

PREVALENCE AND ENVIRONMENTAL RISK FACTORS FOR TEN ZOOSES IN TWO
CREE COMMUNITIES OF JAMES BAY (CANADA)

by

Sophie Campagna

Essay presented to the "Centre universitaire de Formation en Environnement" to obtain
the degree of master in environment (M.Env.)

CENTRE UNIVERSITAIRE DE FORMATION EN ENVIRONNEMENT
UNIVERSITÉ DE SHERBROOKE

Perth, Australia, January 2009

Data sheet

Prevalence and environmental risk factors for ten zoonoses in two Cree communities of James Bay (Canada)

Sophie Campagna

Essay conducted to obtain the degree of Master in Environment (M.ENV.)

Essay directed by Dr Benoit Lévesque

University of Sherbrooke
January 2009

Key words: zoonose, prevalence, *Toxocara sp.*, *Coxiella burnetii*, *Francisella tularensis*, *Leptospira sp.*, *Echinococcus granulosus*, *Trichinella sp.*, *Toxocara canis*, Sin Nombre virus, *Toxoplasma gondii*, Jamestown Canyon, Snowshoe hare, California virus, aboriginal, climate change.

Zoonoses are diseases transmitted from animals to humans and populations in close contact to wildlife are more at risk to contracting them. A study to document the seroprevalence for ten zoonotic infections was conducted in the Cree communities of Eastmain and Wemindji (Canada) in 2007. The general objective of this essay is to present the seroprevalence and environmental risk factors for the populations of Eastmain and Wemindji for the ten pathogens investigated. Estimated seroprevalence are: *Leptospira sp.* (23%), *Coxiella burnetii*, *Francisella tularensis* (17%, titer > 1/20), *Toxoplasma gondii* (5%), the Sin Nombre virus (0%), two of the virus of the California serogroup (10%) (Snowshoe hare and Jamestown Canyon viruses) and of than less 5% for *Echinococcus granulosus*, *Toxocara canis* and *Trichinella sp.* Risk factors associated to the diseases are “being male”, “hunting” and owning a dog”. There are relatively few health effects associated with the diseases. Physician should investigate for both *F. tularensis* and *Leptospira sp.* in cases of severe ocular pathologies and for *F. tularensis* in cases of strong pharyngitis. The effects of zoonotic diseases are marginal compared to the benefits of maintaining a traditional diet and preserving a feeling of connectedness to traditions and culture.

Summary

Zoonoses are diseases transmitted from animals to humans. They are found worldwide and populations in close contact with nature are at higher risk to contracting them. In Quebec, aboriginal populations as well as trappers may be more at risk of contracting zoonoses. These diseases are commonly difficult to diagnose, as their symptoms are non-specific and they may be under reported.

A study to document the seroprevalence for ten zoonotic infections was conducted in the Cree communities of Eastmain and Wemindji (Canada) in 2007. The general objective of this essay is to present the seroprevalence and environmental risk factors for the populations of Eastmain and Wemindji for the ten pathogens investigated: *Leptospira sp.*, *Coxiella burnetii*, *Francisella tularensis*, *Toxoplasma gondii*, *Echinococcus granulosus*, *Toxocara canis*, *Trichinella sp.*, the Sin Nombre virus and two of the virus of the California serogroup (Snowshoe hare and Jamestown Canyon viruses).

Results indicate that there were no statistical differences in seroprevalence between the two communities. *Leptospira sp.* (23%) seroprevalence was higher than found in previous studies in different parts of Quebec. In counterpart, the seroprevalence for *T gondii* (5%) was lower than other regions of Northern Quebec and most industrialized countries. The seroprevalence for *F. tularensis* (17%, titer > 1/20) was comparable to a previous study realised in Nunavik but higher than previously documented in Southern Québec. *C. burnetii* seroprevalence (1%) was lower than already documented for a population from Southern Québec and comparable to data obtained for Inuit populations of Northern Québec. This is the first time that seroprevalence data is presented for the California viruses (Jamestown Canyon and Snowshoe hare viruses) in Northern Quebec (10%). The other zoonoses (*E. granulosus*, *T. canis* and *Trichinella sp.*) had prevalence inferior to 5%, which are comparable to seroprevalence previously estimated in other parts of Northern Quebec. No evidence of Sin Nombre virus was found in Eastmain-Wemindji.

Identification of specific risk factors for the diseases was planned but partially successful. Risk factors to being seroprevalent to any of the ten zoonoses or testing positive to the California serovars were: being male, hunting and owning a dog. The variables “hunting” and “being male” were correlated and results had to be presented in different models. Risk

factors to being seroprevalent to leptospirosis or tularemia could not be identified. As for the other diseases, low seroprevalence resulted in such small sample sizes that the identification of risk factors for contracting these diseases was not possible.

The design of the study was dedicated to verify past exposures to the pathogens investigated without knowing if clinical manifestations of the diseases were present. The review of the medical files permitted to document some health effects possibly related to these infections for few people. However, it did not show major health problems. Nevertheless, considering the potential for exposure, it would be of value to inform clinicians and the population, mostly those in close contact with fauna, about the zoonotic diseases.

There is a paucity of data on zoonotic diseases prevalence for aboriginal populations of northern Quebec. In the absence of data, it is very challenging to predict what would be the impacts of climate changes on the prevalence of zoonotic diseases, or what adaptation measures should be privileged in order to prevent an increase of their prevalence. Climate change could bring exotic diseases and have an effect on wildlife distribution and abundance, which in turn would have an effect on pathogens distribution. Nonetheless, the seroprevalence data collected during this study constitute a good base line in a context of climate change susceptible to modify the epidemiology and surveillance of zoonotic diseases.

It is recommended that health care workers be aware of the zoonoses, in particular *F. tularensis* and *Leptospira sp.* Physician should investigate for both these diseases in cases of severe ocular pathologies and for *F. tularensis* in cases of strong pharyngitis. Hunters and trappers who seem to be more at risk, should be made aware of the clinical features of different zoonotic infections, particularly *F. tularensis* and *Leptospira sp.*, as well as safe procedures for handling dead animals. In general, care must be taken to weigh out the messages that are given to the communities. The fear of zoonotic diseases should not prevent people from consuming country foods. The zoonotic diseases effects are marginal compared to the benefits of maintaining a traditional diet and preserving a feeling of connectedness to traditions and culture.

Sommaire

Les zoonoses sont des maladies transmises par les animaux aux humains. On les retrouve partout à travers le monde et les populations qui sont en contact étroit avec la nature courent plus de risque de les contracter. Au Québec, les populations autochtones ainsi que les trappeurs peuvent être plus à risque de contracter des zoonoses. Ces maladies sont habituellement difficiles à diagnostiquer car leurs symptômes sont non spécifiques et elles peuvent être sous déclarées.

Une étude pour documenter la séroprévalence pour dix infections à caractère zoonotique a été menée dans les communautés Cries d'Eastmain et de Wemindji (Canada) en 2007. L'objectif général de cet essai est de présenter la séroprévalence et les facteurs de risque environnementaux pour les populations d'Eastmain et de Wemindji pour les dix pathogènes investigués : *Leptospira sp.*, *Coxiella burnetii*, *Francisella tularensis*, *Toxoplasma gondii*, *Echinococcus granulosus*, *Toxocara canis*, *Trichinella sp.*, le virus Sin Nombre et deux des virus du séro groupe California (les virus Snowshoe Hare et Jamestown Canyon).

Les résultats indiquent qu'il n'y avait pas de différence statistique entre les prévalence des deux communautés. La prévalence de *Leptospira sp.* (23%) était plus élevée que lorsque mesurée lors d'études antérieures dans différentes régions du Québec. En contrepartie, la séroprévalence pour *T. gondii* (5%) était plus faible que dans d'autres régions du nord du Québec et que dans la plupart des pays industrialisés. La séroprévalence pour *F. tularensis* (17%, titre > 1/20) était comparable à celle d'une étude menée au Nunavik mais plus élevée que précédemment documentée dans le sud du Québec. La séroprévalence de *C. burnetii* (1%) était inférieure à celle documentée pour une population du sud du Québec et comparable aux données obtenues pour les populations inuit du nord du Québec. C'est la première fois que des données de séroprévalence sont présentées pour les virus California (virus Jamestown Canyon et Snowshoe Hare) dans le nord du Québec (10%). Les autres zoonoses (*E. granulosus*, *T. canis*, et *Trichinella sp.*) avaient des prévalences inférieures à 5%, qui sont comparables aux séroprévalences qui avaient été estimées dans d'autres régions du nord du Québec. Aucune évidence du virus Sin Nombre n'a été retrouvée à Eastmain-Wemindji.

L'identification de facteurs de risque particuliers aux maladies était planifiée mais partiellement accomplie. Les facteurs de risque associés à être séropositif pour l'une des dix zoonoses ou tester positif pour les sérovars des virus California étaient : être un homme, chasser et posséder un chien. Les variables « chasser » et « posséder un chien » étaient corrélées et les résultats ont dû être présentés dans deux modèles différents. Les facteurs de risque pour être séropositif pour la leptospirose ou la tularémie n'ont pu être identifiés. La faible séroprevalence estimée pour les autres zoonoses a résulté en de si petites tailles d'échantillons que l'identification des facteurs de risque pour contracter ces maladies n'était pas possible.

L'étude était conçue pour vérifier les expositions aux pathogènes identifiés sans savoir si les manifestations cliniques étaient présentes. L'examen des dossiers médicaux a permis de documenter les effets possibles sur la santé en lien avec ces infections pour quelques personnes. Par contre, l'étude n'a pas révélé de problèmes de santé majeurs. Néanmoins, considérant les risques d'exposition, il serait utile d'informer les cliniciens et la population au sujet des zoonoses, particulièrement ceux qui sont en contact étroit avec la faune.

Il y a peu de données sur la prévalence des zoonoses pour les populations autochtones du nord du Québec. En l'absence de données, il est très difficile de prévoir ce que seraient les impacts des changements climatiques sur la prévalence des zoonoses, ou quelles mesures d'adaptation devraient être privilégiées afin de prévenir une augmentation des prévalences de zoonoses. Les changements climatiques pourraient apporter des maladies exotiques et avoir un impact sur l'abondance et la distribution de la faune. Néanmoins, les estimés de séroprevalence et les données recueillies pourraient s'avérer très utiles dans les prochaines années dans un contexte de changements climatiques et de développement économique de cette région.

Il est recommandé que les travailleurs de la santé soient informés des zoonoses, en particulier sur *F. tularensis* et *Leptospira sp.* Les médecins devraient investiguer pour ces deux maladies dans les cas de pathologies oculaires sévères et pour *F. tularensis* dans les cas de fortes pharyngites. Les chasseurs et trappeurs, qui semblent plus à risque, devraient être informés des manifestations cliniques des différentes zoonoses, particulièrement *F. tularensis* et *Leptospira sp.*, ainsi que des procédés recommandés pour la manipulation des animaux morts. De façon générale, il faut prendre soin de peser

les messages qui sont transmis aux communautés. La peur des zoonoses ne devrait pas empêcher les gens de consommer de la nourriture traditionnelle. Les effets des zoonoses sont marginaux comparés aux bénéfices de maintenir une diète traditionnelle et la préservation d'un sentiment d'appartenance aux traditions et à une culture.

Acknowledgements

I would like to thank my director Benoit Lévesque who has been inspiring and supportive all along this project. Thanks to Robert Carlin, Michael Drebot and Michael Libman who reviewed portions of the essay used for publication. Thanks also to Elhadji A. Laouan Sidi who conducted the analyses and was extremely helpful in helping to interpret the results. The data presented in this essay were collected through the Nituuchischaayihititaa Aschii Multi-Community Environment-and-Health Longitudinal Study in Iiyiyu Aschii. The Cree Board of Health and Institut National de Santé Publique (INSPQ) du Québec were instrumental in this research project. Thanks to all the people who worked on the Nituuchischaayihititaa Aschii survey. I am grateful to the population of Eastmain and Wemindji and particularly to the participants of the study. Several researchers were involved in the collection, sample and data analysis and in commenting an earlier version of this essay. I am indebted to Anne Gauthier who greatly supported this project. Finally, thanks to Marjolaine Rondeau and Nadine Gaudette for the encouragements; and to David Veilleux for the most excellent moral support.

TABLE OF CONTENTS

INTRODUCTION	1
1. ZOOSES	5
1.1 PARASITES	5
1.1.1 <i>Toxoplasmosis</i>	7
1.1.2 <i>Cystic echinococcosis</i>	8
1.1.3 <i>Toxocariasis</i>	10
1.1.4 <i>Trichinellosis</i>	12
1.2 BACTERIA	13
1.2.1 <i>Tularemia</i>	13
1.2.2 <i>Leptospirosis</i>	15
1.2.3 <i>Q fever</i>	17
1.3 VIRUSES	18
1.3.1 <i>California encephalitis virus group (Snowshoe hare and Jamestown Canyon)</i>	18
1.3.2 <i>Hantavirus pulmonary syndrome (HPS)</i>	20
2. JAMES BAY COMMUNITIES AND ENVIRONMENT	23
2.1 JAMES BAY ENVIRONMENT	23
2.2 JAMES BAY COMMUNITIES	26
2.2.1 <i>Wemindji</i>	26
2.2.2 <i>Eastmain</i>	26
2.3 EXISTING HEALTH NETWORK	26
2.4 TRADITIONAL KNOWLEDGE AND ACTIVITIES.....	27
3. CLIMATE CHANGE AND ADAPTATIONS	29
3.1 CLIMATIC PREDICTIONS AND EXPECTED EFFECTS.....	29
3.2 VEGETATION	29
3.3 WILDLIFE	30
3.4 ZOOSES.....	30
3.5 ADAPTATIONS	31
4. MATERIAL AND METHODS	33
4.1 LITERATURE REVIEW	33
4.2 DATA COLLECTION.....	33
4.3 LABORATORY BLOOD TESTS	33
4.4 REVIEW OF MEDICAL RECORDS	34
4.5 STATISTICS.....	35
5. RESULTS	36
5.1 SAMPLES	36
5.2 POPULATION STUDIED	36
5.3 PREVALENCE OF INFECTIONS	36
5.3 REVIEW OF THE MEDICAL RECORDS	37
5.4 IDENTIFICATION OF POTENTIAL RISK FACTORS.....	39
5.4.1 <i>Univariate analysis</i>	39
5.4.2 <i>Multivariate analysis</i>	39
6. DISCUSSION	41
6.1 PREVALENCE OF ZOOZOTIC DISEASES	41
6.1.1 <i>Leptospirosis</i>	43
6.1.2 <i>Tularemia</i>	44
6.1.3 <i>California serogroup virus disease (SSH, JC)</i>	46

6.1.4 <i>Toxoplasmosis</i>	47
6.1.5 <i>Echinococcosis</i>	48
6.1.6 <i>Toxocariasis</i>	48
6.1.7 <i>Q fever</i>	49
6.1.8 <i>Trichinellosis</i>	50
6.1.9 <i>Hantavirus Pulmonary Syndrome (HPS)</i>	51
6.2 RISK FACTORS	52
6.3 EXPECTED IMPACTS OF CLIMATE CHANGE ON ZOOSE PREVALENCE	53
6.4 DIET AND OTHER ISSUES	54
7. RECOMMENDATIONS	56
CONCLUSION.....	57
CONCLUSION (FRANÇAIS).....	59
REFERENCES	61

LIST OF FIGURES

Figure 2.1. First Nations communities of Québec from http://www.ainc-inac.gc.ca/qc/aqc/nat_f.html . (INAC, 2004).	24
Figure 2.2. James Bay region showing road access and communities from http://www.crebj.ca/index.php?option=com_content&task=view&id=21&Itemid=27 (CRE James Bay, 2008)	26

LIST OF TABLES

Table 1.1. Summary of studied zoonotic diseases and symptoms with information on vectors and reservoir adapted for Canada and northern regions. (P): Parasites, (B): Bacteria, (V): Virus.....	6
Table 4.1. Criteria for the interpretation of serologic analyses and estimated antibodies persistence for ten zoonotic infections (from Lévesque et al., 2007 unless otherwise mentioned).....	34
Table 5.1. Results of serological analyses for ten zoonotic infections performed on blood samples obtained from members of the communities of Wemindji (n=140) and Eastmain (n=111) in 2007. For technical reasons, some samples for certain pathogens have not been analysed (E.g.: insufficient amount of serum, sample not received to the laboratory etc.).....	38
Table 5.2. Relationship between several variables and seropositivity to the California serogroup viruses in the two Cree communities of Eastmain and Wemindji, Quebec, in 2007.....	40
Table 5.3. Relationship between several variables and seropositivity to at least one of the ten zoonotic infections investigated in the two Cree communities of Eastmain and Wemindji, Quebec, in 2007.....	40
Table 6.1. Summary table of known seroprevalences of the studied infections. Results should be interpreted with caution, as some of the diagnostic criteria and methods are not identical between studies.....	42

LIST OF ACRONYMS, SYMBOLS AND LOGOS

ELISA:	enzyme-linked immunosorbent assays
INSPQ:	Institut national de santé publique du Québec
IPCC:	Intergovernmental panel on climate change
MADO :	Maladie à déclaration obligatoire
MSSS :	Ministère de la santé et des services sociaux du Québec
PHAC:	Public Health Agency of Canada
SAS:	Statistical analysis software
SNV:	Sin Nombre virus

LEXICON

Accidental host: One that accidentally harbors an organism that is not ordinarily parasitic in the particular species. (Farlex Inc., 2008).

Arbovirus: A contraction of “arthropod borne viruses”. They are viruses that can develop within, and be transmitted by, arthropods. (Séguin, 2008).

Arthropods: Invertebrate animals such as insects and arachnids. (e.g.: mosquitoes, ticks).

Emerging zoonose: A zoonose that is newly recognized or newly evolved, or that has occurred previously but shows an increase in incidence or expansion in geographical, host or vector range. Emerging zoonotic diseases have potentially serious human health and economic impacts and their current upwards trends are likely to continue. (WHO, 2008c).

Endemic: Prevalent in or restricted to a particular region, community, or group of people. Present in a predictable, continuous pattern in an animal community at all times; said of a disease which is clustered in space but not in time. (Farlex Inc., 2008)

Pathogen: An agent that causes infection or disease, especially a microorganism, such as a bacterium or protozoan, or a virus. (Farlex Inc., 2008)

Final host: Definitive host; the organism in which a parasite passes its adult and sexual existence. Also known as primary host (Farlex Inc., 2008).

Reservoir: An alternate host or passive carrier of a pathogenic organism. (Farlex Inc., 2008).

Vector: An organism, such as a mosquito or tick, that spreads pathogens from one host to another. (Farlex Inc., 2008).

Vector-borne disease: Diseases that must be transmitted by an invertebrate host such as a mosquito or a tick. (E.g.: malaria, California viruses, Lyme disease, West Nile virus) (Séguin, 2008).

Zoonose: Disease and infection that are naturally transmitted between vertebrate animals and humans (WHO, 2008d). Also known as zoonosis or zoonotic disease (Farlex Inc., 2008).

INTRODUCTION

Zoonoses are diseases transmitted from animal to humans; interactions between human and animals are the cause of zoonotic diseases prevalence. Transmission of the diseases may happen through direct contact with animals or through ingestion of tainted water or meat.

Of all 1415 species of infectious organism known to be pathogenic to humans, 61% are zoonotic (Taylor et al., 2001). Out of the emerging pathogens, 132 (75%) are zoonotic, and overall, zoonotic pathogens are twice as likely to be associated with emerging diseases than non-zoonotic pathogens, with protozoa and viruses particularly likely to emerge (Taylor et al., 2001).

There are many well-known zoonoses. Malaria has caused an estimated 247 million cases globally (range: 189–327 million) and 881,000 deaths in 2006 (WHO, 2008a). Avian flue (H5N1 strain) that has been responsible of a worldwide alert and 247 persons died from 15 different countries between 2003 and 2008 (WHO, 2008b). The West Nile virus, brought to Canada via migratory birds, has spread across Canada with over 1800 people affected and 46 deaths (Séguin, 2008). Most of Canadians live near the southern border and are concerned with the West Nile Virus and Lyme disease. Luckily, these diseases affect very few Canadians.

Zoonotic diseases are one important subject included in the vast topic of environmental health. It deserves a complete chapter in the textbook “Environnement et santé publique” (Choutet et al., 2003). It is particularly relevant in relation to climate change as recognized by the publication “Human health in a changing climate” published by Health Canada (Séguin, 2008). The INSPQ has recently published a technical report on zoonotic diseases and climate change (Giguère and Gosselin, 2006;). Moreover, a health program that includes a component on zoonotic diseases was added in 2006 to the Ouranos research program. Ouranos is a climate change consortium of researchers based in Montreal, Quebec (Bourque and Simonet, 2008).

Many factors lead to the emergence of zoonotic diseases such as environmental changes, human and animal demography, lifestyle of human populations (e.g.: international travel),

changes in pathogen lifecycle and transmission patterns and changes in farming practice (WHO, 2008b). Some zoonotic diseases have a worldwide distribution but have localized transmission modes, vectors, and hosts. Even their virulence can be different depending on the regions where they occur. Zoonotic diseases are commonly difficult to diagnose, as their symptoms are non-specific and may be under reported. Important regional variations in disease prevalence and epidemiology are noted due to differences in wildlife, environment, and social and cultural factors such as food habits and religious beliefs (Choutet et al., 2003; WHO, 2008c).

Aboriginal populations tend to have greater contact with nature through their hunting, trapping and fishing activities and consumption of untreated water. There is a paucity of data on zoonotic diseases prevalence for aboriginal populations of Northern Quebec. Previous studies have reported zoonoses prevalence from Cree trappers (Lévesque et al., 2007), and populations from Northern Québec (Tanner et al., 1987; Messier et al., 2007). A study was conducted through the ArcticNet program on Inuit communities and included a study of zoonoses (Messier et al., 2007). So far, results have shown that prevalence of zoonotic diseases varies between communities and that risk factors for several diseases remain to be understood.

Climate changes impacting on animal populations and traditional hunting and dietary habits will have an effect on zoonoses prevalence. Climate models predict some temperature increases and modification in precipitation regimes, which in turn would alter some diseases prevalence and distribution due to the range extension of the vectors (e.g.: ticks and mosquitoes) that require milder climate to complete their lifecycle and establish themselves.

This essay presents seroprevalence for ten zoonotic infections among the general population of Eastmain and Wemindji, two communities located on the shores of James Bay (Figure 2.1). The studied zoonotic pathogens are: *Coxiella (C.) burnetii* (Q fever), *Francisella (F.) tularensis* (Tularemia), *Leptospira sp.* (leptospirosis), *Echinococcus (E.) granulosus* (echinococcosis), *Trichinella sp.* (trichinellosis), *Toxocara (T.) canis* (toxocariasis), Sin Nombre virus (Hanta virus infection), *Toxoplasma (T.) gondii* (toxoplasmosis) and infections caused by two viruses, namely Jamestown Canyon (JC) and Snowshoe hare (SSH), which are two serotypes of the California serogroup.

Data used for this essay came from questionnaires and blood samples collected in the setting of the “Nituuchischaayihitaa Aschii Multi-Community Environment-and-Health Longitudinal Study in Iiyiyiu Aschii” on the health of the Cree people that plans to investigate the health of each of the nine Cree communities located in Northern Quebec. It includes research on obesity, diabetes, chronic diseases, contaminants, diet and zoonoses. The research project involves the “Institut National de Santé Publique du Québec”, the Cree Nation Board of Health, physicians and scientists from Laval, McGill and McMaster Universities as well as scientists from several specialized research centres. The project involves scientists, nurses, health care staff, field technicians, epidemiologists, dieticians and statisticians. It is a survey designed to gather social and health information on a variety of themes including different health indicators, standardized physical measurements, and social, environmental and living conditions.

The first three sections of the essay provide general information on the 10 zoonoses studied, the James Bay communities and their environment including a portrait of the two communities and finally, the predicted climate changes and adaptations. These first three sections provide the background to understand the study results and fully understand their environmental context. The rest of the essay is structured like a research paper with the following sections: material and methods, discussion, recommendations and conclusion.

Material and methods section explains mostly the methods used to realise the study. Results of blood test analysis showing presence or absence of antibodies for the zoonotic infections in Eastmain and Wemindji and the relationship with different risk factors are presented in the next section (Results). Data collected were analysed to produce seroprevalence rates for the two populations, which were compared to data from adjacent communities in the Discussion section and explained within an environmental context. Finally, recommendations to health care staff and communities are included.

The general objective of this essay is to determine the prevalence and risk factors for 10 zoonotic diseases for the Cree populations of Eastmain and Wemindji in Northern Quebec. Results found should be useful to Cree populations of Eastmain and Wemindji to provide them with the basic information on zoonotic diseases that are present in their communities and the basic tools to prioritize and recognize the infections. Recommendations based on

the results found are formulated for health care staff and community leaders. Healthcare practitioners may use the information to better detect infections. Data collected will also be useful as baseline data in a perspective of climate change.

1. ZOONOSES

A zoonose is any disease or infection that is naturally transmissible from vertebrate animals to humans (WHO, 2008d). Animals thus play an essential role in maintaining zoonotic infections in nature. Zoonoses may be bacterial, viral, or parasitic, or may involve unconventional agents (WHO, 2008d). As well as being a public health problem, many of the major zoonotic diseases prevent the efficient production of food of animal origin and create obstacles to international trade in animal products (WHO, 2008d).

Disease transmission can be direct through bites or direct contact with contaminated fluids of an infected host or indirect via a vector that carries the disease, for example arthropod (mosquitoes, ticks) that transfer the disease from an host to the next (Choutet et al., 2003). The vector is generally asymptomatic.

In Québec the MADO (maladies à déclaration obligatoire) is a list of diseases that have to be declared by physicians or laboratories to the health authorities as these diseases have a high potential to cause an outbreak, are known threats to health, require monitoring by health authorities or are preventable by health authorities (MSSS, 2005). The diseases investigated in this essay are due to parasites, bacteria and viruses (Table 1.1). From the 10 infections studied, tularemia, Q fever, trichinellosis, infection caused by Hantavirus, and viral encephalitis caused by arthropods (California viruses including Snowshoe Hare and Jamestown Canyon) are included in the MADO list in Québec (MSSS, 2005).

1.1 Parasites

Parasites are organisms that feed on a host or require a host to obtain food as they cannot obtain prey on their own. They can be single-cell organisms such as protozoan or small animals such as worms or larval stages of arthropods. Toxoplasmosis is attributed to the protozoan *T. gondii*, a single-cell organism that is found in the flesh of infected animals or in the water. Flatworms for instance live in the intestine of humans where they obtain food that goes through the digestive system; they can reach an impressive size and may form cysts. *E. granulosus* is a flatworm (platyhelminthes) that form cyst in the infected host and *Trichinella sp.* and *T. canis* are round worms that tend to remain fairly small in size.

Table 1.1. Summary of studied zoonotic diseases and symptoms with information on vectors and reservoir adapted for Canada and northern regions. (P): Parasites, (B): Bacteria, (V): Virus

Disease name	Latin name	Distribution	Vector/reservoir	Risk factors	Symptoms
Toxoplasmosis	<i>Toxoplasma gondii</i> (P)	Worldwide,	Felidae (Definitive host) other mammals (accidental host)	Consuming undercooked infected meat; contaminated hands or food	Asymptomatic, cervical lymphadenopathy and/or a flu-like illness, congenital infection
Cystic echinococcosis	<i>Echinococcus granulosus</i> (P)	World wide rural areas	Canids (final host) Intermediate host (moose/deer-sylvatic cycle)	Exposure to dogs feces. Dogs shed eggs in feces after consuming internal organs of infected mammals	Cysts may develop in internal organs. Remain silent for years
Toxocariasis	<i>Toxocara canis</i> (P)	Worldwide	Dog (definite host) Human (accidental host)	Contact with dogs feces contaminated, consuming eggs in contaminated soil	fever, anorexia, weight loss, cough, wheezing, rashes, hepatosplenomegaly, and hypereosinophilia
Trichinellosis or trichinosis	<i>Trichinella sp.</i> (P)	Worldwide, US/ Europe	Pig, bear, walrus	Ingestion of partially cooked meat	gastrointestinal symptoms, conjunctivitis, fever, myalgias, splinter hemorrhages, rashes, and blood eosinophilia
Tularemia	<i>Francisella tularensis</i> (B)	Temperate regions (north of 30°N)	Muskrats (Canada) Rabbits, hares, rodents, ticks (USA)	Contact with animals (insects, ticks, coyotes, foxes, cats, dogs)	Different types de symptoms (ulcere of the skin, lung problems, fever, adenopathy, conjunctivitis)
Leptospirosis	<i>Leptospira sp.</i> (B)	Tropical/ sub temperate humid regions	Rodents, other mammals	Contact with wildlife, water through water sports,	Flue like symptoms, aseptic meningitis, hepatic or kidney problems
Q fever	<i>Coxiella burnetii</i> (B)	Worldwide	Cats (North America) Sheep, goat, other mammals	Contact with infected animals, particularly at parturition	Fever (3 to 57 days) Pneumonia, Headaches Chronic: endocarditis
Infection caused by California virus	Jamestown Canyon (JC) (V)	North America	Mosquitoes, White tail deer, large mammals	Contact with infected mosquitoes	Asymptomatic, headaches, encephalitis
Infection caused by California virus	Snowshoe hare (SSH) (V)	North America	Mosquitoes, White tail deer large mammals	Contact with infected mosquitoes	Asymptomatic, headaches, encephalitis
Hantavirus Pulmonary Syndrome (HPS)	Sin Nombre virus (V)	North America	Host deer mouse (<i>peromyscus maniculatus</i>)	Contacts with rodents, aerosolized rodent excreta	Pulmonary hemorrhagic fever

1.1.1 Toxoplasmosis

Toxoplasmosis is a disease due to the protozoan *T. gondii* (CDC, 2008a). It is generally asymptomatic in most but may cause flu like symptoms or adverse effect in fetuses if the mother is infected (CDC, 2008a).

Distribution

Toxoplasmosis is one of the most common infections throughout the world although it is more common in warm climate and low altitude (CDC, 2008a).

World prevalence

Toxoplasmosis prevalence in European countries ranges from 10% in the United Kingdom and Norway to 51% in France and Greece (Cook et al., 2000). A survey, conducted from 1988 to 1994, of a representative sample of the US population of 27 145 persons aged \geq 12 years, showed an age-adjusted seroprevalence of 22.5% (CI 95%: 21.1- 23.9) (Jones et al., 2001). The average prevalence is 59.8% in Inuit communities of Nunavik (northern Quebec), with higher prevalence in southernmost communities (Messier et al., 2007).

Vector/host

Cats are the definitive host of the disease; they get the disease through their eating habits (CDC, 2008a). Cats shed oocysts for only 1 or 2 weeks in their life (CDC, 2008a), which can explain why being exposed to cats, is not the main risk factor for contracting the disease (Cook et al., 2000). Intermediary hosts are diverse and include most species of warm-blooded animals (CDC, 2008a) as well as chicken and birds (PHAC, 2001a). The oocysts are resistant to drying, disinfectants but are killed by heating to 70°C for 10 minutes (CDC, 2008a). They remain virulent up to a year in water or moist soil (PHAC, 2001a). Freezing can kill cysts present in meat (Dubey and Jones, 2008). However, if meat is not sufficiently frozen, cysts remain infectious as long as the meat is edible and uncooked (PHAC, 2001a). In Nunavik, the parasite's lifecycle is not well understood, since Felidae are not present in the environment (Messier et al., 2007).

How is it contracted?

The main ways of contracting the disease are through eating undercooked contaminated meat (lamb, beef or game), contact with contaminated soil or travel in developing countries

(Shuhaiber et al., 2003). Known risk factors include consumption of raw meat, unwashed foods or drinking contaminated water (Dubey, 2004). A Toxoplasmosis outbreak due to the contamination of the water municipal supply caused 100 cases of acute toxoplasmosis and infected a few thousand people in Victoria, British Columbia (Bowie et al., 1997; Dubey, 2004). Transplacental transmission is possible and may have very severe effects on the developing fetus (CDC, 2008a). Congenital toxoplasmosis results from an acute primary infection acquired by the mother during pregnancy, the severity in the fetus will depend on trimester at which the mother became infected (CDC, 2008a).

Symptoms/effects

Toxoplasmosis is usually asymptomatic in healthy individuals but 10 to 20% of patients with acute infection may develop cervical lymphadenopathy or flu-like symptoms that will resolve within a few months to a year (CDC, 2008a). Immunodeficient patients often have central nervous system (CNS) disease but may also have retinochoroiditis or pneumonitis. In rare cases, the disease can be fatal (CDC, 2008a). Congenital infection may result in brain damage, hydrocephaly, jaundice, hepatosplenomegaly, even death (Shuhaiber et al., 2003). Some asymptomatic infant may develop retinochoroiditis in the second or third decade of life (CDC, 2008a).

Cure

Toxoplasmosis can be cured through antibiotic. No vaccine currently exists for population who are at risk (Kilstra and Jongert, 2008).

1.1.2 Cystic echinococcosis

Cystic echinococcosis is caused by the larval stages of tapeworms of the species *E. granulosus* where worms develop cysts in various internal organs, particularly the lungs and liver (PHAC, 2001b; CDC, 2008b). There are two variant of the disease: the pastoral form which is contracted through the sheep and dog cycle and that can be lethal if not treated and the sylvatic cycle which is contracted through moose and wolves cycle and that seem less severe (Somily et al., 2005).

Distribution

Cystic echinococcosis occurs worldwide but most common in temperate sheep raising areas (PHAC, 2001b).

World prevalence

It is estimated that about 50 millions people are at risk to contract one of the three forms of echinococcosis in Africa and Asia (Hemphill and Kern, 2008). Approximately 2-3 millions cases of cystic echinococcosis are occurring at any one time in the world (Hemphill and Kemp, 2008). In the 1950's, 31% of 2000 native patients in northwestern Canada showed positive reactions for hydatid fluid antigen (Unruh et al., 1973). Studies have shown that 72% of wolves in Alberta were infected (Unruh et al., 1973). A study of dogs fecal sampling in 12 First Nations communities of Northern Saskatchewan, Central and Northern Alberta and the Northwest Territories revealed that *Echinococcus*/*Taenia* infections were found consistently in all areas. However, methods did not allow species identification between *Taenia* and *Echinococcus* (Unruh et al., 1973). *Taenia*/*Echinococcus* eggs incidence were higher in Alberta and Saskatchewan (around 50%) than in the Northwest Territories (around 20%) (Unruh et al., 1973).

Vector/host

The final host is canine species; especially dogs with intermediary hosts being herbivores such as sheep, bovine, swine, goats and horses (Eckert and Deplazes, 2004; PHAC, 2001b). Coprophagic flies may act as mechanical vectors of the eggs (PHAC, 2001b). In northern North America, *E. granulosus* is maintained in cycles involving wolves and dogs and moose and other cervids (Moro and Shantz, 2006). As already mentioned, there are two types of *Echinococcus granulosus* infections: the pastoral variant, which is transmitted via sheep as the intermediary host and the sylvatic variant that has the caribou or moose as intermediary host (Somily et al., 2005). Molecular techniques permit to distinguish the two forms (Somily et al., 2005). In areas where there are no sheep, it is assumed that it is the sylvatic variant (Somily et al., 2005).

How is it contracted?

Exposure to *E. granulosus* is generally from the ingestion of eggs from dogs' feces that could be present in the environment on soil, plants or on the animals. Canines feed on the infected internal organs of herbivores. The presence of large number of dogs infected with *E. granulosus*, especially stray dogs is a risk factor to echinococcosis emergence (Eckert and Deplazes, 2004). In Alberta, contact with the definitive host was the risk factor with

42% of infected people who were aboriginal people; most infected people were middle-aged women (Somily et al., 2005).

Symptoms/effects

The initial phase of the primary infection is always asymptomatic (Eckert and Deplazes, 2004). Echinococcosis may remain asymptomatic for years and form cysts in lungs, liver or subcutaneous tissues (PHAC, 2001b). There is the possibility that silent cyst form in the liver or the lungs (Eckert and Deplazes, 2004). The onset of symptoms if they appear will depend on the cyst location, numbers and development (Eckert and Deplazes, 2004). Pleuritic chest pain, cough and dyspnea were reported by patients with pulmonary involvement and abdominal pain in some patients with hepatic involvement (Somily et al., 2005). Pulmonary cysts are more common in children and young adults while the hepatic cysts are more common in older people (Somily et al., 2005). Cystic echinococcosis can be lethal if a large cyst collapse, causing an anaphylactic shock (Eckert and Deplazes, 2004). Cyst rupture can have very serious consequences, especially in the pastoral form. The sylvatic form of the disease seems to be more benign than the pastoral form (Somily et al., 2005). The sylvatic variant is prone to rupture without complication or anaphylaxis (Somily et al., 2005).

Cure

The sylvatic variant may rupture without complication or anaphylaxis (Somily et al., 2005). Surgery or cyst aspiration is required to remove silent cysts from the pastoral variant or if there are pressure symptoms or secondary infection in the sylvatic form (Somily et al., 2005).

1.1.3 Toxocariasis

Toxocariasis is a disease caused by ingestion of larval round worms, of the genus *Toxocara*, where worms migrate through organs such as the eye causing partial to complete vision loss or the gastrointestinal system causing pain and various disorders.

Distribution

Toxocariasis is found worldwide (PHAC, 2001c).

World prevalence

The disease is especially prevalent in preschool age children. Toxocariasis infection is common in urban children (Marmor et al., 1987). Contamination of dog prevalence in Halifax was measured to be 26% with a higher prevalence in stray dogs less than 6 months old (56%) (Malloy and Embil, 1978). A study in dogs of 12 First Nations settlements revealed a low incidence in Saskatchewan and Central Alberta, and appeared to be almost non-existent further North (Unruh et al., 1973). *T. canis* prevalence was higher in puppies than in older dogs and in the south; it was virtually absent from the North (Unruh et al., 1973).

Vector/host

There is no vector. The main host is the dog. Foxes have been reported as hosts in New Brunswick and Nova Scotia (Smith, 1978). Puppies generally have a higher prevalence than adults (Unruh et al., 1973; Maloy and Embil, 1978).

How is it contracted?

Eggs are ingested from contaminated soil or unwashed vegetables (PHAC, 2001c). Direct contact with infected dogs and especially puppies is a source of the disease (Malloy and Embil, 1978). It can also be contracted from eating raw infected tissues such as the liver from infected animals such as chicken, sheep or cattle (PHAC, 2001c). Eggs remain viable in soil for months (PHAC, 2001c).

Symptoms/effects

There are two forms of the disease both due to the systemic migration of the larval form of the helminthes; the ocular larval migrans (OLM) that affects the eye and the visceral larval migrans (VLM) that affects the internal organs such as the liver and the lungs (CDC, 2007). VLM causes gastrointestinal symptoms such as nausea or cramping. If larvae migrate in muscle, it causes muscle soreness and pain. Ocular larva migrans (endophthalmitis) symptoms include leukokoria, loss of vision in the affected eye, eye pain and strabismus (PHAC, 2001c). A study suggested that infection might be associated with adverse neuropsychological effects in children (Marmor et al., 1987). Disease is rarely fatal (PHAC, 2001c).

Cure

VLM is treated with antiparasitic drugs, usually in combination with anti-inflammatory medications (CDC, 2007). Treatment of OLM is more difficult and usually consists of measures to prevent progressive damage to the eye (CDC, 2007).

1.1.4 Trichinellosis

Trichinellosis is a disease caused by the ingestion of an intestinal parasite *Trichinella sp.*, a round worm that affects the internal organs of mammals (including humans) causing pain and gastrointestinal problems.

Distribution

Trichinella is found worldwide with localized outbreaks (PHAC, 2001d; Pozio, 2001). The sylvatic cycle is that which occurs in nature among carnivores with cannibalistic and scavenger behavior (Pozio, 2001). This cycle occurs virtually throughout the world, and nearly all of the studies that have attempted to reveal its presence have succeeded in doing so (Pozio, 2001).

World prevalence

In Canada, an average number of cases of 18 per year attributed to consumption of game meat were reported (Pozio, 2001). Most outbreaks of trichinellosis in Canada have been due to *Trichinella nativa*, which is generally found in hosts from Arctic and subarctic regions and is resistant to freezing (McIntyre et al., 2007). The prevalence of 0.06 case per 100 000 inhabitants in Canada is less than in Romania (11.4) and higher than in Germany and the USA which both report 0.01 case per 100 000 inhabitants (Pozio, 2001).

Vector/host

Historically, pigs were considered to be the main reservoir of *Trichinella*, but a recent Canadian survey showed no evidence of *Trichinella* infection in domestic swine populations (McIntyre et al., 2007). Swine related outbreaks have not been reported in Western Europe since World War II and are reported in developing countries or countries at war (Pozio, 2001). Reservoir animals include swine, dogs, cats and wild animals such as fox, bears and marine mammals (PHAC, 2001).

How is it contracted?

Trichinella is contracted through consuming undercooked or raw infected meat. Risk factors for *Trichinella sp.* in Northern Canada have been associated with consuming infected black bear or walrus meat (Public health agency of Canada, 2001a; McIntyre et al., 2007). Large outbreaks associated with consuming infected walrus meat were declared in Nunavik (Public health agency of Canada, 2001d).

Symptoms/effects

Eosinophilia is often substantial and appears early after the infection. Symptoms such as diarrhea, muscle pain or edema appear within 7 to 21 days (McIntyre, 2001). During a trichinellosis outbreak in the Arctic the symptoms of people affected were: diarrhea (50%), muscle pain (47%), fatigue (47%), rash (32%), fever (17%) and edema (PHAC, 2001d). Severe infections can be lethal (CDC, 2004).

Cure

If trichinellosis is considered early in the differential diagnosis and is confirmed by serologic testing as soon as possible, antihelminthic agents such as mebendazole or albendazole may be useful in eradicating larvae-producing worms (McIntyre et al., 2007).

1.2 Bacteria

Bacteria are unicellular, small size organisms. They have the faculty of reproducing very rapidly, exponentially through asexual reproduction. Tularemia, Q fever and Leptospirosis are diseases due to bacterial infections investigated in this study.

1.2.1 Tularemia

Tularemia is an acute, febrile, sometimes highly virulent disease caused by the bacterium *F. tularensis*, transmitted by a range of animals such as rodents and lagomorphs. It may cause epidemics and epizootics (WHO, 2007).

Distribution

Tularemia is a bacterial zoonotic disease of the northern hemisphere with 2 of the 4 subspecies found in North America; the type A being mainly found in the US and the type B, less virulent, being found elsewhere including Canada (WHO, 2007).

World prevalence

Tularemia cases do not have a predictable occurrence. Endemic regions with frequent outbreaks can be next to regions free of tularemia. Moreover, it may occur several years in a row in a region and not be present there again for the next ten years (WHO, 2007). There has been a decline in occurrence since the 1950s, which could potentially be due to the decrease in number of people living in rural areas and/or decreased exposure to rodents (WHO, 2007). In the USA, some 1400 cases were reported from 1990 to 2000, as compared to more than 14 000 cases from 1920 to 1945 (WHO, 2007). In Canada 9, 10 and 15 cases were reported for the years 2002, 2003 and 2004 respectively (PHAC, 2006). In Quebec, an average of 9 cases were declared yearly between 1996 and 2007 (CCWHC, 2008).

Vector/host

Reported vectors are various arthropods such as ticks or deerfly for the Type A (WHO, 2007). In the USA, ticks are considered as the most important vectors east of the Rocky Mountains. *Francisella tularensis* have been reported from 13 tick species (WHO, 2007). Other reported hosts for tularemia are several species of rodents and lagomorphs including voles, hares, beavers and several species of mice (WHO, 2007). Type B, subspecies *holarctica*, could be associated with streams, ponds, lakes, rivers, and semi-aquatic animals such as muskrats and beavers and has been considered by some authors to be a waterborne disease (WHO, 2007). Subspecies *holarctica* has recently been shown to survive and replicate in protozoa found in streams and rivers (WHO, 2007). Nevertheless, Type B has been found also in hares and other animals.

How is it contracted?

F. tularensis is transmitted to humans by arthropod bites (ticks, mosquitoes, deerflies and other), by direct contact with infected animals (primarily hare and rabbits), by infectious animal tissues or fluids, by ingestion of contaminated water or food and by inhalation of infective aerosols (WHO, 2007). There is no human-to-human transmission (WHO, 2007). Transmission patterns may also change over time. In Canada, for example, contact with rabbits was the most common source of infection before the 1950s, while more recently, the water-living muskrat appears to be of greater importance (Martin et al., 1982). Survival outside the host is fairly long: 133 days in carcasses and organs, 136 days in bedbugs or

grain dust, 31 days in rabbit meat, and 3 years in infected frozen (-15C) rabbit meat (PHAC, 2001e)

Symptoms/effects

Tularemia can occur in six different clinical forms depending on route of entry of the bacteria in the body: ulceroglandular, glandular, oculoglandular, pharyngeal (oropharyngeal), typhoidal and pneumonic (Meric et al., 2008). *F. tularensis* subsp. *tularensis* (Jellison type A) and *F. tularensis* subsp. *holarctica* (Jellison type B) are the most common subspecies in human diseases. This last one is associated with relatively milder disease than the first one (Meric et al., 2008). Tularemia symptoms consist of sudden fever, chills, headaches, diarrhea, muscle aches, joint pain, dry cough and progressive weakness (CEC, 2003a). Other symptoms include ulcers on the skin or mouth, swollen and painful lymph glands, swollen and painful eyes, and a sore throat (CEC, 2003a). People can also catch pneumonia and develop chest pain, bloody sputum and can have trouble breathing and even sometimes stop breathing (CEC, 2003a). In type B tularemia, fever predominates and is accompanied by focal symptoms and generally milder symptoms than those of type A tularemia. The disease can be fatal if it is not treated with the right antibiotics (CEC, 2003a). Type B tularemia is much less severe than type A tularemia and fatal cases are rare (WHO, 2007).

Cure

Tularemia can be cured through antibiotics (CEDC, 2003A). A vaccine for tularemia is under review by the Food and Drug Administration and is not currently available in the United States (CDC, 2003a). Tularemia may require a considerable period of convalescence (WHO, 2007).

1.2.2 Leptospirosis

Leptospirosis is a disease caused by bacteria of the genus *Leptospira* that affects humans and animals (CDC, 2005a). There are more than 200 serovars worldwide (PHAC, 2001f).

Distribution

Leptospirosis occurs worldwide but is most common in temperate or tropical climates (CDC, 2005a).

World prevalence

Leptospirosis occurs worldwide but reliable data on its incidence and prevalence in different areas are scarce. It is probably overlooked and underreported in many parts of the world (WHO, 2003).

Vector/host

Reservoirs include farm and pet animals such as cattle, dogs, horses and swine; rats and other rodents act as the normal carriers (PHAC, 2001f). A variety of wild animals such as squirrel, deer, foxes skunks and even reptiles and amphibians can act as carriers (PHAC, 2001f). It has been reported in racoons in Québec where four serovars were found (Mikaelian et al., 1997). The prevalence of infection in lynx and bobcat has been found to be very low (Labelle et al., 2000). Leptospirosis has been hypothesized to be linked with climate change in Ontario, as prevalence increased (Prescott et al., 2002)

How is it contracted?

Humans become infected through contact with water, food, or soil containing urine from these infected animals. Outbreaks of leptospirosis are usually caused by exposure to water contaminated with the urine of infected animals (CDC, 2005a). *Leptospira sp.* organisms have been found in cattle, pigs, horses, dogs, rodents, and wild animals; infected animals may become sick but sometimes have no symptoms (CDC, 2005a). Infection may happen by swallowing contaminated food or water or through skin contact, especially with mucosal surfaces, such as the eyes or nose, or with broken skin (CDC, 2005a). Disease transmission from person to person has not been reported (CDC, 2005a). Soil contaminated by infected urine can remain infectious for weeks (PHAC, 2001f).

Symptoms/effects

Infection by *Leptospira sp.* can be asymptomatic, but symptoms of leptospirosis include high fever, severe headache, chills, muscle aches, jaundice, abdominal pain, vomiting, diarrhea, cutaneous rash and ocular symptoms (uveitis), (CDC, 2005a). If the disease is not treated, the patient could develop kidney damage, meningitis (inflammation of the membrane around the brain and spinal cord), liver failure, and respiratory distress. In rare cases, death occurs. Many of these symptoms can be mistaken for other diseases. Leptospirosis is confirmed by laboratory testing of a blood or urine sample. (CDC, 2005a)

Cure

Leptospirosis can be treated with antibiotic (CDC, 2005a).

1.2.3 Q fever

Q fever is a highly infectious disease due to the bacterium *C. burnetii* (CDC, 2003b).

Distribution

Q fever is a bacterial disease found worldwide and is endemic in many areas (CDC, 2003).

World prevalence

Because the disease is underreported, scientists cannot reliably assess how many cases of Q fever have actually occurred worldwide (CDC, 2003b). The disease may be underreported, as it is often subclinical with only half the patients showing signs of illness (CDC, 2003b). Between 1998 and 2000, some cases of Q fever have been declared in Quebec (35 in 1998, 112 in 1999 and 35 in 2000), and all were related to transmission by sheep or goats or their fluids or excrements (MAPAQ, 2001). In Quebec, a study conducted on trappers found the same prevalence (15%) of infection between trappers and controls and no risk factor could be identified (Lévesque et al., 1995).

Vector/host

Cattle, sheep and goats are the primary reservoirs (CDC, 2003b). Cats, rodents, lagomorphs and birds can contaminate humans (MAPAQ, 2001). Ticks can contribute to maintain the infection in the environment (MAPAQ, 2001).

How is it contracted?

Contamination occurs through airborne exposure of bacteria from dust of contaminated premises and through direct contact with infected animals, especially goats and sheep and their birth products (PHAC, 2001g). Other modes of transmission include tick bites (CDC, 2003b). The contaminated environment remains infectious for months, given that the bacteria are highly tolerant to dryness, heat, cold, detergents and UV (MAPAQ, 2001). In Quebec, some cases were associated to contact with livestock or cats (Goyette et al., 1994). Other cases were linked with parturient sheep or goat in a commercial center or eating outdoors near a goat farm (MAPAQ, 2001). Worldwide, many outbreaks occurred in meat packing plants, stockyards and research facilities housing sheep (PHAC, 2001g).

Symptoms/effects

It can present itself as acute or chronic form (CDC, 2003b). Acute cases of Q fever being a sudden onset of high fever, severe headaches, confusions, sore throat, vomiting, diarrhea, abdominal and chest pain, pneumonia and hepatitis (CDC, 2003b). The chronic form of the disease is uncommon but severe and is characterized by infections that last more than 6 months. Patients who had an acute Q fever may develop the chronic form between 1 and 20 years after the initial infection (CDC, 2003b). It could cause endocarditis (CDC, 2003b).

Cure

Acute Q fever is usually treated with antibiotic doxycycline while treatment of chronic illness requires the use of multiple drugs (CDC, 2003b). A vaccine has been developed in Australia but is not available in North America (PHAC, 2001g). Q fever antibody is very specific and cross reactivity is not known (Herbert et al., 1965).

1.3 Viruses

Viruses are very small organisms that parasitize their host. They are transmitted through a variety of mechanisms including contact with infected fluids from humans or animals. In recent years, the West Nile virus, newly introduced in Canada, and the avian flue have been highly publicized due to their potential for infecting large number of people. The California serogroup consists of several related viruses, some of which cause disease in humans. Two of the California viruses (JC and SSH viruses) and the Sin Nombre virus, a Hantavirus, have been investigated in the present study.

1.3.1 California encephalitis virus group (Snowshoe hare and Jamestown Canyon)

The first recognized case in Canada occurred in 1981 in Ontario (CCWHC, 2000a). The California encephalitis virus group is due to some of the many viruses that are part of the California virus group which includes SSH and JC viruses (PHAC, 1999). SSH and JC viruses have caused human diseases in Canada (PHAC, 2007).

Distribution

The presence of the California virus serogroup has been demonstrated in all provinces and territories in Canada (PHAC, 2007). The JC virus has been reported in Alaska and in several Canadian provinces including Quebec (Artsob, 1990). The SSH virus has been reported from all Provinces and territories in Canada (PHAC, 2007). JC and SSH viruses

are considered emerging in regions of Canada and United States contiguous to Alaska (Walters et al., 1999).

World prevalence

Few human diseases were associated with these viruses until 1960, but now California serogroup virus infections are the most commonly reported cause of arboviral encephalitis in the United States (Eldridge et al., 2001). Prevalence were reported in native populations of Alaska for the JC virus (6.5%), SSH virus (3.5%) and for any of the California virus tested (JC, SSH, INK-Inkoo) (21.8%). There has been one symptomatic case per year between 1978 and 1989 for a total of 20 cases in Canada; most of these were attributable to SSH virus (Meier-Stephenson et al., 2007). There was no notified case from 1990 until 2006 in Cree territory (Carlin, 2007).

Free ranging mammals tested in Alaska had a 96.7% seroprevalence to at least one of the eight viruses tested (Walters et al., 1999). Elk (57%) in Michigan and moose (71%) from Ontario have been known to be seropositive to the JC virus (Grimstad et al., 1986). White-tailed deer had 21% prevalence to JC virus in Connecticut. However, in Connecticut, JC is not thought to be as significant threat for human populations as in other regions of the US (Zamparo et al., 1997).

Vector/host

California viruses are transmitted through mosquitoes and maintained through the wildlife (Walters et al., 1999). Transovarial transmission of California viruses in *Aedes* species mosquitoes appears to be a very effective mechanism for adaptation of these viruses to the Canadian ecosystem (Meier-Stephenson et al., 2007). California viruses are known to infect a variety of mammals including squirrels, chipmunks, hares, deer, moose, cattle, horse and swine (PHAC, 2007).

The vectors of JC virus are snowpool *Aedes sp.* mosquito species (Zamparo et al., 1997). The natural vertebrate hosts of JC virus are white-tailed deer in the eastern United States (Moore et al., 1993). JC virus persists in cycles of infection among wild ungulates, especially the White-tailed Deer (*Odocoileus virginianus*), and several different species of mosquito (CCWHC, 2000a). JC virus prevalence in mosquitoes coincided with warm winters and surge in white tail deer populations in New York (Zamparo et al., 1997).

Many different species of mosquito can become infected with and transmit SSH virus (CCWHC, 2000b). These include many species of the genus *Aedes*, as well as species of *Culiseta* and of *Culex* (CCWHC, 2000b). A wide range of wild mammal species can be infected with SSH virus, and, for most geographic areas in which the virus occurs, it is not clear which species are the principal hosts (CCWHC, 2000b). The Snowshoe Hare (*Lepus americanus*) is thought to be important in some areas of Canada, but other species may be equally or more important as maintenance and amplifying hosts (CCWHC, 2000b). Evidence of infection has been found in wild species, including Snowshoe Hare, 7 rodents, 4 carnivores, 3 ungulates and Ruffed Grouse, and in 4 domestic species - chickens, dogs, horses and cattle (CCWHC, 2000b).

How is it contracted?

California viruses are contracted through bites from infected mosquitoes.

Symptoms/effects

Infection by California serogroup virus results in asymptomatic to mild febrile illness and a variety of neurologic syndromes, including encephalitis (Meier-Stephenson et al., 2007).

Cure

Because the arboviral encephalitides are viral diseases, antibiotics are not effective for treatment and no effective antiviral drugs have yet been discovered (CDC, 2005). Treatment is supportive, attempting to deal with problems such as swelling of the brain, loss of the automatic breathing activity and other treatable complications like bacterial pneumonia (CDC, 2005).

1.3.2 Hantavirus pulmonary syndrome (HPS)

The Sin Nombre virus (SNV) is a rodent-borne Hantavirus that is the main cause in North America of the Hantavirus pulmonary syndrome (HPS), a severe cardiopulmonary illness.

Distribution

The SNV exists for a long time. It appeared in humans following ecological perturbations, which caused infected rodents to be in contact with humans (Ratiarson, 2003). The SNV was discovered in the United States in 1993 (Hart and Bennett, 1999). It is now found from

Alaska to Mexico while it is more abundant in western North America (Graziano and Tempest, 2002). Its distribution mirrors the one of its host, the deer mouse (*Peromyscus maniculatus*) (Calisher et al., 2002).

World prevalence

There are an estimated 100 000 to 200 000 cases of Hantavirus infection each year worldwide (Hart and Bennet, 1999). The annual incidence of Sin Nombre HPS in the United States is 0.02/100 000 population (Hart and Bennett, 1999). Between 1993 and March 2007, there have been 465 confirmed cases of HPS in 30 states resulting in a 35% mortality rate in the United States (Roberts and Lim, 2008). As of October 1st, 2008, there have been 70 cases of HPS in Canada (Drebot, Pers. Comm., 2008). However, only one case has been identified east of Manitoba (Drebot, Pers. Comm., 2008). It was in Quebec, in 2005 (Weir, 2005). Of the four Hantavirus species implicated as etiologic agents of HPS in North America, SNV has been associated with the largest proportion of cases (Drebot and Artsob, 2000).

Vector/host

The primary host of SNV is the deer mouse (Dragoo et al., 2006). It is one of the most common mammals in North America and is found from the Arctic to Mexico (Prescott and Richard, 2004). The presence of Hantavirus infected mice was documented in every province except Prince Edward Island and Nova Scotia, areas where sampling was limited (PHAC, 2000). Seropositive mice have also been found in the Yukon, but not in the Northwest Territories and Nunavut (PHAC, 2000). The Hantaviruses are known to infect rodents, in which they produce asymptomatic chronic infection with viral shedding in urine, feces and saliva (Lindsay et al., 2001). In two studies in Montana and one in New Mexico, prevalence of antibodies to SNV has been found to be nearly twice as high in deer mice (*Peromyscus maniculatus*) in peridomestic settings as in sylvan settings (Douglass et al., 2006). During early investigations of HPS, it was found that most HPS cases were contracted in peridomestic settings (Douglass et al., 2006).

Only a small proportion of infected deer mice are shedding SNV at any one time. Recently infected deer mice are more likely to shed SNV and thus might represent a greater risk of human infection (Safronetz et al., 2008).

P. maniculatus harbours at least two hantaviruses; SNV, primarily in the western United States, and Monongahela virus (MONV) in the eastern United States and Canada, suggesting a phylogeographical split in both host and virus (Dragoo et al., 2006). Some authors consider the Monongahela virus to be a strain of SNV. SNV (family Bunyaviridae, genus Hantavirus) is the principal cause of Hantavirus pulmonary syndrome (HPS) in North America and remains the only etiological agent of HPS identified in Canada (Safronetz et al., 2008). Molecular phylogeography can be used to elucidate population structure among deer mice and develop a predictive framework for discovering novel SNV variants (Dragoo et al., 2006).

How is it contracted?

Humans ingest or breathe infected aerosolized particles or are in contact with infected urine. There is no known man-to-man transmission of the disease (Graziano and Tempest, 2002). The infection predominantly affects people in rural areas and it is most common in the spring and summer in the United States (Graziano and Tempest, 2002). In confirmed cases where exposure information was known, 70% of infected people had had exposures to rodents via domestic activities such as cleaning houses that had rodent infestation (Roberts and Lim, 2008). Occupational exposure is less common but has been seen in grain farmers or field biologists (Roberts and Lim, 2008).

Symptoms/effects

Symptoms are non-specific and resemble any other viral illness: influenza-like illness lasting 3-5 days (Roberts and Lim, 2008). In a few infected people, after seven days, the cardiopulmonary phase of the disease begins and hypotension with progressive non-cardiogenic pulmonary edema and severe hypoxia occur (Robert and Lim 2008). HPS is a highly lethal hemorrhagic fever in humans (Wahl-Jensen et al., 2007). In the United States, the mortality rate was 35% between 1993 and March 2007 (Roberts and Lim, 2008).

Cure

There are no vaccines or specific drugs to prevent or treat HPS, and the pathogenesis is not understood (Wahl-Jensen et al., 2007). Early recognition in the prodromal phase can expedite cardiopulmonary support in an intensive care unit that is associated with improved survival rates (Graziano and Tempest, 2002). There is no specific treatment other than supportive care (Roberts and Lim, 2008).

2. JAMES BAY COMMUNITIES AND ENVIRONMENT

Cree communities (Figure 2.1) are located in Nord-du-Québec (Northern Quebec), an immense territory sparsely inhabited. The Nord-du-Québec administrative region covers 839,000 square kilometers, of which 121,000 square kilometers are lakes and rivers (MDDEP, ND). The Nord-du-Québec administrative region is itself composed of two smaller regions, the Jamésie region south of the 55th parallel and the Nunavik region in the North.

The Nunavik covers over 500 000 km², located between the 55 and 62 degrees latitude. Nunavik has some boreal forest in its southern portion but is mainly tundra, which covers the entire Ungava Peninsula. Only 11 000 people divided between 14 communities reside there of which nearly 90% are Inuit (Régie Régionale de la Santé et des Services Sociaux du Nunavik, 2003). Only one community in Nunavik, Kuujuarapik, is inhabited by both Cree and Inuit peoples. It is the northernmost Cree community.

The Jamésie region extends over 350,000 km² - from the 49th to the 55th parallel and from the eastern shore of James Bay to the Otish Mountains of the Laurentian Plateau. It covers one fifth of the province of Québec (CRE James Bay, 2008) and mainly consists of boreal forest. The population includes over 15 000 Jamesian (MAMR, 2008) and 15 000 Cree people divided between 8 communities (Wemindji, 2006). The two communities involved in the present study are located in the Jamésie region.

2.1 James Bay environment

The James Bay area (Figure 2.2) is considered Quebec's resource region. Natural resources are exploited; mines, hydroelectricity and forestry; more than 50% of Hydro Quebec's hydroelectricity comes from the James Bay region (CRE James Bay, 2008). A large project, the Eastmain 1-A/Sarcelle/Rupert project will produce an additional 8.5 TerraWatt Hours (TWh) of electricity through the diversion north of the Rupert River when completed in 2012 (Hydro Québec, 2008). This represents the power used by Quebec city annually (500 000 homes) (Hydro Québec, 2007)

The Matagami-Radisson highway links the James Bay region to southern Quebec. Chisasibi is located about 1600 km North of Montreal. The nearest town is Matagami

located about 720 km south of Chisasibi. This region is very isolated from the rest of the province. Each community has an airport that offers regular flights to the major cities.



Figure 2.1. First Nations communities of Québec from http://www.ainc-inac.gc.ca/qc/aqc/nat_f.html. (INAC, 2004).

The region is located at the northern limit of the boreal forest (boreal shield ecozone) and the southern limit of the Taiga shield near the Hudson Plains (Environment Canada, 2005). The boreal forest mainly composed of black spruce and larch surrounds the communities and the area is rich in wetlands and lakes and recognized for its diversity in waterfowl as well as abundance of mosquitoes in the summer. Wildlife is plentiful and mainly consists of bears, moose, deer, beavers, wolves and caribous. Geese and several other species of migratory birds are present during their seasonal migration (Environment Canada, 2005).

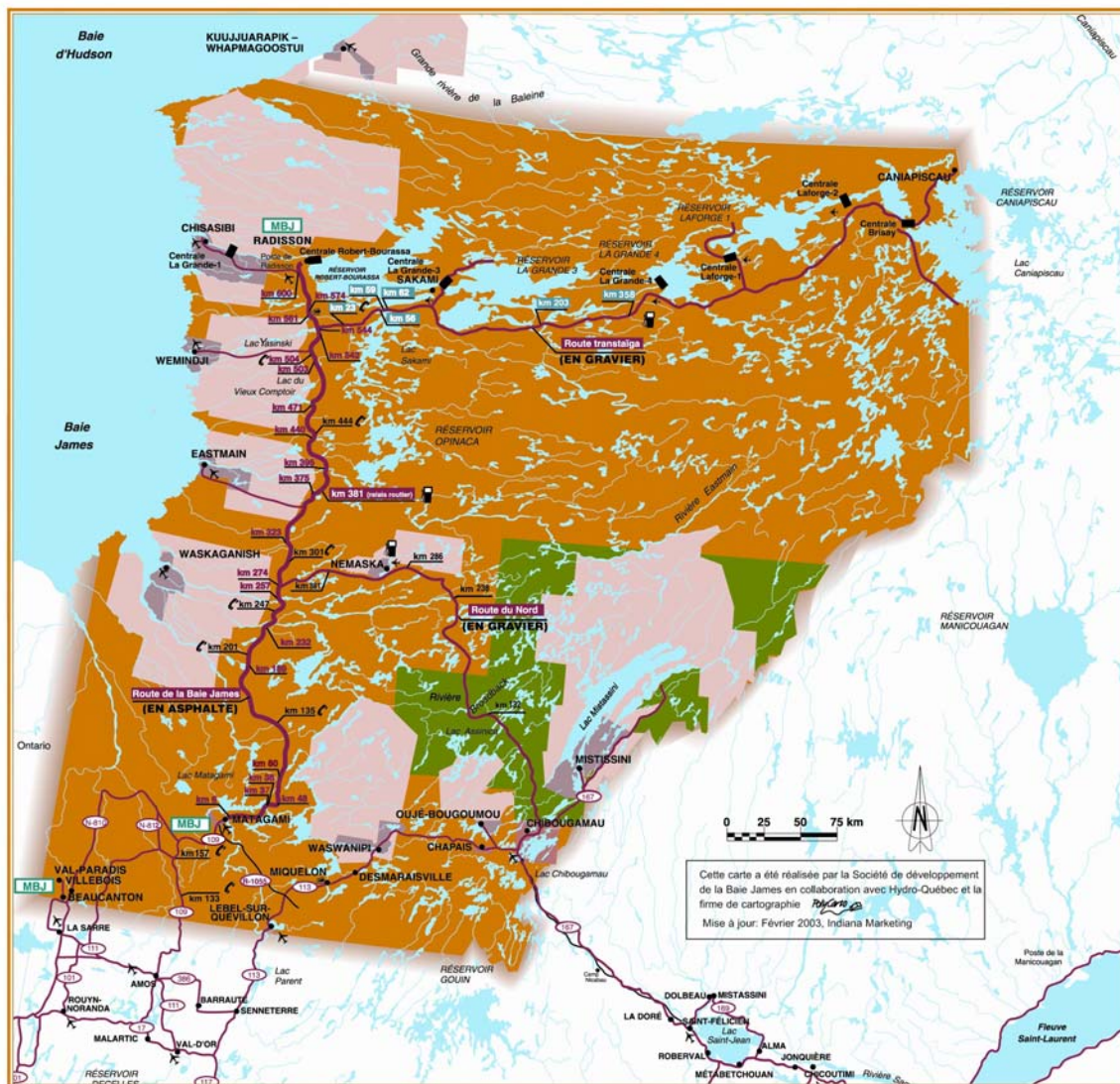


Figure 2.2. James Bay region showing road access and communities from http://www.crebj.ca/index.php?option=com_content&task=view&id=21&Itemid=27 (CRE James Bay, 2008)

2.2 James Bay communities

The Cree communities in the James Bay area include Waskaganish, Eastmain, Wemindji, Chisasibi and Wapmagoostui located on the Coast and four other communities, including Mistissini located inland (Figure 2.1). People from Eastmain and Wemindji are the two populations who participated to the present study. Eastmain is the smallest community with 592 people and Wemindji has 1178 residents (Lejeune, unpublished data 2008).

2.2.1 Wemindji

Wemindji has been relocated since 1958 and now sits at the mouth of the Maquatua River on the east coast of James Bay, in northern Quebec, Canada. The town of Matagami is located 614 km south of Wemindji. The nearest major city is Montreal, which is approximately 1400 kilometers south of Wemindji (Wemindji Cree Nation, 2006). Access Road to Wemindji is 96 kilometres long and open year-round (Cree School Board, ND).

The community has several infrastructures such as social services, a housing service and an environmental health department (Wemindji Cree Nation, 2006). The services that the environmental health department offers are waste management, drinking water monitoring, environment enforcement, Geographic Information System (GIS) land registry, and environment site assessment (Wemindji Cree Nation, 2006). Within the community, a wide variety of human and health services are available to serve the needs of residents throughout their lifespan. They are administered by the Cree Board of Health and Social Services.

2.2.2 Eastmain

Eastmain was established as a trading post in 1719 (Cree cultural institute, ND). There are several businesses, the head office of the Cree Trappers Association and a community clinic operated under the authority of the Cree Board of Health and Social Services in the community (Cree cultural institute, ND).

2.3 Existing health network

The health services are coordinated by the Cree Board of Health and Social Services that was created in 1978 following the signing of the James Bay and Northern agreement (Cree Board of Health and social services, ND). This organization is responsible for the management of health and social services in the entire Cree territory of James Bay.

The “Nituuchischaayihitaa Aschii Multi-Community Environment-and-Health Longitudinal Study in Iiyiyu Aschii” includes research on obesity, diabetes, chronic diseases, contaminants, diet and zoonoses (Pereg and Nieber, 2007). It will provide a very complete picture of the Cree’s health for each of the nine Cree communities located in Northern Quebec to the Cree Board of Health and Social Services. The study will span over nine years. Researchers from several institutions contribute to the study. The first annual scientific gathering held in Montreal November 13-14th, 2008 presented the results from years 2005 to 2007.

2.4 Traditional knowledge and activities

Changes in lifestyle and diet for Cree people have been reported over last decades, going from traditional to market foods (Delormier and Kuhnlein, 1999; Pereg and Nieber, 2007). These changes in the traditional way of life are related to major health problems such as diabetes. The use of traditional knowledge is slowly gaining new recognition. Studies on traditional medicines and diet are on going at McGill University at the Centre for Indigenous Peoples' Nutrition and Environment (CINE). The CINE is an independent, multi-disciplinary research and education resource for Indigenous Peoples, created by Canada's Aboriginal leaders (CINE, 2008).

Traditional knowledge is shared through some formal activities such as multi-communities meetings. In January 2008, a four day meeting brought together participants from the Chisasibi First Nation, Whapmagoostui First Nation and the Sanikiluaq and Inukjuak communities to exchange information on the state of the wildlife and environment in eastern James Bay and eastern Hudson Bay and to develop a community based monitoring (Municipality of Sanikiluaq unpublished report, 2008). Report on wildlife state, abundance, status and trends as well as climate changes were discussed.

Traditional activities also include hunting, fishing, spending time in nature and cooking the game. These are very important activities to the people; they could increase the risk of zoonoses. That is why the epidemiology of zoonoses in their communities is so important for Cree people. Today, a quarter of the population within Wemindji still live year-round in the bush, while others go to their family’s traplines on weekends or when they have free time (Wemindji Cree Nation, 2006). Goose hunting is a most important traditional activity in the fall (Wemindji Cree Nation, 2006; Delormier and Kuhnlein, 1999). Traditional diet

consists of fish, large and small game, a variety of waterfowl, and plant food from the local environment (Schaeffer, 1977).

3. CLIMATE CHANGE AND ADAPTATIONS

Significant climate warming during the last century over the James Bay and Quebec's Northern region has already caused a change in equilibrium between the climate and forest composition (Bourque and Simonet, 2008). Given the sparse literature available on the region, impacts that are not desirable are entirely unknown at this time (Bourque and Simonet, 2008).

3.1 Climatic predictions and expected effects

Climate change would modify the distribution range of parasites and diseases transmitted by animals, insects and ticks, resulting in a rise in existing infectious diseases and the appearance of new infectious diseases in Quebec (Bourque and Simonet, 2008).

An average of the predictions from six climatic models predicts a temperature rise of 3.2 degree Celsius by 2050 in the Central Region of Quebec; this includes the James Bay region (Bourque and Simonet, 2008). Increase in precipitations and snow cover are expected in the James Bay area. This climate change is expected to have an impact on the vegetation, animal migration pattern and behaviour as well as zoonotic diseases.

3.2 Vegetation

The climate change is expected to result in an increase in forest productivity as well as a northern migration of species (Bourque and Simonet, 2008). The increased CO₂ concentration would increase forest growth. The increase in exotic species and increase in drought frequencies could cancel possibly out any gain in productivity (Bourque and Simonet, 2008). Climate change would cause climate zones to move by 515 km north and forest migrate north 10 km/year (Bourque and Simonet, 2008). In some areas, the growing has already lengthened (Bourque and Simonet, 2008).

Black spruce, which is now in the middle of its distribution, will move north and will end up at the southern limit of its distribution (Bourque and Simonet, 2008). Adaptations strategies such as replanting different species better adapted to the increased temperature could be interesting (Bourque and Simonet, 2008).

3.3 Wildlife

Wildlife distribution, range, timing of migration could be altered due to climate change (Bourque and Simonet, 2008). Animal species distribution would move north. Extensive studies on caribous revealed that several opposite drivers are resulting in unpredictable results. Herds that had a million animals went down to 250 000 within a few years. The climate change is already happening; the timing of calving in the spring may no longer correspond to the abundance of lichen, the main food source of the caribou (Couturier et al., submitted).

Southern birds, such as pelicans and cormorants, that have never been seen before in Chisasibi are now seen and there are fewer snow geese, Canada geese and brant geese that used to be extremely abundant (Municipality of Sanikiluaq unpublished report, 2008). Changing weather pattern could affect the animals' fur. When the temperature is warm, the quality of fur goes down (Municipality of Sanikiluaq unpublished report, 2008).

3.4 Zoonoses

The survival and spread of foreign pathogens can be enhanced by warmer climate. Diseases that are limited by temperature in their distribution could see their range increase further North due to the warmer climate. Climate change is expected to have an impact on zoonoses as the warmer climate will increase mosquitoes' survival and accelerate the completion of its lifecycle, as the life cycle of mosquitoes and pathogens are temperature dependant (Séguin, 2008). Increase in temperature and thawing can augment bacteria survival. Increase precipitation can increase amount of feces thawed and washed into lakes and rivers.

The warmer climate and increased precipitations will likely increase rodent survival and thus increase rodent-borne disease spread (Séguin, 2008). Increased temperature expected in the upcoming years could have an impact on vector species distribution, on the northern range expansion of ticks and on the transmission of diseases (Giguère and Gosselin, 2006). Recent studies show that climate change is already having an impact on some vector-borne disease risks (Séguin, 2008). Lyme disease that is carried by ticks has been moving north and is expected to continue moving north with climate change. It will be a mandatory declarable disease in Quebec starting in 2009 (Odgen, 2008).

Introduction of vector-borne diseases from distant geographic areas is possible as demonstrated by the West Nile virus that was imported from a mosquito in New York on an airplane coming from the Middle East (Séguin, 2008). The Northern limit of the West Nile virus is set by mosquito survival. The West Nile virus has been found in birds at 56° latitude north (Ogden, 2008).

Distribution and transmission patterns of diseases may change over time in ways that are difficult to predict. Warmer temperature can influence mechanisms between hosts and vectors by increasing the time spent outdoors by people in warm conditions (Séguin, 2008). In addition, the importation of exotic diseases is quite real in this era of globalization. This poses a diagnostic challenge to physicians unaccustomed to their presenting symptoms (Séguin, 2008)

3.5 Adaptations

Adaptation to climate change is any activity that reduces the negative impacts of climate change and/or positions us to take advantage of new opportunities that may be presented (Burton, 2008). Adaptations can be as diverse as modifications to house insulation and air conditioning, modification to pipes and drainage systems in cities, roads and harbours infrastructures, hunting and fishing quotas, species selected for tree planting after forest harvest, governance and management structure of municipalities and types of emergencies plans required. Adaptations in buildings and infrastructure design, water and energy conservation, renewable energy conservation and diversification of the economy are examples of starting points for communities to increase their adaptive capacity (Burton, 2008). Adaptations involve a wide range of actors, including individuals, community groups, civil society, the private sector and all orders of government (Burton, 2008). Because adaptation is such a multi-stakeholders and place-specific process, heavily top-down or structured approaches would risk inhibiting the diversity of activities and innovations that are required (Burton, 2008). Moving from vision to action needs many steps by many motivated actors (Burton, 2008).

In a northern setting, adaptations may touch building insulation, road structure and maintenance, dam and hydroelectricity infrastructure and wildlife hunting quotas. The warmer conditions could modify food storage and preparation procedures as bacteria survival would increase with the increased temperatures.

Efforts are made to anticipate the changes to come through better and finer scale climatic model simulations and environmental predictions that take into account the effects of changes on habitats and plant and animal populations. The consortium Ouranos has been instrumental in providing information on climate change and several subjects related to climate change such as hydrology, forestry, health and erosion. The climate change is already having effects and will have effects that are unpredictable on the environment.

Adaptations must be local and take into account localised climate change and infrastructures as climate change and temperature increase predicted are not uniform over the province of Quebec. A very good knowledge transfer and multi-disciplinary expertises must be fostered and maintained in order to promptly react to changes. Being proactive and seeking to be part of networks and have the capacity to adapt information to local needs is important. Be on the alert for new programs and funding available as it is a time of great challenge but also of opportunities. Maintaining and strengthening the knowledge base, synthesizing and sharing knowledge, removing barrier to actions, reviewing and contributing to international initiatives are elements required to effect adaptations (Burton, 2008).

Giguère and Gosselin identified the following key knowledge gaps with respect to zoonotic diseases: interdisciplinary approach and training, research network and specialized technical expertise to enhance response capacity (Giguère and Gosselin, 2006). On a more specific ground, they suggested the following adaptations: maintaining integrated surveillance systems, include indicators in surveillance systems, heighten awareness and education for individuals at risk and continue research in technologies to prevent proliferation of vectors (Giguère and Gosselin, 2006). The study presented in the next pages is an effort to trace a baseline of a surveillance system for people of Eastmain and Wemindji about the prevalence of ten zoonoses in a perspective of climate change.

4. MATERIAL AND METHODS

This section describes the methods of collecting and analysis samples and data on zoonoses for the study in Eastmain and Wemindji.

4.1 Literature review

A review of literature (which was used for the discussion of the results) was conducted using several databases accessible through the University of Sherbrooke and specialized websites such as Pubmed, Elsevier and more general search engines such as Google. Websites from Canadian and American departments and research centers were also consulted.

4.2 Data collection

In the summer of 2007, people from Eastmain and Wemindji were asked to answer three questionnaires (individual questionnaire (demographics and lifestyle), wildlife and zoonose exposure, traditional food frequency) from the “Nituuchischaayihitaa Aschii Multi-Community Environment-and-Health Longitudinal Study in Iiyiyiu Aschii”. The participants were randomly selected within the population of each community and were representative of these populations.

After providing written informed consent, questionnaires were administered to participants and blood samples were also collected from those over 18 years of age. Samples were used to test, among other analyses, antibody response to ten zoonotic infections. The pathogens evaluated included three bacteria (*Coxiella (C.) burnetii*, *Francisella (F.) tularensis* and *Leptospira sp.*), three virus (Sin Nombre virus, California serogroup viruses – Jamestown Canyon (JC) and snowshoe hare (SSH) viruses) and four parasites (*Trichinella sp.*, *Toxoplasma (T.) gondii*, *Toxocara (T.) canis* and *Echinococcus (E.) granulosus*). A total of 251 participants were included in the zoonose study.

4.3 Laboratory Blood tests

Immunoenzymatic methods (ELISA) were used for the detection of IgG antibodies against *Trichinella sp.*, *T. canis*, *E. granulosus* (IVD inc.), *T. gondii* (AxSYM, Abbott Diagnostics, Abbott Park, Illinois), *Leptospira sp.* and *C. burnetii* (Virion\Serion, Serion Immundiagnostica GmbH, Würzburg). ELISA assays were used also for the detection of

IgG and IgM specific for the Sin Nombre virus (Feldmann et al., 1993) and for the California serogroup viruses (JC and SSH) (Martin et al., 2000; Johnson et al., 2000). For California serogroup viruses, the presence of JC or SSH specific antibody was confirmed in ELISA positive samples by a plaque reduction neutralization test (PRNT). The detection of antibodies against *F. tularensis* was performed by means of a tube agglutination test (Snyder, 1980; Stewart, 1981). Table 4.1 lists the criteria used to interpret the results and the estimated persistence of antibodies for each serology. For technical reasons, not all tests were performed on all samples (e.g. insufficient amount of serum, sample not received in the laboratory).

Table 4.1. Criteria for the interpretation of serologic analyses and estimated antibodies persistence for ten zoonotic infections (from Lévesque et al., 2007 unless otherwise mentioned).

Pathogens	Criteria			Antibodies Persistence
	Negative	Equivocal	Positive	
Optical density				
<i>Trichinella</i> sp.	< 0.25	≥ 0.25 to < 0.35	≥ 0.35	9 - 18 months
<i>Toxocara canis</i>	< 0.25	≥ 0.25 to < 0.35	≥ 0.35	Unknown
<i>Echinococcus granulosus</i>	< 0.35	≥ 0.35 to < 0.45	≥ 0.45	Possibly life-long
Sin Nombre Virus (IgG-IgM), serum diluted 1/400	< 0.30	≥ 0.30 to < 1.0	≥ 1.0	Possibly > 10 years
Units IgG (IU/ml)				
<i>Leptospira</i> sp.	< 5	≥ 5 to ≤ 9	> 9	6 months - > 20 years ¹
<i>Coxiella burnetii</i>	< 20	≥ 20 to < 30	≥ 30	~ 5 years ²
<i>Toxoplasma gondii</i>	< 2	≥ 2 to < 3	≥ 3	Life-long
Titer				
<i>Francisella tularensis</i>	< 1/20	-	≥ 1/20	> 10 years ³
California serogroup ⁴ , (IgG-IgM) serum diluted 1/400	< 1/20	-	≥ 1/20	> 5 years ⁵

¹ Faine (1998)

² Virion\Serion, Serion Immundiagnostica GmbH, Würzburg

³ Young et al. (1969)

⁴ Serology tested for snowshoe hare (SSH) and Jamestown Canyon (JC). These are titres that correspond to the confirmatory serology (plaque reduction neutralization tests) carried out on the samples.

⁵ Tsai (1991)

4.4 Review of medical records

The medical records were verified for the last five years for those people who had a positive serology for *Leptospira* sp., *C. burnetii* and *Trichinella* sp. and verified for the last ten years for those people with positive serologies for *F. tularensis*, for the three parasites (*T. canis*, *T. gondii* and *E. granulosus*) and for the California serogroup viruses (SSH and JC).

4.5 Statistics

Data were included in a database that includes over hundred of variable and information from surveys conducted for the entire project. Data analyses were conducted using SAS and models written for the specific analysis. Frequency distribution of the seroprevalence data for the ten pathogens were calculated for all the data and stratified by community. The variable “zoonoses” was created to describe people positive for any of the ten pathogens tested. For this variable and for pathogens that had high enough seroprevalence to provide statistically valid results, univariate logistic regression analyses were conducted to verify the relation between positive serologies and different variables (e.g.: community, age, gender, pet animal at home, exposure to wildlife, schooling). Equivocal values were grouped with the negative results. Age, sex and any other variables related to seropositivity ($p \leq 0.1$) were included in a stepwise multivariate logistic regression model to control the confounding variables. To test the colinearity between the variables “age” and “hunting”, a colinearity test was also realised.

5. RESULTS

This section presents the results of the questionnaires and blood samples, statistical analyses and seroprevalence for the 10 pathogens studied for the communities of Eastmain and Wemindji.

5.1 Samples

A total of 251 blood samples were collected. For technical reasons, some samples for certain pathogens have not been analysed (E.g.: insufficient amount of serum, sample not received to the laboratory etc.).

5.2 Population studied

Of the 251 participants who provided blood samples for the study, 140 were from Wemindji and 111 from Eastmain. There were 76 women (mean=37.75 and median=34.5 ages) and 64 men (mean=42.61 years old and median=38 years old) in Wemindji and 70 women (mean=35.77 years old and median=36 years old) and 41 men (mean=35.88 years old and median=34 years old) in Eastmain.

5.3 Prevalence of infections

There was no statistical difference in the prevalence of the infections between the two communities, therefore statistical analyses were realized on the whole sample. A total of 59 participants (28 men, 31 women) tested positive for at least one pathogen in Wemindji and 54 participants (28 men, 26 women) in Eastmain.

The most prevalent pathogens were *Leptospira sp.*, *F. tularensis* and the California serogroup viruses for both communities. The prevalence results found in the study are summarized in [Table 5.1](#). The parasites *E. granulosus*, *T. canis*, and *Trichinella sp.* had seroprevalence lower than 5%.

Concerning exposure to California serogroup viruses, 13 individuals (9%) were IgG positive for either JC or SSH in Wemindji. In Eastmain, 11 participants (10%) had been exposed to JC or SSH based on IgG / PRNT antibody titres. The majority of confirmed California serogroup exposures were to JC viruses (12, Wemindji; 7, Eastmain).

Respectively 2 and 1 people had IgG positive for the two pathogens in Eastmain and Wemindji.

5.3 Review of the medical records

Among those individuals seropositive for *F. tularensis*, there were no documented cases of classical ulceroglandular disease during the preceding ten years. However, a 50 years old woman was diagnosed with an atypical pneumonia and treated with antibiotics in 2004. There were three cases of people aged from 30 to 50 years old who had conjunctivitis: one with recurrent episodes between 1998 and 2003, another who had an associated dacryocystitis, and one who had an episode with a palpebral oedema in 2005. Six other people had pharyngitis; three of which were treated with antibiotics (17 years old in 2002, 21 years old in 2003, 30 years old in 2006). The 21 years old also had cervical adenopathy with a negative test for mononucleosis.

The medical records review did not reveal classical case of hepatorenal failure among the patients who were seropositive for *Leptospira sp.* One 35 years old woman had influenza-like illness for three weeks in 2003, and three patients had ocular pathology. A 29 years old man had uveitis in 2004 and two patients had conjunctivitis (a 26 years old woman in 2006 and a 29 years old man in 2007).

Among those with positive serology for *C. burnetii*, we found one case of atypical pneumonia in a 33 years old man in 2007. Of those with positive serology for California serogroup viruses (either JC or SSH), a 39 years old man had an intense headache lasting 10 days in 2005.

Of those with positive serology for *E. granulosus*, none had typical symptoms or signs indicative of the disease after reviewing their medical file. However, these people were seen in clinic, as there is a possibility that silent cysts could form. Some had few symptoms possibly compatible with an infection. Three out of nine had past history of cutaneous rash. Two of them and one other had sometimes, mild abdominal discomfort. Others had no symptoms at that moment. For *T. canis*, we have documented one 17 years old woman with a history of eosinophilia in 2005-2006, and another history of eosinophilia for a 65 years old woman in 2003. These two people did not have any symptoms related to

Table 5.1. Results of serological analyses for ten zoonotic infections performed on blood samples obtained from members of the communities of Wemindji (n=140) and Eastmain (n=111) in 2007. For technical reasons, some samples for certain pathogens have not been analysed (E.g.: insufficient amount of serum, sample not received to the laboratory etc.).

Pathogen	Wemindji			Eastmain			Total		
	Pos. ¹ n (%)	Neg. ¹ n (%)	Equ. ¹ n (%)	Pos. n (%)	Neg. n (%)	Equ. n (%)	Pos. n (%)	Neg. n (%)	Equ. n (%)
Bacterium									
<i>Leptospira sp.</i>	35 (25)	76 (55)	28 (20)	23 (21)	62 (56)	26 (23)	58 (23)	138 (55)	54 (22)
<i>C. burnetii</i>	3 (2)	128 (92)	8 (6)	1 (1)	106 (95)	4 (4)	4 (1)	234 (94)	12 (5)
<i>F. tularensis</i>	20 (14)	118 (86)	0	22 (20)	89 (80)	0	42 (17)	207 (83)	0
Parasite									
<i>T. gondii</i>	7 (5)	133 (95)	0	6 (5)	105 (95)	0	13 (5)	238 (95)	0 (0)
<i>E. granulosus</i>	4 (3)	134 (96)	2 (1)	5 (4)	103 (92)	3(4)	9 (4)	237 (94)	5 (2)
<i>T. canis</i>	2 (1)	138 (99)	0	6 (5)	104 (94)	1(1)	8 (3)	242 (96)	1 (1)
<i>Trichinella sp.</i>	2 (1)	135 (96)	3 (2)	0	110 (99)	1 (1)	2 (1)	245 (98)	4 (1)
Virus									
Sin Nombre virus	0	140 (100)	0	0	111 (100)	0	0	251(100)	0
California serogroup ²	13 (9)	112 (80)	15 (11)	11 (10)	88 (79)	12 (11)	24 (10)	200 (80)	27 (10)

¹ Pos: positive, neg: negative, eq: equivocal.

² Serology tested for snowshoe hare (SSH) and Jamestown Canyon (JC)

the *T. canis* infection. Finally, a 48 years old man with a positive result for *Trichinella sp.* had also an eosinophilia in 2002 with no classical symptoms of the disease, but he was investigated for an abdominal pain that resolved without treatment in 2004. Files of patients with positive serology for *T. gondii* did not reveal the appearance of any relevant symptoms or signs.

5.4 Identification of potential risk factors

Risk factors identification was conducted using the numerous variables available within the database.

5.4.1 Univariate analysis

There were four variables significantly associated with seropositivity to the California serogroup viruses: age ($p = 0.025$), being male ($p = 0.013$), hunting ($p = 0.019$) and owning a dog ($p = 0.006$).

None of the variable studied were significantly associated with *F. tularensis* or *Leptospira sp.* seropositivity. The univariate analysis were not conducted on the other seropositive results for the other pathogens as their prevalence is so low that the resulting samples are too small to conduct analyses.

From all the variables examined, the only factors significantly associated with seropositivity for at least one pathogen (variable “zoonoses”) were: owning a dog ($p = 0.017$), being male ($p = 0.036$), and hunting ($p = 0.043$).

5.4.2 Multivariate analysis

Results of the multivariate logistic stepwise analysis realized to identify factors respectively associated to seropositivity to the California serogroup viruses and to testing positive to at least one pathogen (zoonoses) are presented in table 5.2 and 5.3. A test of colinearity between “hunting” and “gender” revealed a strong correlation between these variables ($R^2 = 0.454$ ($p < 0.0001$)). Therefore, they are presented in two different models in the multivariate analysis (table 5.2 and 5.3).

Table 5.2. Relationship between several variables and seropositivity to the California serogroup viruses in the two Cree communities of Eastmain and Wemindji, Quebec, in 2007.

Variable	Details	Odds Ratio Point Estimate	95% Confidence interval	P Value
a. variables: age, community, hunting and owning a dog				
Age		1.040	1.011- 1.070	0.006
Community	Eastmain vs Wemindji	1.175	0.472- 2.923	0.729
Hunting	Hunt vs no hunting	2.857	1.089-7.493	0.033
Owning a dog	Yes vs no	6.072	2.018-18.274	0.001
b. variables: age, community, gender and owning a dog				
Age		1.041	1.012- 1.071	0.005
Community	Eastmain vs Wemindji	1.165	0.466- 2.916	0.744
Gender	Female vs male	0.277	0.107- 0.722	0.009
Owning a dog	Yes vs no	7.096	2.298-21.908	0.001

Table 5.3. Relationship between several variables and seropositivity to at least one of the ten zoonotic infections investigated in the two Cree communities of Eastmain and Wemindji, Quebec, in 2007.

Variable	Details	Odds Ratio Point Estimate	95% Confidence interval	P Value
a. variables: age, community, hunting and owning a dog				
Age		1.007	0.990-1.024	0.439
Community	Eastmain vs Wemindji	1.489	0.880-2.520	0.138
Hunting	Hunt vs no hunting	1.777	1.052-3.001	0.032
Owning a dog	Yes vs no	2.848	1.210-6.706	0.017
b. variables: age, community, gender and owning a dog				
Age		1.007	0.990-1.024	0.419
Community	Eastmain vs Wemindji	1.438	0.853-2.424	0.172
Gender	Female vs male	0.544	0.322-0.921	0.023
Owning a dog	Yes vs no	3.040	1.289-7.169	0.011

6. DISCUSSION

The seroprevalence results for the ten zoonotic diseases are discussed with respect to existing disease prevalence and risk factors in adjacent communities and elsewhere in Quebec. The diseases are discussed from the most to the least prevalent. Climate change and emerging diseases information are also discussed.

6.1 Prevalence of zoonotic diseases

This study presents the seroprevalence of ten zoonotic infections in the general population of Eastmain-Wemindji. Overall, with the exception of *Leptospira sp.*, *F. tularensis*, and California serogroup viruses, the seroprevalence is relatively low for the infections studied.

The sample population in Eastmain-Wemindji (EW) was randomly selected from a recently verified list of community members and is thought to be representative of the total population over 18 years old. Care was taken to insure that the list of residents was updated. Of the ten infections tested, the highest seroprevalence rates were for *Leptospira sp.* (23%), *F. tularensis* (17%) and the California serogroup viruses (JC and SSH viruses) (10%). A seroprevalence of 5% was estimated for *T. gondii* and of less than 5% for the three other parasites and *C. burnetii*. Antibodies against the Sin Nombre virus were undetectable in this sample.

Other zoonose seroprevalence studies conducted in the last years in Quebec had different sampling, analytical and laboratory methods (Lévesque et al., 1995; Lévesque et al., 2007; Messier et al., 2007; Tanner et al., 1987). This makes seroprevalence comparisons challenging. Nevertheless, existing data from these previous studies help to estimate the relative importance of the data reported here. Table 6.1 shows comparative data from other seroprevalence studies made in Québec or elsewhere.

A study conducted in the mid 1980's estimated seroprevalence for 5 zoonotic parasitic infections (*E. granulosus*, *Entamoeba histolytica*, *T. canis*, *T. gondii*, *Trichinella sp.*) in 18 Inuit and Cree communities of Quebec, using 2600 sera obtained from patients treated in 2 Quebec regional hospitals (Tanner et al., 1987). About ten years later, another study measured seroprevalence for 3 bacterial zoonotic diseases (*C. burnetii*, *F. tularensis*,

Leptospira interrogans serovars bratislava, hardjo, icterohaemorrhagiae) from the Quebec City region, conducted in 1995. The sample was composed of trappers (n=165) who were compared to an equal number of controls similar in age and location (Lévesque et al., 1995). A study conducted in 2004, in 14 Inuit communities of Nunavik examined the seroprevalence of eight zoonotic pathogens (*Brucella* sp., *C. burnetii*, *F. tularensis*, *Leptospira* sp., *E. granulosus*, *T. canis*, *T. gondii*, *Trichinella* sp.) in a randomly selected sample of 917 persons aged 18 to 74 (Messier et al., 2007). Finally, in 2005, the seroprevalence for eight zoonotic infections (*C. burnetii*, *F. tularensis*, *Leptospira* sp., *E. granulosus*, *T. canis*, *T. gondii*, *Trichinella* sp., Sin Nombre virus) was determined on a sample of 28 women and 22 men constituted by active trappers and their spouse in the Cree community of Mistissini (Lévesque et al., 2007).

Table 6.1. Summary table of known seroprevalence of the studied infections. Results should be interpreted with caution, as some of the diagnostic criteria and methods are not identical between studies.

Infections	Eastmain-Wemindji ¹	Mistissini ²	Nunavik ³	South Quebec ⁴	Northern Quebec ⁵	Others
	2007	2005	2004	1995	1980's	
<i>Leptospira</i> sp.	23%	14%	5.9%	9.1% T ⁶ 4.8% c ⁷	-----	-----
<i>Coxiella burnetii</i>	1%	18%	1%	15% T ⁶ 15% c ⁷	-----	-----
<i>Francisella tularensis</i>	17%	26%	18.9%	2.4% T ⁶ 0.6% c ⁷	-----	-----
<i>Toxoplasma gondii</i>	5%	10%	59.8%	-----	48% (I) ⁸ 12% (C) ⁹	22.5% (gen US) ¹⁰
<i>Echinococcus granulosus</i>	4% (E-W) ¹¹ 4% (E) ¹² 3% (W) ¹³	0%	8%	-----	8% (E) ¹² 4% (W) ¹³	1% ⁵ (I) ⁸ 3% ⁵ (C) ⁹
<i>Toxocara canis</i>	3% (E-W) ¹¹ 5% (E) ¹² 1% (W) ¹³	4%	3.9%	-----	8% (E) ¹² 1% (W) ¹³	11% ⁵ (I) ⁸ 10% ⁵ (C) ⁹
<i>Trichinella</i> sp.	1% (E-W) ¹¹ 0% (E) ¹² 1% (W) ¹³	0%	1%	-----	1% (E) ¹² 0% (W) ¹³	9% ⁵ (I) ⁸ 2% ⁵ (C) ⁹
Sin Nombre virus	0%	0%	-----	-----	-----	-----
² Snowshoe hare (SSH)	3% (E) ¹² 1% (W) ¹³	-----	-----	-----	-----	3.5% ¹⁴ (Alaska)
² Jamestown Canyon (JC)	10% (E) ¹² 9% (W) ¹³	-----	-----	-----	-----	6.5% ¹⁴ (Alaska)

¹ Data from the present study

² Data from Lévesque et al., 2007

³ Data from Messier et al., 2007

⁴ Data from Lévesque et al., 1995

⁵ Sera from 18 Cree and Inuit communities, data from Tanner et al., 1987.

⁶ T: trappers

⁷ c: controls

⁸ I: Inuit

⁹ C: Cree

¹⁰ gen US: a sample of 27 145 adults from the entire United States from Jones et al., 2001

¹¹ E-W: Eastmain-Wemindji, data pooled

¹² E: Eastmain

¹³ W: Wemindji

¹⁴ Data from Walters et al., 1999

As a whole, with the exception of *T. gondii*, the seroprevalence documented in Eastmain and Wemindji are of the same order of magnitude than those documented for the population of Nunavik (Messier et al., 2007) reflecting an exposure relatively similar. The discrepancies for *T. gondii* seroprevalence could be probably explained by difference in diet and food preparation between Cree and Inuit. In comparison with trappers from Mistissini, the low seroprevalence for *C. burnetii* in Eastmain and Wemindji indicating a lower exposure is an interesting fact.

6.1.1 Leptospirosis

Leptospira sp. had a higher seroprevalence in the present study (23%) than in other studies: Mistissini trappers (14%) (Lévesque et al., 2007), Nunavik (5.9%) (Messier et al., 2007), and southern Quebec (trappers: 9.1%; controls: 4.8%) (Lévesque et al., 1995). As in Mistissini (Lévesque et al., 2007), the present study failed to identify risk factors that could explain *Leptospira sp.* seroprevalence. The higher prevalence found in a general population compared to trappers could indicate that the bacteria are found in the village vicinity rather than being related wildlife as Lévesque et al. suggested (2007). Rodents are well known vectors for *Leptospira sp.* but there are no reported rodent problems in those communities.

Dogs could be suspected, as they are a known reservoir for leptospires and can be asymptomatic (WHO, 2003), but we did not find any association with the presence of a dog in the family. Nevertheless, the incidence of infections in domestic dogs has risen markedly in recent years in the United States and Canada (Brown and Prescott, 2008; Prescott et al., 2002; Vincent, 2000). *Leptospira sp.* is thought to be associated with milder and wetter climates. Wetter falls could be contributing to the recent increase in prevalence in dogs in Ontario (Prescott et al., 2002). *Leptospira sp.* has been reported in wildlife in northern regions such wolves in Alaska and Yukon (0 to 1% prevalence) or bobcats and lynxes (a few cases) in Quebec (Labelle et al., 2000; Zarnke et al., 2004).

Known risk factors for *Leptospira sp.* are contact with infected wildlife and water sports. There was no question on practising water sports in the questionnaires used in the study. Given the water temperature for most of the year and the abundance of mosquitoes in the summer, it is unlikely that the water sports would be the source of infection. The contact with wildlife was part of the questionnaire but did not come out in the analyses. There is a

great uncertainty related to the length of antibodies persistence (6 months to 20 years), which makes risk level assessment challenging.

No cases of leptospirosis were declared for the population of Eastmain and Wemindji from 1990 to 2006 (Carlin, 2007). Few clinical manifestations were documented in the medical records of people seropositive for *Leptospira sp.*; an influenza-like illness, and three cases of ocular pathology including one case uveitis. The incidence of ocular signs varies from 2 to 90% during the acute systemic phase of leptospirosis. However, ocular manifestations may be sub-clinical or overlooked (Rathinam, 2005).

6.1.2 Tularemia

There was a 17% seroprevalence (titer >1/20) for *F. tularensis* in Eastmain-Wemindji, which is comparable to the 18.9% prevalence found in Nunavik (Messier et al., 2007) but higher than the 2.4% prevalence found in the trappers or the 0.6% prevalence in controls from the southern Quebec study (Lévesque et al., 1995). On the other hand, it seems lower than the 26% prevalence found in Mistissini, in a study realized for a population of trappers that was heavily exposed to local fauna (Lévesque et al., 2007). Trapping statistics (number and species of prey trapped) revealed a much greater exposure to wildlife in Mistissini than in the Southern Quebec study where trappers lived in peri-urban areas and generally practiced trapping as a hobby. This could explain in part the variation in seroprevalence between the two studies.

In Mistissini, *F. tularensis* seroprevalence was positively associated to the variable “fishing, hunting and trapping on land” (Lévesque et al., 2007). In southern Quebec, the association between hunting muskrat and *F. tularensis* seroprevalence was statistically significant (Lévesque et al., 1995). Our study failed to identify risk factors for *F. tularensis* seroprevalence but the comparable rates found in the Nunavik for a sample of the general population and the higher prevalence obtained in Mistissini for a sample of trappers theoretically more exposed seem to indicate a link with exposure to fauna. The literature review conducted did not find animal studies that would have estimated the tularemia distribution in animal populations.

There are a multitude of factors influencing tularemia prevalence including population dynamics and behaviour of reservoir species. In Alaska, the snowshoe hare (*Lepus*

americanus) is the primary host. Clinical signs of tularemia in hares include ataxia and loss of fear (Morner and Addison, 2001). Hare population density rises and falls in a predictable 10-year pattern (Zarnke et al., 2004). Ticks (*Hemaphysalis leporispalustris*) serve as the primary vector for intraspecific transmission in hares, particularly when hare density is increasing (Zarnke et al., 2004). Predators are exposed when they feed on infected hares (Zarnke et al., 2004). However, there are virtually no data linking specific climatic conditions and outbreaks of tularemia. This is an important area for future research that may yield important tools for predicting and possibly preventing outbreaks (WHO, 2007). For instance, the respective importance of various susceptible animals as reservoirs for *F. tularensis* is still poorly known. Similarly, the role of various arthropods in the transmission of *F. tularensis* among animals and between animals and humans is not yet well understood (WHO, 2007). *F. tularensis* subspecies *holarctica* is associated with water (streams, ponds, lakes and rivers) and aquatic animals such as beaver and muskrat. There is also evidence that the bacterium can persist for months in watercourses, possibly in association with protozoa (WHO, 2007)

Although tularemia is a notifiable disease in Québec, no cases have been declared from Cree territory between 1990 and 2006 (Carlin, 2007). As a passive surveillance system, it would not be uncommon for mild, rare diseases to go unnoticed, especially if health care workers are unaware of it. Review of medical records revealed some cases of pharyngeal and conjunctival infections. In Turkey, most tularemia cases are oropharyngeal including an outbreak of 145 cases that was recently described caused by *F. tularensis* subsp. *holarctica* (Meric et al., 2008). The oculoglandular form is uncommon but it could happen (Steineman et al., 1999). Pharyngitis and conjunctivitis are common diseases with multiple causes, and our current study design, does not allow us to establish a causal relationship between the infection and the diseases. The virtual absence of the classical clinical manifestations of tularemia documented in Mistissini (Lévesque et al., 2007), Eastmain and Wemindji corroborates that the relatively non-virulent subspecies *holarctica* (type B) is probably responsible for seropositivity in these communities. In the cases of severe pharyngitis and ocular pathologies, patients could be tested for tularemia to determine if it is the underlying cause of these clinical manifestations.

6.1.3 California serogroup virus disease (SSH, JC)

We estimated a prevalence of 10% for JC and SSH viruses together in Eastmain-Wemindji. JC virus has been reported in Alaska and in several Canadian provinces including Quebec (Artsob, 1990). The seroprevalence reported here is comparable to the one estimated in native populations of Alaska for the JC (6.5%) and SSH (3.5%) viruses (Walters et al., 1999).

The colinearity between the two variables, “hunting” or “being a male” did not allow statistical distinction between these factors for California serogroup viruses’ seropositivity (Table 5.2). From the mode of transmission of these viruses, it is likely that hunting is the true risk factor. It is difficult to explain our findings of an association between California serogroup viruses’ seroprevalence and owning a dog. California serogroup viruses are known to infect a variety of mammals and it is not unlikely that dogs would be infected also. Nevertheless, the literature consulted did not report dogs as a known carrier of the disease (Grimstad et al., 1986; Zamparo et al., 1997; Public health Agency of Canada, 2007). There have been cases of viral encephalitis in dogs documented but none attributed to the California serogroup viruses, which were not included in the emergent viral pathogens for dogs in Canada (Njaa, 2008). Moreover, among the people who participated to our study, only 28 have declared owning a dog, and the confidence interval is quite large. Therefore, we should be cautious in interpreting these results.

California serogroup viruses are transmitted through mosquitoes and maintained through several species of wildlife (Walters et al., 1999). Free ranging mammals tested in Alaska had a 96.7% seroprevalence to at least one of the eight viruses tested (Walters et al., 1999). Elk (57%) in Michigan and moose (71%) from Ontario have been known to be seropositive to the JC virus (Grimstad et al., 1986). As well, white-tailed deer in Connecticut (Zamparo et al., 1997) and other regions in North America are believed to be important amplification hosts for this virus. For the James Bay region, it is not known what species is the main carrier of the disease.

In the Alaska study, significant risk factors for human exposure to California serogroup viruses were age group, ethnic-linguistic group, biotic province, climate zone, terrestrial vegetation and presence of some ungulates and small mammals in communities (Walters et al., 1999). The presence of small mammals species (vole, squirrel, hare) that can act as

an amplification / reservoir hosts was a risk factor for SSH virus seroprevalence while the presence of moose in the village vicinity was found to be a risk factor for JC virus seroprevalence (Walters et al., 1999).

The anticipated climate warming in northern regions including Québec could result in a longer breeding season and possibly a range expansion among mosquito vector species. Since these viruses are present in a wide range of mammals, the expected climate warming could cause a higher exposure of people to mosquitoes, as people tend to spend more time outdoors in warmer climate.

Encephalitis caused by arthropods is a notifiable disease in Québec. As stated before, this disease may go unnoticed if health care workers are unaware of it. Again, there were no reported cases between 1990 and 2006 in the Cree territory (Carlin, 2007). The review of medical records of patients seropositive for California serogroup viruses in Eastmain-Wemindji showed that one person had an intense headache lasting a period of 10 days. This is a symptom that could be in relation with a California serogroup virus infection.

California serogroup viruses are an under recognized pathogen in Canada and in the United States and should be considered by physicians in case of encephalitis.

6.1.4 Toxoplasmosis

The seroprevalence for *T. gondii* is relatively comparable between trappers in the Mistissini study (10%) (Lévesque et al., 2007) and the general population in Eastmain and Wemindji (6%). Seroprevalence estimates of less than 10% for a general population are quite low (AFSSA, 2005). As said earlier, the toxoplasmosis prevalence rate was found to be 22.5% in the United States (Jones et al., 2001). The seroprevalence estimate for a recent representative sample of the Nunavik population was 59.8% (Messier et al., 2007). This difference in prevalence estimates between the Nunavik and Cree general populations studies may be explained by their different dietary and culinary habits. Inuit regularly consume their meat raw, which increases the risk of exposure (Messier et al., 2007). Both Inuit and Cree populations may drink untreated water from adjacent watersheds. Water source was a possible risk factor to explain the high prevalence in Nunavik (Messier et al., 2007). However, the low prevalence found in Eastmain-Wemindji does not corroborate water as a toxoplasmosis source. This study results tend to prove

that the infection by *T. gondii* in Nunavik is not waterborne as Eastmain-Wemindji people drink water from water sources adjacent and similar to those found in Nunavik. *T. gondii* must infect a felid in order to complete its life cycle and reproduce. The 59.8% seroprevalence estimated in Nunavik remains a mystery in the absence of a known terminal host, as felids are virtually absent from the North.

Unfortunately, for *T. gondii* as for the other parasites, we were unable to verify the influence of different risk factors in reason of the low seroprevalence. The low seroprevalence of *T. gondii* found in Eastmain and Wemindji is reassuring. Nevertheless, pregnant women should be aware of the pathogen, as it could have serious health impact on the unborn child.

6.1.5 Echinococcosis

The prevalence estimated in Eastmain-Wemindji (4%) is comparable to those estimated before (0 to 8%) elsewhere (table 6.1). Exposure to *E. granulosus* is generally from the ingestion of eggs from dogs' feces, which could be present in the environment on soil, plants or on the dogs themselves. The presence of large number of dogs infected with *E. granulosus*, especially stray dogs is a risk factor to echinococcosis emergence (Eckert and Deplazes, 2004). Again, low seroprevalence precluded the analysis of specific risk factors in Eastmain-Wemindji. However, considering the potential importance of dogs in the exposure to *E. granulosus*, we verified the owning a dog in relation to seropositivity to this pathogen. Only one person out of nine seropositive for *E. granulosus* owned a dog.

We did not find symptoms suggestive of echinococcosis in the medical records of people seropositive for *E. granulosus*, and only few possible symptoms were noted at the moment of a medical visit.

Echinococcosis is not a notifiable disease in Québec. However, after a review of the literature, we only found one case of echinococcosis reported in the Cree territories in 1955 (Bégin et al., 1956). In the absence of sheep farming in the area, it is expected that the less severe sylvatic form of the infection is present in Eastmain-Wemindji.

6.1.6 Toxocariasis

Seroprevalence of *T. canis* was low in Eastmain-Wemindji. A previous study in the 1980's found similar seroprevalence rate on a small sample from these same communities.

Existing studies found similar results elsewhere in Canada (**Erreur ! Source du renvoi introuvable.**6.1). Interestingly, one study examined prevalence in dogs and also found very low prevalence, especially further north (Unruh et al., 1973).

In the absence of sufficient numbers of infected people, risk factors could not be isolated. It is possible that *T. canis* eggs have limited survival in very cold conditions, such as those found in northern Canada. Also, the main route of exposure is in children playing in and eating sand. In cold regions, these behaviours ought to be less common than in warmer climate.

In Eastmain-Wemindji, some seroprevalent people had eosinophilia documented but none of the typical symptoms usually associated to toxocariasis such as ocular problems or more rarely bronchitis or pneumonia associated with migrating larvae in the internal organs. *T. canis* does not appear to be a great problem in the Eastmain-Wemindji population as seen in the low seroprevalence estimated and absence of clinical signs. However, only people over eighteen years old participated in the study, and toxocariasis is more common in children.

6.1.7 Q fever

C. burnetii seroprevalence (1%) was very low in Eastmain–Wemindji. This is less than the 18% seroprevalence estimated in Mistissini, which was in a population with a greater exposure to wildlife (Lévesque et al., 2007). In Nunavik, *C. burnetii* seroprevalence was less than 1% (Messier et al., 2007), almost similar to the percentage presented here for people living near the James Bay.

In the southern Quebec study, both the trappers and controls had a prevalence of 15%; no risk factors could be identified (Lévesque et al., 1995). This was surprising as it implies similar risk of infection for both trappers and the general population in southern Québec. The trappers in the latter study were people who would trap during their leisure time, therefore less exposed to wildlife than Cree trappers, like those in Mistissini who are heavily exposed to the fauna of the boreal forest. These data seem to demonstrate that the exposure to *C. burnetii* follows a South-North gradient in Québec.

Risk factor to *C. burnetii* is contact with infected animals, in particular cattle, sheep and goat. The bacteria are excreted in urine, feces, and especially birth products (Marrie and Raoult, 2004). *C. burnetii* outbreaks in Quebec have primarily been associated with cattle, sheep or goats farming, slaughterhouses or packing plants which are absent from Quebec's northern regions (Herbert et al., 1965; Lang, 1989; Vincent and Desjardins, 2001). This could explain the low prevalence found in our study and the higher prevalence in the south of the province, even for the general population more exposed to domestic animals. Moreover, exposure to infected cats, a domestic animal largely distributed in southern Québec, has also been demonstrated to be a major cause of Q fever in the Mauricie region of Québec (Goyette et al., 1994; Dolcé et al., 2003). The lack of farms, petting zoos or slaughterhouse and meat packing plants partially explains the low prevalence in Eastmain-Wemindji. However, It is important to note that other species more related to wildlife such as racoons, skunks, and foxes can also be involved in the exposure to *C. burnetii* (Lévesque et al., 1995), which could explain the higher rates for Cree trappers in Mistissini.

No case of Q fever was declared to the health authorities of the Cree territories for the period of 1990-2006 (Carlin, 2007). The medical records review revealed one case of atypical pneumonia in a man seropositive for *C. burnetii*. The infection by *C. burnetii* is often unrecognized (Marrie and Raoult, 2004). However, the low seroprevalence documented here signify an infrequent exposure for the population of Eastmain and Wemindji, as already documented for people from Nunavik (Messier et al., 2007).

6.1.8 Trichinellosis

The very low prevalence estimated in Eastmain-Wemindji (1%) is similar to the prevalence estimated in Nunavik (1%) and in other studies. As discussed before, known risk factors for *Trichinella sp.* in Northern Canada have been associated with consuming black bear or walrus meat (PHAC, 2001d; McIntyre et al., 2007). Large outbreaks associated with consuming infected fermented walrus meat have occurred in Nunavik (PHAC, 2001d). Very low seroprevalence numbers does not mean that there is no risk to the population. In Nunavik where the seroprevalence is low, there are still some people occasionally infected with *Trichinella sp.* The consequences of an infection can be quite severe. The Trichinellosis Prevention Program tests walrus meat in Nunavik to ensure that it is safe to

eat (Nunavik Research Center, ND). Results are sent to the hunters within 24 hours of receiving the sample at the Research center (Nunavik Research Center, ND).

The walrus is not present in the James Bay area as it is currently found further north (Prescott and Richard, 2004). The black bear is present in the James Bay area and is part of the traditional diet of the Cree people. *Trichinella sp.* resists freezing (-20°C) but cooking the meat thoroughly (internal meat temperature reaching 71°C) will kill the parasite (McIntyre et al., 2007). At the same time, routine controls for *Trichinella sp.* infection in sylvatic animals and the proper disposal of offal from field-dressed animals are useful for the proper management of wildlife and for monitoring the prevalence of infection in order to prevent its transmission to domestic animals and humans (Pozio, 2001). Sharing game meat is a risk factor for outbreaks and the care should be taken to ensure that the meat is free of parasite or else well cooked before sharing it.

Trichinellosis is a mandatory reportable disease and no confirmed cases have been reported from Cree territory between 1990 and 2006 (Carlin, 2007). However, there was one suspected case (Carlin, 2007). Symptoms include diarrhea, muscle pain, fatigue, rash, fever and edema (PHAC, 2001d). These symptoms are non-specific. In our medical record review, a man had eosinophilia and was investigated for abdominal pain few years ago, which seemed to resolve without treatment. The short time that antibodies persist for this infection might limit detection. This disease does not appear to be a problem in Eastmain-Wemindji probably due to the way the meat is prepared prior to eating it.

6.1.9 Hantavirus Pulmonary Syndrome (HPS)

Cases of Hantavirus pulmonary syndrome (HPS) have been described in Quebec, Manitoba, Saskatchewan, Alberta and British Columbia (Drebot and Artsob, 2000; Lindsay et al., 2001; Webster et al., 2007; Drebot, 2008).

Antibodies for SNV were not detected in the population of Eastmain and Wemindji, similar to the findings in Mistissini (Lévesque et al., 2007), indicating no or infrequent exposure in these Cree communities for which we have data. Considering the potential severity of Hantavirus infection, this is good news for the population and corresponds with the low numbers of HPS cases in eastern Canada.

Transfer of the virus to man occurs when man enters the ecosystem inhabited by the primary host (deer mouse) or when the primary host moves into man's habitation (Hart and Bennett, 1999).

Climatic and other environmental factors may govern the population sizes and migration patterns of relevant hosts (Hart and Bennett, 1999). It is, for example, suggested that increased rainfall associated with the 1992–3 El Nino indirectly increased the risk of exposure to SNV (Hart and Bennett, 1999).

Deer mice have a homing behaviour (Calisher et al., 2002) and have been seen returning to their nest from 3 km away within two days (Prescott and Richard, 2004). The smaller home range in peridomestic settings may concentrate shed SNV, and protection from solar ultraviolet radiation inside buildings may increase environmental persistence of SNV (Douglass et al., 2006). Both these factors could lead to increased SNV exposure of deer mice within peridomestic populations and result in higher antibody prevalence (Douglass et al., 2006). The coexistence of humans and deer mice with high SNV infection rates in peridomestic settings provides ample opportunities for humans to be exposed to SNV by incidentally inhaling aerosolized virus (Douglass et al., 2006).

It is of interest to know that the HPS remains a rare disease. This is probably due to the fact that only a small proportion of mice are shedding SNV at any one time (Safronetz et al., 2008). In addition, there is a higher risk to contracting the disease in peridomestic settings than in the forest. Other environmental factors such as a favorable weather for the survival of mice can lead to an increase in mice populations. There are more cases of SNV infection on the West Coast. If decreased biodiversity brings about increased prevalence of SNV infection in deer mice, then severe habitat changes, such as can be caused by extractive mining, outdoor recreational sporting activities, and expanded housing for humans, might be a cause for concern (Calisher et al., 2002). In the context of the development of northern territories, it will be interesting to know in the next few years if the virus will migrate east due to the modification to the environment.

6.2 Risk factors

As stated before, specific risk factors could not be isolated for *Leptospira* sp. and *F. tularensis* even though the seroprevalence was relatively high. Risk factors were

successfully isolated for the California virus group but were fairly general (being male, age, hunting) or difficult to interpret (owning a dog). Very low prevalence for the other diseases resulted in small sample sizes and thus making difficult the isolation of specific risk factors for specific diseases.

The variable “zoonose” that grouped all the seropositive data revealed some risk factors. The utility of grouping 10 different diseases for assessing the risk factors while these disease have different risk factors can be questioned. Generally, the risk factors to all of the disease involve exposure to wildlife, mosquitoes, dogs or rodents; all of these involve spending time outdoors or in bush camps. Given the low seroprevalence in the study, the variable zoonose was a successful attempt at isolating general risk factors. Further studies with greater sample number could refine risk factors for specific diseases, but given the low prevalence associated with the infections investigated in the population studied, it should not be a high priority.

The individual questionnaire for the survey, used in 2005 in Mistissini, was modified for the Eastmain-Wemindji study. Seven questions pertaining to seasonal hunting and fishing habits and type of water consumed were removed from the questionnaire. It is these exact questions that revealed more specific risk factors for trappers in the Mistissini study. It would have been interesting to examine it in a general population. The questions will be added again in the upcoming 2009 survey.

6.3 Expected impacts of climate change on zoonose prevalence

The expected warming of temperature expected for the James Bay region will result in tree and plant species moving north; likely with diseases, pest and other pathogens. The effect on wildlife is difficult to predict and changes in animal population will likely occur. Along with changes in animal populations, the distribution and prevalence of zoonotic diseases will also be impacted. One could see vector-borne diseases that rely on mosquitoes increase due to longer mosquito breeding seasons. Mosquitoes are abundant in Eastmain-Wemindji in the summer but their breeding season is short. Diseases that were not very prevalent could increase if alternate hosts are infected or if host survival is increased due to the increased temperature and precipitation such as those predicted for the James Bay area. Rodent-borne diseases could also be increasing as rodent survival is expected to increase as a consequence of more abundant precipitations and warmer temperatures.

Along with climate change and warmer temperature, the region could see an influx of tourism and increased road infrastructures. On Vancouver Island, British Columbia, the increase in road access for forestry caused the wild deer population to decrease in the forest as the wolves pack use the forestry roads to move faster in the forest. The deer population has been increasing near the towns and cities where hunting is prohibited and predators such as wolves and coyotes are virtually absent. The proximity of ungulates near villages was a risk factor for the California serogroup viruses infections in Alaska (Walter et al., 1999).

The epidemiology of other diseases could be influenced by climate change. The Lyme virus is predicted to move north but it is not anticipated in the James Bay region any time soon. The West Nile virus is already present as far north as 56° latitude in birds. Apart from these known diseases, other diseases could emerge either due to changes in wildlife distribution that is host to the disease or to new hosts as a result of changes in the disease life cycle.

Cree and Inuit people have much different cultural habits that will influence the risk factors associated with zoonose prevalence. The expected increase in temperature could mean changing the traditional way of handling food and being more aware of emerging zoonotic diseases in animals and people. However, zoonotic diseases are not the main concern for the health of Eastmain-Wemindji populations. For example, diabetes and obesity are very pressing concerns (Johnson-Down, 2008). Nevertheless, given the potential to have changes in infections prevalence and distribution, it is important to maintain a strong network of individuals knowledgeable in zoonotic infections in order to be ready for any changes in seroprevalence of infections and outbreaks of diseases.

6.4 Diet and other issues

The rapidly changing environment and diet in Cree communities also have an impact on some zoonose prevalence. Toxoplasmosis, echinococcosis, Q fever, trichinellosis can be transmitted through consuming or exposure to country foods and their prevalence could theoretically decrease as country foods consumption is decreasing. Their prevalence is already low. Therefore, it is unlikely that the change in diet would have much of an effect on their prevalence. The part of the population over 40 years old consumes a greater

proportion of country foods. The zoonose health risk presently associated with consuming country foods is minor compared to the benefits of a traditional diet over the store bought foods.

7. RECOMMENDATIONS

Health care workers

- Considering the high exposure for Cree people to wildlife, and the nonspecific character of many zoonoses, physicians should be aware of these infections in the population, particularly for infections caused by *F. tularensis* and *Leptospira sp.* which seem to be more prevalent in the population of Eastmain and Wemindji.
- Considering the symptoms and signs found in the medical files of people seropositive for the different pathogens investigated, physicians could investigate for *F. tularensis* for those cases of long lasting strong pharyngitis and for *F. tularensis* and *Leptospira sp.* in cases of severe ocular pathologies.

Cree trappers and hunters

- Hunters and trappers who seem to be more at risk, should be made aware of the clinical features of different zoonotic infections, particularly *F. tularensis* and *Leptospira sp.*, as well as safe procedures for handling dead animals.

General

- Weigh out the messages that are given to the communities. The fear of zoonotic diseases should not prevent people from consuming country foods. The zoonotic diseases effects are marginal compared to the benefits of maintaining a traditional diet and preserving a feeling of connectedness to traditions and culture.

CONCLUSION

This essay includes information pertinent in a northern setting for 10 zoonotic diseases. Information on the James Bay communities' environment and expected effects of climate changes on the environment and wildlife are also presented. The essay provides seroprevalence for 10 zoonotic diseases for the general adult population of Eastmain and Wemindji, Quebec and provides recommendations for health care staff and community leaders.

Survey results revealed that the two communities of Eastmain and Wemindji do not have statistically different seroprevalence with respect to the 10 diseases surveyed. The most seroprevalent infections are: *Leptospira sp.* (23%), *F. tularensis* (17%), and California serogroup virus (10%). *T. gondii* has a lower seroprevalence (5%) than normally encountered in developed countries (10%). The other diseases studied have seroprevalence inferior to 5%. The Sin Nombre virus was absent from the samples collected.

Identification of specific risk factors for the diseases was planned but partially successful. Risk factors to being seroprevalent to any of the ten zoonoses or testing positive to the California serovars were: being male, hunting and owning a dog. Hunting and being male variables were correlated and results had to be presented in different models. Risk factors to being seroprevalent to leptospirosis or tularemia could not be identified. For the other diseases, low prevalence resulted in such small sample sizes that the identification of risk factors for contracting these diseases was not possible. The review of medical records did not reveal major health problems related to the zoonotic diseases. Physicians could investigate for *F. tularensis* for those cases of long lasting strong pharyngitis and for *F. tularensis* and *Leptospira sp.* in cases of severe ocular pathologies. Physician should keep in mind that zoonotic diseases are present in the population.

Results should be useful to Cree populations of Eastmain and Wemindji to provide them with the basic information about the prevalence of zoonotic diseases present in their communities permitting to prioritize and address the infections more prevalent.

The expected effects of climate changes on zoonotic diseases are difficult to predict. Diseases that are prevalent in southern Quebec are expected to move northward but it is

not clear when they will reach the James Bay region. Arbovirus in general could increase in prevalence due to the wetter and warmer climate. Hantavirus could also increase in prevalence due to the expected rodent population increase following warmer winter and wetter climate in general. Development in the region could also bring an increase in rodent borne diseases.

Zoonotic disease prevalence and transmission patterns may change over time and it is important to keep a strong network of professionals well connected to ensure that the communities are ready to react and well informed on these diseases. Data collected will also be useful as baseline data in a perspective of climate change.

CONCLUSION (FRANÇAIS)

Cet essai contient de l'information pertinente dans un contexte nordique pour 10 zoonoses. Il fait partie d'une étude plus large sur la santé des Cris. L'information sur l'environnement des communautés de la Baie James ainsi que les effets potentiels des changements climatiques sur l'environnement et la faune est aussi présentée. L'essai contient des estimés de séroprévalence de dix zoonoses pour la population adulte d'Eastmain et de Wemindji, Québec et contient des recommandations pour le personnel soignant et les dirigeants des communautés.

Les résultats de l'étude révèlent que les prévalences pour les dix maladies étudiées ne diffèrent pas statistiquement entre les deux communautés d'Eastmain et de Wemindji. Les maladies les plus prévalentes sont : *Leptospira sp.* (23%), *F. tularensis* (17%) et les sérogroupes des virus California (10%). *T. gondii* a une prévalence (5%) inférieure à celle normalement retrouvée dans des pays développés (10%). Les autres maladies étudiées ont une séroprévalence inférieure à 5%. Le virus Sin Nombre était absent des échantillons recueillis.

L'identification de facteurs de risque spécifiques aux maladies était planifiée mais partiellement accomplie. Les facteurs de risque associés à une séroprévalence pour l'une des dix zoonoses ou à tester positif pour les sérovars des virus California étaient : être un homme, chasser, et posséder un chien. Les variables « chasser » et « posséder un chien » étaient corrélées et les résultats ont dû être présentés dans deux modèles différents. Les facteurs de risque associés à être séropositif pour la leptospirose ou la tularémie n'ont pu être identifiés. Quant aux autres maladies, la faible séroprévalence a résulté en de si petites tailles d'échantillons que l'identification des facteurs de risques pour contracter ces maladies n'était pas possible. L'examen des dossiers médicaux n'a pas révélé de problèmes de santé majeurs en lien avec les zoonoses. L'étude révèle que ces zoonoses n'apparaissent pas problématiques dans cette population. Les médecins devraient investiguer pour *F. tularensis* dans les cas de fortes pharyngites et pour *F. tularensis* et *Leptospira sp.*, dans les cas de pathologies oculaires sévères. Les médecins devraient garder en tête que les zoonoses sont présentes dans cette population.

Les résultats trouvés devraient s'avérer utiles pour les populations Cries d'Eastmain et de Wemindji et leur fournir l'information de base sur les zoonoses qui sont présentes dans leurs communautés ainsi que des outils pour prioriser et gérer ces maladies.

Les effets attendus des changements climatiques sur les zoonoses sont difficiles à prévoir. On s'attend à ce que les zoonoses qui sont présentes dans le sud du Québec migrent vers le nord mais on ne peut se prononcer sur le moment où elles atteindront la région de la Baie James. La prévalence des Arbovirus en général pourrait augmenter à cause du climat qui sera plus humide et plus chaud. La prévalence d'Hantavirus pourrait aussi être à la hausse à cause des augmentations de populations de rongeurs qui surviennent généralement après des hivers doux et pluvieux. Le développement économique dans la région pourrait aussi apporter une augmentation dans les maladies transmises par les rongeurs comme l'Hantavirus qui est plus souvent contracté autour des endroits habités.

La prévalence des zoonoses et les modes de transmission peuvent changer et il est important de maintenir un réseau de professionnels bien informés afin de s'assurer que les communautés soient prêtes à réagir et soient bien informées sur les zoonoses. Les données recueillies seront aussi utiles comme données de base dans une perspective de changements climatiques.

REFERENCES

- AFSSA (agence française de sécurité alimentaire des aliments). (2005). Toxoplasmose : état des connaissances et évaluation du risque lié à l'alimentation. Rapport du groupe de travail « *Toxoplasma gondii* » de l'AFSSA. 318 p.
- Artsob, H. (1990). Arbovirus activity in Canada. *Arch Virol*, suppl 1, p. 249-58.
- Bégin, B.G., Guy, R. and Raymond, O. (1956). Kyste hydatique du poumon dans la province de Québec, *Union Médicale Canada*, vol. 85, p. 665-671.
- Bowie, W.R., King, A.S., Werker, D.H., Isaac-Renton, J.L., Bell, A., Eng, S.B. and Marion, S.A. (1997). Outbreak of toxoplasmosis associated with municipal drinking water. *The Lancet*, N° 350, p.173-177.
- Bourque, A. and Simonet, G. (2008). Quebec: in From impacts to adaptations: Canada in a changing climate 2007, edited by D.S. Lemmen, F.J. Warren, J. Lacroix and E. Bush. Government of Canada, Ottawa, Ontario, p. 171-226.
- Brown, K. and Prescott, J. (2008). Leptospirosis in the family dog: a public health perspective. *Can Med Assoc J*, N°178, p. 399-401.
- Burton, I. (2008): Moving Forward on Adaptation; in From Impacts to Adaptation: Canada in a Changing Climate 2007, edited by D.S. Lemmen, F.J. Warren, J. Lacroix and E. Bush; Government of Canada, Ottawa, ON, p. 425-440, [On line]. http://adaptation.nrcan.gc.ca/assess/2007/pdf/ch10_e.pdf. (Page accessed on September 15th, 2008).
- Calisher, C.H., Root, J.J., Mills, J.N. and Beaty, B.J. (2002). Assessment of Ecologic and Biologic Factors Leading to Hantavirus Pulmonary Syndrome, Colorado, U.S.A. *Croatian medical public health*, Vol. 43 n° 3, p. 330-337.
- Carlin, R. (2007). Notifiable Disease (MADO) Report for 1990 to 2006 for the Cree Territory of James Bay (Eeyou Istchee). Cree Board of health and social services of James Bay. 14 p.
- CCWHC (Canadian Cooperative Wildlife Health Centre), 2008. In Wildlife Health Centre Newsletter. *Spring 2008*, [On line]. <http://wildlife.usask.ca/en/newsletter.php>. (Page accessed on September 15th, 2008).
- CCWHC (Canadian Cooperative Wildlife Health Centre). (2000a). Jamestown Canyon virus in Canadian Cooperative Wildlife Health Centre, [On line]. http://wildlife.usask.ca/wildlife_health_topics/arbovirus/arbojc.php. (Page accessed on September 10th, 2008).
- CCWHC (Canadian Cooperative Wildlife Health Centre), 2000b. Fact sheet on the snow shoe hare virus. In Canadian Cooperative Wildlife Health Centre, *Snowshoe hare*

- virus*, [On line]. http://wildlife.usask.ca/wildlife_health_topics/arbovirus/arbossh.php (Page accessed on September 15th, 2008).
- CDC. (2008a). Fact sheet on toxoplasmosis. *In* Centers for Diseases Control, *Toxoplasmosis*, [On line]. <http://www.dpd.cdc.gov/dpdx/HTML/Toxoplasmosis.htm>. (Page accessed on July 15th, 2008).
- CDC. (2008b). Fact sheet on echinococcosis. *In* Centers for Diseases Control, *Echinococcosis*, [On line]. <http://www.dpd.cdc.gov/DPDX/HTML/Echinococcosis.htm>. (Page accessed July 13th, 2008).
- CDC. (2007). Fact sheet on Toxocariasis. *In* Centers for Diseases Control, *Toxocariasis* [On line]. http://www.cdc.gov/ncidod/dpd/parasites/toxocara/factsht_toxocara.htm#2. (Page accessed on September 10th, 2008).
- CDC. (2005a). Factsheet on leptospirosis. *In* Centers for Disease Control. *Leptospirosis*, [On line]. http://www.cdc.gov/ncidod/dbmd/diseaseinfo/leptospirosis_g.htm. (Page accessed on September 10th, 2008).
- CDC. (2005b). Information on Arboviral Encephalitides. *In* Centers for Diseases Control, *Information on Arboviral Encephalitides*, [On line]. <http://www.cdc.gov/ncidod/dvbid/arbtor/arbdet.htm>. (Page accessed on September 10th, 2008).
- CDC. (2004). Fact sheet on trichinellosis. *In* Centers for diseases control [On line]. *Trichinellosis*. http://www.cdc.gov/ncidod/dpd/parasites/trichinosis/factsht_trichinosis.htm. (Page accessed on September 10th, 2008).
- CDC. (2003a). Fact sheet on tularemia. *In* Centers for Diseases Control, *Tularemia*. [On line]. <http://www.bt.cdc.gov/agent/tularemia/faq.asp>. (Page accessed on September 15th, 2008).
- CDC. (2003b). Fact sheet on Q fever. *In* Centers for Diseases Control, *Q fever*, [On line]. <http://www.cdc.gov/ncidod/dvrd/qfever/>. (Page accessed on September 15th, 2008).
- Choutet, P., Lévesque, B., André-Fontaine, B.G., Brugère-Picoux, J., Christmann, D., Couillard, M., Gaulin, C., Goyette, M., Hansmann, Y., Heller, R., Janbon, F., Lambert, L., Paradis, R., Piémont, Y. and F. Raffi. (2003). Animaux sauvages et domestiques zoonoses. *in* Gérin, M., Gosselin, P., Cordier, S., Viau, C. P Quénel and Dewailly, E., *Environnement et santé publique: fondements et pratiques*. (Chap. 21).
- CINE. (2008). Centre for Indigenous Peoples' Nutrition and Environment, [On line]. <http://www.mcgill.ca/cine/>. (Page accessed on November 10th 2008).
- Cook, A.J.C Cook, Gilbert, R.E., Buffolano, W., Zufferey, J., Petersen, E., Jenum, P.A., Foulon, W., Semprini, A.E. and Dunn, T.D. (2000). Sources of toxoplasma infection

- in pregnant women: European multicentre case-control study. *British Medical journal*, vol. 321, p. 142-147.
- Couturier, S., Côté, S.D., Otto, R., Weladji, R.B. and Huot, J. (submitted). Variations in calf body mass in migratory caribou: the role of habitat, climate, and movements. *Journal of Mammalogy*.
- Cree Board of Health and social services. (ND). General page. In Cree Board of Health, *Welcome*, [On line]. <http://www.mednord.org/en/index.html>. (Page accessed on October 25th, 2008).
- Cree cultural institute. (ND). Eastmain page. In Cree Cultural Institute, *Eastmain*, [On line]. http://www.creeculture.ca/e/land_people/eastmain.html. (Page accessed on October 2nd, 2008).
- Cree School Board. (ND). Wemindji page. In Cree School Board, *Wemindji, Québec*, [On line]. http://www.cscree.gc.ca/Establishments/WEMINDJI/Profile_wemindji.htm#FOUNDING%20AND%20LOCATION. (Page accessed on October 20th, 2008).
- CRE James Bay. (2008). Portrait de la Jamésie. In Conseil régional des élus de la Baie James. Portrait de la Jamesie, [On line]. http://www.crebj.ca/index.php?option=com_content&task=view&id=21&Itemid=27 (Page accessed on October 15th, 2008).
- Delormier, T. and Khulein, H.V. (1999). Dietary characteristics of Eastern James Bay Cree Women. *Arctic*, Vol. 55, p.182-187.
- Dolcé, P., Bélanger, M.J., Tumanowicz, K., Gauthier, C.P., Jutras, P., Massé, R., Montpetit, C., Bernatchez, H., McColl, D. and Hartsob, H. (2003). *Coxiella burnetii* seroprevalence of shepherds and their flocks in the lower Saint-Lawrence River region of Quebec, Canada. *Can J Infect Dis*, vol. 14, p.97-102.
- Douglass, R.J., Semmens, W.J., Matlock-Cooley, S.J., and Kuenzi, A.J. (2006). Deer Mouse Movements in Peridomestic and Sylvan Settings in Relation to Sin Nombre Virus Antibody Prevalence. *Journal of Wildlife Diseases*, vol 42, n°4, p.813–818.
- Dragoo, J.W., Lackey, J.A., Moore, K.E., Lessa, E.P., Cook, J.A., and Yates, T.L. (2006). Phylogeography of the deer mouse (*Peromyscus maniculatus*) provides a predictive framework for research on hantaviruses. *Journal of General Virology*, vol 87, p. 1997-2003.
- Drebot, M.A. (2008). Editing for report zoonose Eastmain Wemindji. Personal communication. Email sent on October 6th, 2008. Michael A. Drebot, Chief, Viral zoonoses. Director, science Tehnology and core Services National Microbiology Laboratory, Public Health Agency of Canada, Winnipeg, Manitoba.
- Drebot, M.A. and Artsob, H. (2000). Hantavirus pulmonary syndrome in Canada. 1989-1999. Public Health Agency of Canada. *Communicable Diseases Report*, vol 26 n°08, p.65-69.

- Dubey, J.P., and Jones, J.L. (2008). *Toxoplasma gondii* infection in humans and animals in the United States. *International Journal for Parasitology*, vol. 38, n° 11, p.1257-1278.
- Dubey, J.P. (2004). Toxoplasmosis – a waterborne zoonosis. *Vet Parasitol*, vol. 126, p.57–72.
- Eckert J. and Deplazes, P. (2004). Biological, Epidemiological, and Clinical Aspects of Echinococcosis, a Zoonosis of Increasing Concern. *Clin Microbiol Rev*, vol. 17, p.107-135.
- Eldridge, B.F., Glaser, C., Pedrin, R.E., and Chiles, R.E. (2001). The First Reported Case of California Encephalitis in More Than 50 Years. *Emerging Infectious Diseases*, Vol. 7, n° 3, p.451-452.
- Environment Canada. (2005). Ecozones of Canada. [On line], <http://www.ec.gc.ca/soer-ree/English/vignettes/default.cfm>. (Page accessed on October 2nd, 2008).
- Faine, S. (1998). Leptospirosis, In Hausler, W.J. and Sussman, M. (eds.), *Topley and Wilson's microbiology and microbial infections*, 9th ed. vol. 3: Bacterial infections, (p. 849-869). Arnold, London.
- Farlex Inc. (2008). The free medical dictionary. [On line], <http://www.thefreedictionary.com>. (Page accessed on November 2nd, 2008).
- Feldmann, H., Sanchez, A., Morzunov, S., Spiropoulou, C.F., Rollin, P.E., Ksiazek, T.G., Peters, C.J., Nichol, S.T. (1993). Utilization of autopsy RNA for the associated with hantavirus pulmonary syndrome. *Virus Res*, vol 30, p.351–367.
- Giguère, M. and Gosselin, P. (2006). Maladies zoonotiques à transmission vectorielle, examen des initiatives actuelles d'adaptation aux changements climatiques au Québec. Institut national de santé publique. 23 pp.
- Goyette, M., Poirier, A., Bouchard, J., Morrier, E. (1994). Q fever in Québec (1989-93): Report of 14 cases. *Can J Infect Dis*, vol 5, p.113-118.
- Graziano, K.L., and Tempest, B. (2002). Hantavirus pulmonary syndrome: a Zebra worth knowing. *Am Fam Physician*, vol 66, p.1015-1020.
- Grimstad, P.R., Schmitt, S.M. and Williams, D.G. (1986). Prevalence of neutralizing antibody to Jamestown canyon virus (California group) in populations of elk and moose in northern Michigan and Ontario, Canada. *J Wildl Dis*, vol 22 n° 4, p.453-456.
- Hart, C.A. and Bennett, M. (1999). Hantavirus infections: epidemiology and pathogenesis. *Microbes and Infection*, vol 1, p. 1229-1237.

- Hemphill, A. and Kern, P. (2008). Special issue: Experimental studies in echinococcosis *Experimental Parasitology*, vol. 119, p. 437–438.
- Herbert, F.A., Morgante, O., Burchak, E.C., Kadis, V.M. (1965). Q fever in Alberta- Infection in humans and animals. *Can Med Assoc J*, vol. 93, p.1207-1210.
- Hydro Québec. (2008). Impact assessment of Eastmain-Sarcelle-Rupert. *In Hydro Québec, Documentation Environmental Impact Statement*. [On line]. <http://www.hydroquebec.com/rupter/en/etudes.html>. (Page accessed on October 22nd 2008).
- Hydro Québec. (2007). Projet Eastmain-Sarcelle-Rupert, *in Hydro Québec. Projet hydroélectrique Eastmain-1-a-Sarcelle-Rupert : Hydro Québec dénonce les faussetés véhiculées par certains groupes*. [On line]. http://www.hydroquebec.com/4d_includes/la_une/PcFR2007-101.htm. (page accessed on October 22nd 2008).
- INAC (Indians and Northern Affairs). (2004). Map of Quebec's First Nations. *In Indian and Northern Affairs. Quebec region. Indian and Inuit Populations in Quebec as of December 31, 2007*. [On line]. http://www.ainc-inac.gc.ca/qc/aqc/nat_f.html. (Page accessed on November 15th, 2008).
- Johnson, A., Martin, D.A., Karanatsos, N. and Roehrig, J.T. (2000). Detection of Anti-Arboviral Immunoglobulin G by Using a Monoclonal Antibody-Based Capture Enzyme-Linked Immunosorbent Assay. *J Clin Microbiol*, vol 38, p.1827-183.
- Johnson-Down, L., Bou Khalil, C. and Egeland, G. (2008). Emerging obesity and dietary habits among James Bay Cree Youth: 3 communities. Personal communication. *Nituuchischaayihititaa Aschii, annual scientific gathering 2008*. November 14th, 2008, Montreal. Unpublished proceedings, 47 p.
- James Bay tourism. (2008). Information on James Bay, *in James Bay tourism, Succumb to the allure of the North*. [On line]. <http://www.tourismebaiejames.com/en/index.asp>. (Page accessed on October 15th, 2008).
- Jones, J.L., Kruszon-Moran, D., Wilson, M., McQuillan, G., Navin, T. and McAukey, J.B. (2001). *Toxoplasma gondii* infection in the United States: seroprevalence and risk factors. *Am J Epidemiol*, vol. 154, p. 357-365.
- Kijlstra, A. and Jongert, E. (2008). Toxoplasma-safe meat: close to reality? Trends in Parasitology, In Press. [On line]. http://www.ncbi.nlm.nih.gov/pubmed/18951847?ordinalpos=1&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DefaultReportPanel.Pubmed_RVDocSum. (Document accessed on December 10th, 2008).
- Labelle, P., Mikaelian, I., Martineau, D., Beaudin, S., Blanchette, N., Lafond, R. and St-Onge, S. (2000). Seroprevalence of leptospirosis in lynx and bobcats from Quebec. *Can Vet J*, vol. 41, p.319-320.

- Lang, G.H. (1989). Q fever: an emerging public health concern in Canada. *Can J Vet Res*, vol. 53, p.1-6.
- Lejeune, P. (2008). Unpublished data. Population, taille d'échantillon et nombre de participants, par groupe d'âge et par sexe. (Pers. Comm., august 13th, 2008).
- Lévesque, B., Messier, V., Bonnier-Viger, Y., Couillard, M., Côté, S., Ward, B.J., Libman, M.D., Gingras, S., Dick, D. and Dewailly, E. (2007). Seroprevalence of zoonoses in a Cree community (Canada). *Diagn Microbiol Infect Dis*, vol 59, p.283-286.
- Lévesque, B., De Serres, G., Higgins, R., D'Halewyn, M.A., Artsob, H., Grondin, J., Major, M., Garvie, M. and Duval, B. (1995). Seroepidemiologic study of three zoonoses (leptospirosis, Q fever, and tularemia) among trappers in Québec, Canada. *Clin Diagn Lab Immunol*, vol 2, p.496-498.
- Lindsay, L.R., Drebot, M.A., Weiss, E., Artsob, H. (2001). Hantavirus pulmonary syndrome in Manitoba. *Can J Infect Dis*, vol. 12, p.169-173.
- Malloy, W.F. and J.A. Embil. (1978). Prevalence of *Toxocara* spp. And other parasites in dogs and cats in Halifax, Nova Scotia. *Can J Comp Med.*, vol 42, n° 1, p. 29–31.
- MAMR. (2008). Carte de la région 10. In Ministère des affaires municipales et des régions. *Cartes-Région 10-Nord-du-Québec*. [On line]. www.mamr.gouv.qc.ca/publications/cartotheque/region_10.pdf. (Page accessed on October 20th, 2008).
- MAPAQ. (2001). Informations on Q fever. Bulletin zoosanitaire N° 29. In Agriculture, pêcheries et alimentation. Fièvre Q, [On line]. http://www.mapaq.gouv.qc.ca/NR/rdonlyres/76B5472D-E840-4191-92AD-F00595AA3457/0/fievre_q.pdf. (Document accessed on October 20th, 2008).
- Marmor, M., Glickman, L. Shofer, F., Amdurer, L., Rosenberg, C., Cornblatt, B. and Friedman, S. (1987). *Toxocara canis* Infection of Children: Epidemiologic and Neuropsychologic Findings. *Am J Public Health*, vol. 77, p. 554-559.
- Marrie, T.J., Campbell, N., McNeil, S.A., Webster, D. and Hatchette, T.F. (2008). Q fever update, maritime Canada. *Emerging Infectious Diseases*, vol. 14, p.67-69.
- Marrie T.J. and Raoult D. (2004). *Coxiella burnetii*. In *Mandell, Douglas and Bennett's Principles and Practices of Infectious Disease*, 6th ed. Eds, GL Mandell, JE Bennett and R Dolin. Philadelphia: Elsevier Churchill Livingstone, pp 2296-2303.
- Martin, D.A., Muth, D.A., Brown, T., Johnson, A.J., Karabatsos, N. and Roehrig, J.T. (2000). Standardization of Immunoglobulin M Capture Enzyme-Linked Immunosorbent Assays for Routine Diagnosis of Arboviral Infections. *J Clin Microbiology*, vol. 38, p.1823-1826.
- Martin, T., Holmes, I.H., Wobeser, G.A., Anthony, R.F., Greefkes, I. (1982). Tularemia in Canada with a focus on Saskatchewan. *Can Med Assoc J*, vol. 127, p. 279–282.

- Meier-Stephenson, V., Langley, J.M., Drebot, M., Artsob, H. (2007). Encephalitis in the summer: A case of snowshoe hare (California serogroup) virus infection in Nova Scotia. *Can Commun Dis Rep*, vol. 33 n° 11, p. 23-26.
- Meric, M., Willke, A., Finke, E.J., Grunow, R., Sayan, M., Erdogan, S. and Gedikoglu, S. (2008). Evaluation of clinical, laboratory and therapeutic features of 145 tularemia cases: the role of quinolones in oropharyngeal tularemia. *APMIS*, vol. 116, p. 66-73.
- McIntyre, L., Pollock, S.L., Fyfe, M., Gajadhar, A., Isaac-Renton, J., Fung, J. and Morshed, M. (2007). Trichinellosis from consumption of wild game meat. *CMAJ*, vol. 176, n° 4, p.449-451.
- MDDEP. (ND). Région administrative du Nord-du-Québec. *In* Ministère du développement durable, de l'environnement et des parcs. [On line]. http://www.mddep.gouv.qc.ca/regions/region_10/portrait.htm#. (Page accessible on October 15th, 2008).
- Messier, V., Lévesque, B., Proulx, J.-F., Ward, B.J., Libman, M., Couillard, M., Martin, D. and Hubert, B. (2007). Zoonotic diseases, drinking water and gastroenteritis in Nunavik: a brief portrait. Nunavik Regional Board of Health and Social Services 18p.
- Mikaelian, I., Higgins, R., Lequient, M., Major, M., Lefebvre, F. and Martineau, D. (1997). Leptospirosis in raccoon in Quebec: 2 case reports and seroprevalence in a recreational area. *Can vet J*, vol 38, p. 440-442.
- Moore, C.G. McLean, R.G. Mitchell, C.J., Nasci, R.S., Tsai, T.F. Calisher, C.H., Marfin, A.A., Moore, P.S. and Gubler, D.J. (1993). Guidelines for arbovirus surveillance programs in the United States. Division of Vector-Borne Infectious Diseases National Center for Infectious Diseases Centers for Disease Control and Prevention Public Health Service U.S. Department of Health and Human Services Fort Collins, Colorado. 81 p.
- Moro, P. and Shantz, P.M. (2006). Cystic echinococcosis in the Americas. *Parasitology International*, vol. 55, p.S181-S186.
- MSSS. (2008). Maladies à déclaration obligatoire. *In* Ministère de la santé et des services sociaux, Surveillance des maladies à dclaration obligatoire, [On line]. <http://publications.msss.gouv.qc.ca/acrobat/f/documentation/2007/07-268-01.pdf>. (Document accessed on October 1st, 2008). 129 p.
- MSSS. (2005). Maladies à déclaration obligatoire. *In* Ministère de la santé et des services sociaux. *Liste des maladies, infections et intoxications à déclaration obligatoire (MADO)*. [On line]. <http://www.msss.gouv.qc.ca/sujets/santepub/mado.php#ancree9>. (Page accessed on October 1st, 2008).
- Municipality of Sanikiluaq unpublished report. (2008). Community environmental monitoring systems (CEMS) workshop Summary Report. Nunavuumi Tasiujarjuamiuguqatigiingit (NTK)/ Nunavut Hudson Bay Inter-Agency working Group. 41 p.

- Nelson, D.M., Gardner, I.A., Chiles, R.F., Balasuriya, U.B., Eldridge, B.F., Scotte, T.W., Reisen, W.K. and MacLachlan, N.J. (2004). Prevalence of antibodies against Saint Louis encephalitis and Jamestown Canyon viruses in California horses. *Comparative Immunology, Microbiology & Infectious Diseases*, vol. 27, p.209–215.
- Njaa, B.L. (2008). Emerging viral encephalitis in dogs and cats. *Vet Clin Small Anim* vol. 38, p.863-878.
- Nunavik research Center (ND). Wildlife diseases and public health. [On line]. http://www.makivik.org/nrc/eng/wildlife_diseases/index.htm. (Page accessed on November 1st, 2008).
- Ogden, N. (2008). *Lyme disease, zoonotic diseases and climate change*. Personal communication. Congrès de l'association des biologistes du Québec, Les changements climatique : impacts, adaptations et solutions. November 13th, 2008, Montréal.
- Pereg, D. and Nieber, E. (eds) (2007). Nituuchischaayihititaa Aschii Multi-Community Environment-and-Health Longitudinal Study in Iiyiyu Aschii: Mistissini. Technical report: summary of activities, results and recommendations. 389 pp. (p.19).
- PHAC, (Public health agency of Canada). (2007). Canada. Snowshoe hare in Canada. In Public Health agency of Canada. *Encephalitis in the Summer: A Case of Snowshoe Hare (California Serogroup) Virus Infection in Nova Scotia*. Communicable Disease Report, vol 33 N° 11 [On line]. <http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/07vol33/dr3311c-eng.php>. (Page accessed July 13th, 2008).
- PHAC, (Public health agency of Canada). (2006). Notifiable diseases online. In Public Health Agency of Canada, *Tularemia*, [On line]. http://dsol-smed.phac-aspc.gc.ca/dsol-smed/ndis/disease2/tula_e.html. (Page accessed July 13th, 2008).
- PHAC (Public health agency of Canada). (2001a). Toxoplasmosis information sheet. In Public Health Agency of Canada. *Toxoplasma gondii - Material Safety Data Sheets (MSDS)*. [On line]. <http://www.phac-aspc.gc.ca/msds-ftss/msds153e-eng.php>. (Page accessed July 13th, 2008).
- PHAC (Public health agency of Canada). (2001b). *Echinococcus granulosus*-Material Safety Data Sheets (MSDS). Material Safety Data Sheet-infectious substances. [On line]. <http://www.phac-aspc.gc.ca/msds-ftss/msds54e-eng.php>. (Page accessed on October 15th, 2008).
- PHAC (Public health agency of Canada). (2001c). *Toxocara canis, Toxocara cati* - Material Safety Data Sheets (MSDS), [On line]. <http://www.phac-aspc.gc.ca/msds-ftss/msds152e-eng.php>. (Page accessed on September 10th, 2008).
- PHAC (Public health agency of Canada). (2001d). Outbreak of trichinellosis associated with Arctic walrus in Northern Canada, 1999. *Can Commun Dis Rep*, vol 27, n° 4, p.31-36. [On line]. <http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/01vol27/dr2704e.html>. (Page accessed on November 1st, 2008).

- PHAC (Public health agency of Canada). (2001e). Tularemia fact sheet. *In* Public health agency of Canada. *Francisella tularensis - Material Safety Data Sheets (MSDS)*, [On line]. <http://www.phac-aspc.gc.ca/msds-ftss/msds68e-eng.php>. (Page accessed on November 1st, 2008).
- PHAC, (Public Health Agency of Canada). (2001f). Leptospirosis. *In* Public health agency of Canada. *Leptospira interrogans - Material Safety Data Sheets (MSDS)*, [On line]. <http://www.phac-aspc.gc.ca/msds-ftss/msds95e-eng.php>. (Page accessed on September 20th, 2008).
- PHAC, (Public Health Agency of Canada). (2001g). Q fever fact sheet. *In* Public Health Agency of Canada. *Coxiella burnetii - Material Safety Data Sheets (MSDS)*, [On line]. <http://www.phac-aspc.gc.ca/msds-ftss/msds43e-eng.php>. (Page accessed on September 20th, 2008).
- PHAC (Public health agency of Canada). (2000). Hantavirus pulmonary syndrome in Canada, 1989-1999. Canada communicable diseases report. Vol. 26-08. Accessed on October 15th, 2008 at: <http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/00vol26/dr2608ea.html>. (Page accessed on September 20th, 2008).
- PHAC (Public health agency of Canada). (1999). California serogroup. *In* Public Health Agency of Canada. *California serogroup - Material Safety Data Sheets (MSDS)*, [On line]. <http://www.phac-aspc.gc.ca/msds-ftss/msds27e-eng.php>. (Page accessed on September 20th, 2008).
- Pozio, E. (2001). New patterns of *Trichinella* infection. *Veterinary Parasitology*, vol 98, p. 133-148.
- Prescott, J. and Richard, P. (2004). *Mammifères de l'est du Québec et de l'est du Canada*. Éditions Michel Quintin, Waterloo, Québec. 400 p.
- Prescott, J.F., McEwen, B., Taylor, J., Woods, J.P., Abrams-Ogg, A., Wilcock, B. (2002). Resurgence of leptospirosis in dogs in Ontario: recent findings. *Can Vet J*, vol. 43, p. 955-961.
- Rathinam, S.R. (2005). Ocular manifestations of leptospirosis. *J Postgrad Med*, vol. 51, p.189-194.
- Ratiarson, A. (2003). Le Hantavirus : est-ce un nouveau virus ? . *In* STA health care communications. *Le clinicien*, vol 18, no 5. 6p. [On line]. <http://www.stacommunications.com/journals/pdfs/clinicien/clinicienpdfaugust03/hantavirus.pdf>. (Page accessed on August 15th, 2008).
- Régie Régionale de la Santé et des Services Sociaux du Nunavik. (2003). Informations on Nunavik. *In* Régie Régionale de la Santé et des Services Sociaux du Nunavik. *La région du Nunavik*, [On line]. <http://www.rrsss17.gouv.qc.ca/fr/nunavik/>. (Page accessed on November 15th, 2008).
- Roberts, H., Lim, W.S. (2008). Viral lung infections and the potential for a human pandemic. *Medicine*, vol 26, n° 6, p. 291-294.

- Safronetz, D., Drebot, M.A., Artsob, H., Cote, T., Makowski, K., and L.R. Lindsay. (2008). Sin Nombre virus shedding patterns in naturally infected deer mice (*Peromyscus maniculatus*) in relation to duration of infection. *Vector-borne and zoonotic diseases*, vol 8, no 1, p. 97-100.
- Schaeffer, O. (1977). Changing dietary patterns in the Canadian North: Health, social and economic consequences. *Journal of the Canadian Dietetic Association*, vol. 38, n° 1, p.17–25.
- Séguin, J. (ed.). (2008). Human health in a changing climate: A Canadian Assessment of vulnerabilities and Adaptive capacities. Health Canada. 484 pp.
- Shuhaiber, S., Koren, G., Borkovic, R., Einarson, T.R., Soldin, O.P., and A. Einarson. (2003). Seroprevalence of *Toxoplasma gondii* infection among veterinary staff in Ontario, Canada (2002): implications for teratogenic risk. *BMC Infectious diseases*, vol 3. [On line]. <http://www.biomedcentral.com/1471-2334/3/8>. (Document accessed on November 15th, 2008).
- Smith, H.J. (1978). Parasites of red foxes in New Brunswick and Nova Scotia *Journal of Wildlife Diseases*, vol. 14, p. 366-370.
- Snyder, M.J. (1980). Immune response to *Francisella*. In Rose, N.R. and Friedman, H. (Eds.) *Manual of Clinical Immunology*. 2nd ed. Washington DC: *American Society for Microbiology*, pp. 479–481.
- Somily, A., Robinson, J.L., Miedzinski, L.J., Bhargava, R. and Marrie, T.J. (2005). Echinococcal disease in Alberta, Canada: more than a calcified opacity. *BMC Infectious diseases*, vol. 5, n° 34, 7p.
- Steinemann, T.L., Sheikholeslami, M.R., Brown, H.H. and Bradsher, R.W. (1999). Oculoglandular tularemia. *Arch Opht*, vol 117, p.132-133.
- Stewart, S.J. (1981). Tularemia. In Balows, A., Hausler, W.S. Jr. (Eds) *Diagnostic Procedures for Bacterial, Mycotic, and Parasitic Infections*. 6th ed. (p. 705–714). Washington, DC: American Public Health Association.
- Tanner, C.E., Staudt, M., Adamowski, R., Lussier, M., Bertrand, S., Prichard, R.K. (1987). Seroepidemiological study for five different zoonotic parasites in Northern Quebec. *Can J Public Health*, vol. 78, p. 262–266.
- Taylor, L.H., Latham, S.M. and Woolhouse, M.E. (2001). Risk factors for human disease emergence. *Philos. Trans. R. Soc. Lond., B, Biol. Sci.*, vol 356, n° 1411, p.983-989.
- Tsai, T.F. (1991). Arboviral infections in the United States. *Inf Dis Clin North Am*, vol. 5, p. 73-102.
- Unruh, D.H.A., King, J.E., Eaton, R.D.P. and Allen, J.R. (1973). Dogs from Indian Settlements in Northwestern Canada: A Survey with Public Health Implications *Can. J. comp. Med*, vol 37, p. 25-32.

- Vincent, C. and Desjardins, F. (2001). Fièvre Q. *Épidémiologie et Santé Publique*, vol. 29 :5p. [Online].
http://www.mapaq.gouv.qc.ca/Fr/Restauration/md/Publications/fievre_q.htm. (Page accessed on August 25th, 2008).
- Vincent, C. (2000). La leptospirose canine : une zoonose en émergence. Réseau d'alerte et d'information zoonositaire. [On line].
http://www.mapaq.gouv.qc.ca/Fr/Consommation/md/Publications/leptospirose_canine.htm (Page accessed on August 26th, 2008).
- Wahl-Jensen, V., Chapman, J., Asher, L., Fisher, R., Zimmerman, M., Larsen, T., and Hooper, J.W. (2007). Temporal Analysis of Andes Virus and Sin Nombre Virus Infections of Syrian Hamsters. *Journal of virology*, vol. 81, n° 14, p.7449–7462.
- Walters, L.L., Tirrell, S.H., Shope, S.E. (1999). Seroepidemiology of California and bunyamwera serogroup (Bunyaviridae) virus infections in native populations of Alaska. *Am.J.Trop.Med.Hyg*, vol 60 n° 5, p. 806-821.
- Webster, D., Lee, B., Joffe, A., Sligl, W., Dick, D., Grolia, A., Feldmann, H., Yacoub, W., Grimsrud, K., Safronetz, D., Lindsay, R. (2007). Cluster of cases of hantavirus pulmonary syndrome in Alberta, Canada. *Am J Trop Med Hyg*, vol. 77, p. 914-918.
- Weir, E. (2005). Hantavirus: 'tis the season. *CMAJ*, vol. 173, no 2, p. 147. [Online].
<http://www.cmaj.ca/cgi/reprint/173/2/147>. (Page accessed on August 25th, 2008),
- Wemindji Cree Nation. (2006). Wemindji community profile. In Wemindji community website, our community profile. [Online]. <http://www.wemindji-nation.qc.ca/>. (Page accessed on August 25th, 2008), 22p.
- WHO (world Health organisation). (2008a). Malaria impacts. In world health organization. Media Centre, *Progress made in malaria control, yet burden is enormous*. [On line].
<http://www.who.int/mediacentre/news/releases/2008/pr32/en/index.html>. (Page accessed on October 25th, 2008).
- WHO (world Health organisation). (2008b). In World health organization. Epidemic and Pandemic Alert and Response (EPR). *Cumulative Number of Confirmed Human Cases of Avian Influenza A/(H5N1) Reported to WHO*. [On line].
http://www.who.int/csr/disease/avian_influenza/country/cases_table_2008_12_16/en/index.html. (Page accessed on December 17th, 2008).
- WHO (World Health Organisation). (2008c). Emerging zoonoses. In World health organization. http://www.who.int/zoonoses/emerging_zoonoses/en/. (Page accessed on December 17th, 2008).
- WHO (World Health Organisation). (2008d). Zoonose definition. In WHO health topics. Zoonoses, [On line]. <http://www.who.int/topics/zoonoses/en/>. (Page accessible on December 17th, 2008).
- WHO (World Health organization). (2007). WHO Guidelines on Tularaemia. Non serial publication.

<http://www.who.int/bookorders/anglais/detart1.jsp?sesslan=1&codlan=1&codcol=15&codcch=721>. (Document accessed on August 15th, 2008). 122p.

WHO (World Health Organization). (2003). Human leptospirosis: guidance for diagnosis, surveillance and control. [On line].

www.who.int/csr/don/en/WHO_CDS_CSR_EPH_2002.23.pdf. (Document accessed on August 25th, 2008). 122 p.

WHO (World Health Organization) (2000). Leptospirosis in Canada. [On line].

http://www.who.int/csr/don/2000_09_21a/en/index.html. (Page accessed on August 25th, 2008).

Young, L.S., Bicknell, D.S., Archer, B.G., Clinton, J.M., Leavens, L.J., Feeley, J.C., Brachman, P.S. (1969). Tularemia epidemic: Vermont, 1968. Forty-seven cases linked to contact with muskrats. *N. Engl. J. Med*, vol. 280, p. 1253–1260.

Zamparo, J.M., Andreadis, T.G., Shope, R.E., Tirrell, S.J. (1997). Serologic Evidence of Jamestown Canyon Virus Infection in White Tailed Deer Populations from Connecticut. *J Wildl Dis*, vol. 33, n° 3, p.623-627.

Zarnke, R.L., Ver Hoef, J.M. DeLong, R.A. (2004). Serologic survey for selected disease agents in wolves (*Canis lupus*) from Alaska and the Yukon Territory, 1984-2000. *J Wildl Dis*, vol. 40, n° 4, p.632–638.