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ZOONOTIC DISEASES, DRINKING WATER AND GASTROENTERITIS IN NUNAVIK: A BRIEF PORTRAIT

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BACKGROUND OF THE NUNAVIK INUIT HEALTH SURVEY

The monitoring of population health and its determinants is essential for the development of effective health prevention and promotion programs. More specifically, monitoring must provide an overall picture of a population's health, verify health trends and how health indicators vary over distance and time, detect emerging problems, identify priority problems, and develop possible health programs and services that meet the needs of the population studied.

The extensive survey conducted by Santé Québec in Nunavik in 1992 provided information on the health status of the Nunavik population (Santé Québec, 1994). The survey showed that health patterns of the population were in transition and reflected important lifestyle changes. Effectively, the Inuit population has undergone profound sociocultural, economic, and environmental changes over the last few decades. The Inuit have changed their living habits as contact with more southerly regions of Quebec increased. A sedentary lifestyle, the switch to a cash-based domestic economy, the modernization of living conditions and the increasing availability and accessibility of goods and foodstuffs imported from southern regions have contributed to these changes. These observations suggest the need for periodic monitoring of health endpoints of Nunavik Inuit to prevent the negative impact of risk factor emergence and lifestyle changes on subsequent morbidity and mortality from major chronic diseases.

In 2003, the Nunavik Regional Board of Health and Social Services (NRBHSS) decided to organize an extensive health survey in Nunavik in order to verify the evolution of health status and risk factors in the population. The NRBHSS and the Ministère de la Santé et des Services sociaux (MSSS) du Québec entrusted the Institut national de santé publique du Québec (INSPQ) with planning, administering and coordinating the survey. The INSPQ prepared the survey in close collaboration with the Unité de recherche en santé publique (URSP) of the Centre hospitalier universitaire de Québec (CHUQ) for the scientific and logistical component of the survey. The Institut de la statistique du Québec (ISQ) participated in methodology development, in particular the survey design.

The general aim of the survey was to gather social and health information on a set of themes including various health indicators, physical measurements, and social, environmental and living conditions, thus permitting a thorough update of the health and well-being profile of the Inuit population of Nunavik. The survey was designed to permit a comparison of the 2004 trends with those observed in 1992. Data collected in 2004 also allowed researchers to compare the Inuit to other Quebecers.

Target population

The health survey was conducted among the Inuit population of Nunavik from August 27 to October 1, 2004. According to the 2001 Canadian census, the fourteen communities of Nunavik have a total of 9632 inhabitants, 91% of whom identified themselves as Inuit. The target population of the survey was permanent residents of Nunavik, excluding residents of collective dwellings and households in which there were no Inuit aged 18 years old or older.

Data collection

Data collection was performed on the Canadian Coast Guard Ship Amundsen, thanks to a grant obtained from the Canadian Foundation for Innovation (CFI) and the Network of Centres of Excellence of Canada (ArcticNet). The ship visited the fourteen villages of Nunavik, which are coastal villages. The study was based on self-administered and interviewer-completed questionnaires. The study also involved physical and biological measurements including clinical tests. The survey was approved by the Comité d'éthique de la recherche de l'Université Laval (CERUL) and the Comité d'éthique de santé publique du Québec (CESP). Participation was voluntary and participants were asked to give their written consent before completing interviews and clinical tests. A total of 677 private Inuit households were visited by interviewers who met the household respondents to complete the identification chart and the household questionnaire. A respondent was defined as an Inuit adult able to provide information regarding every member of the household. The identification chart allowed demographic information to be collected on every member of the household. The household questionnaire served to collect information on housing, environment, nutrition and certain health indicators especially regarding young children.

All individuals aged 15 or older belonging to the same household were invited to meet survey staff a few days later, on a Canadian Coast Guard ship, to respond to an interviewer-completed questionnaire (individual questionnaire) as well as a self-administered confidential questionnaire. Participants from 18 to 74 years of age were also asked to complete a food frequency questionnaire and a 24-hour dietary recall, and to participate in a clinical session. The individual questionnaire aimed to collect general health information on subjects such as health perceptions, women's health, living habits and social support. The confidential questionnaire dealt with more sensitive issues such as suicide, drugs, violence and sexuality. During the clinical session, participants were invited to answer a nurse-completed questionnaire regarding their health status. Then, participants had a blood sample taken and physical measurements were performed including a hearing test, anthropometric measurements, an oral glucose tolerance test (excluding diabetics) and toenail sampling. Women from 35 to 74 years of age were invited to have a bone densitometry test. Finally, participants aged 40 to 74 could have, after consenting, an arteriosclerosis screening test as well as a continuous measure of cardiac rhythm for a two-hour period.

Survey sampling and participation

The survey used a stratified random sampling of private Inuit households. The community was the only stratification variable used. This stratification allowed a standard representation of the target population. Among the 677 households visited by the interviewers, 521 agreed to participate in the survey. The household response rate is thus 77.8%. The individual response rates are obtained by multiplying the household participating rate by the individual collaboration rate since the household and individual instruments were administered in sequence. The collaboration rate corresponds to the proportion of eligible individuals who agreed to participate among the 521 participating households. In this survey, about two thirds of individuals accepted to participate for a response rate in the area of 50% for most of the collection instruments used in the survey. A total of 1056 individuals signed a consent form and had at least one test or completed one questionnaire. Among them, 1006 individuals answered the individual questionnaire, 969 answered the confidential questionnaire, 925 participated in the clinical session, 821 had a hearing test, 778 answered the food frequency questionnaire, 664 answered the 24-hour dietary recall, 282 had an arteriosclerosis test, 211 had a continuous measure of their cardiac rhythm for a two-hour period and 207 had a bone densitometry test. More details on the data processing are given in the Methodological Report.

INTRODUCTION[1]

The Inuit way of life and the special relationship they have with animals and the land during traditional activities of hunting, fishing and trapping, result in the Inuit people being highly exposed to pathogenic agents present in the environment and among wild animals. In Nunavik, common practices such as the consumption of untreated water and raw meat, including that of fish and both marine and land mammals, increase the risk of infection by a variety of micro-organisms associated with this environment. There is little documentation concerning zoonotic diseases – infections transmissible from animals to humans – among the Inuit of Nunavik. For a number of these diseases, little is known about specific hosts and modes of transmission in the Arctic environment. Additionally, their clinical presentation is often unspecific and can make diagnosis extremely difficult. All of these factors make it difficult to determine the significance of these infections for the population of Nunavik.

The presence of permafrost and the absence of water systems have led to a striking difference between methods of distributing drinking water and managing sewage in Nunavik and those prevailing elsewhere in Quebec. In most Inuit communities, drinking water is obtained from unfiltered chlorinated surface water, but about 30% of the Inuit population still uses untreated water (Martin et al., 2005). The treated water is distributed daily by tanker truck and stored in reservoirs inside homes (Hodgins, 1997). Sewage is generally dumped not far from the village in ponds reserved for this purpose, or sometimes spread directly on the ground (Martin et al., 2005).

This brief portrait provides a glimpse of a variety of factors and mechanisms favouring exposure to zoonotic pathogens and to food-borne and water-borne diseases, particularly gastroenteritis. At present we have little data on the prevalence of these infections among the Inuit of Nunavik. Moreover, it is recognized that the number of cases declared to health authorities via the passive surveillance system for Mandatory Reportable Diseases (*Maladies à Déclaration Obligatoire*, MADO) are well below the actual number of cases occurring in the population. Due to their way of life and geographic

[1] For ease of readability, the expression "Inuit" is used throughout the theme paper to define the population under study even though a small percentage of individuals surveyed identified themselves as non-Inuit. Refer to "Background of the Health Survey" for further details regarding the definition of the target population.

location, the communities of Nunavik are probably among the most highly exposed to infection risks related to the environment in Quebec. In view of these risks and the fact that little information is available, there is a genuine need for both better knowledge of risk factors and increased monitoring of infections so appropriate means of prevention may be put in place.

The present chapter will profile the supply of drinking water in Nunavik and describe the prevalence of gastroenteritis and eight zoonotic diseases that have already been documented in the Arctic or are likely to be under-reported among the population of Nunavik. It will also attempt to verify the contribution of a number of risk factors in the transmission of these infections to humans. More precisely, the purpose of this chapter will be to:

- **Describe the supply of drinking water** in Nunavik households;
- **Describe the prevalence of gastroenteritis** in terms of the socio-demographic characteristics of the Inuit population of Nunavik;
- **Describe the seroprevalence of eight zoonotic infections** in terms of the socio-demographic characteristics of the Inuit population of Nunavik;
- **Verify the importance of various risk factors** with respect to gastroenteritis and zoonotic diseases.

METHODOLOGICAL ASPECTS

Data collection

Both the demographic data and information concerning home environment, nutrition and certain health indicators were collected through the Nunavik Inuit Health Survey from the household questionnaire. This questionnaire was administered to the principal respondent of each of the households sampled (n = 521), generally the mother, who answered for every member of the household. The data collected included methods of food preparation and the water supply (the source of drinking water in summer and winter, the type of treatment carried out in the home, the frequency of cleaning the domestic water reservoir). The questionnaire also revealed the number of individuals who had suffered from gastroenteritis during the thirty days prior to the survey, along with how long each episode had lasted. A case of gastroenteritis was defined as an instance in which a person had experienced an episode of diarrhea with at least three liquid stools in a period of 24 hours. Questioning on this topic applied to everyone in the household regardless of age (n = 2550).

To detect the presence of antibodies against eight micro-organisms responsible for zoonotic infections, serological analyses were carried out on blood samples from individuals aged 18 to 74 (n = 917) living in the households visited. For these individuals, complementary information concerning socioeconomic status (education level, personal income, job status), hunting, fishing and trapping practices, and food habits were gathered from the individual questionnaire (n = 1006) and the food frequency questionnaire (n = 778). Among the serologies investigated, four parasites that had been documented as early as the 1980s (Tanner et al., 1987; Curtis et al., 1988) were identified. They are the agents responsible for trichinellosis (*Trichinella* sp.), toxocariasis (*Toxocara canis*), echinococcosis or hydatid disease (*Echinococcus granulosus*), and toxoplasmosis (*Toxoplasma gondii*). Brucellosis (*Brucella* sp.), leptospirosis (*Leptospira* sp.), Q fever (*Coxiella burnetii*) and tularemia (*Francisella tularensis*), four bacterial infections with little or no previous record in Nunavik but with a strong likelihood of being under-reported, were also identified.

Serological analyses

Immunoenzymatic methods (ELISA) were used to detect antibodies against *Trichinella* sp., *T. canis*, *E. granulosus* (IVD inc.), *T. gondii* (AxSYM, Abbott Diagnostics, Abbott Park, Illinois) as well as *Brucella* sp., *Leptospira* sp. and *C. burnetii* (Virion\Serion, Serion Immundiagnostica GmbH, Würzburg). Detection of antibodies against *Francisella tularensis* was performed using a tube agglutination test (Snyder, 1980; Stewart, 1981). Table A1 (Appendix) presents the criteria used to interpret the results, along with the presumed lifetime of the antibodies for each serology. Generally speaking, seropositivity persists over a variable period depending on the agent in question and the detection techniques used. The periods indicated in Table A1 (Appendix) are based on the literature, manufacturers' documentation and the experience of the clinicians who performed the analyses.

Immunoenzymatic tests are very sensitive methods capable of detecting low numbers of antibodies. Nevertheless, with equivocal titres it is generally impossible to know, given the antigens used, whether the results are due to previous infections or are the product of cross-reactions with other pathogens. The antigens used for the detection of antibodies against the parasites studied (*T. gondii*, *T. canis*, *E. granulosus* and *Trichinella* sp.) tend to react with a large number of antibodies. Consequently, while the positive results should be considered to be true positives, cross-reaction seems the likeliest explanation for the equivocal tests for these infections (pers. comm. Dr. Brian Ward and Dr. Michael Libman). On the other hand, the strong reactivity of the samples for zoonotic diseases of some bacterial origin (*Leptospira* sp., *F. tularensis)* and the repeated exposure of the Inuit to micro-organisms, due notably to their way of life and nutritional habits, suggest that the weakly positive or equivocal serologies possibly result from residual immunity acquired from previous infections. In the current study and in its public health context, we postulated that the large number of equivocal results for *Leptospira* sp. and *F. tularensis* is likely to represent positive results and is probably an alternative for describing "true" past exposure of the Inuit population to these bacteria (pers. comm. Dr. Michel Couillard). Moreover, with the standard tube agglutination test, titres of 1:20 and over, which correspond to the equivocal and positive results of this study, are considered specific for *F. tularensis* in the literature (Philip et al., 1967). These several elements were considered when the statistical analyses were conducted.

Statistical analyses

For the principal respondents, information related to drinking water supply was crossed with the following socio-demographic variables: sex, age, region, education level and personal income. For all members of the households visited, data on the prevalence of gastroenteritis as documented by episodes of diarrhea and their duration were crossed with certain nutritional and socio-demographic variables (sex, age, region, principal occupation), along with data on drinking water, promiscuity (the number of persons per household and per bedroom) and the presence of children under five years of age in the home. For variables on the household questionnaire related to methods of food preparation, the information reported by the person doing the cooking was assigned to all members of the household.

When the degree of seroprevalence was sufficient, the results for each zoonotic disease were examined individually with respect to nutritional and socio-demographic variables (sex, age, region, education level, job status, personal income), drinking water and practices of hunting, fishing and berry picking documented among participating adults who had provided a blood sample. Given the importance of age as a factor in seropositivity, significant relationships were verified by stratifying for age. In the case of some bacterial infections (*Leptospira* sp., *F. tularensis)*, the serological results were grouped according to two formats: one consisting only of positive serologies and the other combining positive and equivocal serologies. Chi-square test with a correction for design effect was used to compare proportions. Statistical analyses for comparisons have been conducted at a threshold of α=0.05.

For sub-region analyses, it should be noted that the Nunavik territory has been divided in two regions because place of residence could influence life habits. The Hudson coast includes the villages of Kuujjuarapik, Umiujaq, Inukjuak, Puvirnituq, Akulivik, Ivujivik and Salluit while the Ungava coast includes Kangiqsujuaq, Quaqtaq, Kangirsuk, Aupaluk, Tasiujaq, Kuujjuaq and Kangiqsualujjuaq.

In terms of the education variable, it is important to specify that the choice of answers for post-secondary training were not well adapted to the context of the survey's target population. The answers given for this category reveal that there was likely confusion during data collection between training that requires a post-secondary diploma and training that does not (e.g. driver's license, fishing license, etc). Therefore, the number of people with post-secondary education was likely overestimated.

However, the data used in this module comes from a sample and is thus subject to a certain degree of error. The coefficient of variation (CV) has been used to quantify the accuracy of estimates and the Statistics Canada scale was used to qualify the accuracy of estimates. The presence of an "E" footnote next to an estimate indicates a marginal estimate (CV between 16.6% and 33.3%). Estimates with unreliable levels of accuracy (CV > 33.3%) are not presented and have been replaced by the letter "F".

RESULTS[2]

Drinking water

During winter and summer, nearly 60% of the households primarily consume water from the municipal system or from the tap of the treatment plant. However, about a third normally uses water from natural sources (lake, river, stream, melted snow or ice), while a small percentage, about 6%, primarily consume bottled water. Fewer than half the respondents stated that they treat the water drunk in the home: a quarter of the households boil it, while 21% filter it using a domestic filter (charcoal, Brita or other). About 54% of the households use no supplementary treatment or boil their water only when a public notice requires them to do so. With regard to cleaning the home water reservoir, which involves disinfecting the walls of the tank with bleach, 27% of respondents said they do so every month, 31% every two to six months, 42% once a year or less.

When examining the supply of drinking water in summer and winter according to the age of the principal respondents, significant differences are noticed in the main source of water used by the household. Respondents aged 15 to 49 have a greater propensity to use the municipal water system or the tap of the treatment plant than do those aged 50 and over, while a greater proportion of elders opt for water taken from natural sources ($p < 0.001$ in summer and winter). Moreover, those with a secondary school education drink significantly less natural water and more bottled water than those who have not completed elementary or secondary school ($p < 0.005$ in summer and winter). Also, more people from the Hudson coast consume natural water than people from the Ungava coast, with approximate proportions of 40% versus 25% respectively ($p < 0.001$ in summer and winter).

In addition, a greater proportion of households living along the Ungava coast filter the water consumed in the home ($p < 0.001$). This proportion is also greater among more educated principal respondents ($p = 0.031$) and those with higher personal income ($p < 0.001$). On the other hand, households whose respondents have completed secondary school seem to clean the domestic water reservoir less often than those with less education ($p < 0.001$). Finally, among households from the Hudson coast, only 26% clean the domestic water reservoir once a year or less, while the percentage stands at 60% along the Ungava coast ($p < 0.001$).

Prevalence of gastroenteritis

Table A2 (Appendix) presents variables significant in crossing data on the prevalence of gastroenteritis episodes with socio-demographic and nutritional variables, drinking water, promiscuity and the presence of children under five in the home. Among persons affected, the proportion of individuals who have presented a prolonged episode of diarrhea (three days or more) is also given for these variables. There is no significant difference between men and women with respect to the prevalence of gastroenteritis as defined in this study. The results do however show a significant difference between age categories, with children under five and persons aged 50 and over being more frequently affected by gastroenteritis during the month preceding the survey. There are also more episodes of prolonged diarrhea in the extreme age groups.

The prevalence is significantly lower on the Hudson coast as well as among individuals who clean their domestic reservoir more frequently. However, no relationship was observed when the prevalence of gastroenteritis episodes was examined relative to the source of water used in winter and summer, the treatment performed on water consumed in the home (boiling, filtering or other treatment), or the customary manner of preparing meats and fish, eaten cooked (fried, boiled or roasted) or uncooked (raw, frozen or dried). Neither promiscuity, nor the presence of children under five in the home (for individuals aged five and over) showed any significant association with the prevalence of gastroenteritis. Similarly, on the whole, the principal occupation of participants aged 15 and over during the two weeks preceding the survey displayed no association with gastroenteritis episodes.

Seroprevalence of zoonotic diseases

The seroprevalence of antibodies against the eight micro-organisms studied is presented in Table A3 (Appendix). Immediately worth noting is the strong proportion of positive results for *T. gondii* and the equivocal results for *Leptospira* sp. and *F. tularensis*. The low number of

[2] Given that the analyses were performed on weighted data, the numbers of respondents are not presented in the tables. The overall proportion of partial non-responses is under 10.0% for the variables presented, except for personal income, for which this value is 15.0%. For most of the variables the biases associated with partial non-response are therefore considered to be negligible.

positive or equivocal results ($n \leq 5$) for *Trichinella* sp., *Brucella* sp. and *C. burnetii* do not allow us to present these results in the form of percentages. For this reason, the results for these three zoonotic diseases will not be included in subsequent tables.

Socio-demographic variables

Table A4 (Appendix) presents the seroprevalence results relative to sex, age, region and socioeconomic characteristics. Only the rates for *E. granulosus* and *T. gondii* show a significant difference between men and women. In both cases, more women than men are infected. On the other hand, there are significant variations among the various age groups for *E. granulosus*, *T. gondii*, *Leptospira* sp. and *F. tularensis* (positive and equivocal results combined for the last two micro-organisms). For all of these zoonotic diseases, the seroprevalence of antibodies increases with age.

In examining the data by geographical area, we observe significant variations in the seroprevalence rates of *T. canis*, *T. gondii* and *F. tularensis* (positive and equivocal combined) between the two main regions comprising the territory of Nunavik. Higher proportions for *F. tularensis* are found on the Ungava coast, while higher prevalence rates for *T. canis* and *T. gondii* are observed on the Hudson coast. In both sectors there is a north-south gradient in the seroprevalence of *T. gondii*, the rates for this parasite generally being higher in more southern communities (data not shown).

Personal income is not associated with serological status, whereas education and employment status seem to have an influence on the prevalence of antibodies against the agents responsible for several of the zoonotic diseases investigated. However, apart from *E. granulosus* and *T. canis* infections, where low prevalence does not allow us to stratify for age, these associations are generally non-significant when examined by age group.

Drinking water supply

The results show that variables related to the supply of drinking water are associated with the seroprevalence of *T. gondii* (Table A5, Appendix). The data also indicates that the seroprevalence of toxoplasmosis is significantly lower among those who consume primarily bottled water in summer or in winter compared with those who drink water from the treatment plant or municipal system, or from a natural source (lake, river, stream, melted snow or ice). Similarly, those who filter the water consumed in the home are less infected with *T. gondii*, while the prevalence among those who boil their water stands between those who filter and those who use no treatment at all. As for the frequency of cleaning the domestic reservoir, it appears that the more frequently the tank is cleaned, the greater is the proportion of individuals infected with *T. gondii*. There is a similar statistical relationship in the seroprevalence of antibodies against *E. granulosus* ($p = 0.004$) and a certain tendency in the case of *T. canis* ($p = 0.102$). For *T. gondii*, these relationships were generally unchanged with stratification by age group, with the exception of individuals aged 50 and over. No significant association was detected when the serological results of other micro-organisms were crossed with variables related to the supply of drinking water.

Nutrition, fauna and environment

No significant statistical relationship was observed when nutritional and environmental variables were crossed with the seroprevalence data for *T. canis*, *E granulosus*, *Leptospira* sp. and *F. tularensis*. These variables include the method of preparing fish, marine mammal and other meats, the frequency of hunting and fishing, the number of birds, land mammals and marine mammals handled, and berry-picking. However, among respondents to the food frequency questionnaire, when examining the seroprevalence of *F. tularensis* (positive and equivocal results) relative to the annual frequency of consumption of certain traditional foods (marine and land mammals, fish and feathered game) divided in tertiles, there is a positive association with the consumption of marine mammals ($p = 0.015$), fish ($p = 0.047$) and feathered game ($p = 0.044$). These relationships disappear with stratification by age.

For *T. gondii* (Table A5, Appendix), seroprevalence is significantly lower among those who generally consume seal meat that has been cooked as compared to those who eat it raw, frozen or dried, or who do not eat it at all. When the method of preparing seal meat is stratified for age among those who eat it, the tendency for lower seroprevalence among those who cook their meat is maintained among those aged 18-29, but is only significant among those aged 30-49 (data not shown). A similar effect, though non-significant above the 5% threshold, is observed for the consumption of other meats ($p = 0.095$). The handling of birds, the frequency of fishing and berry-picking were also associated with higher seroprevalence of *T. gondii*. However, these relationships become non-significant when we stratify by age group (data not shown).

Data from the food questionnaire dealing with the annual frequency of consumption of certain traditional foods, presented in tertiles, shows an association with the seroprevalence of *T. gondii* (Table A5, Appendix). Seroprevalence increases significantly with annual frequency of consumption of the meat of marine mammals, fish and feathered game. When stratified by age group, these results remain significant among those aged 18-29, and among those aged 30-49 for fish and feathered game (data not shown). The frequency of consumption of the meat of land mammals was not associated with seropositivity.

DISCUSSION

Drinking water

The Nunavik Inuit Health Survey indicates that about a third of the population of Nunavik consumes untreated water, a risky practice considering that the water comes from various sources of surface water that are subject to contamination by a variety of micro-organisms. Nonetheless, there are significant variations between practices on the Ungava coast and those on the Hudson coast. Ungava coast households consume less natural water and make greater use of filtration, while cleaning of the domestic reservoir is less frequent. This data suggests that practices and perceptions with regard to drinking water differ between the two sectors.

Age and the socioeconomic status of respondents also seem to be linked to the source of drinking water used in the home. Thus, the use of natural water, considered traditional as much as hunting and gathering (Martin et al., 2005), is more frequent among those aged 50 and over, who no doubt are more accustomed to it than to recent infrastructures for the treatment of drinking water. Moreover, some Inuit find that natural water has a better taste and is cooler, clearer and less contaminated than water in a domestic reservoir (Martin et al., 2005). On the other hand, individuals in the more educated category (who have completed secondary school) are apparently more aware of the risks associated with untreated water, since they use less natural water and more bottled water. Filtration of the water consumed in the home is also more frequent among these respondents, as it is among those with a personal income over $20 000. Although domestic filters are primarily used to improve the organoleptic properties of municipal water, the carbon filters commonly used in the home may contribute to removing some of the parasites found in drinking water. The expense of purchasing domestic filters could, however, constitute an obstacle to their use. Cleaning of the domestic reservoir is performed less often among those who have completed secondary school or post-secondary studies. The fact that they consume more bottled or filtered water, or that they lead busier lives, could in part explain this situation.

Gastroenteritis

In 2002, enteric infections from food and water represented 22.3% of all cases reported to the provincial MADO surveillance system (MSSS, 2005). The study revealed the crude prevalence of gastroenteritis cases over a 30-day period was 9.6%, with higher rates among extreme age groups. In a Quebec city study of the risk of gastroenteritis in families using water from a domestic well (Levallois et al., 2004), the overall prevalence of episodes of diarrhea over a period of 14 days, using a definition similar to ours, was found to be 3.4%. In this study, the presence of children under five in the home constituted a risk factor for episodes of diarrhea among the principal respondents. A second Canadian study (Majowicz et al., 2004), defining acute gastrointestinal illness more broadly as any episode of vomiting or diarrhea over a period of 28 days, estimated the prevalence of this health problem in the population of Hamilton, Ontario at 10.0%. Children from 0 to 9 years of age were the group most likely to have experienced one of these episodes.

Age does, in effect, constitute an important risk factor for gastrointestinal infections. As in other studies (Payment et al., 1991; Scallan et al., 2005), our results show a greater prevalence of diarrhea episodes among children under 5 years of age. Diarrheic infections, particularly those of viral origin such as rotavirus infections (Gurwith et al., 1983), are a major cause of ill-health among young children and infants in North America. However, in our study, the strong prevalence among individuals aged 50 and over is strikingly different from the rates measured in four industrialized countries – Canada, Australia, Ireland and the United States – where, on the contrary, the lowest rates were among persons aged 65 and over (Scallan et al., 2005). This data seems to indicate that the way of life and certain environmental factors peculiar to the inhabitants of Nunavik could influence the epidemiology of gastrointestinal infections among Inuit over 50 years of age. In addition, seasonal and regional fluctuations in the incidence of gastroenteritis could have an effect on the prevalence measured in this study. For example, the North American study by LeBaron et al. (1990) shows that the epidemic pattern of rotavirus infections follows a well-defined annual geographical sequence, with a regional peak beginning in the south-west in autumn and ending in the north-east in spring. A similar situation could have influenced the rates we measured over a short period in the communities of Nunavik, in particular among the groups at risk.

Looking elsewhere, a study conducted in Quebec among the Cree population of James Bay showed that age, household size and the village concerned were the main factors associated with parasitic infection (Brassard et al., 1985). According to the authors, children aged 1 to 9, who had the highest prevalence of intestinal parasites, could constitute an important reservoir and play a role in transmission from person to person within the community. Yet our analysis revealed no significant link between the prevalence of diarrhea and either overcrowding or the presence in the home of children under 5. Nonetheless, it should be noted that the prevalence data from our study was, except for the principal respondents, reported by third parties. A recall bias could therefore have reduced the precision of the answers regarding the number of cases reported.

With respect to drinking water supplies, the prevalence of diarrhea episodes is distinctly lower among households that clean their domestic water reservoir at least every two to six months, compared to those who do so less often. At Puvirnituq, at the time of the study, a municipal regulation required that domestic reservoirs be cleaned regularly (Hodgins, 1997; Martin et al., 2005). This regulation could be partially responsible for the low prevalence (2.3%) observed in this municipality. This data suggests that the chlorination used during cleaning of the reservoir, despite being of limited effectiveness against protozoa, seems to be effective against the bacteria and viruses generally responsible for acute episodes of gastroenteritis (OECD & WHO, 2003). These results should, however, be interpreted with caution, since cleaning the reservoir could also indicate greater care for hygiene in the daily activities of the household, including food preparation. Moreover, other variables related to drinking water (principal water source and type of treatment) do not seem to be associated with the prevalence of diarrhea. As for variables related to food, no relationship was found between gastroenteritis prevalence and the customary method of preparing meat and fish.

Zoonotic diseases

The results of the serological analyses reveal a very low seroprevalence of antibodies against *Brucella* sp., *C. burnetii* and *Trichinella* sp. Infection by *Brucella* sp. is relatively widespread in the caribou herds of the Canadian North (O'Reilly & Forbes, 1994), as it is among many species of marine mammals (Forbes et al., 2000; Nielsen et al., 2001). In Nunavut, 90 cases of brucellosis have been reported since 1950, notably in the Baffin and Qitiqmiut regions (Grondin et al., 1996), and two cases occurred in 2001 (PHAC, 2006). Nevertheless, only one case of human brucellosis in Nunavik has been reported to the MADO system since 1990 (NRBHSS, 2003). Among land mammals, in particular caribou, the distribution of this bacterium seems to be limited to areas west of Hudson Bay, while the role of marine mammals in transmission of the infection to humans is still poorly defined. The low prevalence documented in the present study seems to demonstrate limited circulation of the pathogen in the population of Nunavik. This also appears to be the case for *Coxiella burnetii*, the bacterium responsible for Q fever.

Q fever is a zoonotic disease considered to be in emergence in Quebec. In effect, the number of cases reported annually in the province has increased significantly since 1990, with a peak of 110 cases reported in 1999 (MSSS, 2001). According to Marrie et al. (1985), Q fever could constitute an important cause of atypical pneumonia. Infection with *C. burnetii* has been documented among patients in the Trois-Rivières area (Goyette et al., 1994) and in a trapper group in good health living in the Quebec area, among whom seroprevalence was 15.1% (Lévesque et al., 1995). Though domestic ruminants are generally recognized as the principal hosts, cats and a variety of mammals, along with birds and arthropods, including ticks, can be carriers of this bacterium.

In Nunavik, *Trichinella spiralis* infection has been discovered in polar bears (60%), red foxes (16%), arctic foxes (6%), dogs (10%) and walrus (2%) (Curtis et al., 1988). Numerous outbreaks of human trichinellosis following consumption of walrus meat, traditionally eaten raw, have prompted public health authorities to set up a monitoring system for the meat of this animal (Proulx et al., 2002). Despite the low seroprevalence of antibodies against *Trichinella* sp. in the present study, the presence of this parasite in many species traditionally consumed by the Inuit invites caution. Even if bears are rarely implicated in transmission of the infection in Nunavik, cases of trichinellosis associated with black bears still occur regularly (Schellenberg et al., 2003; Ancelle, 2005). The promotion of preventive measures like proper cooking of foods at risk (marine and land mammals, especially predators) and continuation of the walrus meat inspection program are crucial measures toward ensuring food safety.

Generally speaking, it appears that the seroprevalence of zoonotic diseases is greater among persons aged 50 and over than in the rest of the population, most likely due to the persistence of antibodies in the blood and prolonged exposure among such individuals. Of the zoonotic diseases investigated, our data also suggests that the Inuit population of Nunavik is potentially exposed to *Leptospira* sp. and *F. tularensis*, particularly under the hypothesis where equivocal results are considered as past infections. However, apart from age, no precise risk factor for infection by *Leptospira* sp. has been identified, whereas age and the fact of living along the Ungava coast are associated with infection by *F. tularensis*. Age also seems to influence the association between the seroprevalence of *F. tularensis* and the consumption of marine mammals, fish and feathered game, since older individuals consume more traditional foods than those who are younger (Kuhnlein et al., 2004).

The Quebec study by Lévesque et al. (1995), which however used a different methodology, found the seroprevalence of *Leptospira* sp. among a trapper group (n=165) and a control group (n=165) to be 9.1% and 4.8% respectively. These values are comparable to what we obtained when considering only positive results. However, their analyses dealt with the detection of four serovars of *L. interrogans* documented among farm animals and domestic animals in Canada (Lévesque et al., 1995), whereas our results deal with all specific antibodies against the *Leptospira* genus. The insidious character of *Leptospira* sp. infection, which can be asymptomatic, could be linked to the low number of cases reported to public health authorities, both in Nunavik and in the rest of Quebec.

A number of authors have studied tularemia in native populations of the Canadian North and Alaska (Wood, 1951; Greenberg et al., 1958; Philip et al., 1962; Martin et al., 1982). In the Inuit of Nunavik, a seroprevalence of 29% was reported by Greenberg et al. (1958) with an agglutination titre of 1:8 and over as the diagnostic threshold. More recently, Lévesque et al. (1995) obtained a seroprevalence of 2.4% for a titre above or equal to 1:20 among trappers in the Quebec region, a value lower than the 18.9% obtained in this study using an identical threshold. However, few symptoms have been observed among more northern populations, indicating that infection at these latitudes could be caused by a less virulent strain of the bacterium (type B) (Philip et al., 1962; Martin et al., 1982). This could explain the absence of Nunavik cases reported to the MADO system. Rodents, particularly muskrat and hare, are along with arthropods the species primarily implicated in the transmission of *F. tularensis*.

Certain divergences may be noted regarding the seroprevalence of parasitoses when comparing our results with those of studies performed in the 1980s using hospital serums (Tanner et al., 1987; Curtis et al., 1988). In serums from Inuit patients who were hospitalized or under outpatient care, the rates of seroprevalence varied between 1% and 4% for infection by *E. granulosus*, between 2% and 26% for *Trichinella* sp., between 7% and 20% for infection by *T. canis* and between 48% and 69% for *T. gondii*. The results of the present study, performed on a representative sample of the adult Nunavik Inuit population aged 18 to 74, show a similarly high seroprevalence for *T. gondii*, slightly higher prevalence for *E. granulosus* and lower prevalence for *Trichinella* sp. and *T. canis*. Our study reveals a relationship between age and seropositivity for *T. gondii* and *E. granulosus*. Since the blood samples that were used in the studies by Tanner et al. (1987) and Curtis et al. (1988) were taken in the hospital environment or at outpatient units, and may not have been representative of the adult population as a whole, this could account for divergences between the different studies. The sensitivity of the detection techniques used could also explain certain differences.

More women than men are infected by *E. granulosus*, while the population from the Hudson coast is more affected by *T. canis* than that of Ungava coast. Practices related to food handling as well as regional differences in the degree of environmental contamination could explain the differences observed. Echinococcosis and toxocariasis are mainly transmitted by the ingestion of oocysts excreted by canines (dogs, wolves, coyotes, etc.) and present in the soil, on the surface of edible plants or on the animals themselves. For *E. granulosus* and *T. canis*, insufficiently cooked or poorly cleaned foods, as well as soiled objects placed in the mouth, constitute the principal mode of contamination from the environment. Young children are particularly vulnerable due to their propensity to put things in their mouths, along with their exposure to animals and the soil when playing outside. However, the seroprevalence among children under 18 was not evaluated in this study. As for hydatid cysts on the liver or lungs of herbivores, which are the intermediate hosts of *E. granulosus*, these organs are generally avoided by the Inuit and would therefore not be a factor in the transmission of this parasite to humans (Curtis et al., 1988).

Medical follow-up was done with five participants who presented clearly positive results for *E. granulosus*. The cases were referred to the regional medical centre in Puvirnituq or Kuujjuaq, and the patients had a chest X-ray along with a liver echography to check for the presence of cysts. The clinical examinations did not reveal any hydatid cysts among the individuals investigated.

The relationship found between *E. granulosus* and cleaning of the domestic water reservoir is surprising, since no other variable associated with drinking water is a significant factor for this micro-organism; the same is true to a lesser degree for *T. canis*. However, Martin et al. (2005) have hypothesized that frequent but inadequate cleaning of the reservoir could be associated with total coliform presence in drinking water, indicating a possible return to circulation of certain micro-organisms or fresh contamination while cleaning. Despite regular monitoring of the bacteriological quality of the water by Nunavik municipalities, fecal contamination indicators like total coliforms, *E. coli* and enterococci do not necessarily verify the effectiveness of water treatment against parasites. Indeed, the parasites found in water are generally highly resistant to disinfection with chlorine (OECD & WHO, 2003). At the present time, little data exists on surface water contamination by protozoa in Nunavik and there is a great need for microbiological characterization studies on this subject.

Toxoplasma gondii

Age is very strongly associated with seropositivity for *T. gondii*. While generally benign, toxoplasmosis is particularly dangerous during pregnancy due to the grave consequences it can have on the fetus. It can also have significant repercussions on the health of immunodepressed individuals (Montoya & Liesenfeld, 2004). Transmission of *T. gondii* is endemic in Nunavik and seems to be generalized throughout the territory (Tanner et al., 1987). This is most surprising given that felines, the only definitive hosts known for this parasite, are rare in the region. Though the cycle of the disease in Nunavik is poorly defined, it is believed that transmission occurs primarily through consumption of contaminated raw meat, as our results seem to confirm for the consumption of seal meat and, in lesser measure, other meats. The fact that women are more frequently involved in the preparation of food could explain the slight difference in seroprevalence between the two genders.

With regards to country food, the univariate analyses show that consumption of cooked seal meat seemed to be slightly protective, whereas there was a positive association with the consumption of marine mammals, fish and feathered game. A case-control study conducted among pregnant women in Nunavik (n=22) showed an association between seropositivity and both the consumption of seal and caribou meat, and the skinning of fur-bearing animals (McDonald et al., 1990). The presence of *T. gondii* has been demonstrated in several species of animals in Nunavik, including caribou (0.8%; n = 617) (Leclair & Doidge, 2001), seal (14%; n = 28), goose (4.2%; n = 24) and ptarmigan (2.5%; n = 79) (letter from Daniel Leclair, Nunavik Research Centre). In spite of this, few studies have reported marine mammals and feathered game as sources of infection by *T. gondii*. Recent data indicates that marine mammals are naturally infected in the aquatic environment, though the source of contamination remains unknown (Measures et al., 2004). Molluscs could possibly play a role in the transmission of oocysts in marine environments (Lindsay et al., 2001; Lindsay et al., 2004). However, to our knowledge there is at present no indication of fish as potential hosts of this parasite (Omata et al., 2005).

Untreated water and chlorinated but unfiltered surface water could also be a source of infection by *T. gondii* (Bowie et al., 1997; Aramini et al., 1999). A recent study (Bahia-Oliveira et al., 2003) associated the source of drinking water with seropositivity for this parasite. According to the authors, besides age and socioeconomic status, the consumption of unfiltered water (whether from the tap or a well) or untreated water (from lakes, rivers and streams) constituted a risk factor for infection by the agent of toxoplasmosis. Despite the limits inherent in the specifications of our study, which only permit us to suggest hypotheses and not to establish cause and effect relations, our results indicate that filtration and the consumption of bottled water seem to have a protective effect against infection by *T. gondii* in Nunavik. Boiling also seems to have an effect, but a less significant one, perhaps because those who state that they boil their water may do so inconsistently or for an insufficient length of time. In view of the low density, or indeed the absence at these high latitudes of cats or wild felines, which are the only recognized hosts responsible for the excretion of oocysts into the environment, the presence of *T. gondii* in surface water appears at first glance highly improbable. However, we cannot totally reject the hypothesis that the contamination of surface water could result from the presence of a definitive host for the parasite that has not yet been documented.

Frequent cleaning of the domestic water reservoir also seems to be associated with seropositivity for *T. gondii*. The ineffectiveness of chlorination against the protozoan oocysts, which could accumulate in the biofilm covering the walls of the reservoir and be returned to circulation by inadequate cleaning, could in part explain this situation. At present, most Inuit households do not use any supplementary treatment for chlorinated surface water consumed in the home, and a third use untreated water, practices that favour exposure to a variety of pathogens, including parasites potentially resistant to the chlorination of water. Certain limits of the study, notably the number of questions dealing with risk factors associated with *T. gondii*, do not allow us to assess the influence of other variables, such as hygienic conditions that might play a role in the propagation of this infection. Nevertheless, characterization studies of the micro-organisms likely to contaminate drinking water, in particular parasites, should be carried out in order to better define the risk to the population.

There is a strong variation in the seroprevalence of *Toxoplasma gondii* between the Hudson and Ungava coasts. Differences in the environment, in food habits and in species availability could explain the divergences between the communities of the two sectors. In this regard, it would be most interesting to pursue research aimed at collecting seroprevalence data among animal species that are possibly serving as intermediate hosts. Also, the presence of a north-south gradient, particularly evident on the Hudson coast where prevalence decreases gradually to the north, could be associated with the variation of mean annual temperature, a drier and colder climate being less favourable to the survival of oocysts in the environment (Ljungstrom et al., 1995).

CONCLUSION

There is a strong association between the socio-demographic characteristics of the Inuit population and variables related to the supply of drinking water. Respondents who are younger or more educated, or who live along the Ungava coast, consume less natural water. The proportion of households that filter their water is greater among residents living along the Ungava coast, more educated respondents and individuals with an annual personal income of $20 000 or more. The frequency of cleaning domestic reservoirs also varies considerably by region, this practice being more common in Hudson households.

As for gastroenteritis, its overall prevalence in the population of Nunavik has been estimated at 9.6%, with the extreme age groups being particularly affected. While variables associated with overcrowding, the cooking of food, the principal source of drinking water and the type of water treatment do not show any significant link with episodes of gastroenteritis, frequent cleaning of the domestic water reservoir does seem to have a protective effect. This result suggests that water could constitute a vector of the disease. Given the descriptive nature of the present study, it would be interesting to determine through a more robust epidemiological design which risk factors are of greatest significance in the incidence of gastroenteritis in Nunavik.

In a similar vein, the results presented in this chapter on the seroprevalence of zoonotic infections should be interpreted with caution. The data collected in the questionnaires only documents a brief period in the lives of the individuals surveyed, whereas the serological data generally cover many years of exposure. One should therefore be prudent in attempting to interpret the relationships between seroprevalence and present-day exposures, which only partially reflect exposures in the past. Moreover, given the statistical constraints of the Nunavik Inuit Health Survey which restrain the statistical analyses to univariate analysis, the seroprevalence data for *T. gondii* and the other zoonotic diseases presented in this chapter should be examined within a multivariate analysis, which would allow the hypotheses raised to be tested while controlling for potentially confusing factors (Messier et al., in preparation).

Trichinellosis, Q fever, brucellosis, leptospirosis and tularemia are on the list of Mandatory Reportable Diseases (MADO) in Quebec. With the exception of trichinellosis, between 1995 and 2004 none of these diseases was reported to the MADO surveillance system for Nunavik (Bureau de surveillance et de vigie & DGSP, 2005). Both in the North and in the South, a number of limitations affect the declaration of zoonotic diseases and gastrointestinal disorders. The non-specific and sometimes benign manifestations associated with these infections result in a certain fraction of cases never being reported to medical authorities. Isolation and distance from medical centres could also have the effect of limiting the number of cases reported in Nunavik communities. Thus, though few cases have been documented recently, our results show that a portion of the Inuit population has been exposed to the pathogenic micro-organisms responsible for these diseases, and to *Toxoplasma gondii* in particular.

With regard to the risks surrounding the transmission of food-borne, water-borne and zoonotic diseases, in particular gastroenteritis, new knowledge indicates that a number of measures already in place should be intensified, notably in terms of information and public awareness. Particular attention could be paid to the safe handling and consumption of food, including wild game. The reinforcement of personal hygiene measures like frequent hand-washing and the cleaning of utensils used in preparing food or cutting up game could also help reduce risks of infection. Moreover, given the uncertainty surrounding potential sources of infection by *T. gondii*, it would be worth continuing to recommend to seronegative pregnant women and immunodepressed individuals that they avoid the consumption of raw and insufficiently cooked meat.

Concerning water-borne diseases, many people in Nunavik drink surface water without any treatment. It would be advisable for the population to avoid drinking untreated water without boiling it at least one minute, especially immunodepressed individuals and pregnant women. Moreover, it should be kept in mind that the sources for the municipal drinking water systems are surface water treated only by chlorination. For surface water, chlorination alone is insufficient to prevent the transmission of enteric parasitic infections. Given the provincial Drinking Water Regulation, in June 2008, water treatment in all the drinking water supplies in Quebec will have to offer a treatment sufficient to prevent infectious drinking water parasitic diseases for the population. Besides, special attention should be paid to the supply of drinking water, notably with respect to monitoring and the methods used to provide access to water that is of good quality in microbiological terms. Though water supply does present major challenges in Nunavik, efforts already under way should be pursued in order to better define microbiological risks, including the best way to clean the domestic water reservoir.

KEY ISSUES

Drinking water

- About one third of the population of Nunavik consumes untreated water. This practice is more frequent among individuals aged 50 and over. Respondents who are younger or more educated, or who live along the Ungava coast, consume less natural water.
- The proportion of households that filter their water is greater among Ungava residents, more educated respondents and individuals with an annual personal income of $20 000 or more.
- With regard to cleaning the home water reservoir, 27% of respondents said they do so every month, 31% every two to six months, and 42% once a year or less. The frequency of cleaning domestic water reservoirs also varies considerably by region, this practice being more common in Hudson households.

Gastroenteritis

- The overall prevalence of gastroenteritis in the population of Nunavik has been estimated at 9.6%, with the extreme age groups being particularly affected: the prevalence of diarrhea episodes was greater among children less than 5 years of age and among individuals aged 50 and over.
- No significant links were found between episodes of gastroenteritis and variables such as overcrowding, the cooking of food, the principal source of drinking water, and the type of water treatment.
- Frequent cleaning of the domestic water reservoir does seem to have a protective effect, the prevalence of diarrhea episodes being lower among households that clean their domestic water reservoir at least every two to six months, compared to those who do so less often.

Zoonotic diseases

- Although only few cases have been reported recently, the results show that a portion of the Nunavik Inuit population has been exposed to the pathogenic micro-organisms responsible for some of the zoonotic diseases investigated, particularly to *Toxoplasma gondii*.
- The seroprevalence data show infrequent exposure of the Nunavik Inuit to *Brucella* sp., *C. burnetii* and *Trichinella* sp.
- Age is strongly associated with seropositivity for *T. gondii*. There is also a significant variation between the Hudson and Ungava coasts, seroprevalence being higher in the former region. Differences in the environment, in food habits and in species availability could partly explain the divergences between the communities of the two regions.
- The study also reveals a relationship between age and seropositivity for *E. granulosus*, while the population living along the Hudson coast is more affected by *T. canis* than that of the Ungava coast.
- Bearing in mind the limits of a transversal study, which is not designed to identify causal factors or to confirm the etiology of infections but rather allows the formulation of hypotheses, and the fact that serological data generally cover many years of exposure, the results show statistical relationships between the seroprevalence of *T. gondii* and variables related to drinking water supply and nutrition.
- The data suggest that the Nunavik Inuit population is potentially exposed to *Leptospira* sp. and *F. tularensis*. Apart from age, no precise risk factor for infection by *Leptospira* sp. has been identified, whereas age and the fact of living along the Ungava coast are associated with infection caused by *F. tularensis*.
- It appears that the seroprevalence of zoonotic diseases is greater among persons aged 50 and over than in the rest of the population. This association with age is most likely due to the persistence of antibodies in the blood for most diseases and to prolonged exposure among older individuals.

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APPENDIX

Table A1
Interpretive criteria for the serological analyses

Pathogens	Criteria			Lifetime of antibodies
	Negative	Equivocal	Positive	
Optical density (OD)				
Trichinella sp.	< 0.25	≥ 0.25 and < 0.35	≥ 0.35	9 - 18 months
Toxocara canis	< 0.25	≥ 0.25 and < 0.35	≥ 0.35	Indefinite
Echinococcus granulosus	< 0.35	≥ 0.35 and < 0.45	≥ 0.45	Possibly for life
IgG units(IU/ml)				
Brucella sp.	< 20	≥ 20 – < 30	≥ 30	Indefinite
Leptospira sp.	< 5.0	≥ 5.0 – ≤ 9	> 9	6 months - > 20 years[a]
Coxiella burnetii	< 20	≥ 20 – < 30	≥ 30	~ 5 years[b]
Toxoplasma gondii	< 2	≥ 2 – < 3	≥ 3	For life
Titre				
Francisella tularensis	< 1/20	1/20 – 1/40	≥ 1/80	> 10 years[c]

[a] According to Faine (1998).
[b] Virion\Serion, Serion Immundiagnostica GmbH, Würzburg (manufacturer's manual).
[c] According to Young et al. (1969).

Table A2
Variables significantly associated with episodes of gastroenteritis (%), members of Inuit households, Nunavik, 2004

	Prevalence [a]	Prolonged episodes (3 days and more) [a]
Total	9.6	38.9
Age group		
0-4 years	15.1	47.7
5-14 years	5.9[E]	22.2 [E]
15-49 years	8.6	34.6
50 years +	16.0	53.7
P-value	***< 0.001***	***0.008***
Coastal region		
Hudson	7.1	42.1
Ungava	12.9	36.7
P-value	***0.001***	*0.445*
Frequency of cleaning the domestic reservoir		
Once a month	5.3	44.6 [E]
Once every 2 to 6 months	6.8	51.2
Once a year or less	14.8	31.2 [E]
P-value	***< 0.001***	*0.052*

[a] P-values indicated in bold are significant below the 0.05 threshold.
E Interpret with caution.
Source: Nunavik Inuit Health Survey 2004.

Table A3
Seroprevalence of Trichinella sp., Toxocara canis, Echinococcus granulosus, Toxoplasma gondii, Brucella sp., Coxiella burnetii, Leptospira sp. and Francisella tularensis (%), population aged 18 to 74 years, Nunavik, 2004

	Trichinella sp.	*T. canis*	*E. granulosus*	*T. gondii*	*Brucella* sp.	*C. burnetii*	*Leptospira* sp.	*F. tularensis*
Positives	F	3.9	8.3	59.8	F	F	5.9	2.6^E
Negatives	98.9	95.2	89.6	37.2	99.6	99.0	81.7	81.1
Equivocals	F	0.9^E	2.1^E	2.9^E	F	F	12.4	16.3

E Interpret with caution.
F Unreliable estimate.
Source: Nunavik Inuit Health Survey 2004.

Table A4
Seroprevalence of Toxocara canis, Echinococcus granulosus, Toxoplasma gondii, Leptospira sp. and Francisella tularensis according to sex, age, region and socioeconomic characteristics (%), population aged 18 to 74 years, Nunavik, 2004

	T. canis [a]	*E. granulosus* [a]	*T. gondii* [a]	*Leptospira* sp. [a]		*F. tularensis* [a]	
	+ [b]	+ [b]	+ [b]	+ [b]	+/eq. [c]	+ [b]	+/eq. [c]
Sex							
Men	3.5^E	4.2^E	57.0	5.9^E	18.6	2.5^E	18.7
Women	4.2^E	12.6	62.8	5.9^E	17.9	2.6^E	19.0
P-value	*0.579*	***< 0.001***	***0.048***	*0.970*	*0.810*	*0.939*	*0.872*
Age group							
18-29 years	F	7.1^E	41.4	4.9^E	14.4	F	12.8
30-49 years	3.1^E	7.0	63.7	5.4^E	18.2	F	16.0
50 years +	11.2^E	13.1	86.5	8.8^E	25.8	6.7^E	36.3
P-value	-	***0.008***	***< 0.001***	*0.157*	***0.005***	-	***< 0.001***
Coastal region							
Hudson	5.5^E	9.1	65.6	6.0^E	19.5	F	16.2
Ungava	1.7^E	7.2	52.3	5.8^E	16.7	4.0^E	22.3
P-value	***0.002***	*0.265*	***< 0.001***	*0.878*	*0.302*	-	***0.007***
Education level							
Elementary school completed or less	9.1^E	15.4	83.1	8.1^E	23.7	5.8^E	27.3
Secondary school not completed	3.3^E	7.4	56.3	5.6^E	17.2	F	13.7
Secondary school completed or higher	F	3.7^E	46.7	4.6^E	14.5^E	F	19.6
P-value	-	***< 0.001***	***< 0.001***	*0.317*	*0.053*	-	***< 0.001***
Job status							
Work / unemployment insurance / hunter support program / student	3.4^E	7.1	57.5	5.3^E	17.1	1.9^E	16.6
Housework / retired or on pension / social welfare	6.8^E	11.9^E	69.7	7.1^E	19.5	F	25.1
P-value	***0.044***	***0.036***	***0.004***	*0.399*	*0.493*	-	***0.007***
Income							
Less than $20 000	3.3^E	8.8	61.7	4.7^E	17.4	2.2^E	17.4
$20 000 to $39 999	4.7^E	8.3^E	60.9	9.1^E	15.4^E	F	19.6
$40 000 and over	4.9^E	5.6^E	55.4	5.2^E	18.5^E	F	21.6
P-value	*0.540*	*0.390*	*0.353*	*0.078*	*0.709*	-	*0.415*

[a] P-values in bold are significant below the 0.05 threshold.
[b] Positive serologies.
[c] Positive and equivocal serologies combined.
E Interpret with caution.
F Unreliable estimate.
Source: Nunavik Inuit Health Survey 2004.

Table A5
Variables linked to drinking water and food significantly associated with the seroprevalence of *Toxoplasma gondii* (%), population aged 18 to 74 years, Nunavik, 2004

	Seroprevalence[a]
Supply of drinking water	
Source of drinking water – summer	
Bottled water	32.4[E]
Municipal system/treatment plant tap	59.2
Lake, river, stream	65.0
P-value	***< 0.001***
Source of drinking water – winter	
Bottled water	35.2[E]
Municipal system/treatment plant tap	59.1
Melted snow or ice, lake, river	64.9
P value	***< 0.001***
Treatment of water in the home	
Filtration	48.7
Boiling	57.5
No treatment	65.2
P-value	***< 0.001***
Frequency of cleaning the domestic reservoir	
Once a month	68.0
Once every 2 to 6 months	56.0
Once a year or less	57.2
P-value	***0.010***
Method of preparing meat	
Seal	
Cooked (fried, boiled, roasted)	56.4
Raw, frozen or dried	66.8
Don't eat it	65.5
P-value	***0.013***
Frequency of annual consumption, in tertiles[b]	
Marine mammals	
0 to 19 times	51.9
20 to 95 times	63.3
96 times or more	65.7
P-value	***0.003***
Fish	
0 to 35 times	51.6
36 to 115 times	58.1
116 times or more	70.7
P-value	***< 0.001***
Feathered game	
0 to 18 times	49.4
19 to 56 times	59.6
57 times or more	71.2
P-value	***< 0.001***

[a] P-values in bold are significant below the 0.05 threshold.
[b] Presented according to the approximate number of times the food was consumed during the year.
E Interpret with caution.
Source: Nunavik Inuit Health Survey 2004.

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HOW ARE WE?