wall of the small intestine and interferes with the absorption of fat. The most frequent symptoms of giardiasis include: diarrhea, cramps, nausea, weakness, weight loss, abdominal distention, greasy stools, belching, gas and vomiting. Symptoms appear approximately two weeks after exposure to the parasite, and may persist two to three months.

Figure 122 Hospitalization Rate for Shigellosis by Area

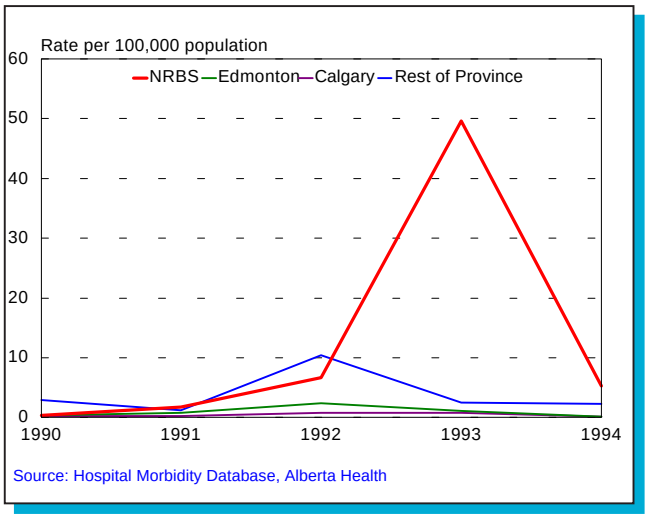
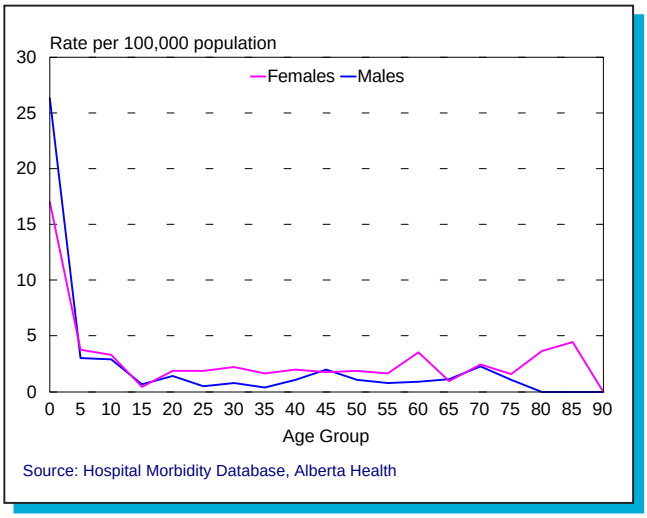


Figure 123 shows the rate of hospitalization for giardiasis for males and females by age group. The pattern of hospitalization for giardiasis is similar to the pattern discussed above for shigellosis: the highest rate of hospitalization is among children younger than 5 years old, and there is no significant difference between the rate of hospitalization for males and the rate of hospitalization for females. The rate of hospitalization for giardiasis is less than 5 people per 100,000 population for all age groups except babies.

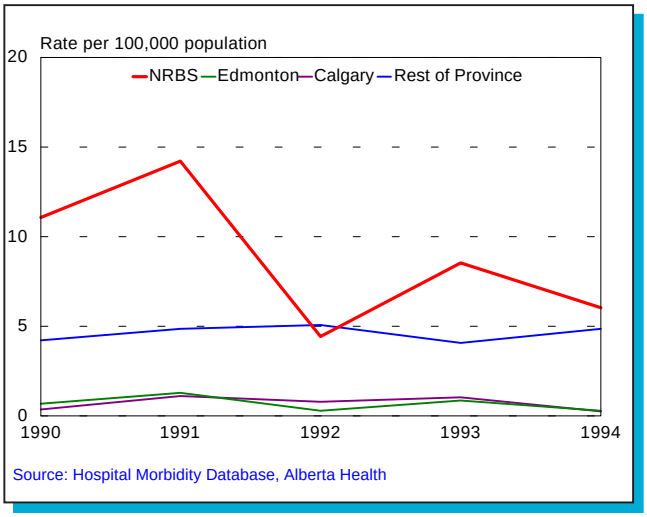
Figure 123 Provincial Rate of Hospitalization for Giardiasis



Source: Hospital Morbidity Database, Alberta Health

Figure 124 compares the rate of hospitalization for giardiasis across areas over time. The rate of hospitalization for giardiasis is consistently higher in the two rural areas than the two urban areas, and the rate of hospitalization in the NRBS area was significantly higher than the rate in the rest of the province in 1990, 1991 and 1993 ($p<0.05$).

Figure 124 Hospitalization Rate for Giardiasis by Area

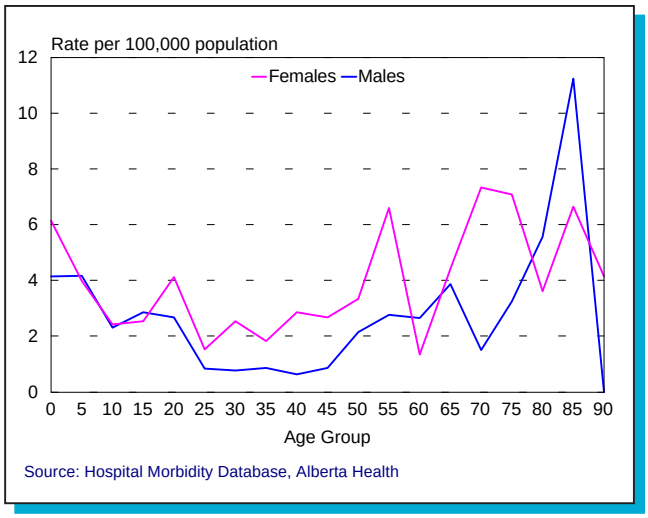


Source: Hospital Morbidity Database, Alberta Health

Escherichia coli, better known as E. coli, is a bacteria that normally exists in the colon and does not cause any pathogenic condition when confined to the intestinal tract. However, when E. coli is introduced into the urinary tract, infection or enteritis usually results. The presence of E. coli in milk, meat products or water usually results from fecal contamination.

Figure 125 shows the provincial rate of hospitalization for E. coli for males and females by age group. Although the rate fluctuates dramatically across the lifespan, there is a relatively consistent increase in hospitalization among babies and older adults.

Figure 125 Provincial Rate of Hospitalization for E. coli



Source: Hospital Morbidity Database, Alberta Health

Figure 126 compares the rate of hospitalization for E. coli across areas over time. The five-year combined rate for the NRBS area was significantly higher than the rate for Edmonton, but was no different than the rate for the two other areas ($p<0.05$).

Figure 126 Hospitalization Rate for E. coli by Area

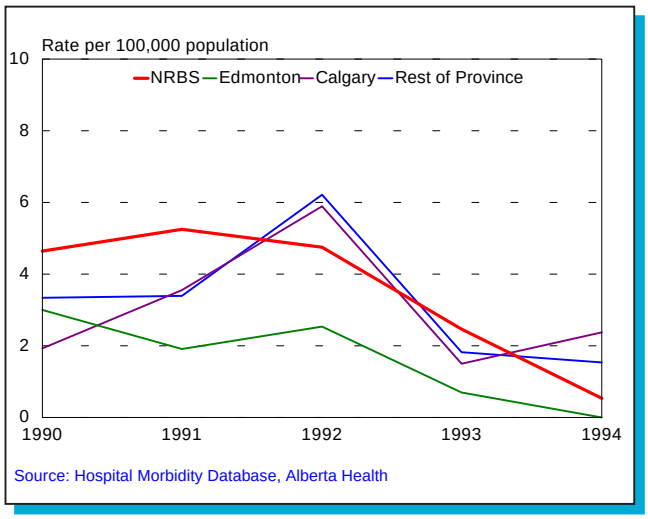
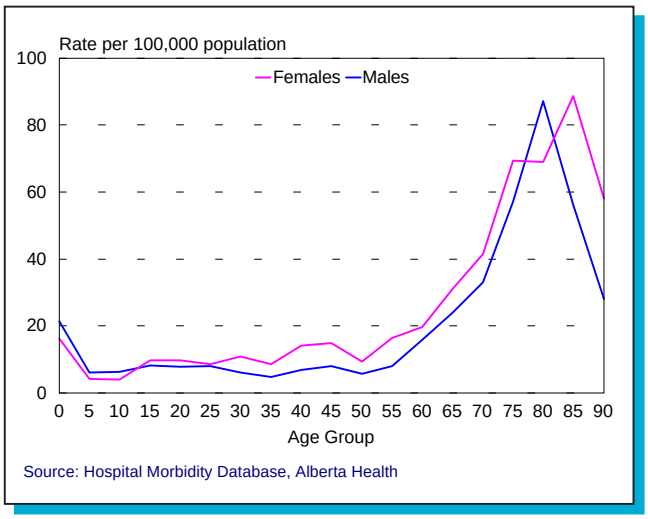


Figure 127 Provincial Rate of Hospitalization for Campylobacteriosis



Campylobacteriosis

Campylobacteriosis occurs due to exposure to the organism “campylobacter”, often found in dairy cattle. In humans, campylobacteriosis is characterized by fever, abdominal pain, and diarrhea. Campylobacteriosis occurs most often in people who are elderly, debilitated, or immunocompromised.

Figure 127 shows the five year average provincial rate of hospitalization for campylobacteriosis by age group and gender. Although people of all age groups are hospitalized with campylobacteriosis, it is among the older age groups, where this type of infection is more dangerous, that hospitalization is more likely. There is very little difference in the rate of hospitalization between males and females at any age group.

Figure 128 compares the rate of hospitalization for campylobacteriosis across areas over time. The rate of hospitalization for campylobacteriosis increased in all four areas over time, although the rate in the NRBS area fluctuated more than the rate in the other areas. In 1994 the rate of hospitalization for campylobacteriosis was highest in the rest of the province, and lowest in the two urban areas. The five-year combined rate for the two urban areas were significantly lower than the rates for the two rural areas.

Figure 128 Hospitalization Rate for Campylo-bacteriosis by Area

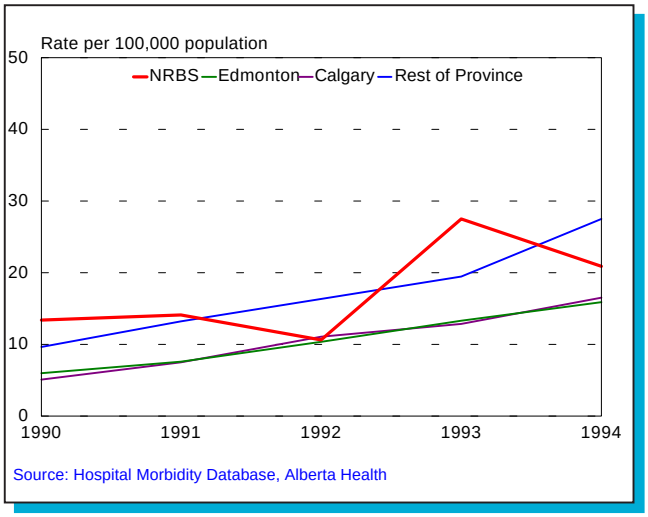
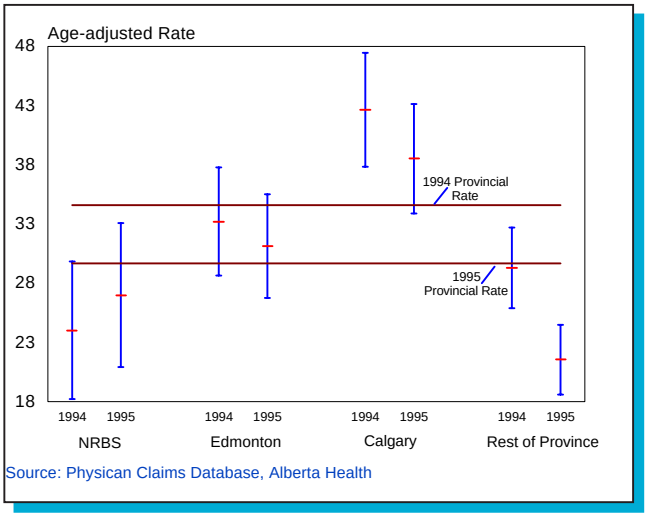


Figure 129 compares the rate of individuals visiting a physician for all parasitic infections across areas for 1994 and 1995. Although the rate of hospitalization in the NRBS area was higher than the rate of hospitalization for several of the parasitic infections, the 1994 rate of individuals visiting a physician for these infections was lower in the NRBS area than the rate in the two urban areas, and remained low in 1995. The difference between the rate of visits in the NRBS area and the rate in Calgary was statistically significant for both years, but there was no statistically significant difference in the rate of visits to a physician between the residents of the NRBS area and the residents of either Edmonton or the rest of the province.

Figure 129 Rate of Individuals Visiting a Physician for a Parasitic Infection by Area



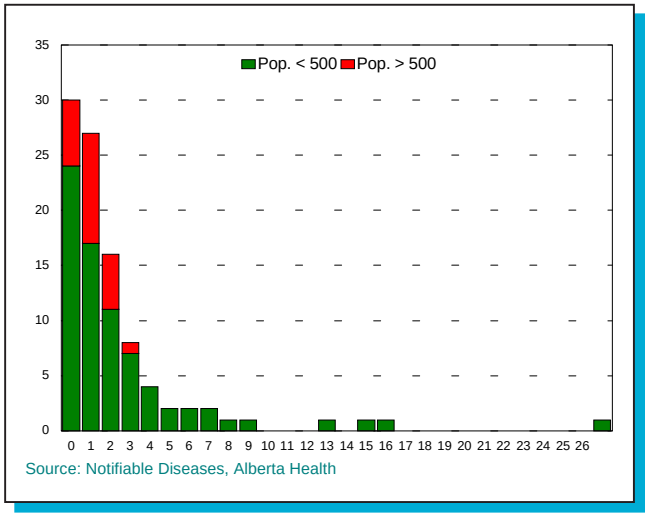
Source: Physican Claims Database, Alberta Health

Water Quality And Health Outcomes

A study was conducted by Prince et al[56] to clarify the link between the source of drinking water and disease rates, and to further examine the differences between the NRBS area and the other areas of the province. The analysis focuses on diagnosed cases of campylobacteriosis, giardiasis, hepatitis A, salmonellosis and shigellosis, and compares rates to records of drinking water quality indicators maintained by Alberta Environmental Protection. An analysis at a provincial level was necessary to determine if any relationship existed, prior to examination of the relationship between community size and water source at a sub-provincial level. A synopsis of the study is included below.

Poorer drinking water quality in small communities is well documented.[57] For example, an evaluation of the microbial database used in this study and other water quality data elsewhere found smaller communities generally have lower quality drinking water than larger communities (see Figure 130). Communities with the highest proportion of samples that were coliform positive were all very small (less than 500 population) communities. In northern Alberta, researchers found communities with small populations (less than 500 people) had significantly higher turbidity levels than larger communities.[58]

Figure 130 Proportion of Coliform Positive Samples by Community Size

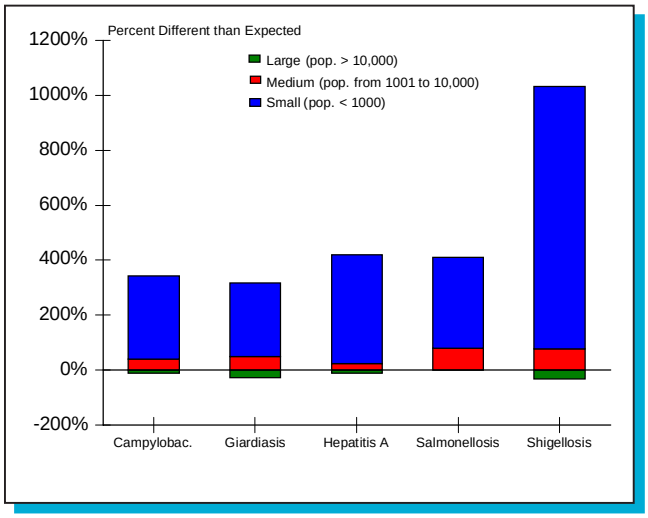


Source: Notifiable Diseases, Alberta Health

Figure 131 compares the proportion of cases of the disease different than expected by community size for each of the five diseases investigated. Campylobacterosis, giardiasis, salmonella, and hepatitis A are all highly correlated with community size, and the correlation between shigellosis and community size was even greater. It is interesting to note that the small

communities (less than 1000 population) were responsible for the majority of the cases of campylobacteriosis, giardiasis, hepatitis A and shigellosis: there were roughly 9 times as many cases of shigellosis in the small communities than expected. Although the correlation between community size and waterborne disease rates is interesting, the analysis does not provide evidence that a causal relationship exists. Given the highly significant trend between

Figure 131 Selected Waterborne Diseases by Community Size



community size and disease occurrence, further analysis of the relationship with drinking water quality and waterborne diseases attempted to control for community size. Practically however, this was not completely possible. There were no large communities with poor water quality. Furthermore, large communities all use surface water and all had consistently good microbial test results. Controlling for population size likely suppresses some portion of any water quality effect. Therefore, comparisons were limited to small and medium sized communities. Some aboriginal communities with water treatment facilities were not included in the analysis below because comparable data were not available.

Campylobacteriosis

Figure 132 compares the actual number of cases of campylobacteriosis to the expected number of cases by community size and microbial sampling test results. Colors used for the following graphs are similar to those used for the maps: green bars above the median line can be interpreted as good or safe, and red indicates a correlation between water source and the rate of diagnosis. If water is the source of contamination for campylobacteriosis, we would expect to see red bars (representing poor quality water) above the median line - indicating that communities that had a large number of poor microbial test results also had more cases of campylobacteriosis than expected. The size of community and source of water was not correlated with the existence of campylobacteriosis when the community was the unit of investigation, but when the unit of investigation was the individual, the correlation between the size of community, source of water and the existence of campylobacteriosis was significant ($p < 0.05$).

Figure 132 Campylobacteriosis Cases by Community Microbial Sample Results

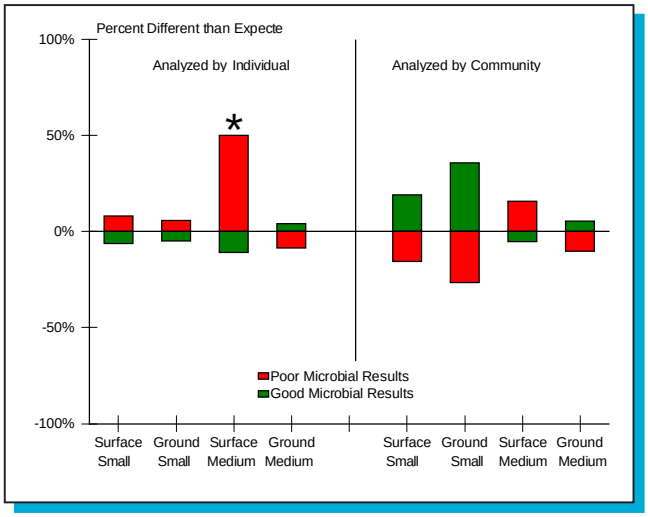
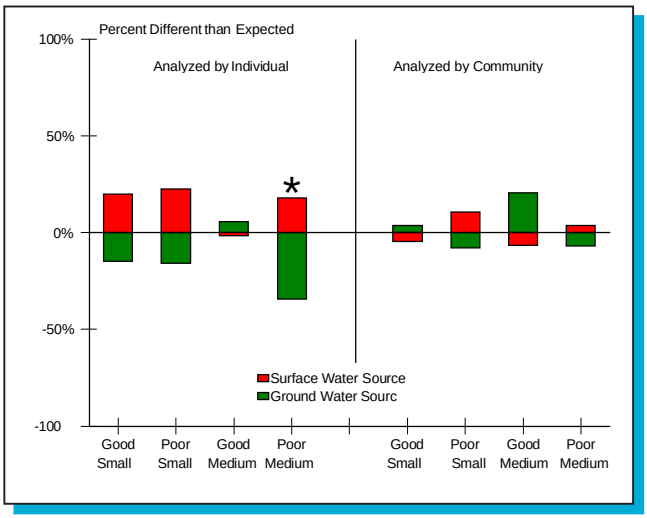


Figure 133 compares the actual number of cases of campylobacteriosis to the expected number of cases by community size and water source. For medium size communities with poor microbial

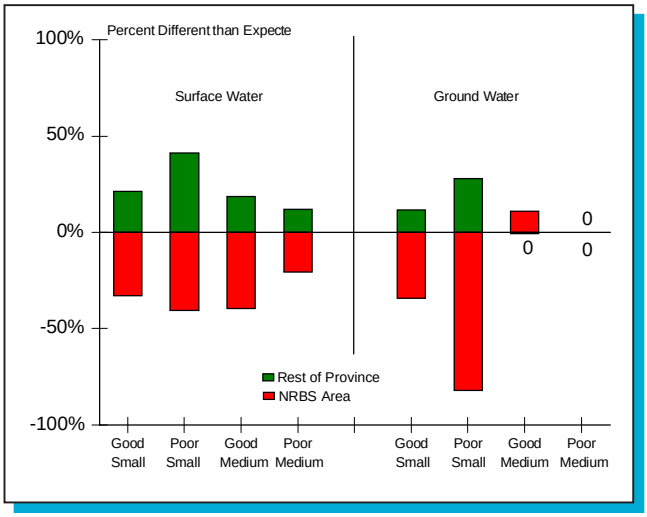
test results, the number of individuals who were diagnosed with campylobacteriosis was greater than expected. However, when using the more stringent test of comparison by community, there is no statistically significant relationship.

Figure 133 Campylobacteriosis Cases by Type of Community Water Source



The analysis shows some relationship between campylobacteriosis and drinking water at the provincial level but the correlation is not strong enough to be significant under the more reliable test based on community disease occurrence. An analysis of occurrence of campylobacteriosis, using the individual as the unit of investigation (comparing site locations while holding the other factors constant) indicates that diagnosis of campylobacteriosis occurred more frequently than expected at sites outside the NRBS area ($p<0.05$). The same analysis using the community as the unit of analysis does not indicate any relationship between the occurrence of campylobacteriosis in the NRBS area and elsewhere in the province (see Figure 134).

Figure 134 Camylobacteriosis Cases by Community Accross Area



Giardiasis

Figure 135 compares the actual number of cases of giardiasis to the expected number of cases by community size and microbial sampling test results. When considering the number of individuals diagnosed with giardiasis, medium communities with poor microbial test results, regardless of the source of water, had more cases of giardiasis than expected. Alternatively, small communities with surface water and good microbial test results had more cases of giardiasis than expected. When analyzed by community rather than the individual, only small communities with good microbial results using surface water had a significantly larger number of cases of giardiasis than expected. The trend in the medium sized communities implicates public drinking water as being an exposure pathway while the trend in the small surface water communities does not. Using the community as the unit of analysis indicates a relationship between giardiasis diagnoses and microbial sampling results in small communities.

Figure 135 Giardiasis Cases by Community Microbial Sample Results

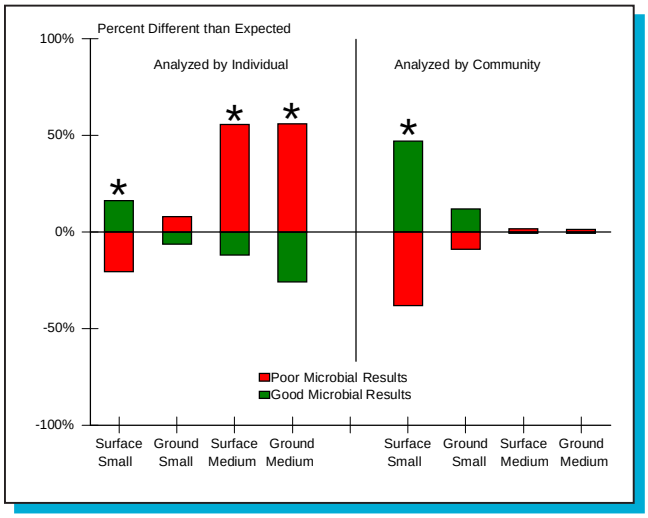
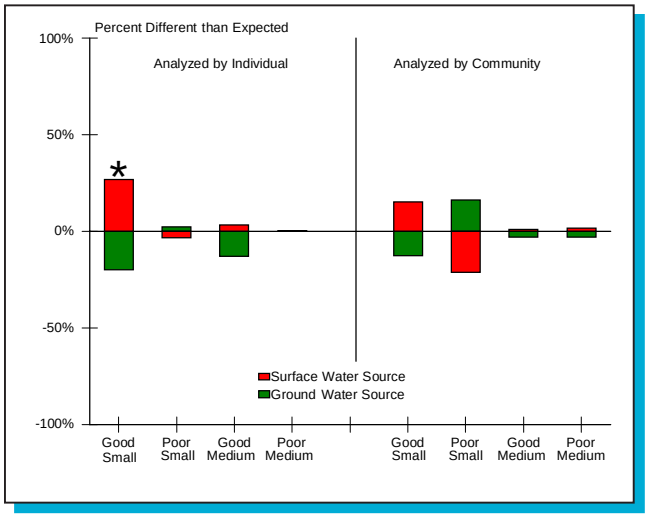


Figure 136 compares the actual number of cases of giardiasis to the expected number of cases by community size and water source. The size of community and microbial sampling test results is not correlated with existence of giardiasis when the community is the unit of investigation, but when the unit of investigation is the individual, the correlation between community size, water source and the existence of giardiasis is significant. Small communities with good microbial test results had more cases of giardiasis than expected when the water was obtained from a surface source.

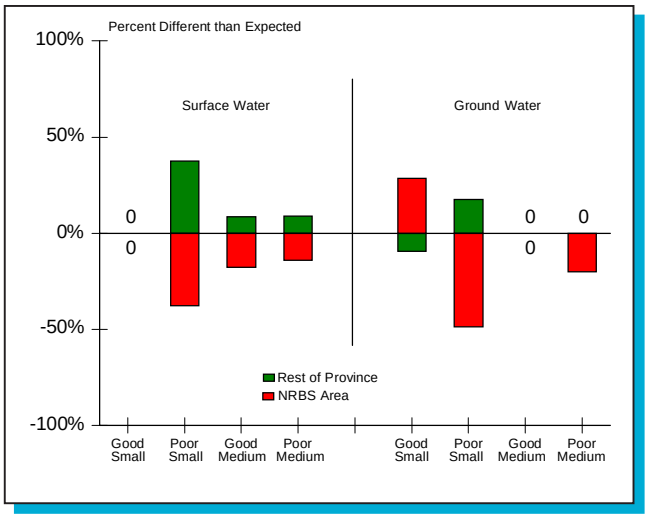
Figure 136 Giardiasis Cases by Type of Community Water Source



Once again, the existence of the diagnosis - in this case giardiasis - shows some relationships to drinking water but the correlation is not strong enough to be significant under the more reliable test, based on community disease occurrence.

Comparison of the water source and disease rates for communities in the NRBS with those outside the NRBS area using the individual as the unit of analysis indicates some significant relationships, but these relationships are not significant using the community as the unit of analysis (see Figure 137).

Figure 137 Giardiasis Cases by Community Across Areas



Hepatitis A

Figure 138 compares the actual number of cases of hepatitis A to the expected number of cases by community size and microbial sampling test results. Comparing individual hepatitis A cases to community microbial sampling results showed a significant relationship between disease cases and poorer microbial results for medium sized communities. The same comparison using the community as the unit of analysis found no significant trends. Some of the bars in the figure appear large but are not significant due to the small number of Hepatitis A cases available for analysis.

Figure 138 Hepatitis A Cases by Community Microbial Sample Results

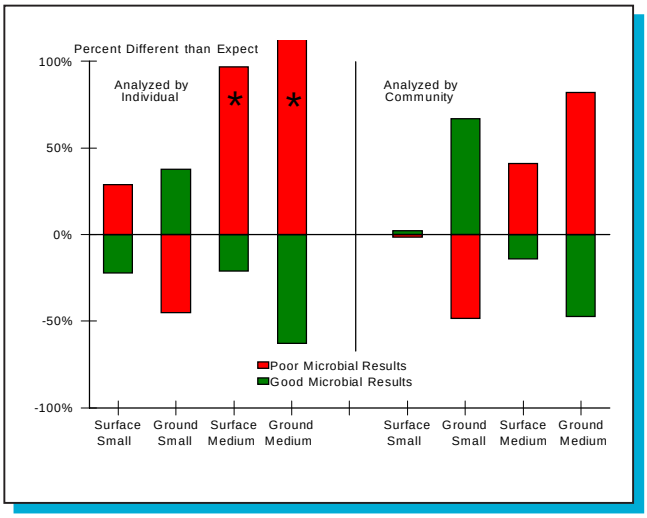
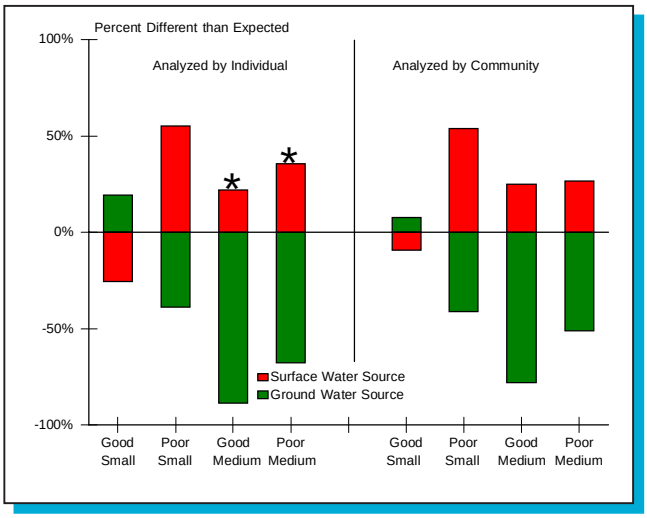


Figure 139 compares the actual number of cases of hepatitis A to the expected number of cases by community size and water source. The comparison of the number of individuals diagnosed with hepatitis A to the type of community drinking water source indicates that there is a significant relationship between disease cases in medium sized communities with surface water as a drinking water source. The comparison using the community as the investigation unit did not show any significant correlations.

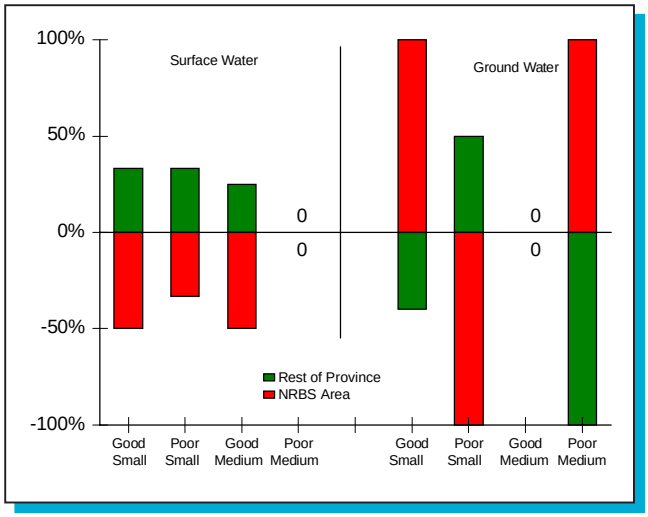
Figure 139 Hepatitis A Cases by Type of Community Water Source



The results indicate that some correlation between hepatitis A and public drinking water in medium size communities does exist. However, the relationship is not strong enough to be significant when the community (more reliable but less sensitive) is the unit of investigation.

Further analysis of the frequency of hepatitis A rates comparing communities in the NRBS area with the rest of the province were hampered by the small number of cases. When using the individual as the unit of analysis, the frequency of diagnosis of hepatitis A for residents of the NRBS area is less than expected. Of those communities where the relationship could be tested, there were no significant correlations between water source, location and water quality (see Figure 140) when using the community as the unit of analysis.

Figure 140 Hepatitis A Cases by Community Across Areas



Salmonellosis

Figure 141 compares the actual number of cases of salmonellosis to the expected number of cases by community size and microbial sampling test results. The figure shows significant dependence between microbial drinking water quality and salmonella cases at medium-sized surface water communities. Using the community as the unit

of investigation, there is no significant correlation between disease cases and microbial drinking water quality.

Figure 141 Salmonellosis Cases by Community Microbial Sample Results

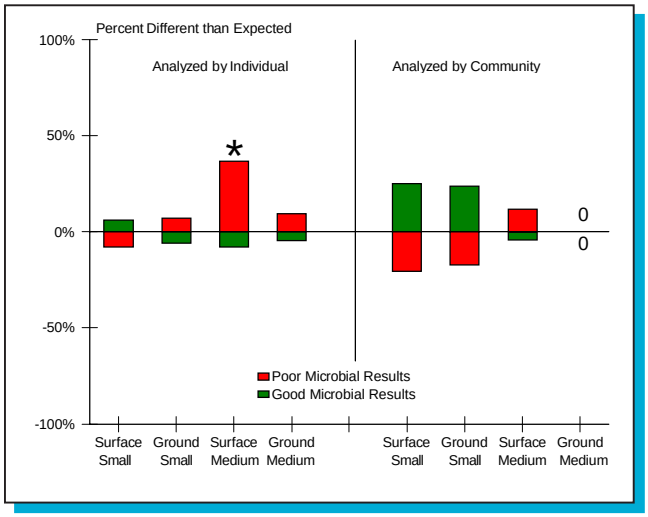
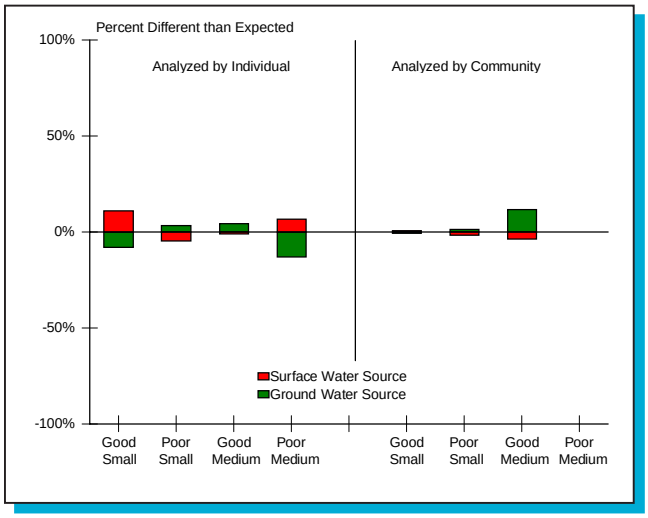


Figure 142 compares the actual number of cases of salmonellosis to the expected number of cases by community size and water source. There are no significant relationships when comparing salmonellosis occurrence to drinking water source using either the individual or the community as the unit of investigation.

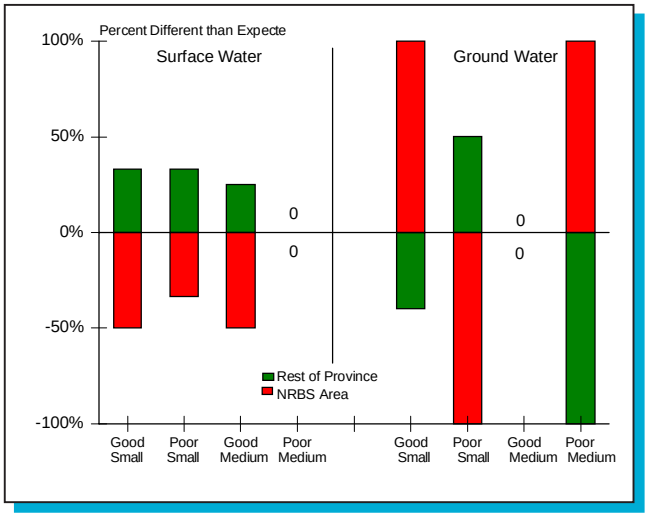
Figure 142 Salmonellosis Cases by Type of Community Water Source



There is no evidence to suggest that public drinking water is a significant exposure pathway for salmonellosis. Because salmonellosis is not expected to be a significant water-borne disease in Alberta, the results are not unexpected.

Analysis of the occurrence of salmonellosis cases using the individual as the unit of analysis and comparing the frequency in communities in the NRBS area with communities outside the NRBS area indicated some significant relationships, but these relationships do not exist when using the community as the unit of analysis (see Figure 143).

Figure 143 Salmonellosis Cases by Community Across Areas



Shigellosis

Figure 144 compares the actual number of cases of shigellosis to the expected number of cases by community size and microbial sampling test results. When comparing the occurrence of shigellosis to community microbial test results by individual, there are several statistically significant relationships: small communities with surface water, and medium sized communities, regardless of water source both had more cases of shigellosis than expected. These relationships are not significant when the community is used as the unit of investigation.

Figure 144 Shigellosis Cases by Community Microbial Sample Results

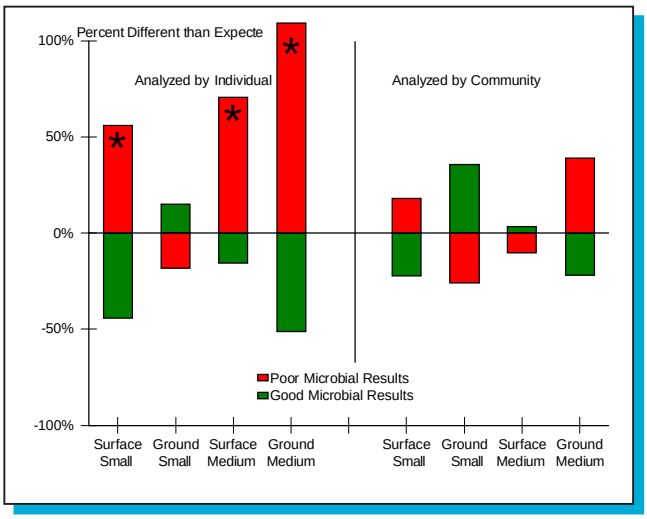


Figure 145 Shigellosis Cases by Type of Community Water Source

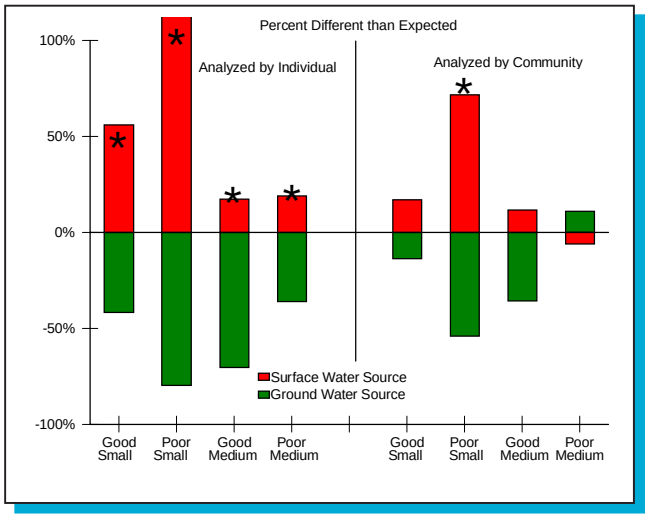
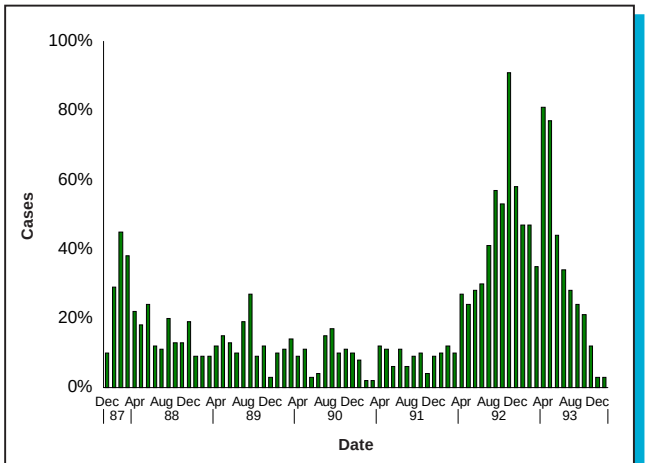


Figure 145 compares the actual number of cases of shigellosis to the expected number of cases by community size and water source. The occurrence of shigellosis was significantly dependent on community water source (ground or surface water) at both community sizes when the individual was the unit of investigation. Using the community as the unit of analysis, the results show that the source of water in small communities with poorer microbial sampling results is the only significant comparison. This relationship suggests that public drinking water is a significant exposure pathway for shigellosis. This is the only significant correlation found which supported the argument that public drinking water is a significant exposure pathway for disease.

Due to the significant correlations between shigellosis and drinking water factors, further analysis was undertaken to evaluate fluctuations in the number of cases of shigellosis over time. Figure 146 indicates that there was a sizable increase in the number of cases of shigellosis beginning in March 1992.

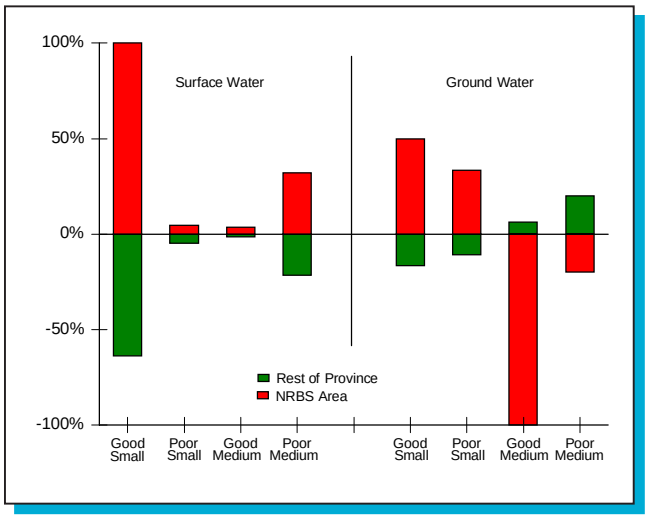
Figure 146 Frequency of Shigellosis Cases by Month



Source: Notifiable Diseases, Alberta Health

Further analysis of shigellosis diagnosis rates using the individual as the unit of investigation shows that six of the eight groups are significantly related to location with more disease than expected occurring in the NRBS area. The analysis using the community as the unit of investigation shows that only one community group (small, surface water, good microbial quality) remains significant (see Figure 147). These results indicate that significantly more individual cases of shigella occur in the NRBS area in nearly all groups but there is no difference between the NRBS and the rest of the province in the occurrence of shigellosis by community. The analysis discussed above found shigellosis at

Figure 147 Shigellosis Cases by Community Across Areas



small surface water communities with poor drinking water quality to be the only disease to implicate drinking water as a significant exposure pathway. When this group is split in to the NRBS and non-NRBS components we find that only in the non-NRBS subgroup is public drinking water implicated as a significant exposure pathway for shigellosis

Endocrine, Metabolic And Nutritional Disorders

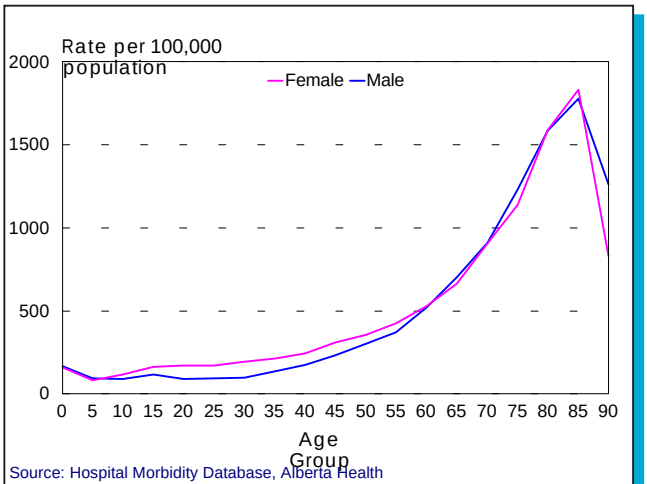
Endocrine, metabolic and nutritional disorders a large chapter of diseases that affect the endocrine system, that show evidence of nutritional deficiencies, or affect the metabolism. All these diagnoses are grouped under a single chapter because they are all related to the human body's ability to absorb and use the foods we eat. The endocrine system includes all glands that produce hormones and other secretions that have an effect on other parts of the body. One of these hormones, the thyroid hormone, affects the rate of metabolism. Metabolism refers to the physical and chemical changes that take place in a body, including all energy functions in the cells. Metabolism is affected by the hormones secreted by the endocrine system, and by the nutrition available for converting into energy and supporting the body. Endocrine, metabolic and nutritional disorders includes such diagnoses as diabetes mellitus and anaemia.

Findings

The analysis indicated that the residents of the NRBS area are not diagnosed with either diabetes or anaemia more frequently than residents of the other areas of the province, although variations may exist among sub-populations in the area.

Figure 148 shows the provincial rate of hospitalization for endocrine, metabolic and nutritional disorders by age group and gender. The hospitalization rate is the same for men as for women, and increases steadily with age.

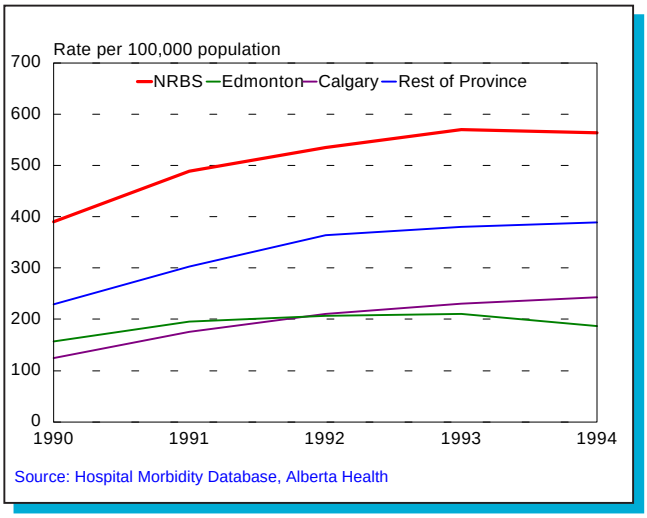
Figure 148 Provincial Rate of Hospitalization for Endocrine, Metabolic, and Nutritional Disorders



Source: Hospital Morbidity Database, Alberta Health

Figure 149 compares the rate of hospitalization for endocrine, metabolic and nutritional disorders across areas over time. The rate of hospitalization in the two urban areas for these disorders is similar. The rates of hospitalization in the rest of the province and the NRBS area are higher than the two urban areas, and the rate in the NRBS area is much higher than the rate in the rest of the province ($p<0.05$). The rate of hospitalization increased in all areas over time.

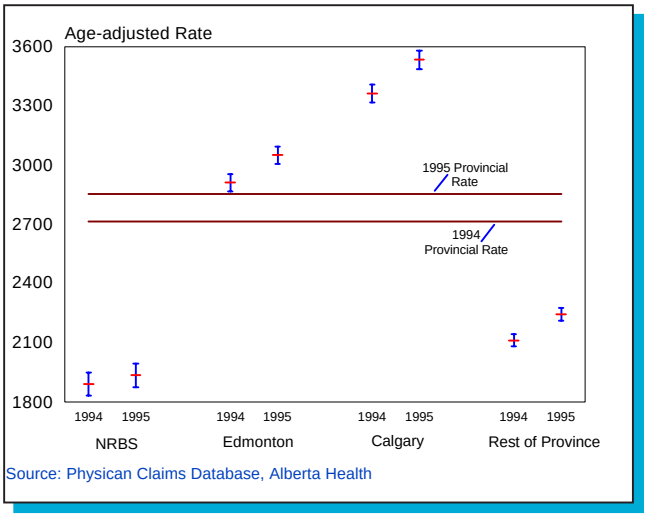
Figure 149 Hospitalization Rate for Endocrine, Metabolic and Nutritional Disorders



Source: Hospital Morbidity Database, Alberta Health

Figure 150 compares the rate of individuals visiting a physician for this type if disorders. The rate of visits to a physician by residents of the NRBS area is lower than any other area of the province. The rate of visits to a physician by residents of the rest of the province was slightly higher than the rate of visits by residents of the NRBS area in both 1994 and 1995. The rate in the two urban areas was much higher than the rate in the two rural areas.

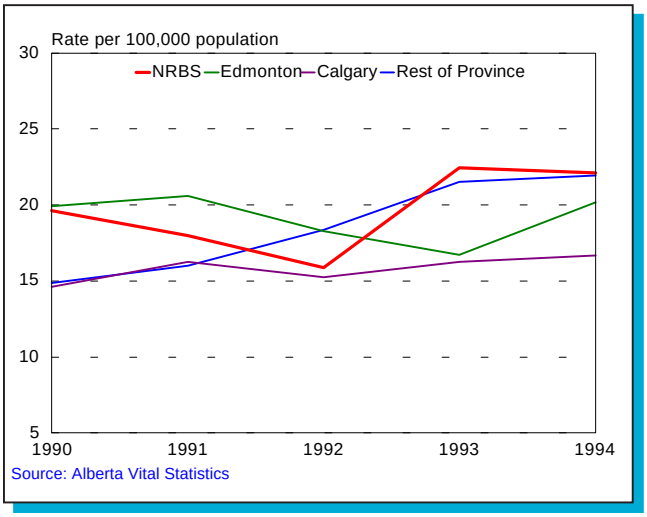
Figure 150 Rate of Visits to a Physician for Endocrine, Metabolic and Nutritional Disorders



Source: Physican Claims Database, Alberta Health

Figure 151 compares the mortality rate for endocrine, metabolic and nutritional disorders by year and area. The mortality rate for people with this group of disorders is low. The rate of mortality in the NRBS area throughout the 1990's is similar to the rate in the other areas of the province.

Figure 151 Rate of Mortality for Endocrine, Metabolic and Nutritional Disorders



Source: Alberta Vital Statistics

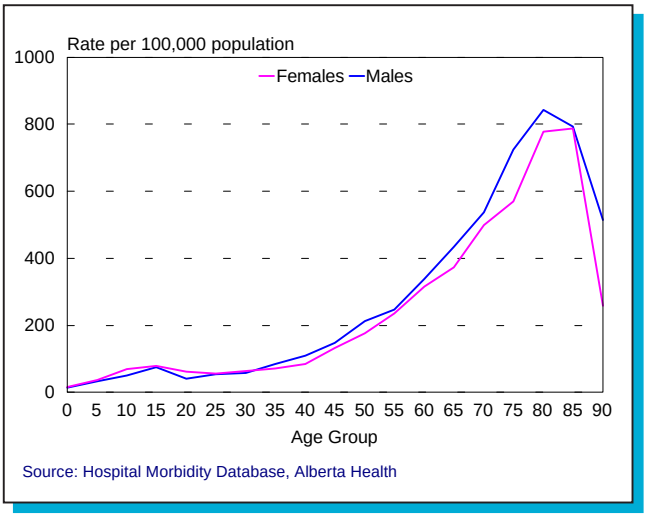
Diabetes

Diabetes mellitus results from inadequate production of insulin by the pancreas, which interferes with the body's ability to metabolize carbohydrates. Diabetes may result from a genetic disorder, or may result from damage to the pancreas caused by inflammation. Diabetes is also related to race - compared to other people in North American, more First Nations peoples are diagnosed with diabetes. Diabetes may also be caused by obesity or low level of activity. According to the 1994 Aboriginal People's Survey,[59] 6.4% of aboriginal people reported having been diagnosed with diabetes by a health care professional. The prevalence rate was higher among Metis (8%) than among First Nations people (5.7%) and was higher for women (8.1%) than for men (4.4%).

According to the National Population Health Survey of the Canadian population:[60] the age-adjusted prevalence rate of diabetes for aboriginal men (7.4 in 100 men) in Canada was more than twice as high as the rate for non-aboriginal men (2.99 in 100 men). The difference in diagnosis of diabetes for women was even more dramatic: the age-adjusted prevalence rate for aboriginal women (11.4 in every 100 women) was more than three times as high as the rate for non-aboriginal Canadian women (3.4 in 100 women).

Figure 152 shows the provincial rate of hospitalization for all diabetes mellitus by age group and gender. There is no difference in the rate of hospitalization for diabetes between men and women. The rate of hospitalization increases steadily with age. Roughly 800 people in every 100,000 were hospitalized for diabetes mellitus in 1994.

Figure 152 Provincial Rate of Hospitalization for Diabetes



Source: Hospital Morbidity Database, Alberta Health

Figure 153 compares the rate of hospitalization for diabetes across areas over time. The rate of hospitalization in the two urban areas for diabetes mellitus is very similar and is relatively stable over time. The rates of hospitalization in the two rural areas, the rest of the province and the NRBS area, are higher than the two urban areas, and the rate in the NRBS area is much higher than the rate in the rest of the province (all differences are statistically significant ($p<0.05$)). The rate of hospitalization increased slightly in the two rural areas over time.

Figure 153 Provincial Rate of Hospitalization for Diabetes Mellitus

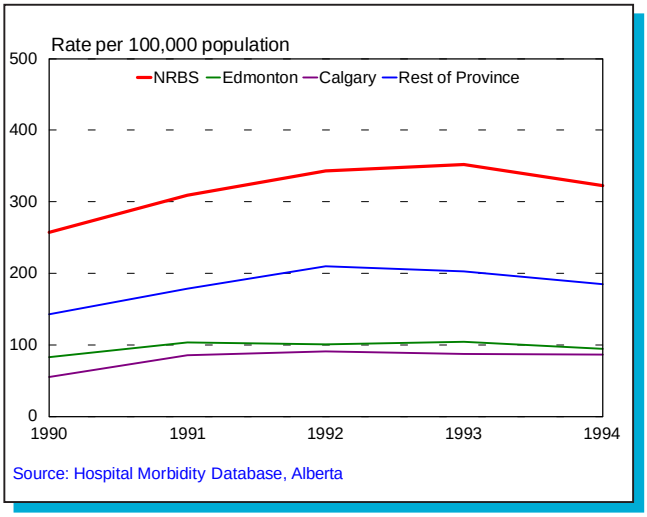


Figure 153 compares the rate of visits to a physician for diabetes mellitus in 1994 with the rate for 1995 by area. The number of people who visited a physician for diabetes mellitus in the NRBS area was similar to the rate in both of the urban areas, and the rate of people visiting a physician in the other rural area, the rest of the province, was much lower. The rate of people visiting a physician for this disorder in the NRBS area increased slightly between 1994 and 1995. The increase in the rate in the Edmonton area was greater than that in the NRBS area. The rate in the Calgary area decreased slightly and the rate in the rest of the province remained stable.

Figure 154 Rate of Visits to a Physician for Diabetes Mellitus

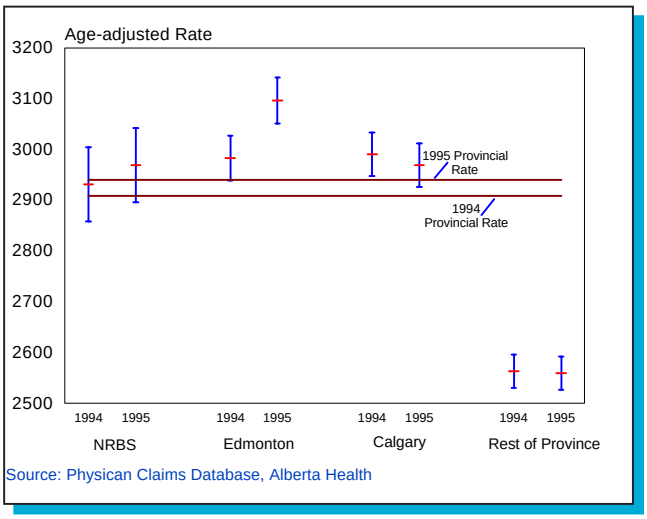
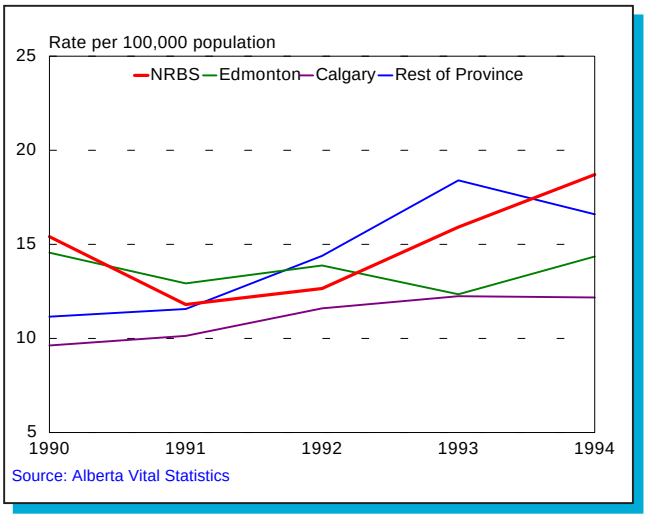


Figure 155 compares the mortality rate for diabetes by area and year. The mortality rate for people with diabetes living in the NRBS area was not statistically significantly different than the rate of mortality for people living in the other areas of the province. The overall rate of mortality from diabetes mellitus is very low, so minor fluctuations appear significant.

Figure 155 Rate of Mortality from Diabetes



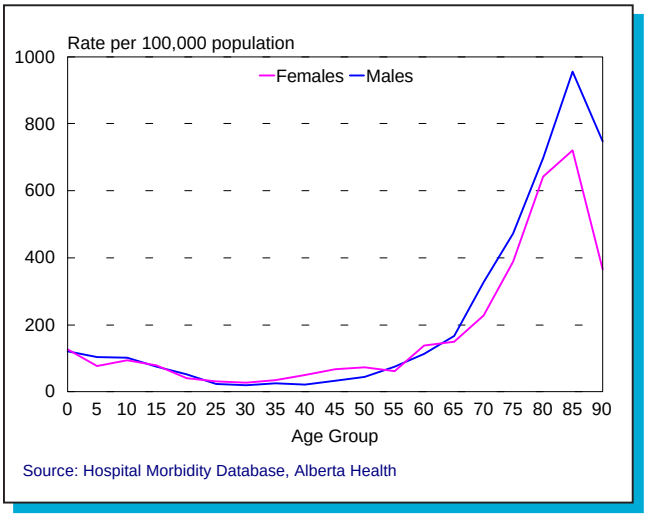
The seemingly high rate of hospitalization for diabetes is balanced by an average rate of visits to a physician for this disorder. There is no apparent difference in the NRBS area and the two large urban centres. The other rural area (rest of province) has comparably low rates of health care utilization.

Anaemia

Anaemia is a symptom of a number of diseases and is characterized by a reduction of the number of red blood cells per volume of blood. Anaemia may result from deficiency of iron or vitamin B_{12} in the diet, or may result from failure of the bone marrow to produce adequate red blood cells.

Figure 156 shows the provincial rate of hospitalization for anaemia by age group and gender. The rate of hospitalization for anaemia is about the same for men and women, with the exception of men older than 80. The rate of hospitalization is greater for children and for people older than 60.

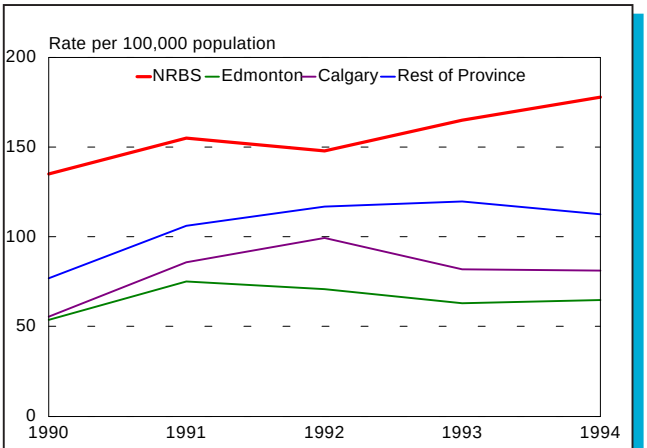
Figure 156 Provincial Hospitalization Rate for Anaemia



Source: Hospital Morbidity Database, Alberta Health

Figure 157 compares the rate of hospitalization for anaemia across areas over time. The rate of hospitalization for anaemia increased over the five year period in the two rural areas. The rate in the two urban areas also increased, but the increase was much smaller. The rate of hospitalization in the NRBS area is signicicantly higher than any other area of the province.

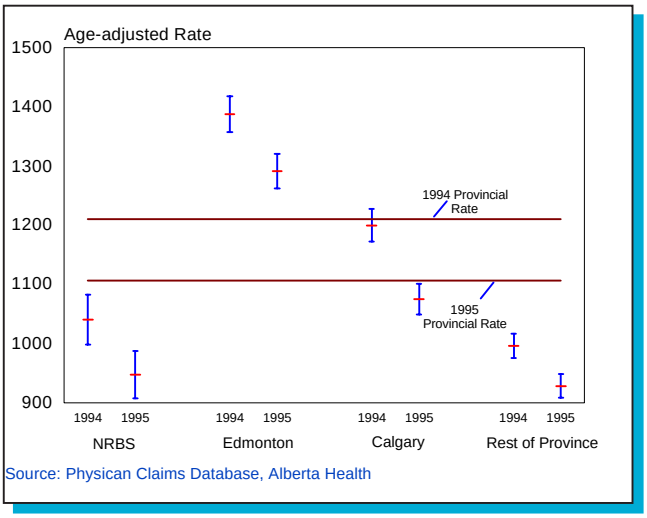
Figure 157 Hospitalization Rate for Anaemia by Area



Source: Hospital Morbidity Database, Alberta Health

Figure 158 compares the rate of visits to a physician for anaemia in 1994 with the rate for 1995 by area. The rate of visits by residents of the NRBS area was lower than the two urban areas each year, and the same as the rate of visits by residents of the rest of the province. The 1995 rate of visits to a physician for anaemia was significantly lower than the 1994 rate in all areas of the province.

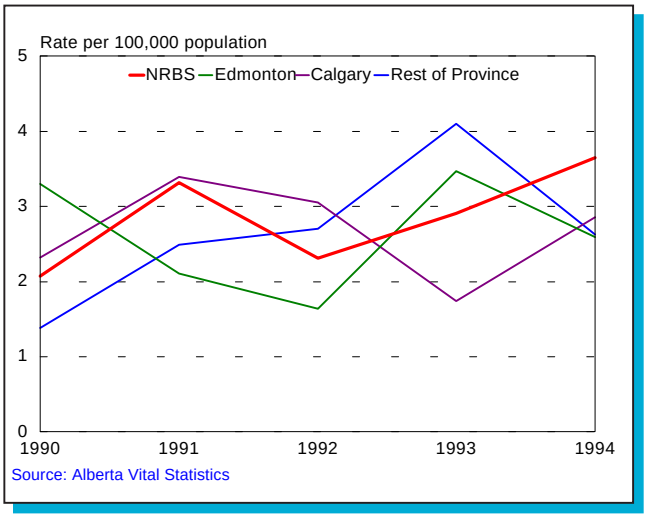
Figure 158 Rate of Visits to a Physician for Anaemia



Source: Physican Claims Database, Alberta Health

Figure 159 compares the mortality rate for anaemia by area and year. The mortality rate for people with anaemia living in the NRBS area was higher than the other areas of the province in 1990, but decreased to the same rate as the other areas of the province after that year. Overall the rate of mortality from anaemia is very small, and there is no difference across the regions.

Figure 159 Rate of Mortality from Anaemia



The high rate of hospitalization for anaemia for residents of the NRBS area is balanced by the low rates of visits to a physician for this disorder. There is no evidence that residents of the NRBS area are diagnosed with metabolic diseases any more frequently than residents of any other area in Alberta.

Neurological Diseases

Neurological diseases refers to a wide range of diseases that affect the brain and the nervous system. The family of neurological diseases include diseases such as Alzheimer's disease, Parkinson's disease, multiple sclerosis and epilepsy.

There are a number of contaminants that have been linked to neurological toxic syndromes, particularly occupational level exposure to large amounts of some contaminants. For example, Albertans may be exposed to high levels of lead through leaded paint used in older buildings, or home-made whiskey. Mercury is another metal that people may be exposed to through natural organic sources, such as fish or contaminated water, or through occupational sources. Exposure to large amounts of mercury causes neuropsychiatric toxic syndromes. Toluene, which may cause hallucinations and even coma, is a component on some paints and glues. Styrene is a solvent used in the manufacture of plastics, and long term exposure can result on permanent neuropsychologic deficits. Trichlorethylene, the chemical used in dry-cleaning, degreasing agents and printing inks, can cause permanent brain damage.

Several insecticides and pesticides, including organophosphates, organochlorides and paraquat, can also cause serious brain damage with exposure to large quantities. Water from a treated source such as a municipality cannot be consumed if these chemicals are measured in the treated water at levels that exceed the Guidelines for Canadian Drinking Water Quality. However, people who get their water from other sources such as wells may not be measuring the quality of their water for these contaminants. A study of farmstead water quality conducted recently under the Canada-Alberta Environmentally Sustainable Agriculture Agreement[61] found very few wells in the provincial survey had measurable levels of pesticides, herbicides, or insecticides. It is unlikely that most people would ever be exposed to large enough quantities of these chemicals to experience any adverse health effects.

Findings

Overall, there is no indication that the residents of the NRBS area are any more likely to be diagnosed with a neurological disorder than residents of any other area of the province. Higher rates of hospitalization for neurological diseases are balanced by lower rates of visits to a physician for this group of diagnoses. The same is true for the specific neurological diseases included in the analysis: hospitalization rates for Alzheimer's disease and Parkinson's disease are higher than the other areas, but these high rates are balanced by lower than expected rates of visits to a physician, and rates of mortality that are the same as the other areas of the province. Residents of the NRBS area are also less likely to be diagnosed with multiple sclerosis than residents of the other areas of the province.

There is some evidence that epilepsy is more frequently diagnosed for residents of the NRBS area than residents of the other areas of the province: the rate of hospitalization is somewhat higher than the other areas of the province, and the rate of visits to a physician are significantly higher than either Calgary or the rest of the province, but lower than the rate of visits by residents of Edmonton. The rate of mortality is no different than the other areas of the province.

Overall, more than 13,200 Albertans visited a physician or were hospitalized for epilepsy in 1994, resulting in a rate of 488 per 100,000 population. In general, communities in Northern Alberta had higher rates of epilepsy than communities in the southern parts of the province, although the small number of cases make it difficult to draw a firm conclusion. Epilepsy is more commonly diagnosed for people who are aboriginal, including both First Nations and Metis, but has not been related to any clear causal factor.

Figure 160 shows the provincial rate of hospitalization for all neurological diseases by age group and gender. The majority of hospitalizations for neurological diseases are for people who are older than 60, and the rate of hospitalization increases dramatically for people between the ages of 60 and 80. There is no difference in the rate of hospitalization between men and women.

Figure 160 Provincial Rate of Hospitalization for All Neurological Diseases

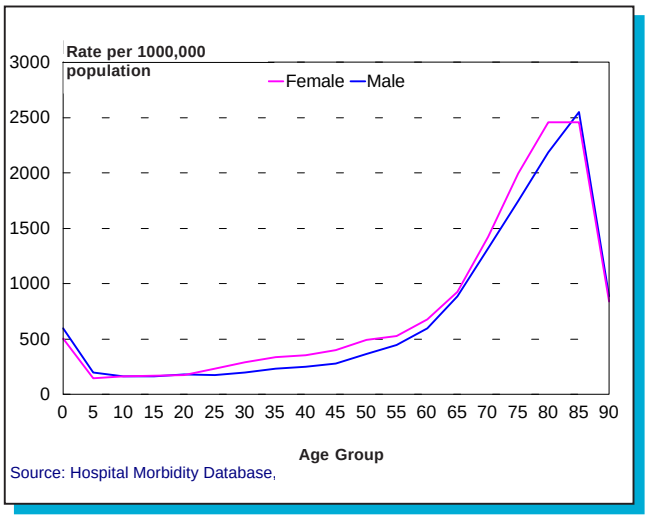
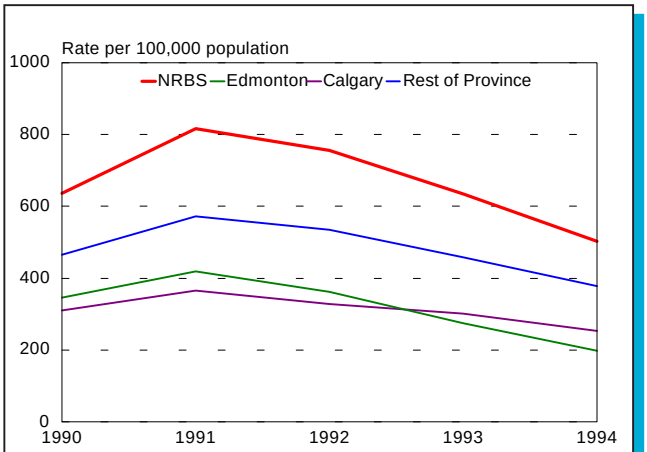


Figure 161 shows the rate of hospitalization for all neurological diseases across areas by year. Once again we see the typical pattern of higher rates in the two rural areas, with the NRBS showing the highest rates of all areas. The rate of hospitalization increased in all areas between 1990 and 1991, followed by a steady decline in the rates in all areas since that year.

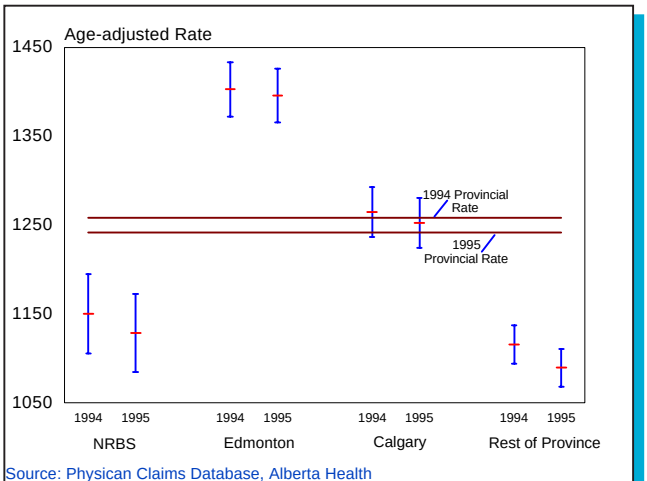
Figure 161 Hospitalization Rate for All Neurological Diseases



Source: Hospital Morbidity Database, Alberta Health

Figure 162 compares the rate of individuals who visited a physician for neurological diseases in 1994 with 1995 across areas. The rate of people visiting a physician for this group of diagnoses was much lower in the two rural areas than the two urban areas, and the rate in both the NRBS area and the rest of the province area was lower in 1995 than it was in 1994. The highest rate was in Edmonton.

Figure 162 Rate of Individuals Visiting a Physician for a Neurological Disease

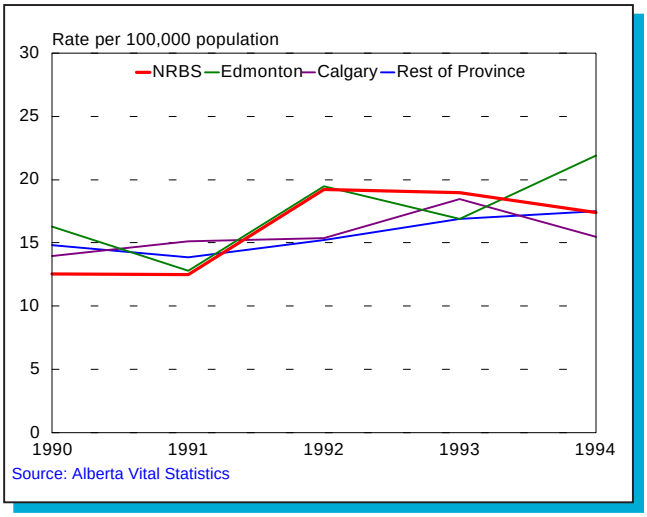


Source: Physican Claims Database, Alberta Health

The high rate of hospitalization combined with the low rate of physician visits for residents of the NRBS area indicates that there is no difference in the number of people experiencing neurological diseases in the NRBS area compared to any other area of the province. The rate of mortality from neurological diseases supports this conclusion.

Figure 163 shows the mortality rate for neurological diseases across areas by year. There is no difference between the NRBS area and the other areas of the province.

Figure 163 Mortality Rate for Neurological Diseases



Source: Alberta Vital Statistics

Alzheimer's Disease

Alzheimer's disease is a form of memory loss termed presenile dementia. Dementia results from shrinking or atrophy of parts of the brain, particularly the frontal and occipital lobes. Onset of Alzheimer's disease usually occurs between the ages of 40 and 60, and is diagnosed more frequently for women than for men. Alzheimer's disease causes a progressive, irreversible loss of memory; a deterioration of intellectual functions; apathy, speech and gait disturbances; and disorientation. It may take anywhere from a few months to 4 or 5 years for the individual completely lose intellectual functioning.

Although the exact cause of the disease is still unknown, there are several suspected links to environmental contaminants, most notably to aluminum: abnormally high concentrations of aluminum have been found in the brain tissue of people suffering from Alzheimer's disease and certain other nervous system diseases.[62] Another study linked untreated tap water used in kidney dialysis machines to aluminum content in the blood of the patients receiving dialysis. Aluminum from the water entered the blood stream directly, and as aluminum accumulated in the patient's body, a progressive brain disease called dialysis dementia developed. The disease is characterized by disruptions of speech, memory disorders, changes in personality, impaired reasoning ability, disorientation, and eventually convulsions and death.[63]

Aluminum can be found in the food we eat and in the water we drink, and accumulates in the body gradually - over a lifetime - causing slow metabolic changes. Although there are recommended limits on occupational air exposures to various aluminum compounds, aluminum levels in the air or drinking water are not regulated. Acid rain washes aluminum out of the soil and into freshwater, killing fish and raising the concentration of aluminum in drinking water to levels that, in combination with other sources, could become a health hazard. The Farmstead Water Quality study[64] found that most wells throughout Alberta were free from contamination with aluminum, although a small percentage of the wells tested did exceed the Guidelines for Canadian Drinking Water Quality.

Figure 164 shows the provincial rate of hospitalization for Alzheimer's disease by age group and gender. The rate of hospitalization increases dramatically for people older than 65. In addition, more males are hospitalized with this diagnosis than are females the same age. This gender difference is likely due to the behavioural changes that are a direct result of this disease, and the difficulty of providing care to an adult male with behaviour and memory problems.

Figure 164 Provincial Rate of Hospitalization for Alzheimer's Disease

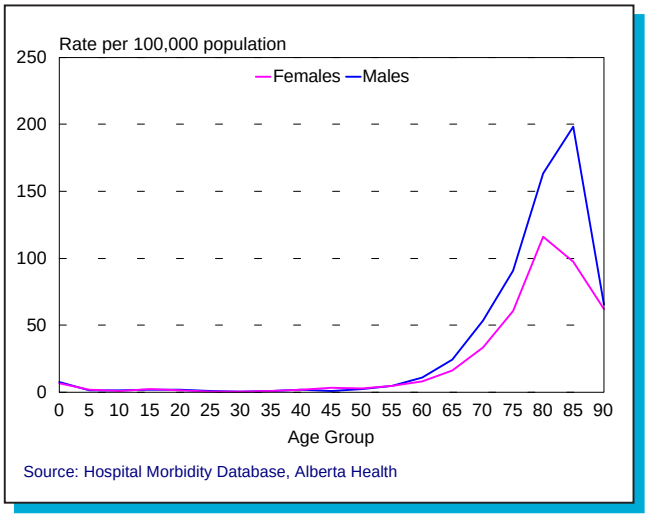


Figure 165 compares the rate of hospitalization for Alzheimer's disease across areas by year. The rate of hospitalization is very low overall, so fluctuations over time appear to be great. The rate of hospitalization in the two urban areas was similar for all five years, and the rate in the two rural areas was similar for the same time period. The five year combined rate for the two rural areas were significantly higher than the two urban areas. The number of people actually hospitalized in the NRBS area for Alzheimer's disease ranged between 19 and 33.

Figure 165 Hospitalization for Alzheimer's Disease by Area

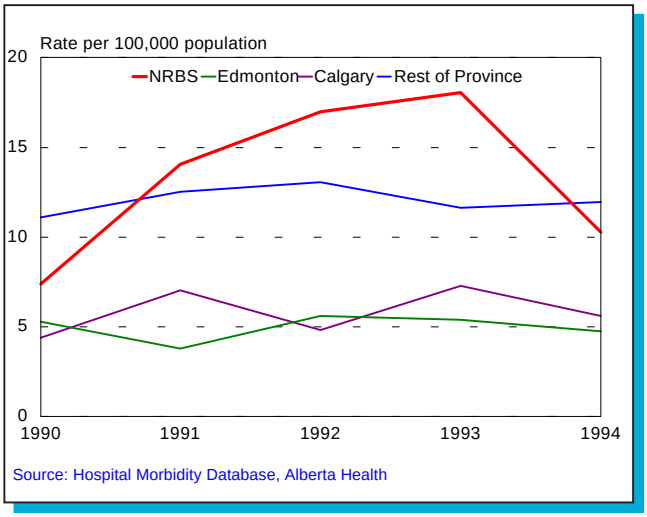


Figure 166 Individuals Visiting a Physician for Alzheimer's Disease

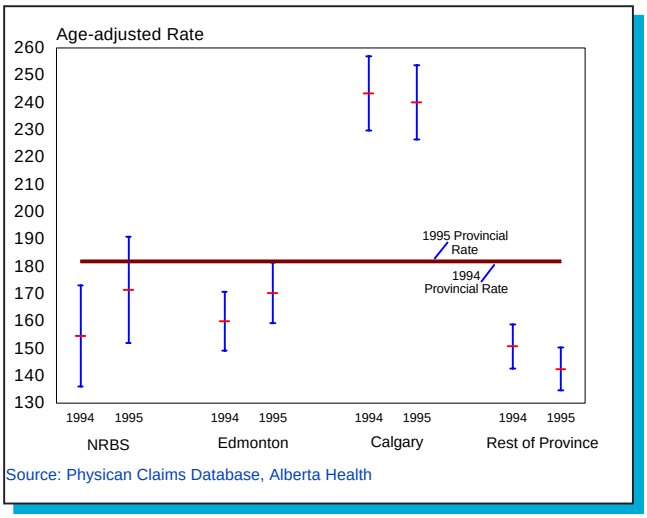
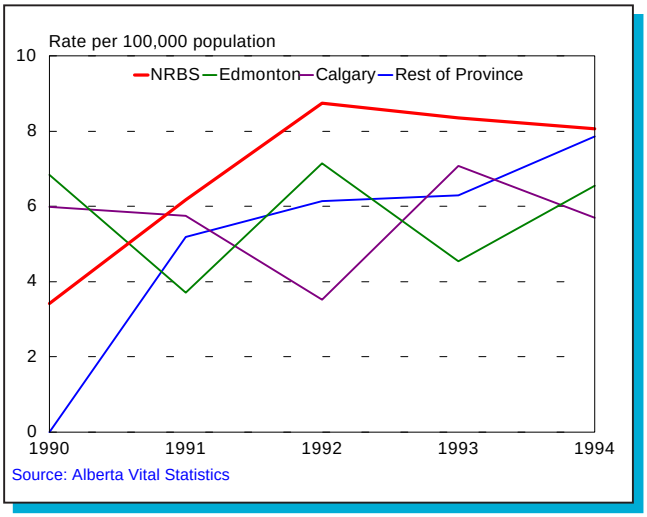


Figure 166 compares the rate of people visiting a physician for Alzheimer's disease across areas in 1994 and 1995. The rate of people visiting a physician for this diagnosis in the NRBS area was lower than the provincial average, and about the same as the rate in the Edmonton area. The rate in Calgary was much higher, and the rate in the rest of the province was slightly lower. The rate of people visiting a physician for this diagnosis increased between 1994 and 1995 in both the NRBS area and the Edmonton area, while it decreased slightly in the Calgary area and decreased somewhat more in the rest of the province.

The high rate of hospitalization combined with the low rate of physician visits for residents of the NRBS area indicates that there is no difference in the number of people experiencing diagnosed with Alzheimer's disease in the NRBS area compared to any other area of the province. The rate of mortality from Alzheimer's disease supports this conclusion.

Figure 167 compares the mortality rate for Alzheimer's disease across areas by year. Overall, the rate of mortality attributed to Alzheimer's disease is very low, so minor fluctuations in the rate may appear significant. There is no statistically significant difference in the rate of mortality attributed to this disease across areas of the province.

Figure 167 Mortality Rate for Alzheimer's Disease



Parkinson's Disease

Parkinson's disease is a chronic disease that affects the nervous system. The most familiar symptoms of Parkinson's disease are the tremors or palsy, the muscular weakness and the peculiar, shuffling walk. There is rarely a recovery once the disease begins to take its course, and the patient may live for many years after initial diagnosis. The cause of Parkinson's disease is unknown, however, chronic exposure to contaminants such as manganese can cause symptoms that mimic those of Parkinson's disease, including Parkinson-type tremors, slurred speech, and mental deterioration.

Figure 168 shows the provincial rate of hospitalization for Parkinson's disease by age group and gender. The pattern of hospitalization for Parkinson's disease is similar to the pattern we saw for Alzheimer's disease: more males than females are hospitalized for this diagnosis, and the rate increases with age. The reasons for the age and gender distribution are likely the same as those mentioned for Alzheimer's disease above: male spouses are more likely to be able to provide care than female spouses, particularly when the symptoms are progressed.

Figure 168 Provincial Rate of Hospitalization for Parkinson's Disease

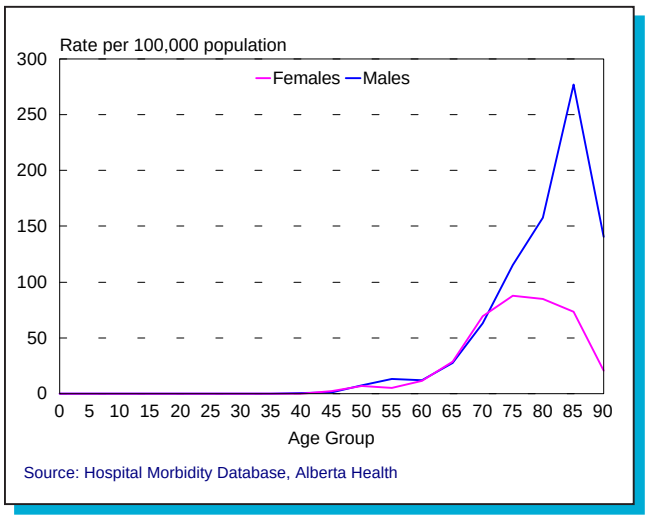


Figure 169 compares the rate of hospitalization for Parkinson's disease across areas by year. The rate of hospitalization for this diagnosis is very low overall, and there is very little difference in hospitalization across the areas. The five year combined rate for the NRBS area was not significantly different from the rate for the rest of the province, but the rates for both rural areas were significantly higher than the rates in the two urban areas.

Figure 169 Hospitalization for Parkinson's Disease

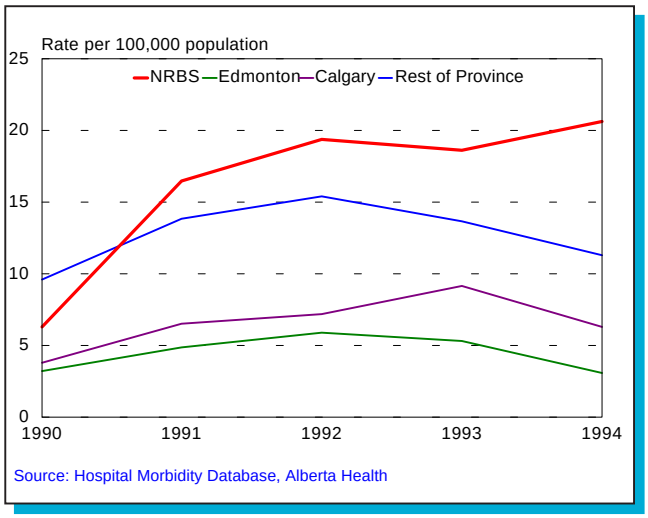
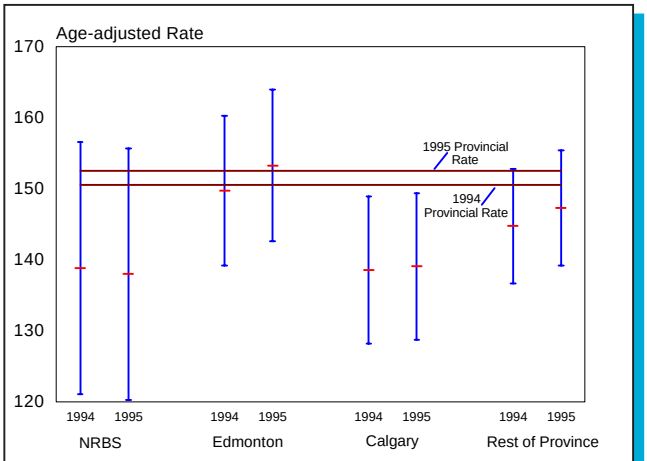


Figure 170 compares the rate of people visiting a physician for Parkinson's disease across areas in 1994 and 1995. The confidence limits are very wide, due to the small number of people who visit a physician each year for this disease. The rate of people visiting a physician for Parkinson's disease was lower in the NRBS area compared to each of the other areas, and the highest rate of people visiting a physician was in the Edmonton area. The rate of people visiting a physician remained stable between 1994 and 1995 in most of the areas.

Although the rate of hospitalization for Parkinson's disease was higher in the two rural areas compared to the urban areas of the province, there was no difference across areas in the rate of visits to a physician for this disease. The rate of mortality attributed to Parkinson's

disease in the NRBS area is also no different from the rate of mortality in the other areas ($p<0.05$).

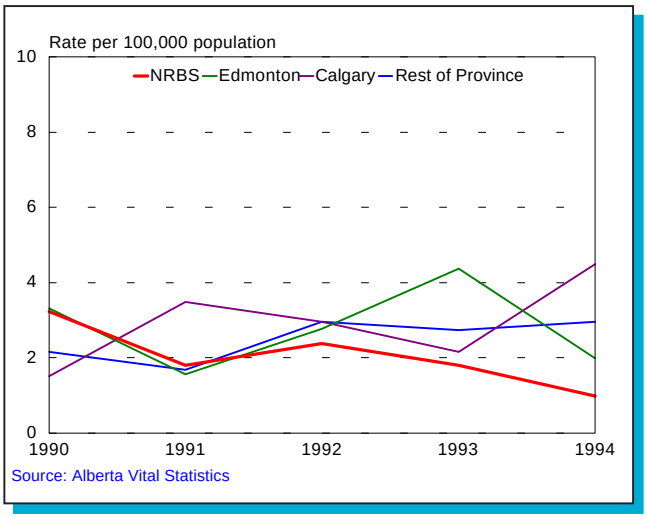
Figure 170 Individuals Visiting a Physician for Parkinson's Disease



Source: Physican Claims Database, Alberta Health

Figure 171 compares the mortality rate for Parkinson's disease across areas by year. Overall, the rate of mortality attributed to this diagnosis is very low. This indicates that the apparently high rates of hospitalization for Parkinson's disease are due to differences in physician practices rather than the health of the population.

Figure 171 Mortality Rate for Parkinson's Disease



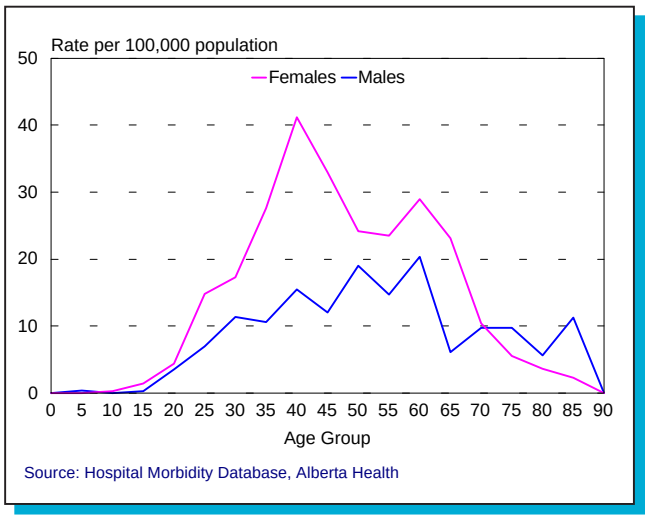
Source: Alberta Vital Statistics

Multiple Sclerosis

Multiple sclerosis is a chronic disease that attacks the central nervous system, resulting in progressively worse symptoms. There are a variety of symptoms, depending upon which part of the brain or spinal column that the disease attacks. The exact cause of multiple sclerosis is unknown.

Figure 172 shows the provincial rate of hospitalization for multiple sclerosis by age group and gender. The age distribution supports the evidence that multiple sclerosis primarily attacks younger adults. More women are hospitalized with multiple sclerosis than males in the same age groups. More women between the ages of 40 and 45 are hospitalized than any other age group.

Figure 172 Provincial Rate of Hospitalization for Multiple Sclerosis

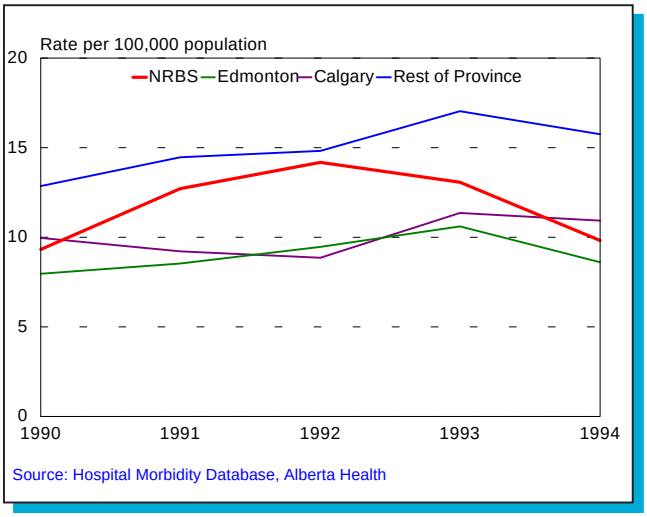


Source: Hospital Morbidity Database, Alberta Health

Figure 173 compares the rate of hospitalization for multiple sclerosis across areas by year. The highest rate of hospitalization for this diagnosis was in the rest of the province ($p<0.05$). The rate in the NRBS area was higher than the rate in the two urban areas between 1991 and 1993, but dropped again by 1994. The five year combined rate of hospitalization for residents of the NRBS area was no different than the rate in the two

urban areas, and was significantly lower than the rate in the rest of the province ($p<0.05$). Overall the rate of hospitalization for multiple sclerosis is quite low, so differences across regions are not significant.

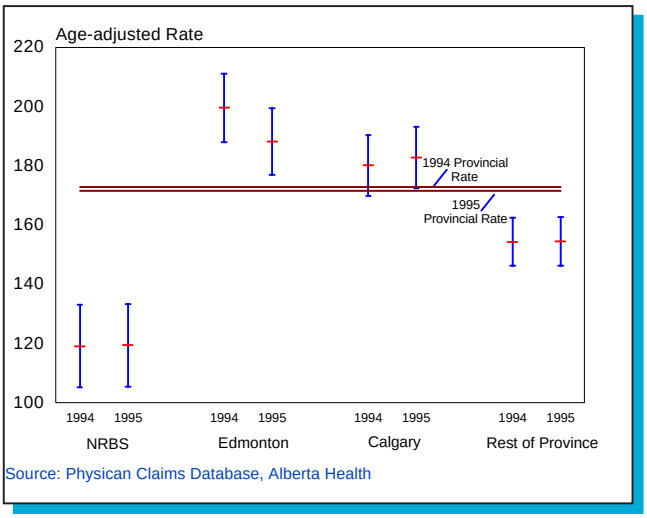
Figure 173 Hospitalization for Multiple Sclerosis by Area



Source: Hospital Morbidity Database, Alberta Health

Figure 174 compares the rate of people visiting a physician for multiple sclerosis across areas in 1994 and 1995. The rate in the NRBS area was significantly lower than the other area of the province in both 1994 and 1995 ($p<0.05$). The other three areas were similar, although the rate of people visiting a physician for multiple sclerosis was higher in the two urban areas than the rate in the other rural area, the rest of the province.

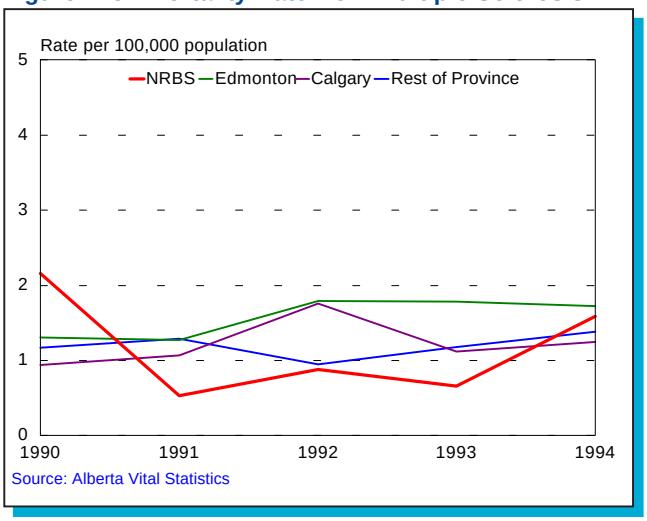
Figure 174 Individuals Visiting a Physician for Multiple Sclerosis



Source: Physican Claims Database, Alberta Health

Figure 175 compares the mortality rate for multiple sclerosis across areas by year. Although the rate of mortality from multiple sclerosis was higher in the NRBS area in 1990 compared to the other areas of the province, the rate in the NRBS area was lower than the other areas for each year since that time. Differences between areas were not statistically significant ($p<0.05$). Lower rates of physician visits, and the similarity in hospitalization patterns suggests there is a lower rate of multiple sclerosis among residents of the NRBS area than among residents of the other areas of the province.

Figure 175 Mortality Rate from Multiple Sclerosis



Source: Alberta Vital Statistics

Epilepsy

Epilepsy is a disorder that affects the normal functioning of the brain. People with epilepsy have brief attacks of seizures. Epilepsy can be further classified by the type of seizure that the person has: grand mal, petit mal or psychomotor; or by the part of the brain that is involved in the seizure: partial or generalized. The most common type of epilepsy, accounting for about 75% of all adults with this diagnosis, is believed to be caused by microscopic brain lesions that occur during birth or some other trauma, or may be due to metabolic disturbances or exposure to toxic pollutants.

Figure 176 shows the provincial rate of hospitalization for epilepsy by age group and gender. Slightly more males are hospitalized for epilepsy than females between the ages of 15 and 75. The rate for hospitalization for epilepsy among males aged 80 to 90 years old is much higher than for females the same age. The rate for both boy babies and girl babies is higher than the rate of hospitalization for adults, likely because the disease is frequently diagnosed during the early years of life.

Figure 176 Provincial Rate of Hospitalization for Epilepsy

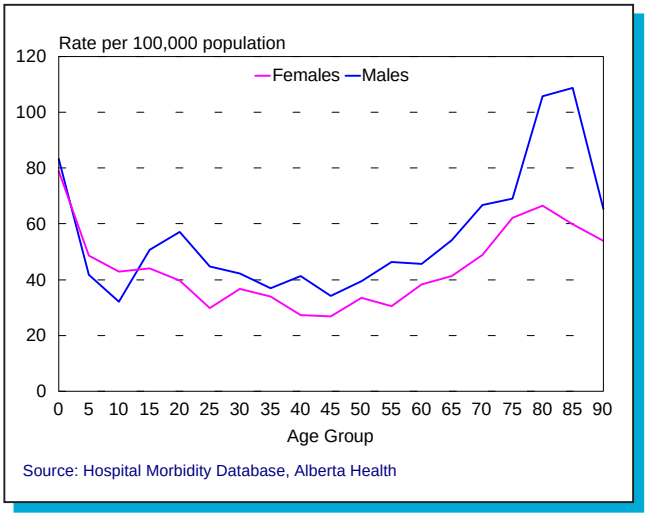


Figure 177 compares the rate of hospitalization for epilepsy across areas by year. Again we see that the rate of hospitalization in the rural areas is higher than the rate in the urban areas. The rate of hospitalization in the NRBS area is significantly higher than the rate in the other areas of the province. The five year combined rate in the rest of the province was significantly higher than the two urban areas, and the rate for Edmonton was significantly higher than the rate for Calgary ($p<0.05$).

Figure 177 Hospitalization for Epilepsy by Area

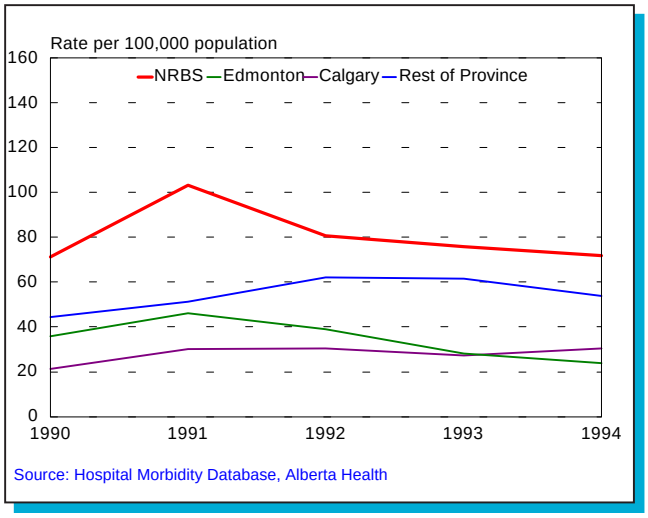
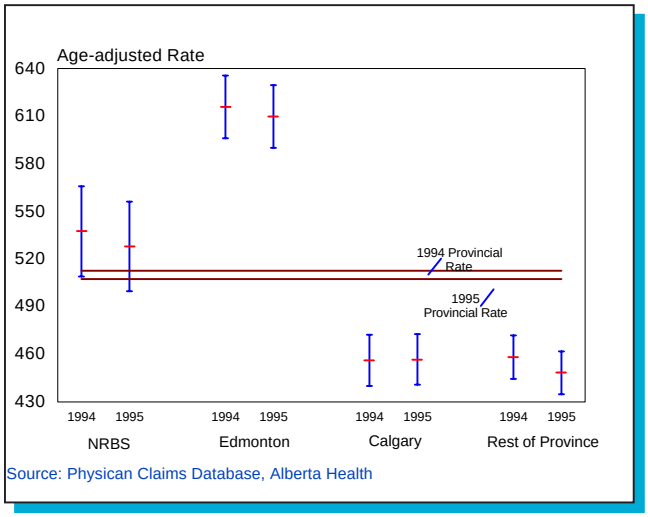


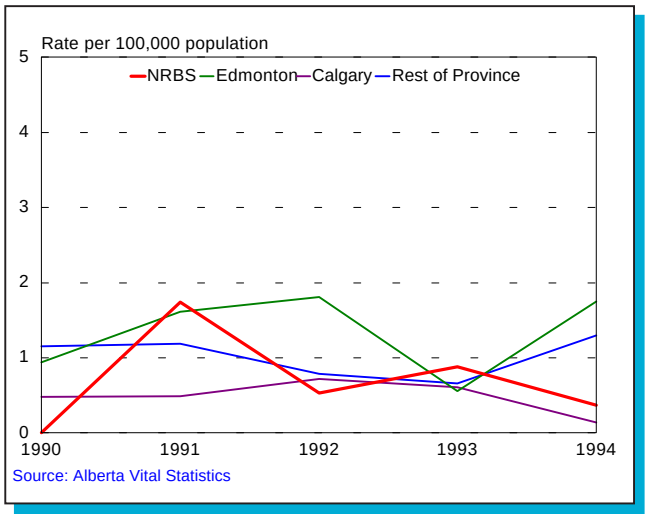
Figure 178 compares the rate of people visiting a physician for epilepsy across areas in 1994 and 1995. The rate of people visiting a physician for epilepsy was higher in the northern areas of the province than in the southern areas of the province. The highest rate of hospitalization was in the Edmonton area, and the rate in the NRBS area was significantly lower ($p<0.05$). The two southern areas, Calgary and the rest of the province, had the lowest rate of people visiting a physician for epilepsy. There is no significant difference in rates between the two southern areas.

Figure 178 Individuals Visiting a Physician for Epilepsy



Source: Physican Claims Database, Alberta Health

Figure 179 Mortality Rate from Epilepsy

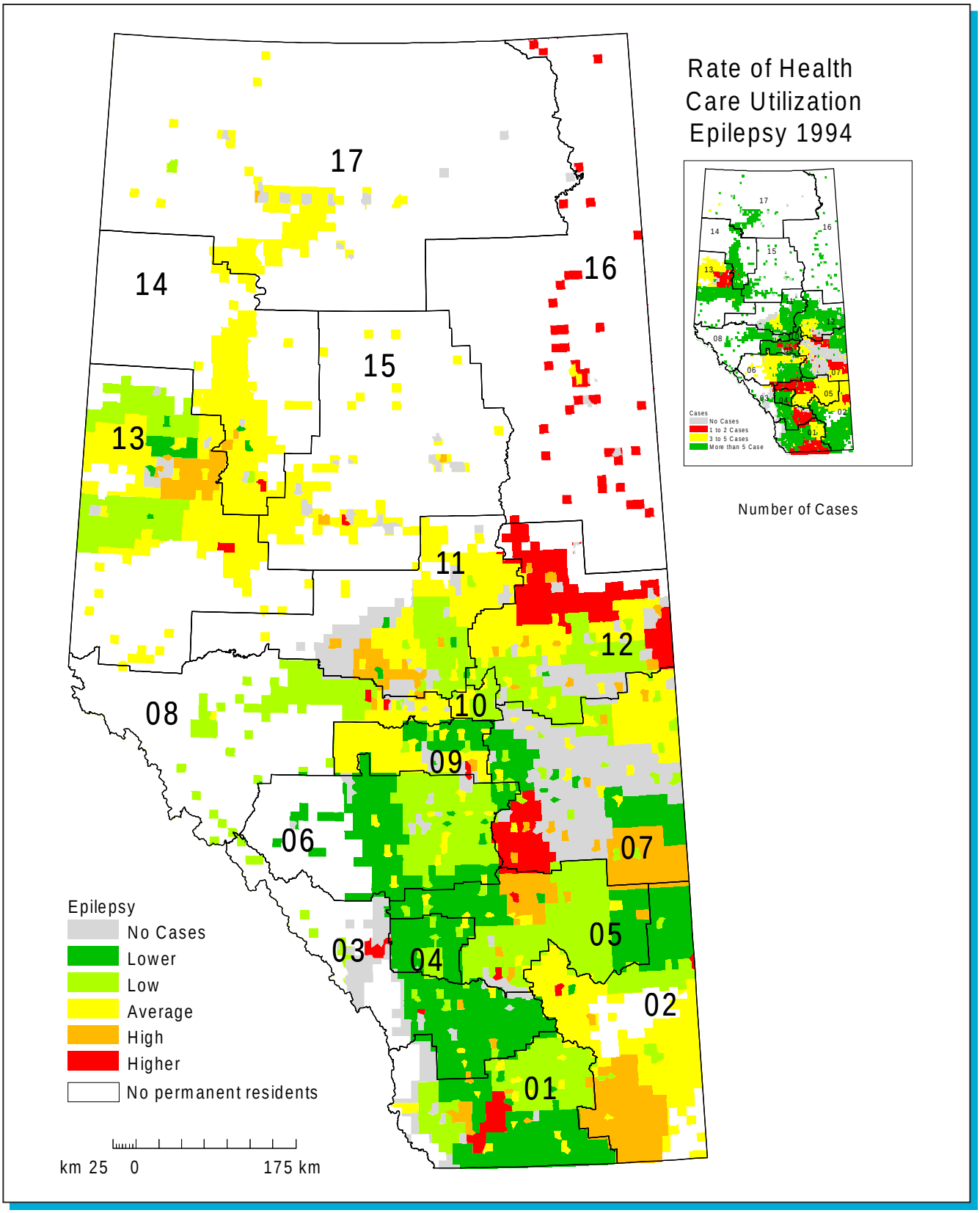


Source: Alberta Vital Statistics

Figure 179 compares the mortality rate for epilepsy across areas by year. Overall, the rate of mortality from epilepsy is very low, and the only statistically significant difference in rates across the areas is between Calgary and Edmonton - the rate of mortality from epilepsy is significantly lower in Calgary than the rate of mortality in Edmonton from this disease ($p<0.05$). Although the rate of mortality among residents of the NRBS area is not statistically different from the mortality rate in any of the other areas, the high rate of physician visits combined with the slightly higher rate of hospitalization for this diagnosis in the NRBS area suggests that residents of the NRBS area may be more likely to be diagnosed with epilepsy than residents of the other areas of the province.

More than 13,200 Albertans visited a physician or were hospitalized for epilepsy in 1994, resulting in a rate of 488 per 100,000 population. Many census subdivisions in northeast Alberta (RHA 16 or census division 10) had a higher rate ratio in 1994 than other areas of the province (Map 14), indicating an increased risk for epilepsy in this region. Although there also appear geographic variations in central and southern Alberta, the small number of cases make it difficult to draw a firm conclusion. In general, communities in Northern Alberta had higher rates of epilepsy than communities in the southern parts of the province.

Map 14 Rate of Health Care Utilization for Epilepsy



Conclusions

The analysis conducted for this report focused an evaluation of the differences in health outcomes across the province and compares the Northern River Basin Study area with the other areas of the province. The report focused on a number of diagnoses identified as potential health problems exposed to both natural and human-introduced environmental chemicals. The diagnoses included a focus on reproductive disorders, birth defects, respiratory ailments, cancers, and neurological disorders. The study also attempted to find correlations between human health outcomes and measures of environmental sources of contaminants wherever information was available.

The objectives stated at the beginning of the report were to:

- estimate the rate of selected health outcomes in the Northern River Basin Study area and compare this with rates for the other parts of the province;
- determine the most common health problems for the people living in the Northern River Basins Study area;
- examine the relationships between selected health outcomes and environmental determinants where data is available ; and
- explore possible contributing factors for the selected health problems in the Northern River Basins Study area.

However, it is important to remember that the report provides baseline information and analysis only, because the scope of the Northern River Basins Human Health Monitoring Program did not include collection of new information, and sought only to compare the rates of disease or diagnosis with potential environmental sources. The possibility of increased incidence of disease in certain regions of the province can be inferred from data collected for administrative purposes, but without good estimates of environmental contaminants and human exposure, there is no way of determining the actual mechanisms that affect incidence rates.

On the other hand, the study can identify areas where follow-up investigations focusing on an evaluation of the impact of environmental factors, genetic endowment and socio-cultural factors on individual diagnosis are relevant and warranted.

Notwithstanding the application of a variety of methods for reducing errors, improving estimates, combining data from various sources, and the use of multiple tests for each potential relationship, the use of administrative data at large geographic units limits the conclusions to conjecture and supposition. For example, if slightly higher than expected amounts of dioxins are measured in fish in one area, and slightly higher rates of congenital anomalies are also recorded for that area, it is mere conjecture to say that the two are related. Dioxins found in fish tissue may be recent additions to the environment, too recent to have had an impact on the growth of the human babies in the area; humans living in the area may not actually be exposed to the dioxins in the environment; and other factors that are known to influence fetal growth and infant health are not included in the equation, such as maternal health, smoking behavior, alcohol consumption, and diet. Because of the restricted applicability of the use of administrative data, it must be emphasized that the results of the analysis merely provide direction for more detailed studies of individual health concerns.

The report began by assessing the distribution of standard indicators of population health across the four areas of the province. We saw that the population of the NRBS area is younger, the

family size is larger, and the residents have their children at a younger age than do people in other areas of Alberta. Overall, the people living in the Northern River Basins area have less education, but comparable income levels to other parts of the province. However, the income levels calculated for the large areas mask the sub-regional variations: the Northern Lights health region had a very high level of income, which skews the distribution and makes the average for the whole NRBS area much higher and not very representative of the other areas. The community socioeconomic status index (CSSI), which is dependent on education, income, and other variables, shows that areas with lower CSSI tend to have higher rates of pneumonia, bronchitis, endometriosis, and peptic ulcer. This suggests that a disadvantaged social and economic environment also contributes to adverse health outcomes. In addition, these factors likely contribute to regional variations of mortality and infant mortality in the province.

The 1991 Canadian Census[65] shows that the proportion of Aboriginal people in the NRBS area is about two times higher than the rest of the province and the two metropolitan cities. Although the Aboriginal Peoples' Survey[66] (Statistics Canada, 1994) found that the majority of aboriginal people (80% of Metis and 73% of other Alberta aboriginal people) obtain their water from a municipally treated water source, many spend at least part of the year living on the land where the water is more difficult to treat and the potential for exposure to water-borne diseases is greater. Furthermore, the study found that a larger proportion of aboriginal people smoke or live in a household with other people who smoke, thereby increasing their risk of respiratory problems. Aboriginal people typically have a higher risk for waterborne diseases, pneumonia, bronchitis, lung cancer, diabetes, endometriosis, peptic ulcer, chronic ischemic heart disease, and some forms congenital anomalies.

A much larger proportion of the population in the Northwestern and Keeweetinok Lakes health regions are aboriginal people compared to the other regions in the NRBS area. In addition, these two health regions have the highest fertility rates, particularly among young mothers, as well as the most crowded living conditions. These two health regions also stand out as having more socioeconomic disadvantages than other regions in the province. The population in these two areas is at a disadvantage because of lower education, lower income, and more unemployment. We can expect to see more poverty-related health problems in the population of these two regions as well as some of the other regions in the NRBS area such as diseases resulting from dietary deficiencies and smoking and alcohol consumption. We can also expect to find more frequent health problems associated with childbirth (complications due to the young age of the mother), congenital anomalies, and those diagnoses which are found more frequently in an aboriginal population, such as diabetes.

The second type of administrative information that was used for the analysis indicates the number of times that people see a physician or are admitted to the hospital for a particular diagnosis. There are a number of reasons why an individual might seek a physician, not all of which are indicative of health or illness, and almost as many reasons why a physician might admit a patient to a hospital. Because of the apparent inconsistencies in visiting and admission practices across regions, only those diagnoses where both physician visits and hospital admissions were higher than other areas were considered different enough to warrant further investigation.

The natural environment is another important determinant of human health. The environment provides the natural resources and space required for human existence and development, but it may

also exposes humans to a large number of environmental hazards. The physical, chemical, and biological agents in water, air, soil, and other environmental media may cause adverse health effects. The effects may vary in type, intensity and magnitude depending on the type of hazard to which people have been exposed, the level of exposure and the number of people involved. Further, variations in climate, particularly small geographic variations such as the frequency of temperature inversions, combined with local air-borne chemicals, dirt and dust may cause additional stresses to lung tissue, resulting in respiratory health problems.

Reproductive and Infant Health

The most sensitive measures of environmental impact and lifestyle on human health are the diagnoses related to reproductive health and childbirth. There was some indication that women who live in the NRBS area seek medical assistance for endometriosis more frequently than women who live in the other parts of the province. Further evaluation of the relationship between endometriosis and potential environmental factors was conducted. The analysis measured the relationship between rates of endometriosis and indicators of different environmental agents found in Alberta, including agricultural activity, and measures of dioxin and furan levels. There were no significant correlations between any of the measures of environmental exposure and the rate of health care utilization for endometriosis in the NRBS area. A more detailed and individual study of women with this diagnosis throughout the province is required to identify potential causes.

Although the infant mortality rates for the NRBS area were higher than the provincial average, they were not as high as the rates for Edmonton. Comparison of the leading causes of infant death between the NRBS area and the rest of Alberta did not indicate any significant differences. The leading cause of infant death in both the NRBS area as well as in the rest of Alberta was sudden infant death syndrome (SIDS).

The incidence rate of heart defects and other anomalies of the cardiovascular system was somewhat higher in the Mistahia health region than other health regions; and the incidence of urinary system defects was somewhat higher in the Peace River health region than other health regions in the province. It is unclear why these regions have higher rates of these congenital anomalies compared to the other health regions in the province. The comparison of incidence rates for congenital anomalies with the measures of environmental contaminants could be used to indicate correlations in geographic distribution, but any relationship identified using this method would likely be spurious. Prenatal exposure to some chemicals or metals (such as methyl mercury, lead, and dioxins), and to drugs or alcohol is associated with increased risk for neural tube defects and other anomalies of the nervous system. However, low birth weight is also associated with neural tube defects and other anomalies of the nervous system, and there are numerous risk factors for cardiovascular system defects, including low birth weight, premature birth, maternal use of drugs, medications or sex hormones during pregnancy, and infections during pregnancy. Further study of the individual babies born with congenital anomalies, the mother's lifestyle, diet and prenatal care habits, and biomarkers of exposure is required before any valid conclusion can be reached.

Respiratory Diseases

The human respiratory system is susceptible to air borne contaminants and particles that can result from a variety of sources, including both man-made sources such as industry and agriculture, and natural sources, such as forest

fires. A variety of respiratory diseases were examined to determine if the residents of the NRBS area required more health care services for this group of diseases than residents of other areas of the province.

The rates of both hospitalization and visits to a physician for bronchitis are consistently higher in the NRBS area than other areas of the province. Pneumonia appears to be a more common diagnosis for residents of the NRBS area than other areas of the province. Comparison of the rates of visits to a physician and the rates of hospitalization for asthma and emphysema by residents of the NRBS area indicated that the frequency of these diagnoses is comparable to the other areas of the province. The conclusions reached from this analysis suggest that the residents of the NRBS area are diagnosed more frequently with pneumonia and chronic bronchitis, but less frequently with asthma and acute upper respiratory infection.

To evaluate the impact from environmental factors, further study examined the potential effects of predicted levels of SO_2 and NO_x on selected respiratory disorders, including asthma, bronchitis, pneumonia, and respiratory infection.

The results of the analysis suggest that the majority of CSDs within the NRBS area have relatively low predicted level of SO_2 and NO_x. No association was found between NO_x and any of the four disorders studied. However, an association was observed between predicted level of SO_2 and the four respiratory conditions at a provincial level. This indicates that the level of SO_2 may increase the risk for asthma, pneumonia, and infections of the upper respiratory system for Albertans. However, this effect is likely very small and makes little contribution to the regional variations of the four disorders examined.

Analysis comparing the rates of diagnosis with a variety of other potential causal factors indicated that latitude, socioeconomic status, population density, and the proportion of the population who are aboriginal appear to be important predictive factors for geographic variations in the diagnosis of respiratory conditions at the community level. However, the model explained very little of the variation in the rate of diagnosis (only 20 - 60%). A number of other factors, such as tobacco use, exposure to smoke from fireplaces and barbeques, and other sources of indoor air pollution likely have a far more direct impact on respiratory health.

Circulatory Diseases

There was no difference in the frequency of contact with the health care system for circulatory diseases between the residents of the NRBS area and residents of the other areas of the province. The rate of hospitalization is higher in the NRBS area for most diagnoses discussed, but the higher rates of hospitalization are consistently balanced by a lower rate of visits to a physician for the same diagnosis.

Gastrointestinal Diseases

There was no evidence to suggest that residents of the NRBS area are diagnosed with more gastrointestinal disorders than are residents of other areas of the province, with the exception of peptic ulcers: a greater proportion of the residents of the NRBS area use health care services because of a peptic ulcer than residents of any other area in the province.

The quality of drinking water is different if the source is from below the ground (i.e. from wells) or the source is a body of water on the surface (i.e. rivers, lakes, and dug-outs). Industries, agricultural activities, and other human activities as well as natural events (rain, snow, flooding) may all affect drinking water quality. Municipal treatment plants are able to remove the majority of chemicals before the water is supplied to consumers, but many people, particularly in rural areas, obtain their drinking water from other

sources, such as wells or dug-outs. Further analysis of peptic ulcer and the source of drinking water found no association.

Giardiasis and shigellosis are common diseases that can be transmitted through water. Again, water from municipally treated supplies are required to be free of these and other harmful coliforms. Although the majority of the residents of the NRBS area have access to municipal water supplies, there are still about 25-45% drinking water from other less reliable sources. Small communities with small treatment facilities tend to have more problems with maintaining adequate treatment and may have poor quality water more frequently than larger communities. Microbial quality of drinking water, measured as a percentage of coliform-positive samples, source of drinking water (i.e. ground or surface), and community population size were compared to rates of diagnosis for a number of water-borne diseases.

The analysis indicates that small communities using surface water or those with more coliform-positive samples had an increased risk for shigellosis. It is also found that of the 183 shigellosis cases reported in the NRBS area in 1993, 67.2% of them were from aboriginal communities including Desmarais, Gift Lake, Lac La Biche, Peerless Lake, and Wabasca.

Neurological Diseases

There was no indication that the residents of the NRBS area are any more likely to be diagnosed with a neurological disorder than residents of any other area of the province. Higher rates of hospitalization for neurological diseases are balanced by lower rates of visits to a physician for this group of diagnoses. The same is true for some specific neurological diseases: hospitalization rates for Alzheimer's disease and Parkinson's disease are higher than the other areas, but these high rates are balanced by lower than expected rates of visits to a physician, and rates of mortality that are the same as the other areas of the province. Residents of the NRBS area are also less likely to be diagnosed with multiple sclerosis than residents of the other areas of the province. There is some evidence that epilepsy is more frequently diagnosed for residents of the NRBS area than residents of the other areas of the province: the rate of hospitalization is somewhat higher than the other areas of the province, and the rate of visits to a physician are significantly higher than either Calgary or the rest of the province, but lower than the rate of visits by residents of Edmonton, and the rate of mortality is no different than the other areas of the province. It is difficult to determine whether there is a relationship between levels of mercury contamination and neurological disease outcomes because of the limitations in information characterizing the distribution of mercury, the number of people drinking untreated water that might be contaminated with methyl-mercury, and the number of people eating wild fish that might be contaminated. However, epilepsy was the only diagnosis where any supporting evidence of a difference in neurological disease rates between residents of the NRBS area and residents of the other areas of the province was found, and there is no scientific evidence linking epilepsy with mercury poisoning.

Overall, the analysis indicated some differences, and some health disorders for which the residents of the NRBS area may be at higher risk. Comparisons with existing information on potential environmental causes did not yield any strong conclusions.

Appendix A

Sources Of Health Outcomes Data

Physician Claims

Each time an individual Albertan visits a physician, the physician submits a bill to Alberta Health in an electronic form. The billing data includes information about:

- the physician, such as the location of the practice, specialization, and other identifiers;
- the patient, such as the patient's home region, gender, age and other identifiers; and
- the event, such as the diagnosis and the service provided to the patient.

Although the Physician Claims system is primarily used for billing purposes, some information can be derived that indicates the number of different people who visit a physician, and the diagnosis and service provided by the physician.

For the purposes of this analysis, several steps were taken to remove error and duplicate entries. Records included in the analysis were restricted to visits to medical doctors unless otherwise stated.

Hospital Morbidity

All acute care facilities currently submit a record of information for each patient who is admitted to that facility to Alberta Health through an organization contracted to manage the information system. Patient data are reported as an abstract, which is a summarized version of the information recorded on a patient's chart for a particular stay in a given hospital. The abstract contains information on demographic characteristics, diagnoses, procedures performed on the patient, transfers to and from other institutions, length of stay, and admission and discharge information.

Vital Statistics

Alberta Vital Statistics maintains a record of all births and deaths in the province. The birth records include information about the child and his or her parents, including where the baby was born, where the parents lived at the time of the birth, the weight of the baby at birth and the number of weeks of gestation. If the baby died at birth or was stillborn, an ICD-9-CM is included indicating cause of death. The mortality database records each death, date of birth and date of death, where the person lived and an ICD-9-CM code indicating cause of death. Alberta Vital Statistics produces an annual summary report to provide the public, health care professionals and planners with information about the births and deaths that occurred during that year. Boundaries identified on this data source are the Regional Health Authority boundaries.

Notifiable Diseases

Health Canada has designated 47 different diseases as Notifiable Diseases. Under federal legislation, every time someone in Alberta is diagnosed with one of these 47 diseases, the federal government must be notified. This information is collected by Alberta Health and submitted to Health Canada. Figures for the provinces and Canada as a whole are published annually.

The data obtained for notifiable diseases was not an electronic copy of the data used by Health Canada, but was taken instead from copies of reports. As a result, there are areas where the information was incomplete, and the data reported will differ somewhat from that reported by Health Canada. For example, Table A compares the number of people diagnosed with five diseases that are transmitted through food or water recorded in the data set used for this report with Health Canada records reported in the Notifiable Disease Annual Summary, (1993). The data set used for this report contains nearly all the shigellosis and salmonellosis cases reported by Health Canada for 1989-1993, and there are four partial years of campylobacteriosis and giardiasis data and three partial years of hepatitis A data. Some of the individual's personal information is incomplete, and several records lack the community name and complete address.

Table A Comparison of Data Sources: Notifiable Diseases Annual Summary vs Study Data set

Disease Type	Data Source	Year					Total
		1989	1990	1991	1992	1993	
Campylobacteriosis	Study Data set		84	720	975	508	2287
	Annual Summary		842	925	1005	1101	3873
Giardiasis	Study Data set		225	1381	1129	801	3536
	Annual Summary		1354	1453	1131	941	4879
Hepatitis A	Study Data set			13	263	162	438
	Annual Summary			228	303	234	765
Salmonellosis	Study Data set	991	759	835	805	671	4061
	Annual Summary	1069	791	839	791	702	4192
Shigellosis	Study Data set	132	107	85	305	377	1006
	Annual Summary	162	117	100	371	424	1174

Conversion Files

A number of files were required to link the separate data sets together. The conversion files used for this purpose are described below.

Postal Conversion Files

The 1991 Postal Conversion file was obtained from Statistics Canada. This file lists all the postal codes in the province along with the corresponding geographic coordinates for the point of distribution. Other fields in this data set include: creation date for the postal code, date on which the postal code was retired, corresponding 1991 Census Sub-Division (CSD) and Enumeration Area (EA) boundaries, and community name. The file used was updated in early 1996. Other fields were appended from geographic layers present in the Geographic Information Systems, such as Regional Health Authority boundary, Northern River Basins boundaries and several additional layers.

Standard Geographic Code to Census Sub-Division Conversion File

For most of the country, the Standard Geographic Code (SGC) and the Census Sub-Division (CSD) code are the same. However, some of the villages in Alberta were assigned a unique SGC

in order to be able to study patterns in the data in more detail (that is, using a smaller unit than a town). This file has been generated to assist in determining the correct CSD for each SGC when doing comparative studies with other databases and record linkages across databases.

Census Sub-Division to Northern River Basin Area

This file was created through an overlay process in the Geographical Information System. The file lists the CSD's in the province and identifies whether they are in the NRBS area.

Publications

In addition, data from the following publications were also used in the report:

- Cancer Incidence And Mortality Of Selected Sites From The Alberta Cancer Board for Years 1964-1995[i];
- The incidence rate of congenital anomalies at birth from the Alberta Congenital Anomalies Surveillance System for the years 1980-1990[ii] (ACASS 1989; 1992);
- Alberta Perinatal and Neonatal Statistics & Maternal Mortality in 1993 from the Alberta Medical Association (1995)[iii]; and
- various NRBS Reports.

Geographic Units For Analysis

Efforts were made to link these data together by using geographic coordinates, including the postal code, Standard Geographic Code (SGC), census subdivision code (CSD), community name, sub-river basin boundary, as well as the latitude and longitude. The linkage was made in the Geographic Information System (GIS) and other packages.

Because the information included on each of the sources of data used for this report was obtained for other purposes (typically administrative), the identification of boundaries is not entirely consistent across data sources. For example, the information from the Population Health Survey conducted in 1996 is grouped together by the boundaries defined by the Regional Health Authorities, as is the information obtained from Statistics Canada. Other information, such as the information collected by the Alberta Cancer Board, is available by census subdivision (CSD), providing a more accurate reflection of the actual Northern River Basins area.

Although the two methods of identifying the Northern River Basins area used for this report do not result in coterminous boundaries, the differences in population between the two boundaries are relatively small. When data are grouped by regional health authority boundaries, the NRBS area is defined as including health regions 8, 11, 13, 14, 15, 16, and 17. This definition is only used when the specific census sub-division information was not available. When the census sub-division was available, the boundary follows that defined by the Northern River Basins Study more precisely. The actual NRBS area boundary used depends upon the source of the data, and was specified with the discussion of the data sources.

The analysis groups the provincial figures in two different ways using these two boundary definitions:

1. Comparisons between the NRBS area and the rest of the province divide the remaining province into three areas: Edmonton (using CSD boundaries) and Calgary (using CSD boundaries), which are large urban areas, and the rest of the province, which is predominantly rural. Comparisons can be made between the latter area (rest of the province) and the NRBS area because both are predominantly rural, with small and medium-sized urban centres scattered throughout.
2. The second analysis group, using Regional Health Authority boundaries, was used to compare the smaller areas within the NRBS area.

For the purposes of clarity, the term regions will be used to refer to health region boundaries, and the term area will be used to refer to the four areas described in the first analysis group.

Appendix B

Terms And Definitions Of Epidemiologic Measures

1. Relative frequency (%) refers to a proportion of a component health outcome in all health outcomes under study in a given time period:

   Percentage = A (A + B + C + ...+ N) * 100%

   where A, B, C, ..., and N represent the number of each component health event, respectively.

2. Incidence rate (IR) is the number of new cases/health events that occurs in a specified time period divided by the population at risk during the period:

   IR = # of new cases or events / population at risk in the period of an area

   Because the population at risk (total number of person-time exposure) may not be available, the total study population during the study period was used as an estimate. For instance, the incidence rate of food and water borne diseases is estimated as the number of reported cases per 100,000 population each year.

3. Rate of physician visits (RPV) is defined as the number of individuals who visited a physician (MD) for a specific disease/ condition in a calendar year divided by the total population in that year:

   RPV = # of individuals with the condition / total population of the year of an area

   Because the health outcome studied are relative rare, the rate is expressed as the number of individuals for a given diagnosis (by a MD) per 100,000 population.

4. Rate of hospitalization (RHV) is defined as the number of hospitalizations for a specific disease/condition in a calendar year divided by the total population in that year:

   RHV = # of hospitalizations for disease / total population of the year of an area

   The rate is expressed as the number of hospitalizations for a given diagnosis per 100,000 population.

5. Rate of health care utilization (RHV) is defined as the number of individuals who either visited a physician (MD) or was hospitalized for a specific condition in a calendar year divided by the total population in that year:

   RHV = # of individuals with the condition/ total population of the year of an area

   The rate is expressed as the number of individuals with a given diagnosis (from a physician and/or a hospital) per 100,000 population.

6. The mortality rate measures the number of deaths in a specified population in a given time period. A few methods of calculating mortality rates were used:

   a. Overall death (mortality) rate (CDR) is defined as the total number of deaths in population in a given time period:

      CDR = # of total death / total population in a given time period of an area

The rate is expressed as one person per 100,000 population unless otherwise specified.

b. Cause-specific death rate (CSDR) is defined as the number of deaths due to a specified (underlying) cause (ICD-9) in a specified population and a given time period:

CSDR = # of death from a cause / total population of the time period of an area

The rate is expressed the number of deaths per 100,000 population.

7. Infertility rate (InferR) is defined as the number of individuals with infertility in a calendar year divided by the total population in that year:

InferR = # of individuals with infertility / total population of the year of an area

The rate of physician visits, hospitalization and the combination of both (physician visits and/or hospitalization) is estimated, and is expressed as the number of persons with infertility per 100,000 population.

8. An abortion is defined as the termination of a pregnancy by natural or external (medical) force, and the abortion rate (AbortR) is defined as the number of abortion for women aged 10-49 years in a calendar year dividedby total women between the ages of 10-49 years in that year:

AbortR = # of abortion in women ages 10-49 years / total women ages 10-49 years in that year of an area

The rate of physician visits, hospitalization and the combination of both (physician visits and/or hospitalization) is estimated. The rate is expressed the number of abortions per 100,000 women ages 10-49 years per year.

9. Rate of menstrual cycle disorders (MensR) is defined as the number of menstrual cycle disorders in women (10-49 years) in a calendar year divided by the total number of women aged 10-49 years in that year:

MensR = # of menstrual cycle disorders in women ages 10-49 years / total women ages 10-49 years in that year of an area

The rate of physician visits, hospitalization and the combination of both (physician visits and/or hospitalization) is estimated. The rate is expressed as the number of individuals with menstrual cycle disorder per 100,000 women ages 10-49 years.

10. Incidence rate of congenital anomalies at birth (DefectR) is defined as the number of individuals with congenital anomalies at birth per 1,000 live birth each year:

DefectR = # of individuals with birth defects / total live births of year of an area

The rate is expressed as the number of anomalies per 1,000 live births.

11. Birth or live birth (LB): The complete expulsion or extraction from the mother, of a fetus who is breathing and heart beating after expulsion or extraction. The live birth rate is calculated using the following formula:

LB rate = 1000 * # of LB / average or mid year population in a given year of an area.

12. Stillbirth (SB): A fetus who has no breathing, heart beating, pulsation of the umbilical cord or unmistakable movement of voluntary muscle, after 20 weeks' pregnancy, or after attaining a weight of 500 grams or more. The

stillbirth (fetal death) rate is calculated using the following formula:

SB rate = 1000 * # of SB / total births in a given year of an area

13. Birth weight is the first weight measurement of the fetus or newborn obtained after birth, preferably within the first hour after birth, before significant post-natal loss has occurred. A baby is considered to be low birth weight (LBW) when it weighs less than 2,500 grams, very low birth weight (VLBW) when it weighs less than 1,500 grams, extreme low birth weight (ELBW) when it weighs less than 1,000 grams. The low birth weight rate is calculated using the following formula:

    LBW rate = 1000 * # of LBW / total births in a given year

16. Gestational age (GA) is the duration of gestation as measured from the 1st day of the last normal menstrual period. A baby is considered preterm if born before 37 full weeks or 259 full days of gestation, and considered full term if born between 37 and 42 weeks or 259 to 293 days of gestation. A baby is considered post-term if born after 42 weeks or 293 days of gestation.

17. Neonatal death (NND) is the death of a live born infant occurring less than 28 full days after birth. Early neonatal death is a death that occurs before the seventh full day or 168 hours of life. Late neonatal death is a death that occurs between the seventh and twenty-eighth full day of life. The neonatal death rate is calculated as:

    NND rate = 1000 * # of NND / total live births in a given year

18. Perinatal death (PMR) is a death that occurs before the seventh full days of life, and includes stillbirths (28 wks+) and early neonatal deaths. The perinatal mortality is calculated as:

    PMR = 1000 * # of SB & Early NND / total births in a given year, or
    PMR = [END + SB (28 weeks+)] / [LB + SB (28 wks+)] * 1000

19. Maternal death refers to the death of a woman known to be pregnant or within 90 days of delivery or termination of the pregnancy, irrespective to the duration or site of pregnancy. The maternal mortality rate is calculated as:

    Maternal mortality rate = 10,000 * # of obstetric (direct or indirect) deaths / total birth

20. Infant death refers to the death of a live born infant occurring less than 365 full days after birth. The infant mortality rate is calculated as:

    Infant mortality rate = 1,000 * # of infant deaths / total live births in a year

21. The fertility rate measures the number of children born in women of reproductive life. Two measures are defined:

    a. Age-specific fertility rate is defined as the number of births to women of a given age group for every 1,000 women in that age group.

    b. Total fertility rate is calculated as the sum of the age-specific birth rates over all ages of the childbearing period (15-49 years).

Five Year Age Adjusted Rate Of Mortality For Selected Diagnoses, 1990 - 1994

Cause of Death	NRBS Area			Edmonton			Calgary			Rest of Province		
	Number	Rate	95% CI	Number	Rate	95% CI	Number	Rate	95% CI	Number	Rate	95% CI
Congenital Anomalies	85	5.3	4.1-6.5	168	5.3	4.5-6.1	186	5.2	4.0-6.0	260	5.0	4.4-5.6
Nervous System Anomalies	23	1.4	0.8-2.0	27	0.8	0.5-1.2	19	0.5	0.3-0.8	34	0.7	0.4-0.9
Cardiovascular System Anomalies	40	2.6	1.7-3.4	74	2.4	1.8-2.9	100	2.9	2.3-3.4	111	2.1	1.7-2.5
Urological System Anomalies	3	0.2	0-0.5	9	0.3	0.1-0.5	5	0.2	0-0.3	13	0.3	0.1-0.4
Respiratory Diseases	609	72.1	66.3 - 77.8	1478	58.3	55.3-61.2	1626	67.4	64.1-70.6	2847	65.6	63.2 - 68.0
Asthma	23	2.6	1.5 - 3.7	54	2.0	1.5 - 2.6	55	2.1	1.5 - 2.6	88	2.0	1.6-2.5
Bronchitis	27	3.3	2.1-4.5	48	1.9	1.4-2.4	30	1.3	0.8-1.7	74	1.7	1.3-2.1
Emphysema	50	6.0	4.3-7.7	114	4.5	3.7-5.4	162	6.7	5.7-7.8	187	4.4	3.8-5.1
Pneumonia	217	25.3	21.9-28.7	547	21.6	19.8-23.4	627	26.0	24.0-28.0	1286	29.3	27.7-30.9
Acute Respiratory Infection	7	0.8	0.2 - 1.3	7	0.3	0.1 - 0.4	9	0.3	0.1 - 0.5	15	0.3	0.2 - 0.5
Other COPD	213	25.8	22.4-29.3	487	19.4	17.6-21.1	565	23.7	21.8-25.7	891	20.8	19.4-22.1
Circulatory Diseases	2548	298.7	287.3 - 310.1	7040	227.1	270.8-283.5	6274	257.3	251.-263.5	11403	275.9	271.0 - 280.7
Hypertension	46	5.5	3.9 - 7.1	163	6.4	5.4 - 7.4	112	4.6	3.8 - 5.5	209	4.8	4.2 - 5.5
Stroke	491	58.1	53.0 - 63.2	1363	53.9	51.0 - 56.7	1290	53.4	50.5 - 56.3	2430	53.7	51.5 - 55.8
Ischematic Heart Disease	682	79.4	73.4 - 85.3	2261	88.8	85.2 - 92.5	1858	76.2	72.7 - 79.6	3243	75.3	72.7 - 77.9
Gastrointestinal Diseases	236	26.2	22.8-29.6	728	28.0	26.0-30.1	731	28.3	26.3-30.4	1174	27.2	25.6-28.7
Gastroenteritis	36	4.4	2.9-5.8	106	4.2	3.4-5.0	117	4.7	3.9-5.6	175	4.0	3.4-4.6
Peptic Ulcer	24	2.9	1.7-4.0	65	2.5	1.9-3.1	68	2.7	2.1-3.4	126	2.9	2.4-3.4
Liver Cirrhosis	66	6.5	4.9-8.2	249	9.3	8.2-10.5	241	8.6	7.5-9.7	308	7.3	6.4-8.1
Endocrine, Metabolic Nutritional Disorders	178	19.6	16.9-22.5	484	18.1	17.4-20.8	405	15.8	14.3-17.4	803	18.6	17.3-19.8
Diabetes	130	14.9	12.3-17.5	349	13.6	12.2-15.0	282	11.2	9.9-12.5	622	14.4	13.3-15.6
Anaemia	25	2.9	1.7-4.0	68	2.6	2.0-3.2	68	2.7	2.0-3.3	117	2.7	2.2-3.1
Neurological Diseases	150	16.1	13.5-18.8	458	17.5	15.8-19.1	402	15.7	14.2-17.3	687	15.7	10.5-16.9
Alzheimer's Disease	59	7.0	5.2-8.8	144	5.7	4.8-6.7	132	5.6	4.6-6.6	266	6.1	5.3-6.8
Parkinson's Disease	19	2.3	1.3-3.4	80	3.2	2.5-3.9	56	2.4	1.8-3.0	109	2.5	2.0-3.0
Multiple Sclerosis	12	1.2	0.5-1.8	4.3	1.6	1.1-2.1	38	1.2	0.8-1.6	51	1.2	0.9-1.6
Epilepsy	8	0.7	0.2-1.2	38	1.3	0.9-1.8	16	0.5	0.3-0.7	46	1.0	0.7-1.3

Rate Of Visits To A Physician For Selected Diagnoses, 1994

Diagnosis	NRBS Area			Edmonton			Calgary			Rest of Province		
	Number	Rate	95% CI	Number	Rate	95% CI	Number	Rate	95% CI	Number	Rate	95% CI
Reproductive System Disorders												
Menstrual Cycle Disorders	15272	19289.7	19023.9-19555.5	39808	20084.4	19908.5-20260.2	45049	19333.6	19174.8-19492.4	48642	17900.1	17758.6-18014.6
Spontaneous Abortion	1237	1469.0	1388.0-1550.1	3804	1817.0	1759.6-1874.5	4926	2058.7	2001.8-2115.5	3614	1334.7	1291.5-1377.9
Infertility	1264	455.6	430.5-480.6	3346	491.9	475.2-508.5	5223	640.0	622.7-657.2	4190	466.9	452.8-481.0
Endometriosis	767	570.7	530.2-611.2	988	298.8	280.1-317.6	1143	293.5	276.4-310.6	767	293.2	277.3-308.9
Congenital Anomalies	1765	556.8	530.2-583.3	4303	676.9	656.7-697.2	5828	922.7	900.7-944.7	6115	599.1	584.0-614.2
Nervous System Anomalies	137	42.9	35.5-50.3	323	51	45.4-56.6	275	37	32.6-41.4	418	41	37-44.9
Cardiovascular System Anomalies	395	119.5	107.5-131.5	747	117.6	109.1-126.1	1296	173.6	164.1-183.1	1127	110.3	103.9-116.8
Urological System Anomalies	34	12.7	8.2-17.1	118	19.2	15.7-22.7	68	9.4	7.1-11.6	126	12.6	10.4-14.9
Respiratory Diseases	120336	38286.2	38104.7-38467.7	306042	41269.7	41153.6-41385.8	335918	40077.2	39968.2-40186.1	398038	37528.8	37433.4-37624.2
Asthma	9810	3464.9	3394.9-3534.9	28317	4624.8	4571.9-4677.6	35476	4993.9	4942.8-5045.0	37312	3773.8	3735.9-3811.6
Bronchitis	15333	5828.7	5735.9-5921.5	2574.0	2533.4	2614.6-4150.9	17208	2602.3	2563.2-2641.3	29968	3178.2	3142.6-3213.8
Emphysema	622	328.3	302.1-354.6	2157	404.9	387.9-421.9	1824	346.0	330.1-361.9	2863	333.8	321.6-345.9
Pneumonia	5384	2088.8	2031.2-2146.3	11891	1984.9	1949.4-2020.5	11334	1725.2	1693.1-1757.2	17386	1816.9	1790-1843.8
Infection Upper Respiratory	98235	32127.1	31952.3-32302.0	262980	38399.7	38282-38517.4	282203	36101.1	35991.7-36210.6	335324	32610.2	32518-32702.4
Other COPD	12520	5767.4	5671.2-5863.6	36892	6370.2	6309.3-6431.1	41211	6572.7	6513.2-6632.2	53727	5919.4	5872.2-5966.7
Cardiovascular Diseases	27622	9972.4	9864.7-10080.1	80727	10246.3	10178.8-10313.9	89820	10248.1	10185.5-10310.7	112292	9606.5	9552.7-9660.3
Hypertension	15322	7873.8	7764.1-7983.4	43857	8124	8057.7-8190.2	49542	8417.9	8353.6-8482.3	60363	7097.7	7047.3-7148.1
Stroke	1136	634.4	597.8-671.1	3908	737.6	714.9-760.2	3592	690.2	667.9-712.5	5477	635.3	618.8-651.8
Chronic Heart Disease	3737	2025.94	1962.9-2089.0	11222	2128.3	2090.6-2166.1	110007	2070.7	2033.5-2107.9	15074	1779.3	1751.9-1806.8
Gastrointestinal Diseases	23673	9285.1	9169.5-9400.6	55406	9240.8	9167.5-9314.2	58799	8705.5	8637.7-8773.3	73589	7994.9	7939.5-8050.3
Gastroenteritis & Duoenitis	6619	2731.8	2665.1-2798.5	16238	2738.1	2696.3-2779.9	17241	2565.1	2526.6-2603.5	19694	2177.0	2146.8-2207.2
Hepatitis A or B	96	36.0	28.7-43.4	516	83.9	76.6-91.3	956	132.5	124-141.0	312	33.8	30.0-37.6
Diarrhea	11843	4071.4	3997.6-4145.1	32923	5139.7	5086-5193.4	36094	4895.3	4846-4944.5	38353	3896.7	3858.5-3934.8
Parasitic Infection	70	24	18.2-29.8	206	33.2	28.6-37.8	309	42.6	37.8-47.5	288	29.3	25.9-32.7
Esophagus Disorders	1808	805.1	767.2-843	5708	1003.1	977.1-1029.1	4552	720.9	699.6-742.2	7259	824.6	805.7-843.5
Enteritis & Colitis	746	292.8	271.4-314.2	2293	375.5	360-391	2064	293.3	280.4-306.2	2625	292.6	281.4-303.8
Peptic Ulcer	3203	1393.4	1344.4-1442.5	7151	1230.9	1202.4-1259.5	6383	989.3	964.7-1013.9	8433	956.4	936.1-976.7
Liver Cirrhosis	221	99.3	85.9-112.7	899	156.4	146.1-166.7	872	138.5	129.2-147.9	770	88.0	81.7-94.2
Endocrine, Metabolic Nutritional Disorders												
Diabetes	5329	2656.0	2585.9-2726.1	14568	2663.8	2621.8-2705.7	15107	2570.3	2530.1-2610.6	19304	2249.3	2218.5-2280.2
Anaemia	2485	1040.5	998.3-1082.8	7962	1386.9	1356.6-1417.3	7615	1199.6	1172.4-1226.9	8970	996.1	975.6-1016.6
Neurological Diseases	2725	1150.1	1105.7-1194.5	8151	1402.6	1372.3-1433.0	7906	1264.9	1236.7-1293.0	10155	1115.4	1093.8-1137.0
Alzheimer's Disease	267	154.5	136.1-173.0	818	159.9	149.1-170.8	1209	243.4	229.8-257.0	1324	150.8	142.8-158.9
Parkinson's Disease	237	138.8	121.1-156.6	769	149.7	139.2-160.2	694	138.5	128.2-148.9	1237	144.7	136.7-152.7
Multiple Sclerosis	248	119.1	105.1-133.1	1162	199.6	188.0-211.1	1224	180.1	169.9-190.4	1371	154.3	146.2-162.5
Epilepsy	1441	537.5	509.0-566.0	3774	616.0	596.2-635.8	3180	456.2	440.1-472.3	1441	458.0	444.2-471.8

Five Year Adjusted Rate Of Hospitalization For Selected Diagnoses, 1990 - 1994

Diagnosis	NRBS Area			Edmonton			Calgary			Rest of Province		
	Number	Rate	95% CI	Number	Rate	95% CI	Number	Rate	95% CI	Number	Rate	95% CI
Menstrual Cycle Disorders	1621	188.4	398.4-439.3	1820	974.5	188.3-206.6	2083	821.6	174.3-190.0	4215	94.3	300.1-318.8
Spontaneous Abortion	1731	413.4	393.9-432.8	3589	342.7	331.4-354.0	3916	320.1	310.9-331.1	4223	316.3	306.7-325.8
Infertility	180	43.7	37.4-50.1	330	319.5	28.5-35.4	309	249.7	22.2-27.8	351	261.1	23.4-28.8
Endometriosis	896	224.9	210.1-239.7	1103	158.7	108.9-122.8	1276	88.8	102.9-114.9	1450	66.1	101.1-112.1
Congenital Anomalies	2016	121.9	116.5-127.3	3301	99.1	85.7-102.4	5189	134.2	130.6-137.8	5750	107.7	104.9-110.5
Nervous System Anomalies	98	5.8	4.7-7.0	180	5.5	4.7-6.3	147	3.8	3.2-4.4	240	4.5	4.0-5.1
Cardiovascular System Anomalies	403	23.8	21.5-26.2	656	18.7	18.2-21.2	982	25.6	24.0-27.2	1043	19.7	18.5-20.9
Urological System Anomalies	108	7.2	5.8-8.6	216	6.6	5.7-7.5	235	6.3	5.4-7.1	284	5.5	4.8-6.1
Respiratory Diseases	39702	2998.1	2967.8-3028.3	24530	819.6	809.3-829.9	32075	978.4	968.5-990.3	85299	1756.1	1744.4-1767.8
Asthma	5747	416.7	405.3-428.0	5443	178.1	173.3-182.9	6229	179.7	175.1-184.2	13307	266.2	261.2-270.7
Bronchitis	2534	230.4	220.9-239.8	784	29.1	27.1-31.2	685	26.5	24.5-28.5	3692	82.5	79.8-85.2
Emphysema	191	21.7	18.6-24.8	463	18.0	16.4-19.7	772	31.0	28.8-33.2	696	16.7	15.4-17.9
Pneumonia	8050	637.9	623.2-652.6	5418	188.0	183.0-193.1	5147	178.3	173.3-183.3	17752	374.9	369.4-380.5
Acute Respiratory Infection	12246	797.4	782.8-812	3803	114.4	110.7-118	3417	93.0	89.8-96.2	18666	364.5	359.2-369.7
Other COPD	1990	233.4	223.1-243.7	1041	40.5	38.1-43.0	1645	66.5	63.3-69.7	4469	106.1	103-109.2
Circulatory Diseases	21059	2313.5	2283.7-2343.4	27908	1059.1	1046.8-1071.3	35115	1315.1	1301.6-1328.6	70926	1671.4	1659.5-1683.2
Hypertension	1803	195.3	186.1-204.4	930	34.8	32.5-37.0	1211	44.5	42.0-47.1	8160	97.9	94.9-100.8
Stroke	2659	306.2	294.5-317.8	4639	179.6	174.4-184.7	4383	173.9	168.7-179	9349	219.8	215.3-224.2
Chronic Ischematic Heart Disease	3369	372.6	359.9-385.2	3672	139.9	135.4-144.5	5569	207.2	201.7-212.6	9889	238.4	233.7-243.0
Gastrointestinal Diseases	32278	2747.1	2716.7-2777.5	30930	1073.1	1061.1-1085.1	38926	1226.4	1214.1-1238.9	80496	1788.9	1987.6-1812.2
Viralenteritis	193	10.9	5.3-12.4	98	2.8	2.3-3.4	136	3.4	2.8-4.0	259	4.8	4.2-5.3
Hepatitis A	31	2.1	1.3-2.8	27	0.9	0.5-1.2	45	1.2	0.8-1.6	125	2.5	2.1-2.9
Hepatitis B	17	1.4	0.7-2.0	70	2.2	1.7-2.8	56	1.7	1.2-2.2	57	1.3	1.0-1.7
Salmonellosis	85	6.4	5.0-7.9	101	3.2	2.6-3.8	131	3.8	3.1-4.4	352	7.5	6.7-8.2
Shigellosis	215	12.8	11.1-14.6	31	1.0	0.6-1.3	17	0.5	0.2-0.7	207	3.9	3.3-4.4
Giardiasis	138	8.8	7.3-10.4	22	0.7	0.4-1.0	27	.07	0.5-1.0	238	4.6	4.0-5.2
E. coli	50	3.5	2.5-4.5	48	1.6	1.2-2.1	103	3.1	2.5-3.7	153	3.3	2.8-3.8
Campylobacteriosis	206	17.3	14.8-19.8	306	10.7	9.5-11.9	329	10.6	9.5-11.8	789	17.3	16.1-18.5
Peptic Ulcer	3796	340.7	329.5-351.8	1840	66.3	63.2-69.3	2082	69.9	66.8-72.9	7267	164.7	161.0-168.5
Liver Cirrhosis	366	33.8	30.3-37.3	843	30.5	28.4-32.5	843	28.4	26.1-29.9	1221	28.4	26.8-30.0
Endocrine, Metabolic Nutritional Disorders	5356	510.3	496.2-524.3	5444	191.8	186.7-196.9	6102	187.4	182.3-202.4	14803	333.7	328.3-339.1
Diabetes	3153	317.2	305.8-328.5	2730	97.5	93.8-101.2	2488	81.2	77.9-84.4	8028	183.9	179.9-188.0
Nutritional Deficiency	1789	156.4	148.8-164.0	1906	65.5	62.6-68.5	2557	81.0	77.7-84.1	4873	106.7	103.7-109.7
Neurological Diseases	8063	669.2	654.0-684.4	8989	319.6	312.9-326.2	9431	311.9	305.5-318.4	21786	481.3	474.9-487.7
Alzheimer's Disease	125	13.4	11.0-15.8	136	5.0	4.1-5.8	157	5.8	4.9-6.8	526	12.1	11.0-13.1
Parkinson's Disease	136	16.4	13.6-19.1	114	4.5	3.7-5.3	165	6.6	5.6-7.6	544	12.8	11.7-13.8
Multiple Sclerosis	140	11.8	9.9-13.8	272	9.1	8.0-10.1	349	10.1	9.0-11.2	659	15	13.8-16.1
Epilepsy	1055	80.6	75.6-85.6	1071	34.6	32.5-36.6	967	27.9	26.1-29.7	2580	54.6	52.5-56.7

Appendix D

Emissions in Alberta

Sector	Pollutant Emissions in Tonnes				
	Particulates	SO2	NOx	VOC	CO
Industrial Processes					
Asphalt Production	3,225				
Bakeries				348	
Cement and Concrete Manufacture	8,499	294	4,908		474
Coal Industry	20,006	2,753	1,579	337	59
Crude Oil Production		51,200			
Ferrous Foundries	45		2	2	863
Grain Industries	10,677				
Mining and Rock Quarrying	264				
Natural Gas Processing	474	237,505	96,687	2,371	13,805
Oil Sands	4,149	148,211	15,855	32	10,485
Other chemicals	2,460	245	9,640	2,218	4,929
Petrochemical Industry	188	1,277	8,090	5,482	1,339
Petroleum Refining	760	7,078	5,737	6,244	2,651
Plastics and Synthetic Resins Fabrication				1,483	
Pulp and Paper Industry	2,179	1,212	1,203	301	1,414
Upstream Oil and Gas Operations				437,279	
Wood Industry	29,794	3	1,674	1,752	47,455
Other Industries	4,349	3,727	34,342	184	4,098
Fuel Combustion					
Commercial Fuel Combustion	265	379	4,329	164	1,100
Electric Power Generation	81,731	101,629	87,935	877	54,663
Residential Fuel combustion	1,011	492	5,757	672	9,371
Residential Fuelwood combustion	453	5	37	1,804	3,248

Transportation					
Aircraft	146	198	2,770	1,021	6,246
Heavy-duty Diesel Vehicles	4,140	3,666	51,802	5,838	23,435
Heavy-Duty Gasoline Trucks	31	25	2,320	2,130	29,817
Light-Duty Diesel Trucks	15	287	365	154	289
Light-Duty Diesel Vehicles	7	125	136	48	110
Light-Duty Gasoline Truck	174	482	16,346	24,284	233,225
Light-Duty Gasoline Vehicle	314	688	30,847	46,603	425,693
Marine		8	15	2,229	7,281
Motor Cycles	2	2	67	333	1,159
Off-Road use of Diesel	5,652	3,178	58,106	6,509	18,758
Off-Road use of gasoline	806	303	13,170	17,760	370,316
Railroads	1,761	1,371	32,637	1,585	13,031
Tire Wear	4,914			96	
Incineration					
Other Incineration	10	157	193	228	309
Wood Waste Incineration	880	15	152	1,668	19,717
Miscellaneou					
Application of Surface Coatings				4,724	
Cigarette Smoking	297				119
Dry Cleaning				1,242	
Fuel Marketing				10,227	
General Solvent Use				41,172	
Pesticides and Fertilizer Application	4,734			8,211	
Structural Fires	36		13	46	554

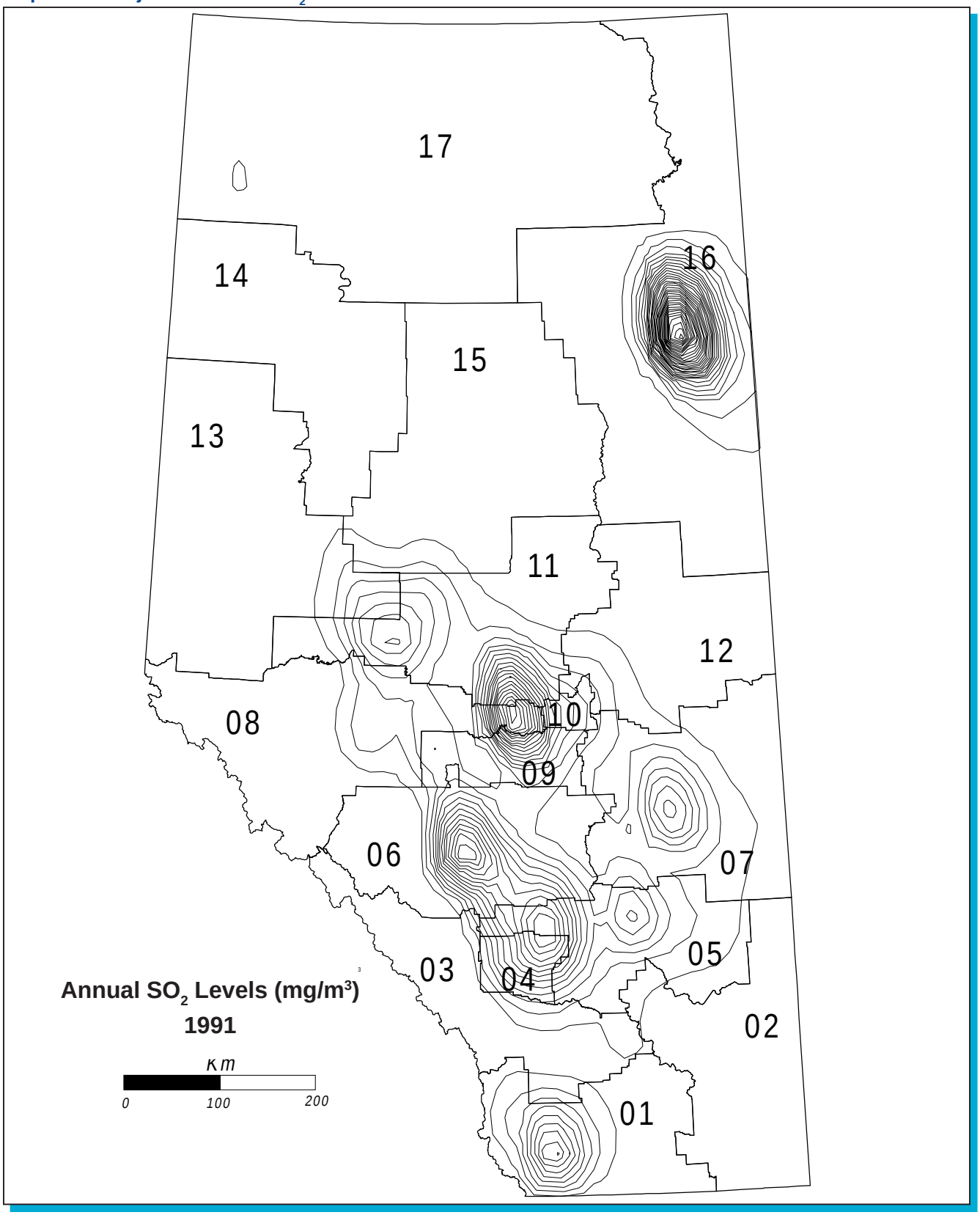
Appendix E

It is clear from research conducted in other parts of the world that the quality of the air may increase the risk for some respiratory diseases, such as asthma, bronchitis or emphysema. For example, several studies have reported increased risk for asthma in relation to high concentrations of SO_2 in the air, although no such relationship has yet been measured in Alberta. According to a recent report by Alberta Environmental Protection (1995), the level of all of the pollutants monitored were below the Guidelines over 90% of the time in 1993, regardless of the location of the monitoring station. This means that the level of airborne contaminants is below the guidelines for measurable health impact most of the time in Alberta, and the level of airborne contamination exceeds that level only occasionally.

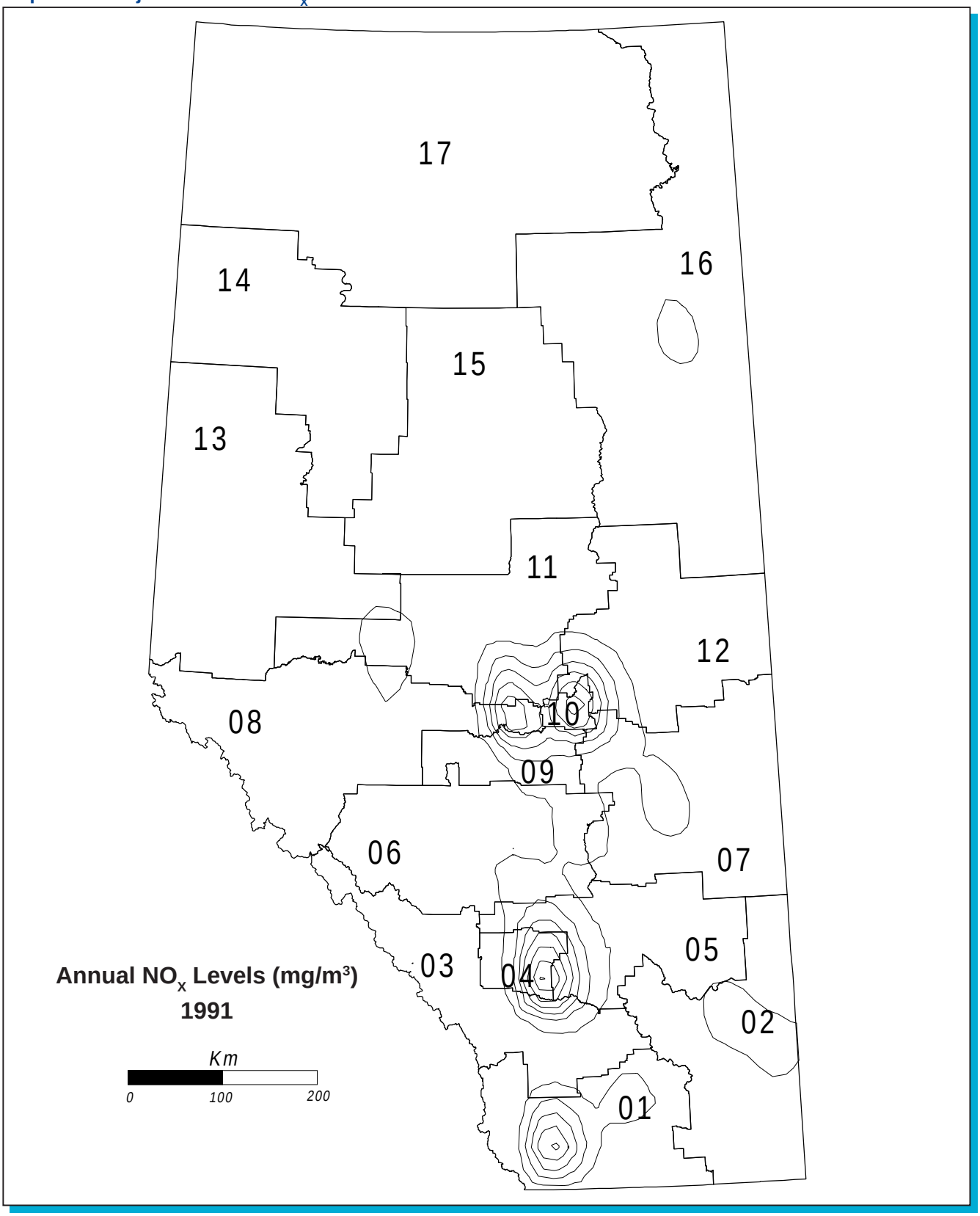
The level of ambient air pollution varies by geographic area as a result of urbanization, industrial development, and other human activities. Evaluation of the geographic distribution of the measures of airborne contaminants and its correlation with human health outcomes may help identify potential effects from airborne substances, although this type of analysis can only point to potential issues, and cannot clearly identify the source of variation in disease. This weakness in the method of analysis, resulting from the use of existing information rather than collection of new information, is further complicated by the fact that the data collected on airborne contaminants do not include many areas of the province, and had not been collected over a long period of time.

Alberta Environmental Protection (AEP) recently developed a database which predicts the concentrations of the ambient air substances for the whole province. Using a model from the U.S. Environmental Protection Agency with some modifications, AEP's new model simulates the transport, dispersion, chemical transformation, and wet and dry removal processes in the atmosphere to predict ground level ambient concentrations for specific contaminants. Data from this model suggest large geographic variations of SO_2 in the province. There were eight areas where relatively high SO_2 concentrations were predicted: Fort McMurray, Whitecourt, Wabamun, Rocky Mountain House, Crossfield, Drumheller, Waterton Lakes/Pincher Creek, and Castor. Map 15 shows the projected levels of concentration of SO_2 across the province, and Map 16 shows the projected levels of concentration of NO_x by area of the province.

Map 15 Projected Annual SO_2 Levels



Map 16 Projected Annual NO_x Levels



Air Quality Mapping

Lack of the appropriate environmental data substantially hampered our ability to study the relationship between environmental factors and health outcomes. The predicted level of the ambient air SO_2 and NO_x is based on the Alberta Environmental Protection (AEP) model, which is an adaptation of the model from the U.S. Environmental Protection Agency (EPA). While no information on model validation was available, the predicted higher level of the ambient SO_2 in Fort McMurray area (Fort McMurray and Fort McKay) agrees with the higher levels of SO_2 concentrations measured at Fort McMurray and Fort MacKay during the same period (AEP, 1990). Also, the predicted higher level of the ambient SO_2 in Fort McMurray area and other seven areas (Whitecourt, Wabamun, Rocky Mountain House, Crossfield, Drumheller, Waterton Lakes/Pincher Creek, and Castor) appear to correlate with locations of air quality and precipitation quality monitoring stations. The selected locations for monitoring are often the areas of concern. Nonetheless, updated air quality data based on the validated model will certainly increase our ability to examine the relationship between the ambient air quality and selected health outcomes.

Four databases were used for the following analysis:

1. Census Subdivision (CSD) Profile Database: this data set includes a CSD code, the NRBS boundary code, a urban/rural indicator, population, latitude, and longitude. This file has a total of 396 unique CSDs;

2. CSD-Level Health Outcome Measures Database: this file includes data on the rates of physician visits, hospitalization, total health care utilization (physician visit and/or hospitalization), and death for each CSD. In addition, the person-physician visit ratio, person-hospitalization ratio, person-health care utilization ratio for several conditions are also included. The total number of CSDs in this database varies by disease and variable, to a maximum of 324;

3. Model-Based Ambient Air Quality Database: this file has the predicted annual average concentration of SO2 and NOx for each CSD in 1990. A total of 439 CSDs are identified; and

4. Community Demographic and Socioeconomic Profile database: this file was developed using data from the 1991 census. The major variables include population, population density, average income among the adult population (15 year and older) who had an income in 1991, the proportion of aboriginal people, and a community socioeconomic status index. The index was generated using average annual income for the adult population with income, education, rate of unemployment, and the number of children ever born for every 1,000 women aged 15 years and over. A total of 392 CSDs are identified in this database. Suppression of values for some small CSDs by Statistics Canada reduced the number of CSDs for which information was available to 300 CSDs for some variables, such as community socioeconomic index.

Complete information for all the variables included in the analysis was available for only 320 CSDs. The two large metropolitan CSDs (Calgary and Edmonton) were excluded from the multivariate analyses, because they are extremely different than any other single CSD. The final analysis was restricted to 318 CSDs. Again, two sets of models were fitted: (1) models including

all CSDs with health outcome information, and (2) models including CSDs with complete information on all study variables. The former will allow the evaluation of the effects of explanatory variables but does not include analysis of the effect of community socioeconomic status, while the latter method will allow the complete assessment of all explanatory variables in a model even though a large amount of data is missing. The implications of the missing data are discussed in Appendix C.

Table A Predicted Annual Average SO_2 Level

Annual SO_2 Level($\mu g/m^3$)	Frequency	Percent
1	187	42.6
2	54	12.3
3	45	10.3
4	39	8.9
5	30	6.8
6	13	3.0
7	18	4.1
8	8	1.8
9	4	0.9
10	7	1.6
11	6	1.4
12	7	1.6
13	4	0.9
14	4	0.9
15	3	0.7
16	5	1.1
17	3	0.7
20	1	0.2
28	1	0.2

Using the model developed by Cheng, the expected levels of SO_2 and NO_x were determined for each CSD in the province. Table shows the number and percentage of CSDs at each predicted level of SO_2, and table 15 shows the number and percentage of CSDs at each predicted level of NO_x. Initial analysis shows that the distribution of data is highly skewed, with values ranging from 1 to 28 (g/m^3 for SO_2, and 1 to 7 (g/m^3 for NO_x. To maintain a reasonable number of observations at each level and for ease of interpretation, data was grouped into three categories, indicating low, medium, and high concentrations of these contaminants (Table C). For SO_2, level 1 is the original value, level 2 combines values 2, 3, and 4, and level 3 combines the rest of the values (5-28). This results in a distribution of 42.4%, 33.0%, and 24.6% for levels 1, 2, and 3. For NO_x level 1 is the original value, level 2 combines values 2 and 3, and level 3 combines the rest of the values (4-7), resulting in a distribution of 64.9%, 24.1%, and 10.9%, respectively.

Table B Predicted Annual Average NO_x Level

Annual NO_x Level($\mu g/m^3$)	Frequency	Percent
1	285	64.9
2	85	19.4
3	21	4.8
4	21	4.8
5	22	5.0
6	4	0.9
7	1	0.2

Comparison of the number of CSDs at each predicted level of contaminant emission between the NRBS area and the rest of the province enables the estimation of the potential impact, if any, from the ambient air environment. Table 16 shows that most CSDs in the NRBS area are predicted to have relatively lower levels of airborne SO_2 and NO_x - 75% of the CSDs in the NRBS area have very low levels of SO_2, and 96% have very low levels of NO_x - while more CSDs

in the rest of the province have higher predicted levels of the same airborne contaminants. This suggests that the likelihood of a measurable health impact from these airborne contaminants should be lower for residents of the NRBS area than for residents of other parts of Alberta.

Table C Number of CSDs by Level of Contaminant Emission

Level		NRBS Area		Rest of Province		p-value
		N	%	N	%	
SO_2	1	63	75.0	104	33.5	
	2	17	20.2	113	36.5	
	3	4	4.8	93	30.0	.001
NO_x	1	81	96.4	181	58.4	
	2	3	3.6	89	28.7	
	3	0	0.0	40	12.9	.001

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