Nituuchischaayihtitaau Aschii

Multi-community environment-and-health study in Eeyou Istchee, 2005-2009: Final Technical Report

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Conseil Cri de la santé et des services sociaux de la Baie James
Cree Board of Health and Social Services of James Bay

Miskamoon Corporation

Public Health Report Series 4 on the Health of the Population
Cree Board of Health and Social Services of James Bay

September 2013

Nituuchischaayihtitaau Aschii

Multi-community Environment-and-Health Study in Eeyou Istchee, 2005-2009: Final Technical Report

Chisasibi

Eastmain

Mistissini

Nemaska

Oujé-Bougoumou

Waskaganish

Waswanipi

Wemindji

Whapmagoostui

Public Health Report Series 4 on the Health of the Population
Cree Board of Health and Social Services of James Bay

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ABBREVIATIONS AND GLOSSARY OF CREE TERMS

Agency and Program Abbreviations

AMAP:	Arctic Monitoring and Assessment Programme
FAO:	Food and Agriculture Organization of the United Nations
CBHSSJB:	Cree Board of Health and Social Services of James Bay
CDC:	Centers for Disease Control and Prevention (USA)
CHU:	Centre hospitalier universitaire
CINE:	Centre for Indigenous People's Nutrition and Environment
HBC:	Hudson's Bay Company
IDF:	Internationl Diabetes Federation
INSPQ:	Institut national de santé publique du Québec
MADO:	Maladies à déclaration obligatoire
LSPQ:	Laboratoire de santé publique du Québec
NML:	National Microbiology Laboratory
PHAC:	Public Health Agency of Canada
SPPOS-CHU:	Axe santé des populations et pratiques optimales en santé - Centre de Recherche du CHU de Québec
UNU:	United Nations University
WHO:	World Health Organization

Cree Terms

Nituuchischaayihtitaau Aschii	Learn about us and our earth
Eeyou	Cree person
Eeyouch	Cree persons
Eeyou Ayimuwin	Cree language
Eeyou Istchee	Cree Territory (Category 1, 2 and 3 lands)

Cree terms used are spelled according to Eastern James Bay Cree Dictionary – Northern and Southern Dialects (electronic version) ©2004 Cree School Board (http://www.carleton.ca/ecree/en/dictionary.html)

Abbreviations

ADE:	analysis of ecological data
AMDR:	acceptable macronutrient distribution range
ANOVA:	analysis of variance
Apo A1:	apolipoprotein A1
Apo B:	apolipoprotein B
BLL:	blood lead level
BMI:	body mass index
BMR_{est}:	basal metabolic rate (estimated)
BP:	blood pressure
BUA:	broadband ultrasound attenuation
C:	cholesterol
CA:	correspondence analysis
CA-1:	correspondence axis 1

CI:	confidence interval
CIMT:	carotid intima-media thickness
CRP:	C-reactive protein
CVD:	cardiovascular disease
DBP:	diastolic blood pressure
DHA:	docosahexanoic fatty acid
DM:	diabetes mellitus
EAR:	estimated average recommendation
EI:	energy intake, or Enterococci
ELISA:	enzyme-linked immunosorbent assay
EM-1:	Eastmain-1
EPA:	eicosapentaenoic fatty acid
FA:	fatty acids
FFQ:	food frequency questionnaire
HCB:	hexachlorobenzene
HDL-C:	high-density lipoprotein (so-called "good" cholesterol)
HF:	high frequency
Hg:	mercury
HRV:	heart rate variability
HTN:	hypertension
ICP-MS:	inductively coupled plasma mass spectrometry
IFG:	impaired fasting glucose
IgG:	immunoglobin G
IgM:	immunoglobin M
IL-6:	interleukin-6
IPAQ:	International Physical Activity Questionnaire
IQR:	interquartile range
IU:	international unit
JC:	Jamestown Canyon (virus)
LDL-C:	low-density lipoprotein (so-called "bad" cholesterol)
LF:	low frequency
LOD:	limit of detection
MUFA:	monounsaturated fatty acids
NA:	not applicable
OCs:	organochlorines
OCPs:	organochlorine pesticides
PBB:	polybrominated biphenyl
PBDE:	polybrominated diphenyl ether
PCA:	principal component analysis
PC-1:	principal component axis 1
PCBs:	polychlorinated biphenyls
PBDEs:	polybrominated diphenyl ethers
PFOA:	perfluoroctanoate
PFOS:	perfluoroctane sulfonate

PFHxS:	perfluorohexanesulfonate
PON-1	paraoxonase 1
POPs:	persistent organic pollutants
p,p'-DDE:	dichloro-diphenyl dichloroethylene
p,p'-DDT:	dichloro-diphenyl trichloroethane
PRNT:	plaque reduction neutralization test
PUFAs:	polyunsaturated fatty acids
QUS:	quantitative ultrasound
RAE:	retinol activity equivalent
RBC:	red blood cell
SAS:	statistical analysis system
SBP:	systolic blood pressure
SD:	standard deviation
SFA:	saturated fatty acids
SPSS:	Statistical Package for the Social Sciences
SSH:	snowshoe hare (virus)
T2D:	type 2 diabetes
T3:	3,5,3′-triodothyronine
T4:	thyroxine
TC:	total cholesterol or total coliform
TFA:	trans-fatty acid
TG:	triacylglycerol
TNF-α:	tumour necrosis factor
TSH:	thyroid stimulating hormone
WC:	waist circumference

1. PROJECT BACKGROUND AND OBJECTIVES

(Elizabeth Robinson and Jill Torrie)

1.1 Background

The people of *Eeyou Istchee* have experienced major changes in their environment and their way of life in the last 60 years. Before the 1960s, children were sent out to residential schools for most of the year, and many families spent a good part of the year on their hunting territories. As services developed, including schools and clinics, people began to spend more time in the communities. At the same time, mining and forestry development started to affect the southernmost Cree bands – Oujé-Bougoumou and Waswanipi. In the 1960s it was discovered that some fish contained high levels of mercury, and people were told to stop eating it. With the start of Hydro development in the 1970s, roads were built in the territory and food and other goods from the south became more and more accessible, while lifestyle changes (e.g., less walking, use of motorized vehicles, office jobs) led to people being less physically active than before. All these changes have had a dramatic effect on health. Some improvements have occurred – for example, far fewer babies and children die of infectious diseases like gastroenteritis and meningitis. But other diseases – such as diabetes and thus also heart disease – have been on the increase.

The introduction of the hydro-electric projects in the region in the 1970s came with new concerns about increasing mercury levels linked to these dams. In the context of the La Grande Project, this led to the 1986 Mercury Agreement between the Grand Council of the Crees (GCC), the government of Quebec and Hydro-Québec; subsequently, the 2001 Mercury Agreement was implemented in the context of the Eastmain-1 project. Mercury is a concern for human health either from the risk of eating contaminated fish or the risk of poor nutrition linked to not eating fish. For this reason, the 2001 Agreement provided significant money to stimulate the fishery, with $8M set aside to study Cree fish consumption patterns and benefits, as well as exposure to mercury and other contaminants. A legal vehicle, the Eeyou Namess Corporation, was set up to plan, approve and manage projects carried out with these funds.

For a time, there was a question within the Public Health Department about how to best respond to the significant mandate set out in the 2001 Mercury Agreement. Surveillance of a population's health is one of the primary functions within public health, so the mandate itself was never at issue. Rather, the concern was on how to implement such a large mandate in a small Department with many other priorities.

The response evolved through two processes, one involving a quite separate initiative. The latter was a 2002 study carried out in Oujé-Bougoumou (with Nemaska serving as a non-impacted community); it was designed to look at the health impacts of mine tailings on the environment and human health (Dewailly and Nieboer, 2005). In effect, the design of that study addressed many of the objectives of the 2001 Mercury Agreement, and thus was able to serve as a precursor and model for subsequent studies developed under the Mercury Agreement (2001) funds. The other process was a direct, planning consultation with the communities and Cree entities about their needs for and the feasibility of doing such a comprehensive environment-and-health study with the Mercury Agreement funds (Nieboer and VanSpronsen, 2004). This happened in late 2003 and early

2004, and it led directly into the development of the protocol for a study which was accepted by the Eeyou Namess Corporation[1] for a pilot study in 2005 in Mistissini.

1.2 Objectives

The links between mercury and the other components of the study are as follows: contaminants such as mercury in people's bodies are thought to come mainly from eating traditional foods, so it was decided to ask people what kinds of traditional foods they eat. Because of the alarming rise in the incidence of diabetes in *Eeyou Istchee*, questions about store-bought foods and physical activity were also included. A serious consequence of diabetes is heart disease. Since fish and possibly other foods in the traditional Cree diet potentially protect against these diseases, indicators of heart and blood vessel disease were included in the study. Other clinical laboratory tests were also incorporated to permit an examination of links between diet, contaminants, lifestyle issues and health indicators. Testing for diseases spread by game animals and birds (zoonoses) and micro-organisms in traditional sources of water was also added, as well as women's bone health.

Thus, the main objectives of the *Nituuchischaayihtitaau Aschii Environment-and-Health Longitudinal Study in Eeyou Istchee* were to: investigate health effects in relation to lifestyle, environmental contaminants exposure, and diet (assess exposure to environmental contaminants and nutrient intake); and investigate the links between wildlife health, quality of aquatic environments and human health.

1.3 Field Work Synopsis

The field work in the seven communities took place over a two- to four-week period during the spring and/or summer of the years indicated below.

Mistissini	2005
Eastmain and Wemindji	2007
Chisasibi and Waskaganish	2008
Waswanipi and Whapmagoostui	2009

A random sample of participants was selected from each community. The target number varied with the population size of the community. A total of 1,405 persons from all age groups participated; between 150 and 288 per community depending on community size. Individuals were free to accept or refuse to participate. Participants answered questions about their diet and physical activity; they gave blood, hair, nails and urine samples for laboratory analyses, and had tests for their heart rhythm, arteries and bone strength. During the time the study team was in the community, activities for children and youth were organized with the aim of interesting them in science.

[1] The mandates of the Eeyou Namess Corporation were transferred to the Niskammon Corporation in 2005. The Niskamoon Corporation manages funds from several Cree Hydro-Québec agreements.

1.4 Funding

Financial support for the *Nituuchischaayihtitaau Aschii* study was obtained from the Niskamoon Corporation, through monies set aside in the 2001 Mercury Agreement between the Grand Council of the Crees (*Eeyou Istchee*) and Hydro Québec, for monitoring exposure of *Eeyouch* to mercury and other contaminants. It was carried out by researchers from three universities – Laval, McGill and McMaster– in partnership with the CBHSSJB.

1.5 Previous Reports

Two detailed reports have been prepared to date on the *Nituuchischaayihtitaau Aschii* study findings: one for Mistissini (Bonnier-Viger et al., 2007) and that already mentioned for Eastmain and Wemindji (Bonnier-Viger et al., 2011). These documents are available on the CBHSSJB Public Health Department websites (http://www.creehealth.org/library/online?f[type]=1001&s=author&o=asc); also see the list of references for the indicated documents. The present report includes results for all seven communities, but gives more details for the four communities for which the findings have not previously been reported (Chisasibi, Waskaganish, Waswanipi and Whapmagoostui). When possible, results from the Oujé-Bougoumou and Nemaska study were included in the analyses of the current report. Permission was obtained from those two communities to allow merging their data into that of the *Nituuchischaayihtitaau Aschii* study. Furthermore, the findings have been and will continue to be published in scientific journals. All such publications are listed online with each study.

How the report is organized (by chapter):

Chapter 1 – Project Background and Objectives

Chapter 2 – Field Study and Methods

Chapter 3 – The Regional and Community Context of the *Nituuchischaayihtitaau Aschii* Multi-community Environment-and-Health Study

Chapter 4 – Dietary Assessment and Physical Activity

Chapter 5 – Exposure to Environmental Contaminants

Chapter 6 – Heart Disease Risk Factors, Diabetes, Bone Health and Thyroid Disorders

Chapter 7 – Zoonoses

Chapter 8 – Drinking Water

Chapter 9 – Educational Activities

Chapter 10 – Conclusions

For chapters 4-7 and 9, the results for each of the communities surveyed in 2008 (Chisasibi and Waskaganish) and 2009 (Waswanipi and Whapmagoostui) are highlighted. To supplement the various chapters, supporting data and related technical materials and documents are provided in 11 appendices.

1.6 Community Permission, Individual Consent, and Reporting of Results

Before carrying out the study in a community, a presentation was made at a Council meeting to obtain a Council resolution for it.

Individuals who agreed to participate, individuals and the parent or guardian of participants under 18 years of age, or the parent or guardian of children 7 years of age or younger, were asked to sign a consent form. After the study, the results for a community were presented at a Council meeting, or more commonly at a Local Annual General Assembly, by one or more of the researchers and CBHSSJB staff. A pamphlet or booklet summarizing the major findings was also distributed at the gathering. Copies of these are available on the website of the Public Health Department of the CBHSSJB under the section Documents Centre", by community (http://www.creehealth.org/library/online?f[type]=1001&s=author&o=asc). Each individual participant also received his or her results by mail and, if the participant had consented, a copy was also sent to the local clinic. Further details are provided in Chapter 2.

1.7 Research Agreement

Although the formal *Research and Data Use Agreement* for the *Multi-community Environment-and-Health Longitudinal Study in Eeyou Istchee: Nituuchischaayihtitaau Aschii* (http://www.creehealth.org/library/online?f[type]=1001&s=author&o=asc) was only signed in 2011 by the CBHSSJB's Executive Director, a senior administrator of each of the three participating universities and the principal investigators, the unsigned draft of the agreement had previously been followed by the project investigators and managers. It makes the commitment to follow the spirit of Canada's Tri-Council Guidelines for Research Involving First Nations, Inuit and Métis Peoples of Canada (CIHR/NSERC/SSHRC, 2010) and complies with the approach adopted by the Cree Board of Health and Social Services. This agreement was promulgated to establish Cree control over the basic data file of the study and declare joint ownership of new data created from the basic data file.

Among other conditions, it requires researchers to:

- Sign a confidentiality agreement and obtain consent from the CBHSSJB in order to obtain access to the databank;
- Present research plans to the Public Health Department of the CBHSSJB before beginning specific analytical projects;
- Present the results to the community before presenting at scientific conferences;
- Obtain community permission before naming a community in a scientific communication; and
- Give the Public Health Department of the CBHSSJB time to comment on drafts of articles before they are submitted to scientific publications.

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2. Field Study and Methods

(Evert Nieboer)

2.1 Overview

A summary of field activities and scientific methods employed are provided in this chapter. To curtail the size of this report and circumvent repetition, only overviews are provided. When appropriate, the reader is directed to consult specific sections of the *Nituuchischaayihtitaau Aschii* study's second report (Bonnier-Viger Y et al., 2011; referred to as the E&W Report) for more detailed methodological information.

This chapter not only features details of the field and scientific activities for the last four communities surveyed in 2008 and 2009, but also supports the report's objective to compare (where possible) the findings with those of Mistissini (Bonner-Viger, et al., 2007), Eastmain and Wemindji (E&W Report), and the earlier Oujé-Bougoumou and Nemaska exposure and preliminary health assessments conducted in 2002 (Dewailly and Nieboer, 2005). However, the protocols for the communities studied in 2005 and thereafter included more health measures (e.g., bone density, heart variability, carotid artery ultrasound and contaminant estimates in blood plasma (specifically, dioxins, furans and emerging contaminants like fire retardants).

2.2 Study Populations, Questionnaires, and Consent

Prior to initiating the *Nituuchischaayihtitaau Aschii* study, sample size calculations indicated that the recruiting targets should be 150 individuals in the smallest community (i.e., Eastmain) and 300 in the largest (i.e., Chisasibi) (Section 4.2.1, E&W Report, p.26). Basic recruitment details for all communities are provided in Table 2.1, and supplemental sampling and participation status information in Table A1 of Appendix 1. Note that the study subjects were stratified by age: children 0-7 and 8-14 years and adults, 15-39 and 40 years and older.

The relationship between environmental contaminants and diet on the one hand, and health endpoints on the other, is affected by many parameters related to lifestyle. It is essential that these be documented within the framework of an environment-and-health study. In order to document these parameters, the individual and clinical questionnaires were designed to collect information on: lifestyle, occupational details, socio-demographic situations, self-reported health endpoints, etc. Dietary habits were documented using 3 specially designed questionnaires (namely, 24-hour recall, market food, and traditional food questionnaires), and handling of animals was assessed by the Zoonoses Questionnaire. Questions from an international physical activity questionnaire were also administered. The information from the questionnaires was entered directly on a tablet computer using an automated sequence programmed in Microsoft Access.

TABLE 2.1 RECRUITMENT AND PARTICIPATION

Community (month, year of fieldwork)	**Population**	**Invited**[a]	**Participants**	**Participation rate** (%)
Oujé-Bougoumou (October, 2002)	622	329	225	68.4
Nemaska (November, 2002)	616	242	100	41.3
Mistissini (June, 2005)	2,679	516	288	55.8
Wemindji (June, 2007)	1,178	301	202	67.1
Eastmain (August, 2007)	561	236	150	63.6
Waskaganish (June, 2008)	1,967	473	176	37.2
Chisasibi (June/July, 2008)	3,820	702	266	37.9
Whapmagoostui (August, 2009)	798	320	161	50.3
Waswanipi (August/September, 2009)	1,473	469	162	34.5

a. Selected randomly from the *Eeyou* Beneficiary List. Additional details are provided in Table A1.

Sample questionnaires are assembled in Appendix 2 and summaries of their contents, objectives and administration are provided in Sections 4.3 (p.29), 4.7 (p.44), and 4.8 (p.45) of the E&W Report. It should be emphasized that the individual questionnaires (including the zoonoses questions) were administered by locally trained interviewers in either *Eeyou Ayimuwin* or in English; the clinical questionnaire by a research nurse in English assisted by a local interpreter; and the dietary questionnaires by local interviewers and translators.

Four separate consent forms and information sheets were prepared for the following age groups: 0-7, 8-14, 15-17 and adults aged 18 years and older (see Appendix 3). Consent for those in the first three age groups was given by one of the child's parents or guardian.

2.3 Clinical Tests, Collection of Samples, Laboratory Analyses & Methods, and Clinical Assessments

Table 2.2A provides an age-stratified overview of the questionnaires administered and the body fluids and tissues collected. Note that a time-reimbursement was provided to the participants at the end of their visit. A few visits were done at the homes of participants who were not able to come to the clinic (e.g., seniors), or who requested this service. A summary of the anthropometric and clinical measurements conducted are summarized in Table 2.2B; the environmental contaminants determined in whole blood, plasma, hair, toenail or urine in Table 2.2C; the clinical chemistry analytes measured in blood plasma or urine in Table 2.2D; and miscellaneous clinical chemistry analytes in selected tissues in Table 2.2E.

The rationale for the selection of these various tests and substances are provided in Sections 3.2.4-3.2.6 of the E&W Report (pp. 19-22); field protocols in Section 4.4 (pp. 30-31); laboratory analytical methods in Section 4.5 (pp. 34-40); details of the anthropometric and clinical assessments in Section 4.6 (pp. 40-43); and dietary and physical activity assessment in Sections 4.7-4.8 (pp. 44-46). The limits of detection (LODs) of the chlorinated and brominated compounds analyzed are summarized in Appendix 3 of the E&W Report (pp. 325-326). For statistical manipulations involving all nine communities, the LODs were set uniformly at the INSPQ's most conservative values (see Table A8.2.1 of the current document).

The methodological details of the zoonoses study are provided in Section 6.2 (pp. 193-195), and the microbial drinking water tests in Section 7.2 (pp. 209-211) of the E&W Report. Based on tests conducted in Mistissini, Wemindji and Eastmain of various sources of drinking water consumed (well, surface and community-supplied tap water), it was decided that a clear enough picture of its microbial contamination had been obtained. Consequently, the drinking water quality assessment component was not included in the 2008 and 2009 field work. Nevertheless, the feedback about different drinking water sources obtained through the Individual Questionnaire will be compiled and used as an indication of the probability of consuming microbially-contaminated water.

Table 2.2A Questionnaires administered and specimens collected

Age group	Informed consent form	Individual questionnaire (including zoonoses)	Clinical (women only) and Physical Activity Questionnaires	24-hour recall and 2 Food Frequency Questionnaires (FFQs)	Blood sampling: contaminants	Blood sampling: clinical biochemistry	Hair sampling	Toenails
0-7 years old	√				Lead only		√	
8-14 years old	√	√		√[2]	√	√	√	√
≥15 years old	√	√	√[1]	√	√	√	√	√

1. Section on physical activities to be administered to participants aged 15-69 and zoonoses to participants aged ≥15 years old.

2. 24-hour recall and FFQs (traditional and market) from 9 years old and over.

Table 2.2B Anthropometric and clinical measurements

Age group	Blood pressure/pulse	Height/weight and circumferences: waist/hip, sitting height	Body composition	2-hour Holter	Ultrasound bone densitometry	Ultrasound carotid	Oral temperature
0-7 years old							
8-14 years old	√	√	√				
≥15 years old	√	√	√	√	√ if a woman and ≥35-74	√	√

TABLE 2.2C ENVIRONMENTAL CONTAMINANTS MEASURED IN TISSUES

Age group	**Lead** (whole blood)	**Cadmium, total mercury, selenium, cobalt, copper, molybdenum, nickel, and zinc** (whole blood)	**Selenium** (toenail)	**Total mercury** (hair 1st cm)	**POPs** (PBBs/OCs/ PBDE/ Toxaphenes in plasma)	**PFOS/ PFOA/ PFHxS** (in plasma)	**Dioxin-like compounds** (CALUX, in plasma)	**PON-1** (in plasma)	**Inorganic arsenic and metabolites of contaminants** (in urine)
0-7 years old	√			√					
8 years old and over	√	√	√	√ + arsenic (3rd cm)	√	√	√	√	√

TABLE 2.2D CLINICAL CHEMISTRY ANALYTES MEASURED IN BLOOD PLASMA (OR URINE)

Age group	**Lipids** (cholesterol, HDL, LDL, TG, total lipids, LDL phenotype)	**Glucose**[1]	**Insulin**[1]	**T3, T4, TSH**	**Inflammatory markers** (TNF-α, CRPs, IL-6)	**Oxidized LDL**	**Apoproteins** (Apo A1, Apo B-100)	**Iodine, creatinine** (in urine)
8-14 years old	Total lipids only	√	√					√
15 years old and over	√	√	√	√	√	√	√	√

1. The samples are to be collected after an 8-hour fast.

TABLE 2.2E MISCELLANEOUS CLINICAL CHEMISTRY ANALYTES MEASURED IN SELECTED TISSUES

Age group	**Fatty acids, *trans*-fat in erythrocyte membranes**	**White cells**	**Vitamins D, E, β-carotene** (in serum)	**Zoonotics** (*Francisella tularensis, Coxiella burnetii, Leptospira* sp, Hantavirus, California virus, *Trichinella* sp, *Echinococcus, Toxocara, Toxoplasma gondii*, and *Cryptosporidium* in plasma)
8-14 years old	√			
15 years old and over	√	√	√	√

2.4 Medical File Review

The form reproduced in Appendix 4 features the information retrieved from individual medical files. This activity was initiated to verify some of the clinical chemistry and zoonoses test results and health-related information retrieved through the questionnaires. Permission was obtained from the Cree Health Board to have access to the archived medical chart of each participant, and help was sought from the head nurse of the local clinics visited. The medical chart review involved one research nurse working full-time in the community concurrent with the clinical field work. The research nurse checked the consent from signed by each participant 8-years old and over to make sure approval for the review had been granted. Additional details are provided in Appendix 4 of the E&W Report (pp.327-335).

2.5 Statistical Analyses

Statistical analyses were conducted with a significance threshold of $\alpha = 5\%$ using SAS (SAS Version 8.2 and 9.2, SAS Institute, Cary, NC). The principal component analysis (PCA) employed SPSS (versions 11 and 17, SPSS Inc. Chicago, IL), and the correspondence analysis (CA) the ADE-4 multivariate analysis and graphical display software package (Thioulouse et al, 1997). Software for Intake Distribution Estimation (Iowa State University, 1996) was used to calculate nutrient intake distributions using observed intakes on repeated days, adjusting for the interview sequence and the day of the week. Additional details are provided for each area of study in Section 4.9 (pp.46-49) of the E&W Report.

2.6 Educational Activities

A primary objective of the educational activities was to use the curiosity and interest raised by the arrival of the study team as an opportunity to build bridges between the community members and the visiting field team, the Cree Health Board representatives, and local administrators. The aim was to build stronger and more efficient communication channels that could be used to share information about health and environmental issues. Children and youth activities constituted a special focus and were designed to encourage interest in sciences related to nutrition, health and the environment.

The activities organized by the project education team varied somewhat between communities, but generally included: use of opening ceremonies as an educational opportunity; consultation with local teachers; an open house for the youth to provide the background and details of the *Nituuchischaayihtitaau Aschii* study; nutrition and environmental science workshops; summer science camps and field trips; and provision of training opportunities (summer interns).

2.7 Reporting of Results to Individual Study Participants

On completion of the interviews and clinical tests, each participant (or guardian) received a Health Passport. Results for the following parameters were recorded in it: blood pressure, pulse rate, temperature, body measurements (weight, height, etc.), body mass index, body fat, and bone density. Normal values were provided for comparison in both Cree and English. A brief explanation of the *Nituuchischaayihtitaau Aschii* project is also provided, as well as contact details. A copy is provided in Appendix 5.

The protocol for reporting laboratory test results to individual study participants was essentially that used in Wemindji and Eastmain, and described in the E&W Report (Chapter 9, pp.229-230). The reporting categories employed are summarized in Table 2.3.

TABLE 2.3 TEST RESULTS REPORTING CATEGORIES

Reporting Category	Tests in Category
A – abnormal clinical results available immediately	Blood pressure Body measurements – height and weight Temperature
B – abnormal results available after analysis; clinic notified by phone	Holter monitor Carotid Doppler (artery blood flow to the brain) Selected zoonotic antibodies
C – normal and abnormal lab results; participant notified by letter	Glucose, insulin Lipids Heel ultrasound Vitamin D Thyroid Environmental toxins: lead, cadmium, mercury and polychlorinated biphenyls (PCBs) Other zoonotic antibodies.
D – for research purposes, in group report only; results not reported to individuals	Other persistent organic pollutants (POPs), vitamins, apolipoproteins and CRP (heart disease markers), perfluoroctane sulfonate (PFOS), selenium, omega fatty acids, others.

To assist in the above reporting process, and to provide guidance for physicians and clinical staff, clinical algorithms were formulated for cadmium, lead, mercury and total PCBs concentrations (as Aroclor) observed in blood (and/or hair), or urine. They focus on levels of concern and action levels, which are defined below.

Level of Concern: The contaminant is not of immediate danger to impact health. However, it is important to identify the sources of the contaminant.

Level of Action: The contaminant is at a high enough concentration to impact health. The person should follow up with a health care professional.

The clinical algorithms are reproduced in Appendix 6. Recent developments that have resulted in lower guidance levels than employed in the *Nituuchischaayihtitaau Aschii* study are also noted and discussed briefly.

2.8 Project Evaluation

Comprehensive third party review of the Mistissini component of the *Nituuchischaayihtitaau Aschii* study was carried out (Chapter 10, pp. 220-225 and Appendix 5, pp. 347-389; Bonnier-Viger et al, 2007). This was done since the Mistissini study constituted a pilot phase. The recommendations made were implemented in the

Wemindji/Eastmain component. A less detailed third party review was carried out in this instance (see E&W Report Chapter 10, pp.231-234 and Appendix 7, pp.362-376). Formal evaluation was not conducted for the final phases described in the current report.

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3. The Regional and Community Context of the *Nituuchischaayihtitaau Aschii* Multi-community Environment-and-Health Study

(Alan Penn and Jill Torrie)

3.1 Overview

3.1.1 Introduction

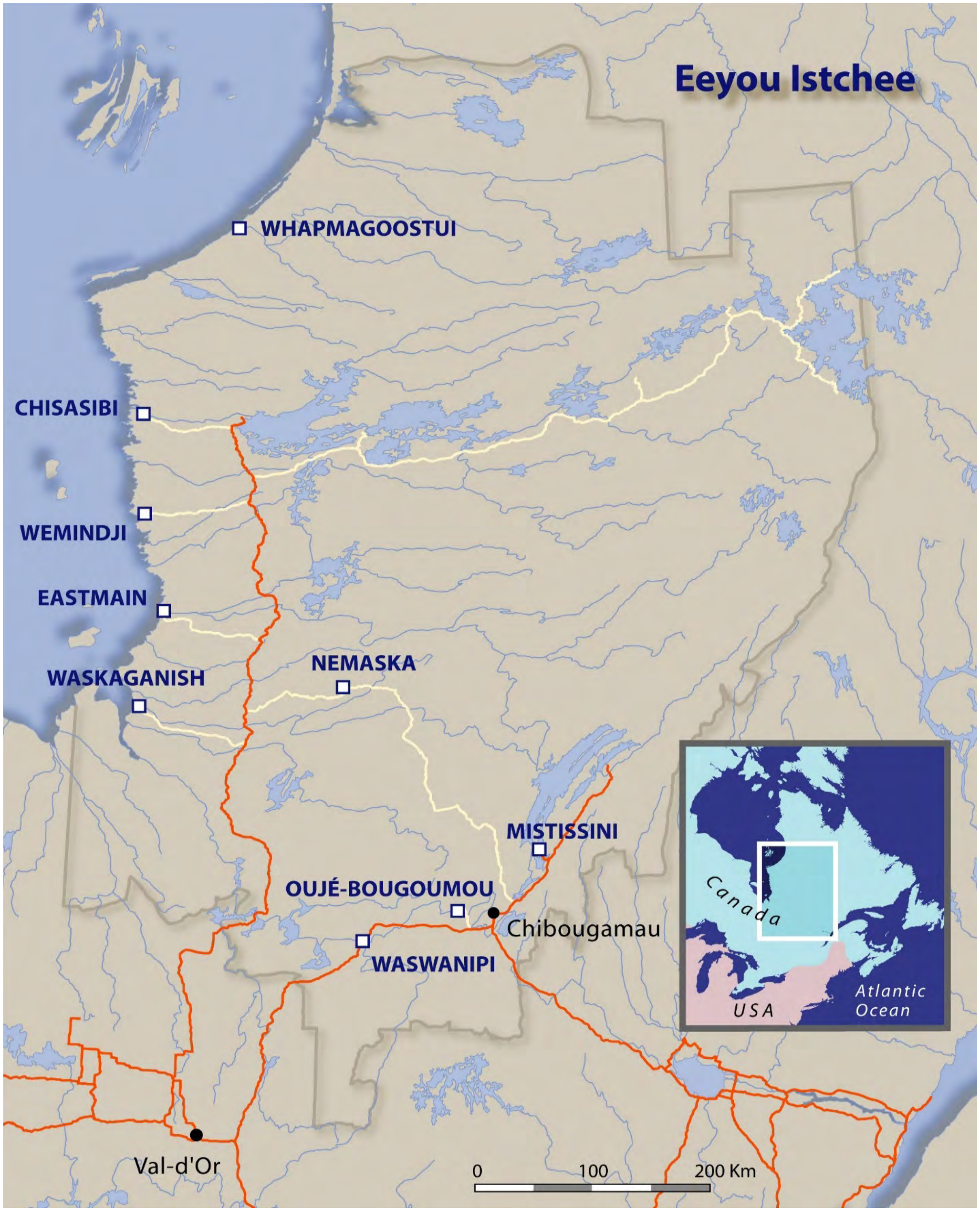
This chapter provides some of the geographic, demographic and recent historical context for the *Nituuchischaayihtitaau Aschii* Multi-community Environment-and-Health Study. The overview section presents a brief synopsis of some of the historical and social issues affecting this region of Québec which is substantially larger than the settled regions to the south. It begins with an introduction to selected aspects of the geological and recent post-glacial history of the *Eeyou* territory (*Eeyou Istchee*). The location of the *Eeyou* communities, and relevant aspects of the hunting economy that provides the basis of local food production systems, have evolved from this geography and history. Subsequently, the recent history of human settlement – *Eeyouch*, Inuit and non-aboriginal – and the recent physical growth of these settlements as we know them today are reviewed. Some aspects of the evolving hunting economy relevant to the health study are also considered. The chapter ends with a discussion of some features of the changing demographic features of the communities themselves, and of the region as a whole, followed by short descriptions of each of the nine communities.

3.1.2 Geological considerations

The *Eeyou* population of Northwestern Québec is historically associated with the major watersheds which drain western and central Québec in the direction of James Bay and southeastern Hudson Bay. This area of roughly 450,000 km^2 (see Figure 3.1) is sparsely populated with a very unevenly distributed resident population of about 40,000 namely one person for every 100 km^2, whether aboriginal or non-aboriginal. The watersheds are carved into an ancient Archaean landscape, whose granites, volcanic and sedimentary rocks dating back nearly three billion years, form part of the larger geological region known as the Canadian Shield (Hocq and Dubé, 1994). Two million years ago, a series of glaciations buried this landscape under a major ice cap. A mere seven or eight thousand years ago, this melted and generated immense inland lakes (larger than any known to the Quebec *Eeyou* nations today, including the reservoirs built for hydroelectric development). Later, the James Bay coastal zone was covered by a marine invasion which inundated part of the previously depressed land. Fish populations recolonized this new landscape progressively (Hocq and Dubé, 1994). Slowly and successively, soils developed in this newly-exposed landscape. The boreal forest ecosystems, which emerged on these generally nutrient-poor soils, were diverse and included most of the tree and shrub species known today (Jacqmain et al. 2008). These supported the ungulates, moose and caribou, which around five thousand years ago fed groups of early hunters who, for the last two millennia or more, have been identifiable as the ancestors of the modern *Eeyouch* (Girard et al., 2012).

FIGURE 3.1 MAP OF *EEYOU ISTCHEE* SHOWING THE COMMUNITIES AND MAJOR ROADS (YELLOW, MINOR; RED, MAJOR)

[Permission to reproduce this figure was received from the Cree Board of Health and Social Services of James Bay.]



The interface between this forest environment and the young and very complicated networks of lakes and streams was colonized by beaver and muskrat. These provided the basis for the fur trade which has done so much to shape the history and economy of the region in the last three centuries (Morantz, 2002). The resulting landscape, though, was relatively poor in terms of both productivity and biological diversity. Human survival in the resulting ecosystems has been uncertain and unpredictable. This helps to explain the historically low *Eeyou* population density of the region as a whole, which even in the early decades of the 20th century stood at less than a tenth of the contemporary *Eeyou* population of over 16,000.

The wetlands which developed in this landscape stored substantial amounts of organic carbon in the form of extensive muskeg and other categories of organic soils. The slow processing of this carbon by bacteria also resulted in the methylation of mercury, a trace metal present throughout this Shield environment and one which tends to accumulate in soils rich in organic matter. Over time these processes resulted in the production and mobilization of organic (methyl) mercury, its transport to rivers and lakes, and the uptake of mercury by the fish populations in these emerging aquatic ecosystems. As far as we know, the *Eeyou* population has been historically exposed to methyl mercury through local or subsistence fisheries. The relative importance of such fisheries would have depended on the hydrological characteristics of the different drainage basins, community locations and the evolving nature of the *Eeyou* hunting economy. The evolving role of fish within that food production economy (both seasonally and geographically) and the changing technological bases of fishing activities constituted important considerations. What this probably meant in terms of mercury exposure levels is hard to assess. Some reconstruction is possible and it appears likely that some sectors of the *Eeyou* population went through periods of exposure to mercury comparable to or greater than during the 1970s when measurements first became available (Chevalier et al., 1997).

From a geological perspective, hydroelectric development added another dimension to this problem in the sense that the creation of reservoirs, which are young and rapidly evolving lake ecosystems, provided the conditions necessary for a further pulse of methyl mercury production. Now it is widely believed that the future creation of man-made reservoirs has to be taken into account in the production, transport and bioaccumulation of methyl mercury. This is one aspect, among others, of the geological and geomorphological history of the *Eeyou* territory which is of potential relevance to the Multi-community Study[2].

3.1.3 The Eeyou hunting economy

Much of the concern about exposure to environmental contaminants in Canadian aboriginal communities in general has focused on the local harvesting and consumption of wildlife. This focus has, of course, roots in the study of methyl mercury exposure in aboriginal populations, for whom the dominant source of exposure was

[2] It is recommended that the reader consult the indicated pages of AMAP (2011) for supportive data and extensive discussion of these topics: pp. 32 (Fig. 2.20), 39 (Fig. 2.23), 50 (Fig. 3.3), 86 (Fig. 5.1), 87 (Fig. 5.2), 98, 99, 104 (Fig. 5.1) (Fig. 5.11), 111-112. Also see Goodsite et al. (2013).

presumed to be the local harvesting and consumption of fish (and to a lesser degree fish-eating game). In the last three decades, interest has shifted to some extent to the hunting and consumption of waterfowl and large mammals (and, in the case of Inuit populations, marine mammals). In the last decade, a growing interest has been shown in the transport and environmental behaviour of halogenated organics, including chlorinated, brominated and fluorinated compounds. The latter two still occur in household products so that significant exposure can take place in urban residential settings. These exposure trends are national in scope, and are relevant to the *Eeyou* population in Québec and to the Multi-community Study.

As in other northern Canadian regions, ongoing, reliable and verifiable information on aboriginal hunting economies is scarce. Although many (if not all) of the recent northern aboriginal land claim agreements include provisions intended to support and protect the local "subsistence" food production component of community economies, this has proved to be a particularly difficult section to implement in the context of these land claim settlements. There are significant practical consequences for wildlife management as well as for health-risk assessment. The *Eeyouch* in northern Québec are no exception to these general observations.

Within this context, the Québec *Eeyouch* do maintain an active presence "on the land" which, in part, is expressed in the form of some 300 family hunting territories or "traplines," with areas ranging from a few hundred to a few thousand square kilometers . Families maintain cabins on one or more sites in these territories that are used with greater or lesser frequency depending upon their patterns of being on the land in different seasons, as well as the location of and access to the territory. Some cabins are built along main roads for ease of route. In the last forty years, clusters of homes have been built in proximity to four communities but on Category III lands[3]; one community has developed cabin lots along an adjacent water body, while other communities have camps on the sites of their "old" settlement prior to official relocation. All of these constructions, whether regulated by the local administration or not, are undertaken with the permission of the holder or "tallyman" of the local family hunting territory upon which a cabin is located[4].

Land tenure associated with traplines (see Figure 3.2) is changing and, depending on the region, the trapline system is used to exercise a degree of aboriginal control over aboriginal access to and use of wildlife

[3] Four categories of lands are recognized in the *James Bay and Northern Québec Agreement*: Categories IA and IB, II and III. The eight *Eeyou* communities at the time of the *Agreement* sit on Category IA lands, while those of Oujé-Bougoumou, the ninth community, were transferred in late 2013 to Category IA status. Under the terms of the *Agreement*, "administration, management and control" of Category IA lands were transferred to Canada. The communities are administered under the provisions of the Cree-Naskapi (of Québec) Act.

Adjacent to Category IA lands, Category IB lands are held in ownership by *Eeyou* landholding corporations and administered by village corporations under Québec legislation. Within Categories I and II lands, the *Eeyouch* have exclusive wildlife harvesting rights. Category III are public lands where the Cree have rights of occupancy and use for purposes of the traditional hunting economy.

The James Bay Municipality is responsible for the administration of the vast territory comprising Categories II and III lands through Québec municipal legislation. It currently functions as a Jamesian organization because the Cree-Jamesian Zone Council established by the *Agreement* for the administration of Category II lands was never implemented. In 2012, the *Eeyouch* and Québec finalized a new joint *Eeyou*-non-*Eeyou* governance structure for this Québec municipality, but its enabling legislation is only at the drafting stage (CBHSSJB, 2013a.).

[4] See Cree Trapper's Association, *Cree Hunting Law*. Accessed on November 25, 2013 at http://www.creetrappers.ca/law.php

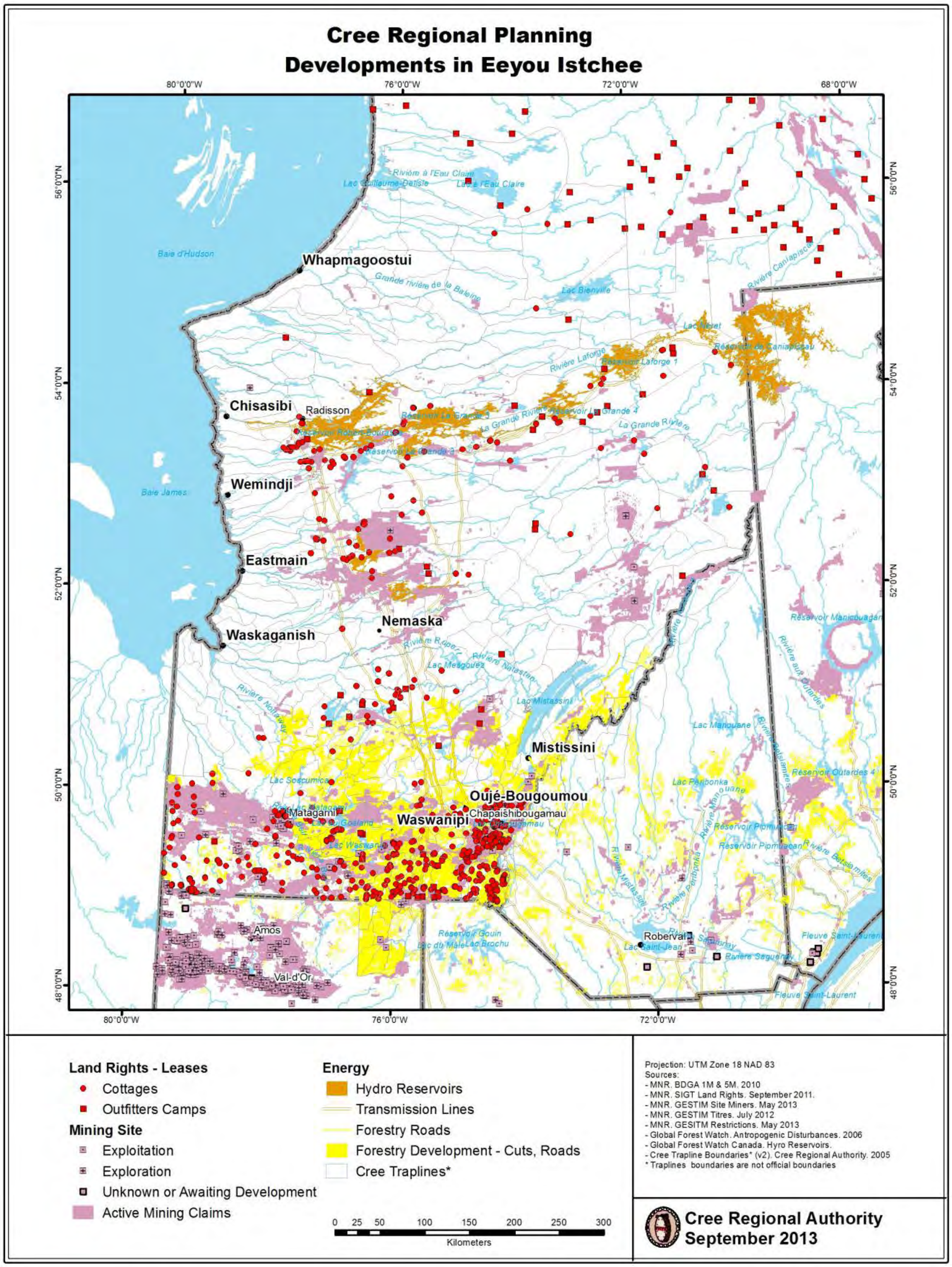
resources. Superimposed on this system of family territories is the growing emergence of "commons," typically in the form of corridors opened up by the road and transmission line corridor infrastructure. These are areas which have to some extent become areas of general access to wildlife resources and, as can be imagined, the transition between a hunting territory-based tenure and common- property tenure is complex, sometimes contested, and evolving in different ways across the *Eeyou* region. As noted earlier, aboriginal occupation of land and related hunting activities take place in the presence of a non-aboriginal pattern of land use, which includes hunting and fishing throughout the region with the general exception of Category I and II lands[2]. This active non-aboriginal population is probably substantially larger than the active *Eeyou* hunting population.

We have limited information on overall trends in harvesting activities. However, there are important institutional and economic factors at play, which have been shaping the evolution of subsistence harvesting in the different *Eeyou* communities in recent years. Hunting is supported by a diverse array of subsidies and support mechanisms, aimed in some cases at stimulating production and in others at subsidizing or supporting transportation, or improving living conditions at hunting camps. It is a complex and geographically diverse situation, but one which nevertheless needs to be taken into account in the interpretation of results from the Multi-community Study that relate to local food production systems.

It is also relevant to this overview that in many ways the changing transportation infrastructure in the *Eeyou* region (roads, four-wheeled vehicles, all-terrain vehicles, skidoos, and powerful outboard motors) have had the overall consequence of increasing access to wildlife resources and of facilitating the transport and processing of the products of harvesting. The evolving technologies of hunting and fishing also have had implications for the yields of fish and terrestrial game. In this context, the methods used in commercial forestry operations to disturb and then regenerate the terrain can have greater or lesser impacts on the productivity of moose (Jacqmain et al., 2008), as well as of different species of small game. Reduced productivity operates within the context of greatly enhanced access and improved hunting technology. In this respect, and taking into account the construction over the last four decades of well over 10,000 km of road, it seems reasonable to postulate that overall harvesting levels are probably at least equivalent to those documented in the Native Harvesting Research Project in the mid-1970s (James Bay and Northern Québec Harvesting Research Committee, 1982), and that it is possible that harvesting levels have grown in rough proportion to changes in the size of the resident *Eeyou* population (CBHSSJB, 2013b; Torrie et al., 2005).

FIGURE 3.2 DEVELOPMENTS IN *EEYOU ISTCHEE*

[Permission to reproduce this figure was received from the Cree Regional Authority.] Details on specific hydroelectric power-generating stations, their watersheds and locations are available from: http://www.hydroquebec.com/learning/histoire/pop_complexe_grande.html



3.1.4 Forestry, hydroelectric development and mining – implications for the Eeyou population

The *Eeyouch* have been living with the impacts of economic development throughout the modern period. Mapping and prospecting occurred in the territory from the mid 19th century onwards. Impacts from the construction of the transcontinental railroad further to the south in the 1910s were felt by the peoples of Waswanipi and Washaw Sibi (Torrie and Lejeune, 2008). From the mid-1920s, northern Québec (like the rest of northern Canada) was opened to southerners with the arrival of bush aircraft, which brought isolated aboriginal communities into direct contact with medical and freight services.

The peoples of Waswanipi and, what would later become Oujé-Bougoumou, first experienced impacts from mining in the 1930s, but only for a few years. They suffered documented negative impacts[5] when the region's mining took off in the 1950s and 1960s and the communities of Chapais and Chibougamau developed (Wilson, 1952; Mansion, 2009). The mining boom of the 1950s and 1960s happened without any mitigation for the social impacts on *Eeyouch*. This first period of developmental impacts can be contrasted to those starting later from the 1970s to the present, for the difficult achievement of the *Eeyouch* has been to negotiate their rights to take an increasing role in the development of the region (CBHSSJB, 2013a; Penn, 2013; Grand Council of the Crees, 2010; Torrie et al., 2005).

3.1.4.1 Forestry

Between one quarter and one third of the southern part of the territory known as *"Eeyou Istchee"* has been opened up to commercial logging. Although some operations were approaching the territory in the 1950s, rapid expansion of the forest products sector took place at roughly the same time as the negotiation of the *James Bay and Northern Québec Agreement (JBNQA*). Forestry operations have extended north to the Broadback River and, further inland, to the hill country NE of Mistissini (see Figure 3.2). Much of the existing saw mill capacity dates back to the mid-1970s. The *Eeyouch* have had limited overall direct involvement in the forest products sector, except for a model forest program and saw mill at Waswanipi, which is no longer in operation at the time of writing. People from Waswanipi and Mistissini found employment in seasonal logging operations from the 1950s and 1960s, mainly in the region between Senneterre and Chibougamau.

Roughly 10,000 km of roads (primary, secondary and tertiary) have been built to serve the industry, and a substantial proportion remains accessible with trucks, ATVs or skidoos. In this way, forestry has opened large segments of the territory and facilitated access to land and wildlife resources by both the *Eeyouch* and the general public. This has had far reaching implications for the control over their traditional lands by the *Eeyouch*, which are now shared with a substantial number of non-beneficiary hunters and fishermen, whom as mentioned earlier may well outnumber *Eeyou* hunters and fishermen. However, *Eeyouch* have year-round access to resources without restrictions due to regulations and permits. In the southern third of *Eeyou Istche*e,

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[5] Private papers, Rev. James Scanlon (see also, Scanlon, 1975).

forestry has provided the necessary transportation infrastructure allowing access to a year-round supply of bush food, meat and fish for the communities and for the families who choose, for various reasons, to remain in the bush during the year. This is making possible the commercial/economic transformation of the bush food economy in these communities. Forestry roads have also provided access to territories for mineral exploration activities on different scales and for different purposes.

There are only a few studies on the shorter-term impacts of forestry practices on animal populations in *Eeyou Istchee*. Jacqmain et al. (2008) argue that in agreement with the observations of some *Eeyou* hunters, they found evidence that clear-cutting and certain silviculture practices can greatly reduce optimum moose habitat of mature mixed-wood and mature balsam fir stands. The availability of these mature stands may influence moose home-range size, explain variation in moose densities, and therefore be considered as crucial for the species. *Eeyou* knowledge and scientific evidence also agreed on the negative impact of pre-commercial thinning in regenerating moose habitats, which removes food and cover for moose and other wildlife (Jacqmain et al., 2008). Within the region, *Eeyou* trappers are reported to have observed declines in marten populations following forestry operations. A recent study found that the marten habitat also depends upon maintaining mature mixed-wood forests and that martens are sensitive to human-induced disturbances from clear cuts, edges and roads (Cheveau et al., 2013). For woodland caribou, Rudolph et al. (2012) also identified the impact of human-induced disturbances. They argue that the vulnerable status of the three Québec herds has been caused by the landscape transformations from forestry and roads. Since the signing of the *Paix des Braves* in 2002, Québec and the *Eeyouch* have co-managed forestry operations (SAA, 2002; Jacqmain et al., 2008) and placed a new focus on forestry practices adapted to maintaining other forest uses.

The longer-term impact of forestry practices on large game populations is not so evident despite the above views. Local hunters have been said to report a continuing expansion of moose, bear and small game populations in the context of forestry. Obviously, forestry improves access to existing, previously isolated, animal populations which may help to explain increased yields for *Eeyou* hunters, and also for non-aboriginals. But there is no scientific information on the long-term relation between populations within the time-continuum of forestry operations over decades, so it is not known if reports of increasing yields refer to absolute population increases or to the result of improved access to existing, previously isolated, populations. Overall, the effect has been to facilitate a greater emphasis on the hunting of terrestrial game and a diminishing emphasis on the fisheries associated with the major lakes and rivers of the region, with implications for the long-term diet.

3.1.4.2 Hydroelectric development

Of all the sectors of industrial development in the *Eeyou* region, that of hydroelectricity has played a disproportionate role in shaping the vast structural changes within *Eeyou* society since the 1970s (Penn, 2008). When hydroelectric development first came to the attention of the *Eeyouch* in 1972, their social organisation was based on extended family units, and their relations with the larger society mediated through their "traditional" relations with the Hudson Bay Company (HBC) and the church (mostly Anglican), as well as those created through the rudimentary *Indian Act*-based band organization and the nursing stations of the Indian Health Services.

Today, with a population of over 16,000, the *Eeyouch* are increasingly defined through a complex of institutional structures that have no parallels for similar-sized distinct groups within Québec and Canada. Hydro-Québec, as an important economic development arm of the Québec Government, has played an overarching role in this institutional evolution which touches all areas of *Eeyou* life, including the genesis of and funding for this current study[6]. The reasons for this are grounded in the geomorphology of the region, the specificities of which not only permitted the engineering of the La Grande hydroelectric complex project in the 1970s but also the commissioning of the Eastmain-1A and Rupert Diversion project in 2012. Each of the discrete hydroelectric projects since the 1970s, as well as the additions and adjustments to each of them, now form an extremely complex entity that constitutes an integrated, hydroelectric development within the territory (see Figure 3.2 for the location of hydroelectric development sites and energy transport lines). Although the *James Bay and Northern Québec Agreement* (*JBNQA*) was negotiated in the context of the construction of the La Grande complex, Chapter 8 of the *Agreement* "recognized that there exists a possibility of future hydroelectric developments in the Territory." How these future developments would actually evolve was not understood at the time. The 1975 *Agreement* envisaged the potential for new and separate projects. In fact, these took the form of additions or adjustments to the original La Grande complex plan. Each change, no matter how minor or major, to the La Grande complex led to a renegotiation of that aspect of the *JBNQA* and gave rise to new relationships and institutional structures between the *Eeyouch* and Hydro-Québec (Penn, 2013).

The direct employment of or contracting by *Eeyouch* in this thirty-year history of hydroelectric development changed significantly over time. From relatively little during the construction of the La Grande complex, their involvement evolved through subsequent amendments to the *JBNQA* and new agreements. Consequently, during the Eastmain-1A and Rupert Diversion Project, *Eeyou* companies had access to preferred contracts and individual employment was promoted. Because there was no concerted plan within the *Eeyou* institutions during the run-up to the Eastmain-1 and Eastmain-1A projects to promote skills and trades development, *Eeyouch* were disproportionately represented in the unskilled jobs, but were highly paid and incomes were tax

[6] "Hydro-Québec has corporate policies which, sometimes directly and often indirectly, cover at least the following aspects of Cree society: language, linguistics and literacy in the Cree language; archaeology and cultural heritage; museums and related cultural-policy issues; tourism and recreational development in Cree society; Cree land tenure – and the system of hunting territories; environmental impact assessment – procedural and administrative aspects; environmental impact assessment – substantive issues (content); environmental monitoring policies; authority structures and economic influence within the hunting economy; a number of different aspects of wildlife management; wildlife surveys – and population estimates; contaminant exposure, with particular reference to mercury; methyl mercury toxicology and epidemiology; public facilities in Cree communities; transportation infrastructure; public access to territory; business development and contracts; manpower training and accreditation in construction trades; taxation regimes; employment in the construction sector – and in project operations; local and regional government structures and institutions; and planning of remedial measures, including habitat modification for specific hydroelectric projects. The extent of the influence of Hydro-Québec in these areas of public policy varies, but nevertheless needs to be taken into consideration on a case-by-case basis." (Penn December 15, 2008).

free (Genivar, 2012; Torrie et al., 2005). Since the completion of hydroelectric development in 2012-13, the entire focus is now on its maintenance.

3.1.4.3 Mining

The emergence of a mining industry in the *Eeyou* territory, especially since the 1950s, has also had implications for *Eeyou* society. Since the end of the 19th century, considerable effort has been devoted to mapping and evaluating areas of promising "greenstone" belts of mineral formations in the region. The continuing work to some extent is made possible by the infrastructure of the La Grande hydroelectric complex, and now each project in the development stage is furthering the infrastructure of road networks. In the 1950s, mining was the foundation for the towns of Matagami, Chapais and Chibougamau (zinc, copper, gold and silver), and the rail and principal road infrastructure for the southern portion of the *Eeyou* territory (Wilson, 1952). The creation of these mining towns had major implications for what we now recognize as the Waswanipi, Oujé-Bougoumou and Mistissini Cree Nations, and the modern location of these communities can be explained in relation to the location of these mining towns (and their nearby mines) and related transportation infrastructure (see southern portion of the Figure 3.2 map). The population of these mining/forest products industry towns is mostly non-aboriginal or non-*JBNQA* beneficiaries and now represents roughly half of the regional population.

Further to the north and to the northeast, mining interest has been directed generally towards a region between Nemaska and Lake Mistissini where the Troilus gold and copper mine was located and the current focus is on the extraction and processing of ores containing lithium. This reflects the growing interest in the use of lithium in advanced battery technology. The inland portions of the hunting territories of Wemindji and Eastmain extend also into promising geological formations for mineral exploration. For reasons grounded in the ancient geological history of the *Eeyou* territory, for the most part it is the inland *Eeyou* population (roughly 40% of the total) who occupy landscapes of interest to the minerals industry. They are also within striking distance of transportation and infrastructure which has supported, and may well continue to support, the regional mining industry. In this respect, this geographical pattern of mineral exploration and development (which includes the Éléonore gold mine in the Wemindji territory and the Renard diamond mine in the Mistissini territory, both at the development stage) will no doubt have major implications for future economic, social and political development in the region.

3.1.5 Changes in the Eeyou communities

A major underlying theme of this chapter is that *Eeyou* society is changing, and that the nature of those changes is relevant to the interpretation of the information gathered in the course of the Multi-community Study. Contemporary exposure to contaminants in the *Eeyou* communities generally needs to be understood in the context of an overall process of sedentarization, facilitated and shaped by the emergence of a large and influential public sector economy. It is this economy which largely supports patterns of use of hunting camps and patterns of both hunting and fishing, but the investment in the residential housing in the communities is also relevant to interpreting exposure to the contaminants often associated with carpeting, curtains and upholstery (including brominated and fluorinated compounds, as already mentioned).

Changes due to sedentarization are only part of the relevant picture for interpreting the Study. The geographical location of the majority of the *Eeyou* communities evolved in relation to the fur trade between the 17th and early 20th centuries, and community locations can therefore be explained by the major water routes in NW Québec: the James Bay coast, the major estuaries, as well as the lakes and rivers which linked the coastal and interior regions to the St. Lawrence River watershed to the south and east. Away from the communities themselves, access to key wildlife resources is still shaped by the main physiographic features of the *Eeyou* territory. This can be illustrated by the following dimensions: the complex coastal ecosystems, which support intensive waterfowl hunting in the spring and fall; the major lakes in the southern and central portions of the territory, which support local fisheries; and the transformation in the forest cover in the inland areas that now supports a flourishing big game hunting economy.

Many of the community locations may have originated with the fur trade, but all of them now function as tightly nucleated settlements with many typically suburban characteristics – for the most part laid out in the decade following the implementation of the *JBNQA* from 1975. Five of them have been relocated in recent history, and four of these relocations have taken place since the negotiation of the *JBNQA*. They support a large and complex public sector, which in addition to providing local and regional government services includes health services, education (including adult education and vocational training), policing and the administration of justice. The public sector is large enough to account for nearly full employment in some age and educational groups, and it strongly influences conditions of other employment. This works to distort the local economy to the extent that the local private sector cannot match wage levels. In addition, the public sector has favoured the employment of women in public administration and public social-support services such as day-care services and Home Care.

Although the public sector is clearly a major presence, there is also an important population of young adults who do not benefit from its employment and who tend to have low educational levels. Given the tax structures in First Nations communities, the resulting social inequities are thus exaggerated between this group of youth and young adults, and those who benefit from the public sector. This growing marginalized segment of youth in the population faces particular challenges as *Eeyou* society adjusts to new conditions and prospects, now that the construction of the La Grande Complex is complete. The contemporary *Eeyou* population is mobile, in the sense that visiting other communities and travel to southern urban centres is frequent. The resident population of some communities shrinks sharply during spring and fall waterfowl and moose-hunting periods, as well as on weekends – and this aspect of the mobility of the population is evident to visitors to the region. Feasting and games (at both the community and regional level) are conspicuous in the summer months, and can account for a significant portion of local food production and consumption at key times of the year. There is also a substantial and developing informal market for local products of hunting, fishing and leather-based crafts, and a considerable proportion of the beaver meat now available to the communities is acquired through trade outlets from non-aboriginal trappers from outside the *Eeyou* territory. Meanwhile, the quality of outlets for groceries has improved considerably in the last two decades (within the timeframe of the Multi-community Study). With some exceptions, the *Eeyou* population now has access to retail food supplies which, in many communities, now compare favourably with those available to the non-aboriginal population in the region.

It is a complex picture, and one which is still evolving. A key observation in this chapter is that, from a public health perspective, the *Eeyouch* exhibit many of the characteristics of a society undergoing a nutritional transition and in some important respects are now deeply involved in an increasingly urban environment.

3.1.6 Population

In mid-2012, the official population of Cree Beneficiaries of the *James Bay and Northern Québec Agreement* in *Eeyou Istchee* was 16,010 with almost 60% living in the five coastal communities and just over 40% in the four inland ones. Up to 2012, the five-year average rate of growth of the beneficiary population was 2.15% per year. A baby boy born in *Eeyou Istchee* between 2005 and 2009 is expected to live 74.6 years, compared to 78.4 for boys in the rest of Quebec; for a baby girl, life expectancy is 81.8 years compared to 83.1 years. In contrast to patterns elsewhere, *Eeyou* men continue to outnumber *Eeyou* women.

The population is young and in general comparable to the First Nations population in Canada[7]. Individuals aged 0 to 14 comprise 30.5% of the population[8], while those aged 65 and over comprise 5.5%. In Canada as a whole, the percentages are 12.9% and 14.2%. Within the communities of *Eeyou Istchee*, around 50% of the population is under the age of 25 and educational levels are low. This means there is a very high ratio of those who are dependent compared to other adults. Thus there are limited opportunities for an important group who should have become independent, but who do not have the education or training to participate. This demographic profile has a great deal to do with the social problems in the communities.

The nine communities[9] are spread over the vast territory. Two hours is the shortest driving time between the closest two communities, while fifteen hours is the longest. The most northerly community of Whapmagoostui does not have road access (see Figure 3.1).

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[7] http://www12.statcan.gc.ca/nhs-enm/2011/as-sa/99-011-x/99-011-x2011001-eng.cfm

[8] Due to late registration of those aged 0 to 3, this proportion might be closer to 33%.

[9] The 10th and final community of Washaw Sibi is comprised of *Eeyouch* who were in the southern Harricana River area when the Québec-Ontario border was determined. They were recognised in the New Relationship Agreement with the Federal Government in 2007, but do not yet have a town site (Government of Canada, 2008; Torrie and Lejeune, 2008).

TABLE 3.1 CHARACTERISTICS OF THE NINE COMMUNITIES

	Relocated	Coastal/ inland	Northern/ southern	Population		Access
				size	mid-2012	
Chisasibi	yes	coastal	northern	large	4,143	semi-remote
Eastmain	no	coastal	northern	small	680	semi-remote
Mistissini	no	inland	southern	large	3,512	rural
Nemaska	yes	inland	southern	small	722	semi-remote
Oujé-Bougoumou	yes	inland	southern	small	793	rural
Waskaganish	no	coastal	southern	intermediate	2,159	semi-remote
Waswanipi	yes	inland	southern	intermediate	1,710	rural
Wemindji	pre-1975	coastal	northern	intermediate	1,403	semi-remote
Whapmagoostui	no	coastal	northern	small	888	remote

3.2 Brief Description of Each Community

The geographical distribution of the *Eeyou* communities can generally be explained by the complex history of decisions relating to the establishment, during the last three centuries, of fur trading posts along the coasts of James Bay and Hudson Bay and trading routes in the direction of the St. Lawrence watershed. However, the *Eeyou* settlements we recognize today are a more recent phenomenon. They began to take shape in the 1960s and reflect the growth of the public sector economy, in which the provision of health services, education, and a range of government services define the roles of individual communities[10]. As mentioned above, approximately half of the *Eeyou* population reside in communities which underwent relocation in the years following the signature of the *JBNQA* in 1975.

The *Eeyou* settlements have benefitted from integrated water supply and distribution systems since the early 1980s. The preferred technology for wastewater collection and treatment is the aerated lagoon, and it is this technology which now serves all of them. Chisasibi had been equipped with septic tanks after the community relocation to make way for the La Grande Complex. However, rising water tables and concerns about the health implications of inadequate subsurface drainage led to the installation of an integrated collected and aerated lagoon-based treatment system there as well. The communities located at the mouths of the major rivers are supplied with river water following appropriate treatment. Eastmain, at the residual mouth of a diverted river, has a complicated supply system drawing on shallow groundwater; the system is being expanded in order to draw a portion of its supply from a stream draining neighbouring wetlands. Whapmagoostui has chosen to use a groundwater resource rather than rely on the Great Whale River. Elsewhere, in the inland communities the preference is for groundwater, and all four use well-water supplies that involve groundwater resources associated with recent post-glacial sediments.

[10] The maps in Figures 3.1 and 3.2 will be useful references for reading this section.

In each of the communities, major nutritional and public health challenges can be linked to: the increase in population since the 1940s, the emergence of settlements from the late 1950s and 1960s, changes in food production, the development of transfer-based economies built around public services, and the great expansion of roads.

3.2.1 Whapmagoostui ("river of beluga"; not-relocated, coastal, northern, small, remote)

Whapmagoostui comprises half the population of approximately 1,600 *Eeyouch*, Inuit and non-aboriginals living on an exposed sandpit at the mouth of the Great Whale River where it discharges into Hudson Bay. In many respects, they present themselves to the outside world as a single community. They are not connected to the south by road, but since 2012 discussions have been underway about the building of a road link to the Radisson/LG-2 area.

The traditional *Eeyou* hunting territories extend eastward to Lake Bienville and beyond, and to the north and north east to include Richmond Gulf, the Nastapoka River and the Clearwater lakes. It is a large area which is also hard and expensive to reach. Whapmagoostui faces challenges in securing access to and use of its territory, to a greater degree than the other *Eeyou* communities.

Sporadic trading posts operated from the mid-1700s in this area, but only continuously from 1837. The Inuit, *Eeyouch* and Naskapi came together in this location around a whale processing factory which closed in the late 19^{th} century. Great Whale River became a major regional facility during the operation of the mid-Canada radar defense line from the mid-1950s to the mid-1960s. The major air transportation infrastructure dates from this period. When the mid-Canada line was terminated in 1964, these facilities were used as the basis for the Québec government's service delivery to the Hudson Bay Inuit communities. The *JBNQA* had the practical effect of dividing the community into three distinct demographic units of *Eeyouch*, Inuit and non-aboriginals based upon the creation of separate and ethnically-defined public institutions for the *Eeyouch* and the Inuits.

The *Eeyouch* in this region were inlanders who followed, and depended upon, the migratory caribou. The Inuit also depended on the caribou, but were also specialized hunters of marine resources along the Hudson Bay coast. Both *Eeyouch* and Inuit were very hard-hit by the virtual disappearance of caribou in the first half of the 20^{th} century, and experienced periods of famine and starvation.

The initial surveys of mercury exposure in 1976 showed that Whapmagoostui people had very high blood mercury levels, as high as in the *Eeyou* communities to the south and southeast. This was strong evidence that mercury exposure could be found throughout the *Eeyou* territory wherever there is extensive reliance on local fisheries in the summer. Nevertheless, the findings did come as a surprise. Although lake trout are likely the explanation, there is more that one would like to know. The high levels of mercury in blood and hair account for the major role played by Whapmagoostui in the 1978-79 epidemiological study of mercury-related health effects known as the McGill Methyl Mercury Study (Chevalier et al., 1997).

3.2.2 Chisasibi (relocated, coastal, northern, large, semi-remote)

Because it had been predicted that altering the water flow of the La Grande River was likely to erode the banks of the island on which the original community of Fort George was located; the latter was moved in 1980 to the mainland to become Chisasibi.

Sandwiched between the eroding banks of the La Grande River to the east and the highway and lands reserved for a future port facility to the west, this community of over 4,000 – three times the population size at the time of the negotiation of the *JBNQA* – now faces distinct challenges for planning urban development. A community of about 100 Inuit also lives in Chisasibi.

The La Grande Complex and its drainage basin, with its four principal powerhouses and forebays (the Caniapiscau diversion and the reservoir on the Caniapiscau plateau) coincided with the limits of much of the traditional Chisasibi territory. While land was lost to flooding, the community acquired year-round use of some 1,500 km of roads built for the project. This greatly facilitated access to the inland hunting territories. The community was also able to incorporate into its territory a large area which had previously been identified with the Nichicun (or northern Mistissini *Eeyouch*).

The first Hudson's Bay Company trading post in the area opened in 1803. The Anglican Mission operated from 1852, with a school from 1907. In 1927, a Catholic Mission and School also opened. Throughout much of the 19th century, Fort George, along with Rupert House, was one of the largest trading posts in *Eeyou Istchee* and in the 20th century became an important regional service centre for education.

Because of its location, its sizeable population and its institutional history since the *JBNQA*, the economy of Chisasibi became more dependent upon hydroelectric development in various ways than any other community. After four successive development phases over a 40-year period, construction was completed in 2012-13.

Chisasibi has become a regional service centre for the coastal Cree First Nations, and in some areas for the *Eeyou* region as a whole (e.g. police services, the Niskamoon Corporation and the Cree Health Board). Consequently, it is home to a sizeable public sector which, as an employer, contributes substantially to the maintenance of the local hunting economy. There is, in practice, a close relationship between wage employment and hunting. However, equity is an issue, in the sense that access to land for hunting depends on family linkages, access to hunting territories and to local employment and their inter-relationships. However, the maintenance of a subsistence hunting economy in the relatively limited corridors associated with the roads and the coast is ultimately constrained by the productivity of the resources to be found there.

Chisasibi was included in the pediatric, but not the adult, component of the 1978 McGill Methyl Mercury Study mentioned above.

3.2.3 Wemindji ("red ochre mountain"; relocated pre-1975, coastal, northern, intermediate-sized, semi-remote)

The present location at the mouth of the Maquatua River dates from 1958, when Old Factory (also known as Vieux Comptoir or Paint Hills) was relocated. Although the diverted Eastmain River (and now the Rupert River as well) runs through Wemindji's territories, the community was largely unaffected by the extensive flooding involved in the creation of the major reservoirs. However, there are important impacts due to elevated water levels on Sakami Lake through which the diversion passes. From the late 1980s onwards, the people of Wemindji have been able to reach many of their inland territories using ground transportation (long-distance skidoo trails, followed by a winter road, and subsequently by an all-season road), although a few territories to the east of the diversion are still inaccessible by road.

Although in contact with Europeans since the late 17th century, the first permanent HBC post opened in 1935. Families from Wemindji went through difficult periods of starvation in the 1930s and 1940s. Old Factory Band was first established in 1951 on an island, but eight years later moved to its present location.

Wemindji has a long history of rapid and early adaptation to opportunities for local economic development, based initially on hydroelectric power generation and more recently on mining. This happens both on individual and community corporate levels. Although Wemindji shares in the regional public sector economy, the community has a relatively strong history of wage employment including work related to hydroelectric development and mineral exploration for the Éléonore gold mine on its territory.

Wemindji is the community where there has been the greatest focus on testing for radon gas in private dwellings[11] because of uranium in local groundwater, which was formerly the source of the community water system. The community now takes its water supply from the Maquata River.

Prior to the development of road networks, the geographic situation of Wemindji in the mid-1970s was like Chisasibi and meant that people did not have access to summer inland fisheries. On this basis, they were not included in the epidemiological studies of mercury exposure at that time. However, the local administration took a strongly entrepreneurial approach to the programme of funding made available by the Niskamoon Corporation to support fish production and delivery to the Wemindji community, but this has now ended. Much of this involved harvesting coastal fisheries resources (sea-run trout and whitefish), in which tissue mercury concentrations are generally lower than in inland lake species. There were, nevertheless, concerns that the subsidized inland fisheries could prove to be unsustainable, notably in the case of lake sturgeon.

[11] Of 250 radon dosimeters placed in private residences in 2011, two-thirds registered values over the Health Canada acceptable level.

3.2.4 Eastmain (old, coastal, northern, small, semi-remote)

The community of Eastmain is located at the mouth of the Eastmain River, sometimes called the Slude River in HBC documents. It was originally built in 1685 and became the HBC's east coast headquarters for a hundred years until 1821, after which it declined in importance. Today, it is the headquarters for the Cree Trappers Association.

The more productive wetland habitat in this community's land base has been particularly vulnerable to the flooding generated by the Eastmain diversion (and later the Eastmain-1 reservoir). Furthermore, the northward diversion of the Eastmain and Opinaca Rivers reduced river flow at the river mouth to just 8% of pre-diversion discharge, thus largely putting an end to the community fishery at the first rapids.

Although one of the oldest *Eeyou* settlements, Eastmain was a small, isolated community with a population of only 300 when the *JBNQA* negotiations took place. In 1974 and 1975, Eastmain was often regarded as the most "traditional" of the *Eeyou* communities. Like Wemindji, Eastmain did not acquire access *via* ground transportation to its inland territories until the late 1980s, but in stages (progressing from skidoo trails, to winter roads, to an all-season highway). Assessing the level of involvement in the hunting economy is difficult, but it is evident that the territory used by Eastmain hunters has undergone a particularly thorough transformation. Eastmain is still the home base for a number of active hunters, but their resource base and territory are now considerably reduced. It is the community with the lowest rate of participation in the Income Security Program for Cree Hunters and Trappers.

For the reasons identified above for Chisasibi and Wemindji, Eastmain residents were found not to be significantly exposed to mercury at the time of surveys in 1975 and 1976 (Chevalier et al., 1997), and neither the adult nor child populations took part in epidemiological studies at that time. Similar to Wemindji, Eastmain families with inland territories (which became accessible in the 1990s and subsequently) are more likely to show a trend towards higher levels of exposure to mercury.

3.2.5 Waskaganish ("Little House"; old, coastal, southern, intermediate sized, semi-remote)

The old "Rupert House" is located near the estuaries of four of the main rivers which drain the southern part of the *Eeyou* territory – the Rupert, Broadback, Nottaway and Harricana Rivers. Rupert Bay itself has some features of a wide, shallow estuary for the first three of these rivers, while the Harricana discharges further to the west just beyond the Ontario border.

Fort Rupert, now known in Cree as Waskaganish or "Little House," in reference to the original fur trading post, describes itself as "the birthplace of the fur trade." Originally built by Groseilliers in 1668 as Fort St. Charles, it was renamed Rupert's House in 1670 and over the following centuries switched between English and French control. After 1821, the headquarters of the HBC for the area moved from Eastmain to Rupert's House. The post became the supply centre for the inland trade involving people associated with posts at Nemaska, Mistissini, Waswanipi, Nichicun and Neoskweskau, until the opening of the railroad in the early

20th century (Anderson, 1961). The *Eeyou* people who used this area maintained close links with Moosonee and Moose factory, to the west of the Harricana River.

Today, Waskaganish has a population of over 2,000 and it functions as a regional air-transportation hub. Like the other communities, it has grown substantially, and has moved away from the river. There is a substantial public sector economy, but the community is not large enough to function as a regional service centre. It has been accessible by an all-season road for about twenty years, and is within comparatively easy reach of towns like Matagami, Amos and Val d'Or.

In a geological sense, this is a different region. Most of the traditional territory of the Waskaganish people is located on the clay, silt and muskeg or peat deposits associated with the James Bay lowlands (similar to the country to the west of James Bay). Waskaganish has rivers which were essential as transportation routes and for fisheries, but lacks the lakes which are so prominent in the Canadian Shield landscapes of the Québec *Eeyou* communities further east and north. As it was the inland lakes which shaped the history of exposure to mercury, Waskaganish does not have a history of high levels of mercury, and the possible effects of mercury exposure have not been investigated in this community.

3.2.6 Nemaska ("Plenty of Fish"; relocated, inland, southern, small, semi-remote)

The community of Nemaska[12] is located in the centre of the *Eeyou* territory, mid-way between the James Bay coast and Mistissini. It has road access westward to the James Bay highway and Waskaganish, and to the southeast by the "Route du Nord," leading to Mistissini and Chibougamau. The townsite for the population of over 700 is on the shores of Champion Lake.

Nemiscau, one of several relatively small inland trading posts operated by the HBC, was situated on the shores of Lake Nemiscau which has a rich fishery. With the closing of the trading post in 1970, the people were divided into two groups. Living in tent and shack settlements half relocated outside Waskaganish, while the others moved to Mistissini. At that time, there was little means of contact between them. This situation prevailed for a period of roughly fifteen years, between the closing of the trading post and the opening of the new community named Nemaska in the 1980s. It is located over 60 km northeast of the former site, well away from the limits of the nearest proposed reservoir for the Nottaway-Broadback hydro-electric complex which was subsequently cancelled.

The Champion Lake settlement site, from a geographical perspective, appeared to be well placed as a regional hub; and this was indeed a consideration when the community was planned. Nevertheless, Nemaska remains a relatively small and isolated community which, like Eastmain, maintains strong attachments to its land base with emphasis on the lakes to the south of the community.

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[12] The original spelling of the HBC post was Nemiscau. The new community is Nemaska. However, the Hydro-Québec workers camp and sub-station and the airport are known as Némiscau.

Like Eastmain, Nemaska has been particularly affected by hydroelectric development. In Nemaska's case, it has been the diversion northwards of the Rupert River to the Eastmain-1 reservoir and the construction of the two powerhouses (1 and 1A) on the Eastmain reservoir which have changed life in the community. In part, this is because the community is located a few kilometers away from the Némiscau and Albanel substations for the high-voltage power transmission lines. These Hydro-Québec installations play a major role in the high-voltage transmission systems from the La Grande project further north. Némiscau also served as a logistics centre for the work on the Eastmain reservoir and its powerhouses. This put Nemaska in close proximity to the largest construction camp for the Eastmain-1 and Sarcelle units and, following the signing of the *Paix des Braves* agreement in 2002, the Eastmain-1A and Rupert diversion projects. For several years immediately following the construction of the Nemiscau workers camp, this proximity created upheaval in the Nemaska community and led to unanticipated pressure on health services and a sudden increased access to alcohol.

Nemaska has a population of over 700 and hosts the headquarters of the Grand Council of the Crees and the Cree Regional Authority. Some of the Nemaska people took part in the epidemiological study of the effects of mercury exposure as part of the Mistissini population. This is not surprising because as inlanders, those who settled outside Mistissini depended on lakes and rivers in the summer period and found themselves in the category of relatively exposed groups. The contemporary community of Nemaska was studied in 2001 as a control group for the Oujé-Bougoumou investigation of health-related issues arising from mining operations in the region (Dewailly and Nieboer, 2005).

3.2.7 Mistissini ("big rock"; not relocated, inland, southern, large, rural)

Its relatively large traditional land base extends north to the eastern sector of the La Grande project, and to the east beyond the Otish Mountains into the upper reaches of the rivers draining to Lac St-Jean. Compared with the other communities, its land base remains relatively inaccessible except by bush plane, although road access has improved as a result of corridors created for the eastern sector of the La Grande Complex and with the current extension of Highway 167 to serve the mining sector. In the early 1800s, the community of Mistissini's current location was a summer encampment around the HBC's newly-established fur trading post. The North West Company and other fur traders were also in the vicinity.

A substantial segment of the population has a strong attachment to the lands associated with the former Nichicun and Neoskweskau trading posts, as the families who hunted those areas relocated to Mistissini when the HBC closed operations almost a century ago. The community has a history of involvement in wage employment somewhat similar to that of Waswanipi. In the early 1950s and 1960s, groups of Mistissini men and their wives travelled south for seasonal employment in logging. Prospecting (line cutting) and guiding also provided seasonal work. The community has some recent experience with employment in both the mining sectors (the Troilus gold mine, an open pit operation which is now closed) and in forestry; and, more importantly, groups of Mistissini men became closely involved in contract work for the James Bay Energy Corporation from 2007 to 2012, and since then with the extension of Route 167 to the north.

Mistissini is a large, bustling and rapidly expanding community of over 3,500 with an impressive array of new public buildings and homes. It has a substantial public sector serving both regional and local levels in the health services field, education and the administration of justice. A partnership between the Cree Nation of Mistissini (CNM) and the Government of Québec has created the Albanel-Témiscamie-Otish (ATO) Park, which is located entirely on traditional territory and under the management of the CNM.

Mistissini also had its fair share of involvement in epidemiological studies of the effects of mercury exposure. Some individual families participated in three separate studies between 1975 and 1980 (Chevalier et al., 1997). Both children and adults were involved. This can be understood by the reliance on summer fishing camps in the 1960s, which was a factor in the local hunting economy. It strongly enhanced the participation rates in surveys conducted during the summer, since much of the Mistissini's population was in or near the community and in a position to do so (as in some other communities).

3.2.8 Oujé-Bougoumou (relocated, inland, southern, small, rural)

This community is located 47 km from Chibougamau on the shores of Lake Opemiska, close to all the traditional trap lines.

Oujé-Bougoumou (the name is etymologically related to Chibougamau and refers to the waterways near the height of land which linked the James Bay territory with the St. Lawrence watershed to the south-east) is the youngest of the nine *Eeyou* communities in some respects. The land base which we now identify with the Oujé-Bougoumou *Eeyouch* is more-or-less centred on the mineral deposits which were first described at the beginning of the last century, and which later (in the 1950s) gave rise to the towns of Chapais and Chibougamau. Four distinct mineral processing centres operated in this region, using ore mined (mainly for gold and copper) from over 20 distinct mines (both open-pit and underground; Girard et al., 2012 b).

The Oujé-Bougoumou people identify themselves as a distinct group or First Nation within the *Eeyouch*, based on their affiliation with former trading posts to the south of Chibougamau Lake. When the *JBNQA* was negotiated, most of the the Oujé-Bougoumou people were registered with Mistissini because registration under the provisions of the *Indian Act* had taken place about 30 years earlier. It was in this context that they were considered to be Mistissini *Eeyouch* at the time of the negotiation of the *JBNQA* (as well as during the course of the epidemiological studies of mercury exposure which took place between 1975 and 1980; Chevalier et al 1997). Recognition of the Oujé-Bougoumou people as a distinct *Eeyou* population took place roughly a decade later. Prior to the construction of the new community in the early 1990s, a number of families were living in cabins scattered throughout their land base and as members of Mistissini had access to the Income Security Program and other types of support for hunting families.

Although the history of gold and copper mining in the area had seemingly drawn to a close, in 2012 there was significant new activity in this sector. Industrial development in this area, of course, has not been limited to mining. Both Chapais and Chibougamau have diversified into the forestry industry.

The community was designed by a well-known architect, Douglas Cardinal, and has received awards from the United Nations, Habitat II, Expo 2000, and Canada Mortgage, as well as the United Nations Global Citizen Award in 1995. *Aanischaaukamikw*, the Cree Cultural Institute is located in the community, as is the headquarters of the Cree Regional Economic Enterprise Company (CREECO).

As implied above, the Oujé-Bougoumou people participated in four distinct epidemiological studies on mercury exposure because of their location close to Chibougamau (Chevalier et al., 1997). The most recent was the 2002 study funded by Québec, in response to publicity about adverse health impacts from the mining waste in Oujé-Bougoumou territory, with Nemaska as the study control community as mentioned earlier (Dewailly and Nieboer, 2005). The principal researchers of that project subsequently were invited by the Cree Board of Health to design the current multi-community study of the remaining seven communities.

3.2.9 Waswanipi (relocated, inland, southern, intermediate sized, rural)

Waswanipi, the most southerly of the *Eeyou* communities, has a particularly complicated settlement history. These days, it is a community of 1,700 living close to where Highway 113 (which links the Chibougamau region with Lebel-sur-Quévillon and Val d'Or) crosses the Waswanipi River on its way to the lake of that name.

When the HBC arrived in this area in 1820, they found that the traders of the NorthWest Company had a well-established trading post on Waswanipi Island, and had been operating in the region in competition with occasional traders from Montreal and Quebec throughout the last quarter of the 18th century. Waswanipi Post also attracted Atikamekw hunters from as far east as Oskalaneo, and Waswanipi hunters sometimes used other trading stations located near the southern limits of the James Bay watershed. In the early 20th century, they were the first *Eeyouch* to experience the various consequences following the arrival of rail transportation systems. The railroad crossed their lands bringing colonists and mineral prospectors to their doorstep, and with the opening of the highway system in the 1950s, the forest products industry interfered with their hunting territories.

Waswanipi people were among the first *Eeyouch* to be hired as industrial labourers, initially in the 1950s and 1960s; and in forestry, mining and commercial fisheries in the 1960s. Thus the Waswanipi people have had a relatively long experience with the wage-earning sector of the Québec economy. They moved to the peripheries of forestry and mining towns that were established in the region in the 1950s to take advantage of job opportunities. By the early 1960s, the people of Waswanipi became scattered among the emerging communities of Matagami, Senneterre, Miquelon, Desmaraisville and Chapais. By 1964, no more than a few elderly persons remained on the old Post and the HBC closed its operations on Waswanipi Island. The years leading up to the *JBNQA* negotiations, and the eventual agreement on the present-day community site, were difficult. Even today, the community is relatively scattered and retains links to the places where families settled in the 1950s and 1960s. Nevertheless, the community supports a public sector-based economy similar to that in the other *Eeyou* communities. A distinguishing feature is the extent of recent involvement in wage labour in the forestry sector (both logging and silviculture), although this source of employment is less important today.

The Waswanipi people also experienced mercury as an environmental contaminant. Indeed, for many years this community stood out as one of the Canadian aboriginal communities most severely affected by mercury contamination. As in the case of the other inland *Eeyou* communities (and likely Whapmagoostui as well, as mentioned earlier), it is the history of fisheries based on inland lakes which helps to account for this background – probably combined with poverty and the limited choice of food sources. Added to this were the consequences of the loss of mercury from a large pulp and paper/chlor alkali plant complex on the Bell River, a tributary of the Nottaway River, at the limits of the *Eeyou* territory.

Waswanipi underwent four distinct epidemiological studies during the wave of interest in the toxicological consequences of mercury exposure in the *Eeyou* population between 1975 and 1980 (Chevalier et al., 1997).

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4. Dietary Assessment and Physical Activity

4.1 Dietary Habits and Nutritional Status

4.1.1 Anthropometry (Louise Johnson-Down and Grace Egeland)

Adult guidelines for anthropometric parameters are based on cut-off values for individuals over 20 years of age. A BMI of 30 or greater indicates a high risk of health-related complications due to excess body weight for height. Using age and gender-specific cut-off values for percent body fat from a three-country study indicates elevated health risks (Gallagher et al., 1999). Central-fat patterning based upon WHO cut-off waist circumference values of 88 cm for women and 102 cm for men (WHO, 2000; Health Canada, 2006) can lead to health-related complications. The results for adults in all nine communities are summarized in Table 4.1.1 below.

The number of individuals at risk, using waist circumference as the measure, showed significant differences between communities (Chi-square test) (Health Canada, 2006). Whapmagoostui ranked higher than all the others, while Eastmain and Waswanipi ranked higher than Mistissini and Oujé-Bougoumou (ANOVA pairwise comparison).

Table 4.1.1 Percent individuals evaluated using standard anthropometric cut-offs for adults 20 years of age and older[1,2]

	Community	*n*	BMI			Percent body fat	Waist circumference
			Healthy weight	Over-weight	Obese	At risk	At risk
			%	%	%	%	%
Women	**Oujé-Bougoumou**	99	4.3	18.3	77.4***	NA	89.4***
	Nemaska	42	13.5	10.8	75.7***	NA	89.2***
	Mistissini	112	6.4	20.2	73.5***	95.7***	92.6***
	Wemindji	70	2.9	29.0	68.1***	98.6***	97.1***
	Eastmain	60	3.5	17.5	79.0***	98.3***	96.5***
	Waskaganish	54	6.0	26.0	68.0***	98.0***	90.4***
	Chisasibi	95	6.7	12.4	80.9***	94.3***	93.4***
	Whapmagoostui	45	2.3	2.3	95.4***	97.7***	100***
	Waswanipi	47	4.6	11.4	84.1***	97.7***	95.6***
	All communities	624	5.4	17.3	77.3***	96.9***	91.2***

	Community	*n*	BMI			Percent body fat	Waist circumference
			Healthy weight	Over-weight	Obese	At risk	At risk
			%	%	%	%	%
Men	**Oujé-Bougoumou**	56	16.4	34.6	49.1*	NA	66.1*
	Nemaska	18	5.9	29.4	64.7*	NA	70.6$^{\#}$
	Mistissini	75	10.0	31.7	58.3***	93.2***	61.9
	Wemindji	59	12.1	13.8	74.1***	92.9***	83.1***
	Eastmain	33	12.1	18.2	69.7***	90.9***	75.8**
	Waskaganish	39	22.2	36.1	41.7	94.3***	48.7
	Chisasibi	64	0.0	25.8	74.2***	100***	87.5***
	Whapmagoostui	36	6.7	16.7	76.7***	89.7***	90.6***
	Waswanipi	37	8.6	31.4	60.0***	91.4***	81.1***
	All communities	417	10.4	26.4	63.2***	93.5***	72.1***

1. In adults 20 years of age and greater, cut-offs for healthy weight, overweight and obesity are BMI < 25, 25 ≤ BMI < 30, and BMI ≥ 30 respectively; with cut-off points of 88 cm (women) and 102 cm (men) for waist circumference (WHO, 2000).

2. Chi-square test #p < 0.1 *p < 0.05 **p < 0.01 ***p < 0.001 for differences between the observed and expected rates of obesity (Health Canada, 2006), percent body fat (Gallagher et al., 2000) and waist circumference (WHO, 2000; Health Canada, 2006)

TABLE 4.1.2 PERCENT INDIVIDUALS 8-19 YEARS OF AGE EVALUATED USING STANDARD ANTHROPOMETRIC CUT-OFFS[1,2]

	Community	*n*	BMI			Percent body fat	Waist circumference
			Healthy weight %	Over-weight %	Obese %	Mean ± SD	Mean ± SD
Girls	**Oujé-Bougoumou**	20	10.0	25.0	65.0**	NA	92.8±14.4
	Nemaska	13	23.1	30.8	46.2	NA	99.0±18.4
	Mistissini	44	40.5	21.4	38.1	36.4±9.48	87.5±17.8
	Wemindji	21	28.6	19.1	52.4	37.0±9.24	90.7±15.9
	Eastmain	24	34.8	13.0	52.2#	39.7±7.35	94.6±11.8
	Waskaganish	23	39.1	17.4	43.5	37.5±8.28	91.1±15.2
	Chisasibi	30	36.7	20.0	43.3	36.7±10.1	88.2±17.7
	Whapmagoostui	28	50.0	3.57	46.4**	37.2±8.87	88.4±18.3
	Waswanipi	25	44.0	16.0	40.0	36.2±9.85	90.8±18.1
	All communities	227	36.0	17.8	46.2***	37.1±9.07	90.6±16.7
Boys	**Oujé-Bougoumou**	20	45.0	25.0	30.0	NA	85.8±15.3
	Nemaska	15	40.0	6.7	53.3#	NA	89.2±15.3
	Mistissini	27	38.5	19.2	42.3	26.8±11.7	87.6±14.7
	Wemindji	21	42.9	33.3	23.8	23.8±10.8	88.9±17.2
	Eastmain	20	30.0	45.0	25.0	29.1±10.2	94.1±13.7
	Waskaganish	29	51.7	10.3	37.9*	25.9±12.0	87.0±16.7
	Chisasibi	37	30.6	44.4	25.0	28.7±9.92	90.3±15.3
	Whapmagoostui	30	20.0	26.7	53.3#	32.4±11.4	96.4±24.5
	Waswanipi	22	40.9	13.6	45.5	29.8±12.2	95.0±20.3
	All communities	221	37.0	26.0	37.0#	28.2±11.3	90.6±17.6

1. Children and adolescents less than 20 years of age are placed in healthy weight, overweight and obese categories based on BMI values that correspond to adult thresholds of risk (Cole et al., 2000).

2. Chi-square test #p < 0.1 *p < 0.05 **p < 0.01 *** p < 0.001 for differences between the observed and expected rates of obesity (Cole et al., 2000).

BMI cut-off points for children were adopted from the standards developed by Cole et al. (2000). The proportion obese was significant ($p \leq 0.05$) for girls in Whapmagoostui and boys in Waskaganish (Chi-square test) (Table 4.1.2). This was not evident when considering percentage of body fat or waist circumference.

High weight during childhood predicts being overweight and obese in adulthood (Guo and Chumlea, 1999). Consequently, the data suggested that some youth were at risk for future obesity and health-related complications due to excess adiposity. For adults, the anthropometric parameters suggested the same for a large proportion of community members. Women in particular showed greater prevalence of obesity than men.

4.1.2 Dietary assessment and traditional foods (Louise Johnson-Down, Megan Beggs and Grace Egeland)

4.1.2.1 Participation

Details of the repeat dietary recalls administered are summarized in Tables A7.1A (Waskaganish), A7.1B (Chisasibi), A7.1C (Whapmagoostui) and A7.1D (Waswanipi). A total of 135 (Waskaganish), 214 (Chisasibi), 130 (Whapmagoostui) and 122 (Waswanipi) individuals participated in the dietary component of the study. Total participation and number of repeat recalls are presented in Table 4.1.3. In Oujé-Bougoumou and Nemaska, only the traditional food frequency questionnaire was administered.

TABLE 4.1.3 TOTAL NUMBER OF PARTICIPANTS AND REPEAT 24-HOUR RECALLS COLLECTED IN CREE COMMUNITIES

Community	Participants *n*	Repeat recalls *n (%)*
Oujé-Bougoumou	183	NA
Nemaska	81	NA
Mistissini	221	37 (14.3)
Wemindji	164	42 (20.4)
Eastmain	131	36 (21.6)
Waskaganish	135	48 (26.2)
Chisasibi	214	70 (24.7)
Whapmagoostui	130	31 (19.3)
Waswanipi	122	36 (22.8)
All communities	1381	300 (21.2)

For dietary intake, age ranges correspond to requirements as defined by the Dietary Reference Intakes published by the Institute of Medicine (IOM, 2003). Energy intake (EI) estimates based on the consumption data from the 24-hour recall questionnaire were validated by comparing them to estimated basal metabolic rate (BMR_{est}) calculated from the standard World Health Organization equations (FAO/WHO/UNU, 1985). The ratio of EI to the estimated BMR is used to determine whether the amount of energy reported to have been consumed is realistic, given the energy requirements of one's height, weight, gender and age. In adults, an $EI:BMR_{est} < 1.5$ for a group indicates underreporting (Black, et al., 1991), although it should be noted that the equation may overestimate BMR in women with BMI > 35 (Black, 2000), and that this group represented 47% of the women in our study.

Because of under-reporting tendencies, caution is required in interpreting the absolute values of micronutrient intakes. Comparisons of estimated BMR to energy intake reported yielded no differences between communities for children. However, a greater ratio of reported EI:BMR_{est} was observed for men in Waskaganish compared to Chisasibi, Whapmagoostui and Mistissini, and for women in Waswanipi and Waskaganish compared to those in all other communities (Table 4.1.4). Further investigation is required to determine the reason for the apparent underreporting in men. One possibility is that men may be impatient answering dietary questions.

TABLE 4.1.4 COMPARISON OF ENERGY INTAKE ON THE 24-HOUR RECALL TO ESTIMATED BASAL METABOLIC RATE IN SEVEN COMMUNITIES

Community	Girls (9-18 y)	Boys (9-18 y)	Women (≥19 y)	Men (≥19 y)
Mistissini	1.26±0.43	1.42±0.53	1.09±0.44	0.99±0.38
Wemindji	1.50±0.87	1.40±0.59	1.12±0.47	1.34±0.58[2]
Eastmain	1.23±0.62	1.16±0.54	1.22±0.45	1.34±0.59
Waskaganish	1.38±0.70	1.55±0.47	1.51±0.66[1]	1.41±0.56
Chisasibi	1.14±0.44	1.35±0.57	1.22±0.60	1.13±0.48
Whapmagoostui	1.36±0.74	1.40±0.84	1.24±0.68	1.07±0.44
Waswanipi	1.55±0.64	1.50±0.53	1.67±0.64[1]	1.32±0.52[2]
All communities	1.33±0.64	1.40±0.59	1.27±0.59	1.20±0.53

1. Intra-gender T-test, $p < 0.05$

2. Inter-gender T-test, $p < 0.05$

4.1.2.2 Traditional food intake *(Louise Johnson-Down, Megan Beggs, Grace Egeland)*

Tables A7.2A, B, C and D summarize data on the percentage of the population consuming traditional foods based on the frequency questionnaire. These tables indicate the average monthly frequency of consumption of these foods in days/month. In Waskaganish, moose, goose, rabbit, beaver and ptarmigan and other related birds were the most common, with over 75% of participants having eaten these foods in the past year. In Chisasibi, goose, caribou, moose, and ptarmigan and other related birds were most frequently reported; 80% of participants reported eating these foods in the past year. In Whapmagoostui, caribou, goose, and ptarmigan and other related birds were favoured with 85% of participants having eaten these foods in the past year. In Waswanipi, moose, goose, and ptarmigan and other related birds were the most common with 60% of participants eating these foods in the past year.

When traditional food consumption was evaluated by gender and age in Waskaganish, Chisasibi and Waswanipi, findings showed that adults over 40 years of age consumed more traditional foods than younger individuals and men consumed more than women (Figures A7.2.1A, B and D). In Whapmagoostui, this trend was not evident except for fish and berries: on average, children ate more game than adults, and almost as much fowl as adults over 40 (Figure A7.2.1C). By contrast, the 24-hour recalls indicated that the consumption of these food items was similar in all communities for older adults, and higher compared to younger adults and children (Figures A7.2.2A-D).

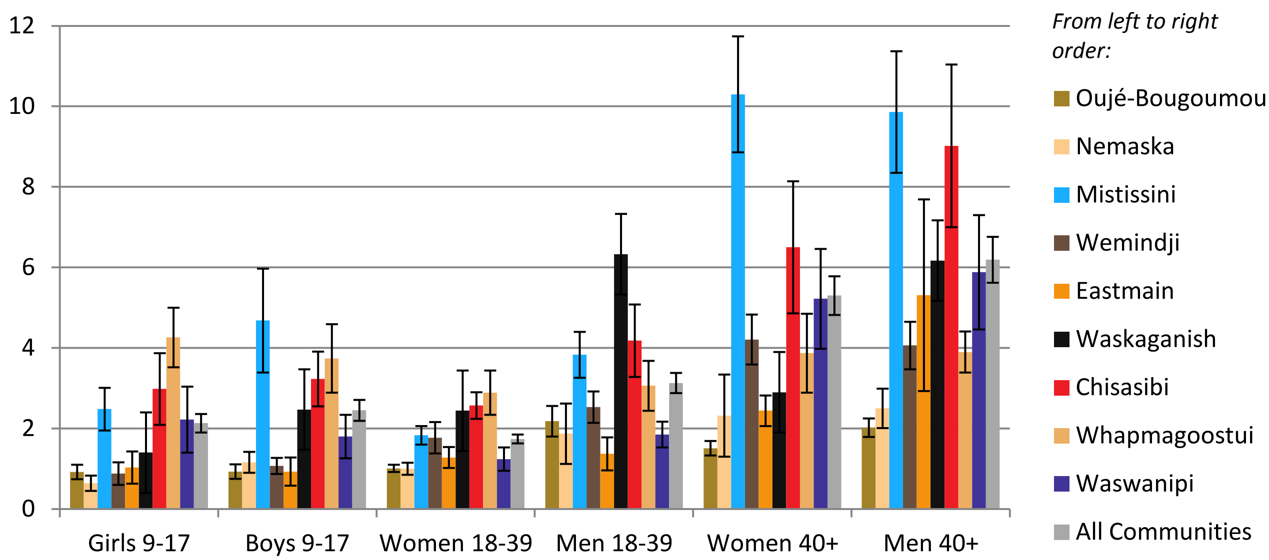
TABLE 4.1.5 FREQUENCY OF CONSUMPTION (NUMBER OF DAYS/MONTH) OF TRADITIONAL FOOD ITEMS FOR *CONSUMERS ONLY* BY AGE AND GENDER[1]

	Community	n	Game	Fish	Fowl	Berries	All (excluding berries)
Girls	**Oujé-Bougoumou**	15	1.70±3.50	1.33±1.81	2.21±1.33	NA	5.24±5.78
	Nemaska	13	1.36±1.14	1.15±0.91	2.52±2.23	NA	5.02±4.07
	Mistissini	30	4.47±5.77	2.64±4.93	4.01±5.70	3.04±6.74	11.1±12.8
	Wemindji	14	0.96±1.01	1.64±3.54	1.21±1.01	0.89±2.02	3.81±4.54
	Eastmain	17	2.53±5.97	0.22±0.50	1.97±2.33	0.60±1.66	4.72±7.44
	Waskaganish	14	2.67±2.17	0.80±1.02	2.61±2.09	3.90±7.00	6.09±4.09
	Chisasibi	22	1.96±1.73	2.36±3.95	8.63±14.8	0.27±0.48	13.0±18.2
	Whapmagoostui	21	6.74±9.23	2.40±3.49	7.79±7.55	0.36±0.62	16.9±14.3
	Waswanipi	18	7.96±13.7	0.92±1.45	1.28±1.82	1.72±2.36	10.2±15.9
	All communities	136	4.09±7.36	1.74±3.44	4.29±7.68	1.57±4.21	10.1±13.3
Boys	**Oujé-Bougoumou**	12	1.55±1.48	0.74±0.55	1.45±1.47	NA	3.74±2.61
	Nemaska	8	0.76±0.48	0.72±0.79	1.41±0.86	NA	2.89±2.01
	Mistissini	18	11.2±16.2	3.38±5.53	5.76±6.63	2.04±2.68	20.3±23.8
	Wemindji	17	1.99±2.43	0.65±0.97	2.00±1.46	1.36±4.16	4.64±3.61
	Eastmain	15	1.92±4.20	0.23±0.55	1.89±1.72	0.22±0.37	4.04±5.84
	Waskaganish	19	3.75±3.97	3.07±4.93	4.47±5.61	0.85±1.28	11.3±10.5
	Chisasibi	30	4.40±7.15	3.67±5.27	5.94±6.40	0.78±1.82	14.0±16.2
	Whapmagoostui	24	3.88±5.37	4.67±10.1	7.50±9.60	0.21±0.28	16.1±17.4
	Waswanipi	17	5.12±8.03	1.23±1.66	1.47±2.16	0.87±1.87	7.83±9.58
	All communities	140	4.62±8.18	2.69±5.68	4.53±6.26	0.88±2.13	11.8±15.2

	Community	n	Game	Fish	Fowl	Berries	All (excluding berries)
Women	**Oujé-Bougoumou**	57	2.97±3.04	2.53±4.00	3.58±4.49	NA	9.08±8.38
	Nemaska	18	3.52±3.56	3.14±4.05	2.69±1.88	NA	9.34±8.57
	Mistissini	109	8.75±9.94	5.29±8.74	4.4±4.78	2.06±4.36	18.4±20.4
	Wemindji	73	4.48±6.01	3.30±6.34	3.70±3.63	1.67±3.25	11.5±13.4
	Eastmain	61	3.50±4.45	0.76±1.31	3.44±3.66	0.73±1.57	7.70±7.80
	Waskaganish	57	4.44±5.41	3.02±5.61	3.85±3.53	1.09±2.29	11.3±12.0
	Chisasibi	94	3.76±4.49	2.87±4.73	6.44±7.91	0.87±1.87	13.1±13.3
	Whapmagoostui	50	4.32±4.61	3.64±7.82	6.79±9.71	0.61±0.91	14.8±17.6
	Waswanipi	46	8.24±13.3	2.44±5.29	2.33±3.77	3.54±9.42	13.0±18.5
	All communities	490	5.5±7.73	3.27±6.43	4.55±5.89	1.49±4.03	13.3±15.8
Men	**Oujé-Bougoumou**	98	2.10±2.02	1.17±1.03	1.84±1.43	NA	5.10±3.65
	Nemaska	42	2.22±2.69	0.86±1.39	1.96±1.44	NA	5.05±5.18
	Mistissini	72	10.3±9.47	7.06±10.50	6.07±6.83	1.64±3.12	23.4±22.0
	Wemindji	61	5.08±4.57	4.37±5.71	4.37±3.89	1.04±2.21	13.8±11.8
	Eastmain	36	3.95±4.66	1.53±2.83	3.19±2.61	2.23±8.02	8.66±8.93
	Waskaganish	40	9.74±8.14	7.77±6.34	6.15±6.13	1.25±1.60	23.7±16.8
	Chisasibi	63	5.94±6.41	6.58±8.94	10.2±9.11	1.15±2.35	22.8±19.6
	Whapmagoostui	36	5.53±6.98	2.28±2.41	7.49±5.51	0.60±1.37	15.3±10.8
	Waswanipi	39	10.6±16.8	3.09±6.32	2.45±2.33	1.54±2.87	16.1±20.2
	All communities	347	7.39±9.03	5.07±7.59	5.98±6.47	1.34±3.45	18.4±17.8

1. Girls and boys are aged 9-17 y, and adults 18 y and older

FIGURE 4.1.1 AVERAGE (± STANDARD ERROR) NUMBER OF TIMES PER WEEK PARTICIPANTS REPORTED EATING TRADITIONAL FOOD ON THE TRADITIONAL FOOD FREQUENCY QUESTIONNAIRE



In Figure 4.1.1 and Table 4.1.5, the total intake frequency of traditional food items (i.e. game, fish and fowl) are compared for all nine communities. It is important to note that although there appeared to be significant differences, the variation was also considerable. The statistical significance of pairwise comparisons between age, gender, and communities are provided in Table 4.1.6 below. Interpretation of this table is difficult but one could, for example, state that traditional food intake reported in Eastmain for men 18-39 years old was lower than in Mistissini, Waskaganish, Chisasibi and Whapmagoostui. The 18-39 year-old women in Whapmagoostui reported higher intakes than Oujé-Bougoumou, Nemaska, Wemindji, Eastmain and Waswanipi, while girls aged 9-17 from Whapmagoostui did so when compared to girls in Oujé-Bougoumou, Nemaska, Wemindji, Eastmain and Waswanipi. Boys 9-17 years old in Eastmain showed lower intake than in Mistissini, Waskaganish, Chisasibi and Whapmagoostui. Women over 40 years old in Mistissini showed higher intake than in Oujé-Bougoumou, Nemaska, Eastmain, Waskaganish and Whapmagoostui. Similarly, men in the same age group in Mistissini, Waskaganish and Chisasibi reported higher intakes than in Oujé-Bougoumou and Nemaska. In Figure 4.1.2, the percentage of children consuming traditional meats and fish in the past day ranged from 9% in Waswanipi to 27% in Whapmagoostui, and slightly more in adults aged 18-39 (16% in Eastmain to 30% in Chisasibi and Whapmagoostui). Adults over 40 years of age were the most frequent consumers, with 37% in Eastmain and 67% in Wemindji.

TABLE 4.1.6 COMMUNITY COMPARISONS OF WEEKLY REPORTED TRADITIONAL FOOD INTAKE FROM THE TRADITIONAL FOOD FREQUENCY QUESTIONNAIRE[1]

Community	Girls 9-17	Boys 9-17	Women 18-39	Men 18-39	Women ≥40	Men ≥40
Oujé-Bougoumou	B	AB	C	BCD	C	B
Nemaska	B	AB	C	CD	BC	B
Mistissini	AB	A	ABC	AB	A	A
Wemindji	B	AB	BC	BCD	AB	AB
Eastmain	B	B	C	D	BC	AB
Waskaganish	AB	A	AB	A	BC	A
Chisasibi	AB	A	AB	AB	AB	A
Whapmagoostui	A	A	A	BC	BC	AB
Waswanipi	B	AB	C	BCD	ABC	AB

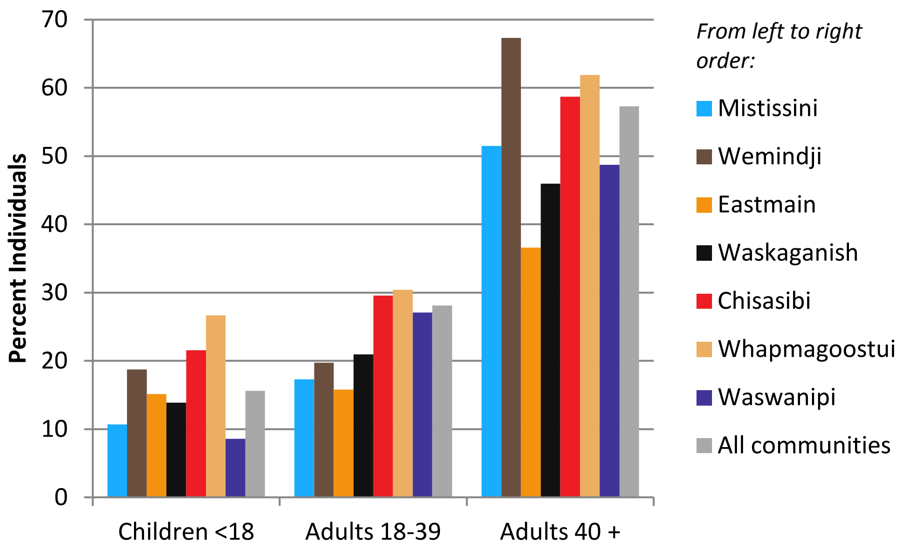
1. Communities with the same letter are not significantly different on ANOVA pairwise comparisons of ranks. The letter “A” represents the highest ranking of intake, and the letter “C” represents the lowest ranking of intake.

TABLE 4.1.7 NUMBER OF DAYS SPENT IN THE BUSH DURING THE PAST YEAR AND WEEKLY TRADITIONAL FOOD INTAKE FOR PARTICIPANTS (≥15 YEARS) IN WASKAGANISH, CHISASIBI, WHAPMAGOOSTUI AND WASWANIPI

Activity	Waskaganish	Chisasibi	Whapmagoostui	Waswanipi
	n (%)	n (%)	n (%)	n (%)
Number of days in bush during the past year				
None	34 (31.5)	25 (13.8)	7 (6.60)	9 (9.09)
≤3 per month	47 (43.5)	90 (49.7)	40 (37.7)	58 (58.6)
≥1 per week	27 (25.0)	66 (36.5)	59 (55.7)	32 (32.3)
Weekly traditional food consumption frequency				
Never	1 (0.76)	0 (0)	0 (0)	1 (0.82)
< median (2.19)	58 (43.9)	88 (40.9)	59 (44.4)	71 (58.2)
≥ median (2.19)	73 (55.3)	127 (59.1)	74 (55.6)	50 (41.0)
Weekly traditional fowl consumption frequency				
Never	1 (0.76)	0 (0)	2 (1.50)	15 (12.3)
< median (0.70)	66 (50.0)	64 (29.8)	36 (27.1)	84 (68.9)
≥ median (0.70)	65 (49.2)	151 (70.2)	95 (71.4)	23 (18.9)
Weekly traditional game consumption frequency				
Never	1 (0.76)	2 (0.93)	3 (2.26)	3 (2.46)
< median (0.65)	55 (41.7)	111 (51.6)	72 (54.1)	54 (44.3)
≥ median (0.65)	76 (57.6)	102 (47.4)	58 (43.6)	65 (53.3)
Weekly traditional fish consumption frequency				
Never	22 (19.5)	25 (14.4)	23 (22.6)	16 (18.6)
< median (0.27)	8 (7.08)	29 (16.7)	16 (15.7)	22 (25.6)
≥ median (0.27)	83 (73.5)	120 (69.0)	63 (61.8)	48 (55.08)

Participants in Whapmagoostui spent more time in the bush (see Table 4.1.7) compared to those in Waskaganish, Chisasibi and Waswanipi (Chi-square test, $p < 0.05$). Comparisons between time in the bush and traditional food intake, as reported on the traditional food frequency questionnaire, showed no significant associations. This suggests that the intake of traditional food is dependent on multiple factors, and not solely on time spent in the bush.

FIGURE 4.1.2 PERCENTAGE OF INDIVIDUALS CONSUMING TRADITIONAL FOODS IN THE PREVIOUS 24 HOURS



A higher frequency of intake of traditional food by older individuals was a consistent observation in all communities. This trend was maintained when expressing its consumption as percent energy (data not shown). Non-parametric comparisons of percent energy as traditional food between communities by age category yielded no differences in intake by children, but did so for adults. Pairwise comparisons of communities showed no differences for children and younger adults, but higher intakes in Wemindji compared to Waswanipi, Waskaganish and Eastmain in adults over 40 years of age.

4.1.2.3 Factor Analysis *(Evert Nieboer and Ian Martin)*

Another approach to dealing with multiple dietary consumption variables is to carry out factor (principal component) analysis. As mentioned in Section 2.5, it involves a mathematical approach in which the number of variables (e.g., frequency of specific food items consumed) is reduced to fewer independent variables, referred to as "factors" or "axes" that summarize the consumption of related food items. To generate Table 4.1.8, all of the responses to the 36 market food questions asked in the market food frequency questionnaire, as well for as 31 traditional food questionnaire responses, were used to generate a number of new variables summarizing unique consumption patterns. Six of the most prominent are summarized in Table 4.1.8; together they explain 27.1% of the variation (i.e., the amount of spread in consumption explained by the 6 PC variables, relative to the amount of spread in the original 67 questionnaire variables). Clearly, the PC-1 axis constitutes a traditional food axis, since all of the values (referred to as loadings) are positive, and a number are of substantial magnitude (≥0.50).

The plot of the PC-1 values in Figure 4.1.3 clearly indicates that older individuals (40 y and older) eat more traditional food than children (8-14 y) and younger adults (15-39 y), especially in Mistissini. The PC-2 axis reflects the consumption of snack/fried foods. By contrast to traditional food consumption, the magnitude by age is reversed with children and young adults generally eating more than older adults (Figure 4.1.4). This pattern is most evident in Eastmain, Waskaganish, Chisasibi, and Whapmagoostui. PC-3 constitutes a measure of how frequently vegetables are consumed (Figure 4.1.5). In most communities (Mistissini exempted), the general trend is: children < younger adults < older adults. A similar trend exists for the consumption frequency of moose meat relative to fish, fish eggs and liver (see PC-4 plot in Figure 4.1.6), with adults in Waswanipi recording the most frequent relative intake of moose.

TABLE 4.1.8 PRINCIPAL COMPONENT ANALYSIS OF MARKET AND TRADITIONAL FOOD FREQUENCY DATA FOR SEVEN JAMES BAY CREE COMMUNITIES (CORRELATION MATRIX)[1,2]

a) Market Foods[3]	PC-1 (9.8%)	PC-2 (4.7%)	PC-3 (3.5%)	PC-4 (3.4%)	PC-5 (2.9%)	PC-6 (2.8%)
Q1: Fresh fruit	0.06	0.35	0.25	0.07	-0.11	-0.10
Q2: Canned fruit	0.17	**0.41**	0.14	-0.07	-0.15	0.20
Q3: Dried fruit	0.13	-0.03	0.30	0.14	-0.05	0.08
Q4: Potatoes	0.18	0.27	0.31	0.21	-0.02	-0.16
Q5: Carrots, peas or corn	0.11	0.29	**0.50**	0.28	-0.05	-0.19
Q6: Salad or coleslaw	0.19	0.12	**0.46**	0.15	0.05	-0.21
Q7: Tomatoes	0.12	0.20	**0.56**	0.26	0.09	-0.10
Q21: {Cakes}, donuts, pies, pastries	0.10	0.38	0.20	-0.03	-0.02	0.03
Q22: Cookies	0.15	**0.46**	0.00	-0.07	-0.02	-0.06
Q25-1: Soft drinks – Regular	-0.03	0.30	-0.36	-0.17	0.09	-0.08
Q25-2: Soft drinks – Diet	-0.02	0.13	0.18	0.15	0.00	-0.07
Q26-1: Ice tea – Regular	-0.05	0.37	-0.27	-0.18	0.08	-0.06
Q26-2: Ice tea – Diet	0.07	0.22	0.00	-0.04	0.00	0.10
Q27: Fruit drinks or Sports drinks	-0.04	0.37	-0.17	-0.06	0.06	0.00
Q28: Real fruit juice	-0.05	0.28	-0.01	-0.04	-0.01	-0.02
Q29-1: Milk – Whole	-0.01	0.10	0.08	0.06	0.00	-0.07
Q29-2: Milk – 2%, Grand Pré	0.03	0.17	-0.06	0.02	-0.08	-0.04
Q29-3: Milk – 1%	-0.01	0.06	0.05	0.04	-0.02	-0.04
Q29-4: Milk – Skim	-0.03	0.02	0.04	0.01	-0.01	0.03
Q30: Chocolate milk	-0.02	0.31	-0.07	-0.11	-0.05	-0.02
Q32-1: Beer – Regular	-0.03	0.04	-0.13	0.18	**0.52**	0.25
Q32-2: Beer – Light	-0.05	-0.04	0.08	0.05	-0.05	-0.08
Q33: Wine	0.00	-0.04	0.10	0.17	0.25	0.02
Q34-1: Alcohol – Mixed with juice or pop	-0.01	0.04	-0.09	0.25	**0.65**	0.33
Q34-2: Alcohol – Shooters or on ice	-0.03	0.09	0.00	-0.02	0.03	-0.06
Q42: Chips, crisps, cheese puffs	-0.10	**0.59**	-0.22	-0.21	0.07	-0.11
Q43: Nacho chips with melted cheese	-0.01	**0.43**	-0.12	-0.07	-0.04	0.03
Q44-1: Microwave Popcorn – Regular	-0.02	**0.47**	-0.06	-0.15	0.03	0.06
Q44-2: Microwave Popcorn – Light or Low fat	-0.06	0.06	0.04	-0.01	-0.08	-0.05
Q47: Poutine	-0.09	**0.54**	-0.16	-0.20	0.03	0.00
Q48: French fries, fried potatoes or hash browns	-0.03	**0.48**	0.14	-0.03	0.06	-0.03
Q49: Deep fried snacks	0.15	**0.43**	0.07	-0.15	-0.13	0.31

Q50: Butter	0.02	0.16	-0.05	0.28	0.24	0.09
Q51: Margarine	0.00	0.13	0.01	0.15	0.13	0.16
Q52: Lard or shortening	0.14	0.06	-0.05	0.29	**0.49**	0.33
Q53: Vegetable oil	0.08	0.13	0.09	0.25	0.35	0.04
b) Traditional Foods						
Q1: Bear meat, dried	**0.44**	-0.03	-0.25	0.20	0.04	**-0.41**
Q2: Bear meat, cooked	**0.44**	-0.03	-0.09	0.24	-0.05	-0.25
Q4: Moose meat, dried	0.29	0.05	-0.15	0.30	-0.19	0.07
Q5: Moose meat, cooked	**0.49**	0.07	-0.17	**0.41**	-0.27	0.06
Q7: Caribou meat, dried	0.38	0.05	-0.33	0.17	0.01	-0.10
Q8: Caribou meat, cooked	**0.41**	0.08	-0.24	0.18	0.10	-0.15
Q10: Beaver meat	**0.52**	0.05	-0.07	0.10	-0.32	0.39
Q11: Rabbit meat	**0.41**	0.02	0.01	0.21	-0.30	0.34
Q12: Smoked game animal meat	**0.41**	0.05	-0.05	0.06	-0.07	0.02
**Organ meats (mammal, bird)	**0.56**	-0.11	0.04	-0.24	0.10	0.06
**Other game	0.30	-0.09	-0.03	-0.10	0.05	0.12
Q17: Speckled trout	**0.55**	-0.05	-0.30	0.04	0.04	-0.24
Q18: Walleye	**0.46**	0.07	-0.10	0.19	-0.25	0.22
Q19: Whitefish	**0.42**	-0.07	0.13	-0.38	0.12	0.23
Q20: Pike	**0.71**	-0.05	-0.17	-0.04	-0.11	0.14
Q21: Lake Trout	**0.55**	-0.01	-0.34	0.03	0.12	-0.31
Q22: Sturgeon	0.29	-0.01	0.02	0.13	-0.20	0.19
Q23: Burbot	0.38	-0.03	0.26	-0.24	0.11	-0.21
Q24: Red or White Sucker	**0.55**	-0.11	0.20	-0.35	0.13	-0.08
Q25: Fish from the ocean	0.08	-0.04	0.09	0.06	-0.01	0.03
Q26: Fish eggs	**0.49**	-0.11	0.16	-0.37	0.10	0.23
Q27: Smoked wild fish	**0.49**	0.01	-0.10	0.03	-0.06	0.12
**Other fish	0.04	0.03	0.06	0.13	0.22	0.01
**Fish liver	0.30	-0.13	0.17	-0.34	0.13	0.16
Q33: Geese	**0.45**	0.06	0.02	-0.07	0.08	0.00
Q34: Dappler Ducks	**0.62**	-0.10	0.06	-0.32	0.13	-0.07
**Loon, Sea, other ducks	**0.59**	-0.03	0.11	-0.15	0.19	-0.38
Q48: Bear grease	**0.50**	0.00	0.28	-0.07	0.01	0.14
Q49: Goose grease	**0.46**	0.03	0.00	-0.10	0.13	-0.06
**Wild Berries, jam	**0.52**	0.02	0.02	0.24	0.07	-0.10
**Other animal fat	0.11	0.00	0.01	0.05	-0.04	0.06

1. Highlighted numbers (called loadings) indicate that the variance in the corresponding food items contribute substantially to the variance summarized by that principal component (PC).

2. Oujé-Bougoumou and Nemaska are not included, as their food frequency questionnaires did not include market foods.

3. **: Indicates a simple summary variable combining several related food frequency variables, before PCA was performed.

FIGURE 4.1.3 DEPENDENCE OF PC-1 (THE TRADITIONAL DIET CONSUMPTION FREQUENCY VARIABLE) ON AGE AND COMMUNITY (AGE GROUPS ARE IN LEFT TO RIGHT ORDER)

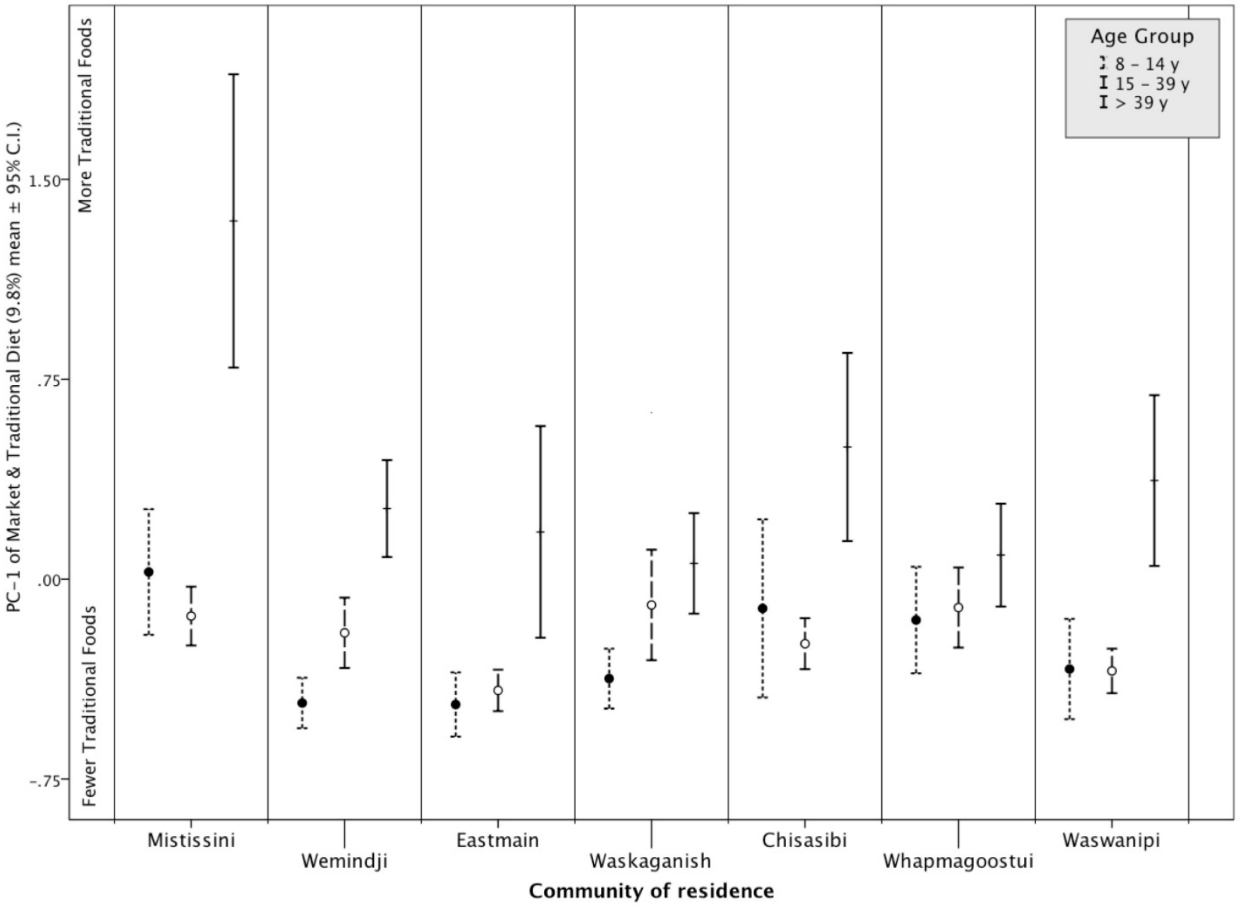


FIGURE 4.1.4 DEPENDENCE OF PC-2 (THE SNACK/FRIED FOODS CONSUMPTION FREQUENCY VARIABLE) ON AGE AND COMMUNITY (AGE GROUPS ARE IN LEFT TO RIGHT ORDER)

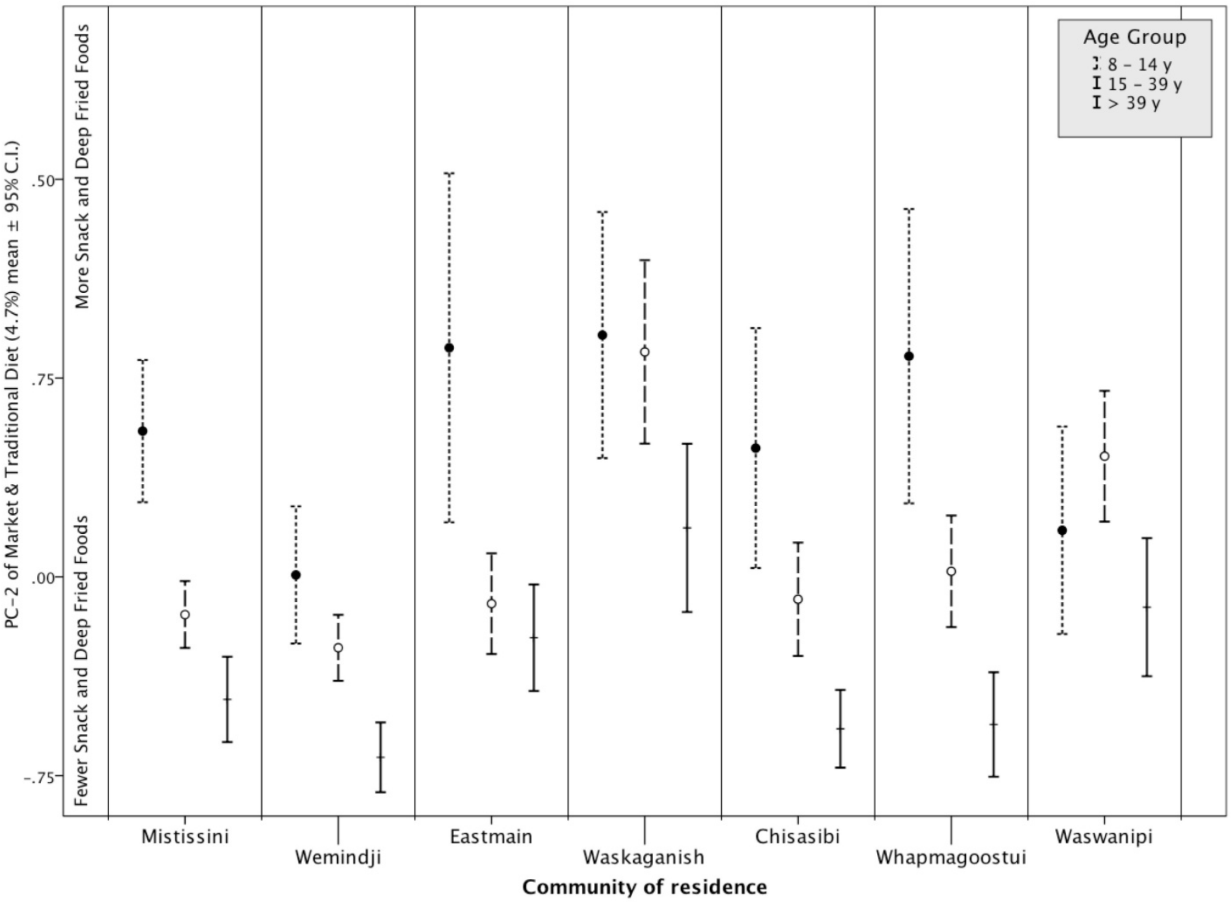


FIGURE 4.1.5 DEPENDENCE OF PC-3 (THE VEGETABLE CONSUMPTION FREQUENCY VARIABLE) ON AGE AND COMMUNITY (AGE GROUPS ARE IN LEFT TO RIGHT ORDER)

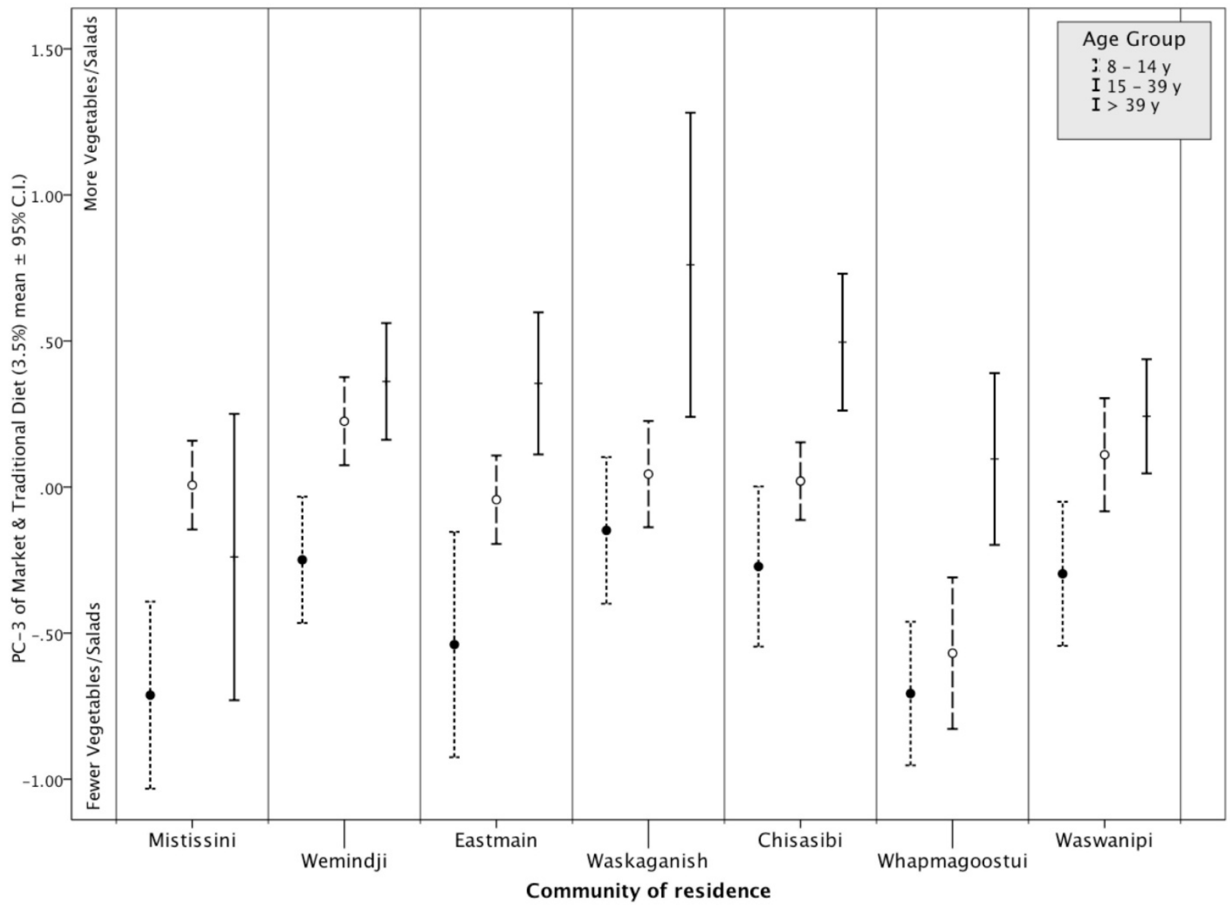
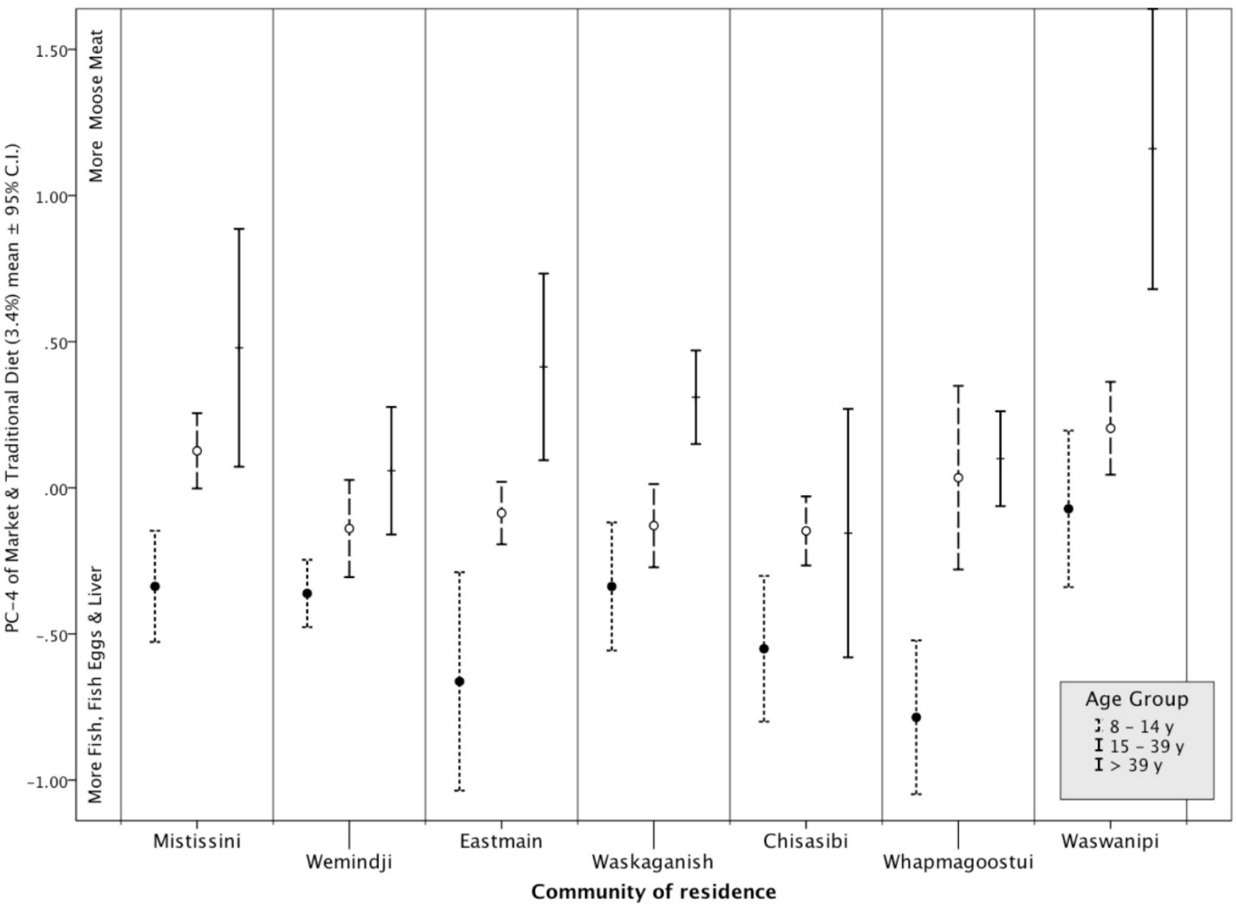


FIGURE 4.1.6 DEPENDENCE OF PC-4 (THE VARIABLE REPRESENTING THE CONSUMPTION FREQUENCY OF MOOSE RELATIVE TO FISH, FISH EGGS & LIVER) ON AGE AND COMMUNITY (AGE GROUPS ARE IN LEFT TO RIGHT ORDER)



4.1.2.4 Nutrient intake estimates *(Louise Johnson-Down, Megan Beggs, Grace Egeland)*

Macronutrients, saturated fat and cholesterol

For the four communities surveyed in 2008 and 2009, the percent of energy as protein, total fat, and carbohydrates are depicted in Figures A7.3.1A-D (women 19 and over), A7.3.2A-D (men 19 and over), A7.3.3A-D (girls 9-18 years), and A7.3.4A-D (boys 9-18 years). Respectively, the mean and median intake for nutrients (including supplements) and percent individuals above and below the recommended values are given for these four groups in Tables A7.3.1A-D, A7.3.2A-D, A7.3.3A-D, and A7.3.4A-D.

When comparing the four communities most recently surveyed, there were no differences in percent energy as fat or as saturated fat in adults. Girls in Wemindji had higher intakes of percent energy as fat than in Mistissini and Chisasibi, while boys in Eastmain consumed more than in Chisasibi. Girls in Eastmain reported higher percent energy as saturated fat compared to Waskaganish, Waswanipi, Chisasibi, Whapmagoostui and Mistissini; for boys, no such differences were noted. Protein intake was similar across the communities. For intake by women, Eastmain reported more cholesterol than Waswanipi, and no other differences were reported for other age and sex categories. Fiber consumption was less than adequate in all age and sex categories and communities.

Acceptable Macronutrient Distribution Range (AMDR) for fat intake as a percent of total energy ranges from 20-35% for adults and 25-35% for children (IOM, 2005). In women, the proportion of individuals above the AMDR for energy percent from fat ranged from a low of 62% in Waskaganish to a high of 71% in Eastmain; in men, from 58% in Waswanipi to 81% in Whapmagoostui; in girls, from 5% in Waswanipi to 56% in Wemindji; and in boys, 11% in Waswanipi and 39% in Eastmain (see Table 4.1.6) (IOM, 2000a).

Previous guidelines have recommended that daily cholesterol intake be limited to 300 mg/day. The estimated median intake of cholesterol was highest for men (614 mg/day in Waskaganish, 568 mg/day Chisasibi, 526 mg/day Whapmagoostui and 574 mg/day in Waswanipi). Also, median cholesterol levels were high for women (397 mg/day in Waskaganish; 393 mg/day Chisasibi; 448 mg/day Whapmagoostui; and 373 mg/day in Waswanipi). The median intake of girls and boys varied from a low of 197 mg/day in girls in Whapmagoostui to a high of 417 mg/day for girls in Waswanipi. For these four communities, less than 1% of individuals of any age reported protein intake below the estimated average requirement (IOM 2000a, 2005). In the past, Canadian guidelines have suggested that saturated fat intake ought to be less than or equal to 10% of the energy consumed, to prevent type 2 diabetes and heart disease. Perusal of Table 4.1.9 suggests that more than 70% of children, men and women in the four communities reported percent energy as saturated fat above 10% (Figures A7.3.5A-D). It is now recommended that the daily consumption of saturated fat and cholesterol be as low as possible while consuming a nutritionally adequate diet (IOM, 2005).

TABLE 4.1.9 MEAN OF SELECTED MACRONUTRIENTS AND PERCENT INDIVIDUALS BELOW RECOMMENDATIONS BY COMMUNITY[1]

			Percent energy as fat	Percent energy as fat from traditional foods	Percent energy as fat	Percent energy as saturated fat	Percent energy as saturated fat	Fiber (g)	Fiber
		n	Mean ± SD	Mean ± SD	% above AMDR	Mean ± SD	% above 10%± SE	Mean ± SD	% below AI
Women	**Mistissini**	103	36.0±9.52	1.58±3.94	66.0	11.6±4.01	82.5	10.1±5.79	100
	Wemindji	71	37.2±11.0	3.91±9.58	70.4	11.8±4.58	83.1	13.4±7.43	98.6
	Eastmain	61	38.8±10.6	1.51±4.73	70.5	12.3±3.60	95.1	13.8±9.87	96.7
	Waskaganish	55	37.3±8.87	2.00±4.29	61.8	10.8±3.14	80.0	12.9±6.34	100
	Chisasibi	95	35.3±10.7	5.05±9.99	63.2	10.4±3.57	73.7	10.4±6.80	98.9
	Whapmagoostui	46	38.9±10.0	5.11±7.95	65.2	11.7±3.62	82.6	10.0±5.69	100
	Waswanipi	46	34.6±9.55	0.73±2.72	63.0	11.0±4.06	73.9	14.9±6.99	100
	All communities	477	36.7±10.2	2.93±7.13	67.2±9.82	11.3±3.87	81.6±15.1	11.9±7.23	98.9
Men	**Mistissini**	64	38.3±9.76	1.78±6.08	75.0	11.7±4.00	89.1	11.9±6.61	100
	Wemindji	58	36.9±8.68	5.72±9.56	67.2	11.5±3.41	84.5	10.6±6.88	100
	Eastmain	34	38.8±9.07	2.54±7.64	79.4	12.5±3.79	94.1	15.2±12.5	100
	Waskaganish	40	37.9±6.94	2.74±5.33	77.5	11.2±3.44	92.5	17.1±9.28	100
	Chisasibi	65	39.6±9.91	5.44±8.73	76.9	12.0±4.21	83.1	12.0±8.40	100
	Whapmagoostui	36	39.4±11.6	4.60±9.27	80.6	11.8±4.34	88.9	11.0±5.60	100
	Waswanipi	36	36.0±10.4	1.51±3.67	58.3	11.4±4.04	80.6	16.8±9.27	100
	All communities	333	38.2±9.53	3.62±7.73	71.3±6.70	11.7±3.89	85.4±15.3	13.1±8.60	100

			Percent energy as fat	Percent energy as fat from traditional foods	Percent energy as fat	Percent energy as saturated fat	Percent energy as saturated fat	Fiber (g)	Fiber
		n	Mean ± SD	Mean ± SD	% above AMDR	Mean ± SD	% above 10%± SE	Mean ± SD	% below AI
Girls	**Mistissini**	31	30.5±9.16	1.55±5.07	8.57	10.1±4.05	74.3	11.9±7.64	100
	Wemindji	15	38.0±7.95	3.13±7.07	56.3	13.5±4.98	93.8	10.3±6.00	100
	Eastmain	18	36.5±10.0	0.29±1.21	38.9	13.9±4.91	94.4	10.1±5.84	100
	Waskaganish	18	32.9±7.23	0.33±1.02	16.7	9.99±2.53	88.9	13.7±4.83	100
	Chisasibi	23	29.4±8.64	1.58±3.92	17.4	9.46±3.26	78.3	11.1±6.45	100
	Whapmagoostui	24	31.9±10.3	4.37±7.28	23.1	10.1±3.93	84.6	10.5±6.20	100
	Waswanipi	21	31.0±7.65	0.11±0.35	4.76	9.98±2.86	81.0	16.0±12.3	95.2
	All communities	150	32.4±9.13	1.66±4.78	14.1±42.3	10.8±4.09	81.4±325	12.0±7.61	99.9
Boys	**Mistissini**	23	32.7±9.22	0.78±3.58	26.9	11.2±4.45	73.1	11.6±7.06	100
	Wemindji	20	34.4±9.34	0.87±3.20	30.0	11.4±4.87	90.0	15.9±17.3	100
	Eastmain	18	39.4±12.3	1.58±5.90	38.9	12.9±5.66	88.9	11.5±5.97	100
	Waskaganish	22	32.1±7.21	0.17±0.62	18.2	10.3±2.79	81.8	12.8±8.08	100
	Chisasibi	31	30.9±12.2	3.34±8.66	12.9	9.75±3.72	74.2	12.6±7.94	100
	Whapmagoostui	24	36.1±8.15	1.75±6.72	36.0	12.0±3.23	96.0	12.3±7.12	100
	Waswanipi	19	31.3±7.99	0.04±0.17	10.5	10.3±3.24	84.2	14.5±5.88	100
	All communities	157	33.6±9.98	1.39±5.46	21.1±60.5	11.0±4.08	79.0±67.5	13.0±9.05	100

1. Age cut-offs defined by IOM are: 9-18 y for children, and greater or equal to 19 y for adults.

Micronutrient intake by adults

The daily mean nutrient intakes for adult women and men (19 and older) compiled in Tables A7.3.1A-D and A7.3.2.A-D are listed in relation to Dietary Reference Intakes (DRIs) and, when applicable, as the percentage of individuals consuming less than the estimated average requirement (EAR) values (IOM, 1997, 1998, 2000a, 2000b, 2000c, 2005, 2011). Inadequate intake can only be quantified by the EAR cut-point method where the data is adjusted to model usual intake (IOM, 2000a, 2003). In addition, it is necessary to stratify each nutrient intake by age and gender. Using this method on observed intake can overestimate inadequacy by more than 100% (Jahns et al., 2004).

In Waskaganish, Chisasibi, Whapmagoostui and Waswanipi (see Tables A7.3.1A-D and A7.3.2A-D) more than 30% of men and women had inadequate vitamin A intake (IOM, 2000b). A small percentage of men (25% or less) were below the EAR for daily folate intake (IOM, 1998), and only 15% or less of women. Less than 35% of women did not meet the EAR for vitamin C (IOM, 2000c), and between 22-48% of men did not. Using the new EAR for vitamin D intake (IOM, 2011), the percent of individuals with inadequate intake ranged from 60-73% in men and 54-85% in women. Please note that some of these percentages may reflect underreporting.

The mean daily calcium intake in the last four communities surveyed was below 700 mg/day for women and for men, ranging from 615 mg/day in Chisasibi to 907 mg/day in Waswanipi (see Tables 4.1.10, A7.3.1A-D, and A7.3.2A-D); and a minimum of 55% of adults were below the new EAR of 1000-1300 mg/day (IOM, 2011). Also noteworthy was the low magnesium intake among men and women; for 50 to 78% of men it was inadequate (IOM, 1997). Women fared a little better with 33-74%. Iron intake was adequate in men in all four communities (IOM, 2000b). Analysis showed a very small probability of inadequate iron intake in the women of pre-menopausal age (19-50 years old), with 0% in older women (>50 years of age) in the four communities.

There were significant differences in vitamin A intake when comparing seven communities (Table 4.1.10) although only Eastmain women had greater intakes than women in Waswanipi, Mistissini, Wemindji, Chisasibi and Waskaganish. Further, men in Waswanipi took in more than men in Whapmagoostui, Wemindji and Chisasibi in pairwise comparisons. However, there were no overall differences in folate intake between communities. Also, there were no overall differences for vitamin C intake in women but there were in men. In pairwise comparisons, men in Wemindji and Whapmagoostui consumed less than in Waswanipi. For vitamin D, there were no differences in comparisons of the seven communities in men but there were among women. Pairwise comparisons in women showed that intake in Whapmagoostui was comparable to Eastmain but higher than Waskaganish, Chisasibi, Wemindji, Mistissini and Waswanipi.

There were differences in calcium intake for men when comparing all communities. Pairwise comparisons for men showed higher values in Waswanipi than in Mistissini and Chisasibi. There were differences for magnesium intake for both men and women in overall comparisons. In pairwise comparisons, Waswanipi had higher intakes than Eastmain, Mistissini, Wemindji, Whapmagoostui and Chisasibi by men, while they were higher in Eastmain compared to Mistissini for women. Iron intake was different across all communities in both men and women: pairwise comparisons in men showed that Waswanipi ranked higher than Whapmagoostui and there was no evidence for differences in women.

TABLE 4.1.10 PERCENT INDIVIDUALS BELOW RECOMMENDATION FOR SELECTED MICRONUTRIENTS BY COMMUNITY[1]

	Community		Vitamin A (RAE)	Vitamin A	Vitamin D (µg)	Vitamin D	Calcium (mg)	Calcium	Magnesium (mg)	Magnesium
		n	Mean ± SD	% below EAR±SE	Mean ± SD	% below EAR±SE	Mean ± SD	% below EAR±SE	Mean ± SD	% below EAR±SE
Women	**Mistissini**	103	823±2538	50.5	5.90±6.82	83.5	607±315	82.5	235±87.9	58.3
	Wemindji	71	540±799	52.1	6.13±6.37	84.5	678±478	73.2	279±109	38.0
	Eastmain	61	669±415	36.1	7.78±6.34	68.9	768±477	70.5	307±132	40.9
	Waskaganish	55	472±368	61.8	7.62±9.21	80.0	643±328	81.8	277±99.5	40.0
	Chisasibi	95	450±324	45.3	7.65±10.5	80.0	610±345	84.2	246±97.6	55.8
	Whapmagoostui	46	670±555	37.0	14.1±23.2	54.4	689±443	76.1	256±89.5	50.0
	Waswanipi	46	593±694	54.4	4.93±4.27	84.8	676±382	87.0	282±125	37.0
	All communities	477	610±1275	46.7±3.14	7.42±10.5	88.6±26.8	657±393	78.9±5.75	264±107	46.7±14.2
Men	**Mistissini**	64	678±585	56.3	7.67±8.37	67.2	633±365	73.5	280±112	78.1
	Wemindji	58	544±426	69.0	10.6±14.1	72.4	655±349	72.4	290±122	74.1
	Eastmain	34	743±577	58.8	7.45±6.84	76.5	730±444	70.6	309±171	73.6
	Waskaganish	40	882±794	40.0	13.6±29.6	60.0	838±531	55.0	348±185	57.5
	Chisasibi	65	551±490	61.5	8.69±11.1	70.8	615±384	73.9	284±135	73.9
	Whapmagoostui	36	600±572	58.3	11.7±15.5	72.2	685±434	66.7	297±158	75.0
	Waswanipi	36	864±481	33.3	7.94±7.33	72.2	907±483	58.4	380±152	50.0
	All communities	333	673±570	51.7±3.27	9.53±14.6	68.4±4.12	703±426	72.5±4.19	306±147	69.0±7.39

	Community		Vitamin A (RAE)	Vitamin A	Vitamin D (µg)	Vitamin D	Calcium (mg)	Calcium	Magnesium (mg)	Magnesium
		n	Mean ± SD	% below EAR±SE	Mean ± SD	% below EAR±SE	Mean ± SD	% below EAR±SE	Mean ± SD	% below EAR±SE
Girls	**Mistissini**	31	469±366	51.7	3.72±3.12	100	690±506	90.3	234±102	54.8
	Wemindji	15	407±262	40.0	2.56±1.80	100	801±621	86.7	204±88.8	66.7
	Eastmain	18	348±242	65.6	3.01±3.19	100	736±452	94.4	200±86.4	71.9
	Waskaganish	18	625±376	36.3	6.28±5.58	100	845±351	100	277±131	53.8
	Chisasibi	23	292±140	47.8	3.75±2.75	100	526±201	100	218±94.1	52.2
	Whapmagoostui	24	453±406	62.5	6.53±9.04	100	633±399	91.7	219±99.8	83.3
	Waswanipi	21	622±492	42.9	5.06±3.47	100	797±439	90.5	259±98.4	52.4
	All communities	150	459±361	45.6±36.6	4.47±4.93	100.0	706±438	94.4±8.65	231±102	60.2±16.1
Boys	**Mistissini**	23	586±515	56.5	5.68±5.00	82.6	917±503	87.0	278±99.7	69.6
	Wemindji	20	671±669	60.0	4.67±3.51	100	869±664	95.0	314±285	45.0
	Eastmain	18	517±441	50.0	5.25±6.52	84.4	758±602	88.9	257±130	55.6
	Waskaganish	22	454±278	59.1	5.19±3.30	100	823±385	86.4	229±99.0	45.5
	Chisasibi	31	516±538	58.0	5.38±5.05	93.6	742±563	90.3	225±99.1	67.8
	Whapmagoostui	24	604±529	54.2	6.67±6.84	75.0	893±729	87.5	283±174	62.5
	Waswanipi	19	522±433	52.6	6.32±3.21	94.7	1055±451	89.5	331±98.8	47.4
	All communities	157	552±496	51.9±4.66	5.60±4.95	94.6±8.26	858±567	88.8±19.7	270±153	60.5±19.6

1. Age cut-offs defined by IOM are: 9-18 y for children, and greater or equal to 19 y for adults.

Micronutrient intake in children

The daily mean nutrient intakes for children are compiled in Tables A7.3.3A-D and A7.3.4A-D in relation to Dietary Reference Intakes (DRI) and, when applicable, as the percentage of individuals having intakes below the EAR values (IOM, 1997, 1998, 2000a, 2000b, 2000c, 2005, 2011).

In Waskaganish, Chisasibi, Whapmagoostui and Waswanipi, 36-66% of all boys and of girls 9-18 years took in inadequate amounts of vitamin A (IOM, 2000b). In Waskaganish, Whapmagoostui and Waswanipi, none of the girls were below the EAR for folate (IOM, 1998), and the percentage below the EAR was low in Chisasibi (7-13%). In boys, only those aged 9-13 years in Waswanipi were above the EAR with the percent below ranging from 8-25% in the other communities. For boys aged 14-18 years of age, the percentages below the EAR varied from 6-20%. In the 9-13 year-old group, all individuals met their vitamin C requirements in Waskaganish, Chisasibi, Whapmagoostui and Waswanipi (IOM, 2000c). For older girls and boys 14-18 years of age, in some communities, the risks of inadequacies were higher (from 0-41%). Iron intakes were adequate in 100% of individuals aged 9-13 (IOM, 2000b). By contrast, for girls aged 14-18, the prevalence of inadequacy ranged from 7-28%. Magnesium intakes were lower than desired in 45-83% of boys and girls in Waskaganish, Chisasibi, Whapmagoostui and Waswanipi (IOM, 1997). All girls and 75-100% of boys were below the EAR for vitamin D, while for calcium intake it was below the EAR in 86-100% of both boys and girls (IOM, 2011).

There were no differences in vitamin A, folate, vitamin D and calcium intake in estimates for children in the seven communities studied. A difference for vitamin C intake was only observed for girls, with Waskaganish exhibiting higher intakes compared to Wemindji in pairwise comparisons.

4.2 Food Intake Analyses *(Louise Johnson-Down, Megan Beggs and Grace Egeland)*

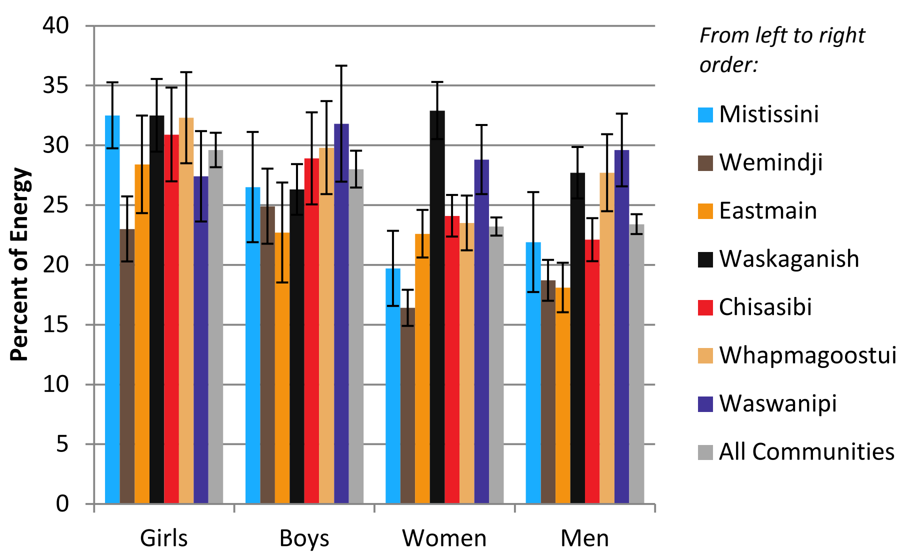
4.2.1 Canada's Food Guide, high-sugar and high-fat foods

The dietary habits in the communities were compared to those recommended in *Eating Well with Canada's Food Guide – First Nations, Inuit and Metis* (Health Canada, 2007) (Tables A7.4.1A-D). All daily servings of vegetables, fruits and milk products were below the recommendations. This further enhances the suggested inadequacies in vitamin D, calcium and magnesium intakes mentioned above.

Energy from foods not found in Canada's Food Guide was compared between communities (see Figure 4.2.1), and generally involved items that could be eliminated from the diet with little impact on the intake of vitamins and minerals while reducing caloric intake. No differences were found between communities for children but there were some for adults.

Based on the 24-hour recall, we also examined the proportion of individuals consuming high-sugar foods or foods with greater than 25% energy as sugar (see Figures A7.4.1A-D) and the percent of total energy intake that these foods provided (Figures A7.4.2A-D). (Note that nutrient-rich foods, which naturally contain high levels of sugar, were excluded from the list, such as fruits and vegetables.) For the last four communities surveyed, more than 95% (and 100% for children; Waskaganish), 90% (Chisasibi), 87% (Whapmagoostui) and 95% (Waswanipi) of the total population tested consumed high-sugar foods based on the 24-hour recall. Sweet drinks were consumed by 50% or more individuals in Waskaganish, 40% or more in Chisasibi and Waswanipi, and ≥30% in Whapmagoostui. The consumption of sweet drinks was even higher for children: 78% (girls) and 95% (boys) in Waskaganish; 80% of boys and girls in Chisasibi and Whapmagoostui; and 76% (girls) and 89% (boys) in Waswanipi. Such drinks represented 13-20% or more of the daily energy intake for the men, women, and children who consumed them (Figure A7.4.2A-D). On average adults who consumed them drank the equivalent of 1.3-3.2 cans/day, whereas for youth it was 2.1-3.7 cans/day (see Figure 4.2.2). It is evident from this figure that there were no differences in the consumption of high-sugar drinks by children between communities, but this was not so for women and men. In pairwise comparisons, men in Waskaganish had higher intakes than in Wemindji, while Waswanipi and Waskaganish ranked higher than Whapmagoostui and Wemindji for women (Table 4.2.1).

FIGURE 4.2.1 PERCENT ENERGY (± STANDARD ERROR) FROM FOODS NOT REFLECTED IN CANADA'S FOOD GUIDE ON THE 24-HOUR RECALL[1,2]



1. These foods include all fats such as oils, butter and margarine, candy, cakes, cookies and sugar-sweetened drinks.

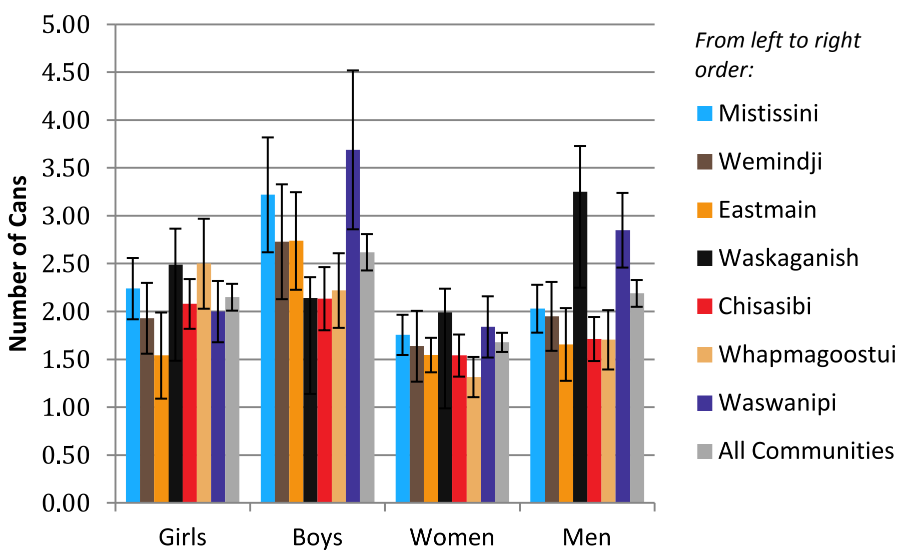
2. Age cut-offs defined by IOM are: 9-18 y for children, and greater or equal to 19 y for adults.

TABLE 4.2.1 COMMUNITY COMPARISONS OF PERCENT ENERGY FROM FOODS NOT REFLECTED IN ON CANADA'S FOOD GUIDE ON THE 24-HOUR RECALL[1]

Community	Girls 9-18 y	Boys 9-18 y	Women ≥19 y	Men ≥19 y
Mistissini	A	A	CD	AB
Wemindji	A	A	D	B
Eastmain	A	A	BC	AB
Waskaganish	A	A	A	A
Chisasibi	A	A	BC	AB
Whapmagoostui	A	A	BC	AB
Waswanipi	A	A	AB	A

1. Communities with the same letter are not significantly different on ANOVA pairwise comparisons of ranks. The letter "A" represents the highest ranking of intake.

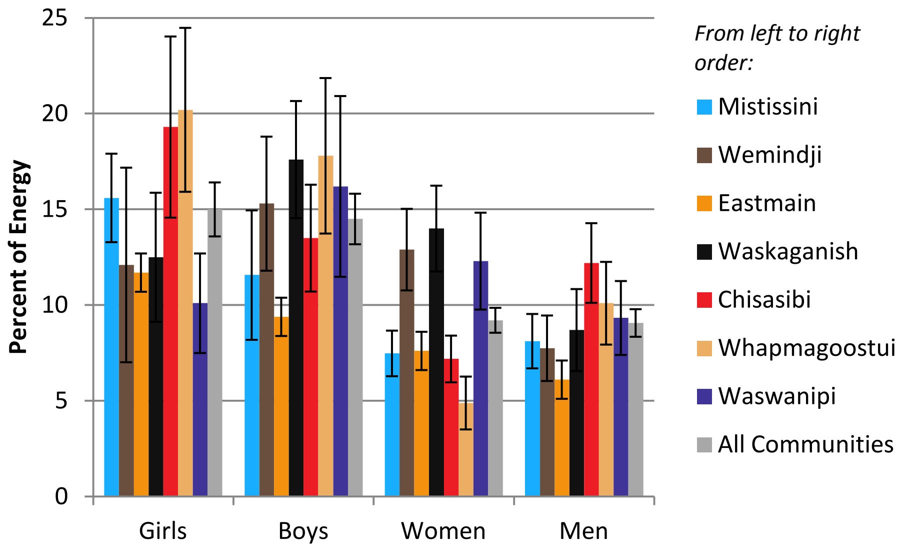
FIGURE 4.2.2 NUMBER OF CANS (± STANDARD ERROR) OF HIGH-SUGAR DRINKS (INCLUDING SOFT DRINKS) IN CONSUMERS[1]



1. Age cut-offs defined by IOM are: 9-18 y for children, and greater or equal to 19 y for adults.

In Figures A7.4.3A-D the proportion of individuals consuming high-fat foods (defined as fast, snack and baked foods with >40% of the energy as total fat) is depicted, and the percent of total energy that these foods represented (based on the 24-hour recalls) is summarised in Figures A7.4.4A-D (see also Figure 4.2.3). For girls and boys in the communities of Waskaganish, Chisasibi, Whapmagoostui and Waswanipi, percent energy from these foods ranged from 17-30% and in adults from 15-24%. A closer examination of Figure 4.2.3 involving Chi-square analyses indicated no differences in the percent of energy reported as high-fat foods within each group shown. Pairwise comparisons ranked the women in Waskaganish higher than the women in Mistissini, Eastmain, Chisasibi and Whapmagoostui.

FIGURE 4.2.3 PERCENTAGE OF ENERGY (± STANDARD ERROR) FROM HIGH-FAT FOODS[1,2]



1. High-fat foods are foods with >40% energy as fat (excluding bread, pasta, eggs, ice cream, meat, fish, milk products, main dishes, nuts, soups and traditional foods).

2. Age cut-offs defined by IOM are: 9-18 y for children, and greater or equal to 19 y for adults.

4.2.2 Vitamin D status assessment (Louise Johnson-Down and Grace Egeland)

Serum 25(OH)D (25-Hydroxy vitamin D) is considered the best indicator of vitamin D status; it reflects both cutaneous production and dietary exposure. Based on IOM guidelines (IOM, 2011), the results for this vitamin indicated that for *Eeyou* summer-time vitamin D status a total of 45% of individuals in the communities studied were at risk of inadequacy (i.e. inadequate levels) of serum 25(OH)D; differences between communities were evident (see Tables 4.2.2 and 4.2.3). Since the blood samples were drawn in late spring or early summer, there may have been some sunlight enhancement of endogenous production of vitamin D. During the winter months, fat from traditional food, milk, cheese, and yogurt can provide vitamin D. These results indicate a need for supplementation for almost half the population even when conditions for subcutaneous production of vitamin D were optimal. The results would likely show a greater prevalence of inadequacy if the survey had been conducted in the winter months.

The percentage of individuals with inadequate serum levels was 15% in Waskaganish, 5.4% in Chisasibi, 9.3% in Whapmagoostui and 2.9% in Waswanipi (Table 4.2.3); while 57% (Waskaganish), 42% (Chisasibi), 34% (Whapmagoostui) and 25% (Waswanipi) were considered at risk of *inadequacy*.

TABLE 4.2.2 SERUM 25(OH)D BY COMMUNITY

Community	Women/Girls 15-50 y		Women >50 y		Men/Boys 15-50 y		Men >50 y		p-value[2]
	n	Serum 25(OH)D±SD (nmol/L)	n	Serum 25(OH)D±SD (nmol/L)[1]	n	Serum 25(OH)D±SD (nmol/L)	n	Serum 25(OH)D±SD (nmol/L)[1]	
Mistissini	87	45.9±11.7	23	61.4±14.2**	63	55.4±12.0	15	51.9±9.93	**
Wemindji	61	47.8±14.6	15	61.6±16.8**	47	56.1±15.5	18	64.6±16.4	**
Eastmain	63	52.1±16.4	7	71.6±14.9*	33	59.6±19.7	9	66.3±15.2	
Waskaganish	53	38.0±10.4	10	51.9±6.76**	41	47.6±13.4	6	48.7±10.4	**
Chisasibi	83	47.1±14.8	20	74.3±19.7**	62	54.5±16.4	19	68.5±12.5**	*
Whapmagoostui	48	46.0±16.1	13	97.9±24.1**	39	52.2±17.5	8	73.1±15.4**	
Waswanipi	38	58.9±20.0	17	64.5±19.9	34	60.9±18.2	14	71.7±14.2*	
All communities	433	47.5±15.5	105	68.7±21.4**	319	54.9±16.2	89	64.3±15.4**	**

1. Intra-gender by age group T-test: * p < 0.05, ** p < 0.01

2. Inter-gender (both age groups) T-test: * p < 0.05, ** p < 0.01

TABLE 4.2.3 MEASURES OF VITAMIN D SUFFICIENCY USING CUT-OFFS OF SERUM 25(OH)D BY COMMUNITY, DURING THE SPRING AND SUMMER MONTHS

Community	Serum 25(OH)D				p-value[1]
	Inadequate (<30 nmol/L) n (%)	At risk of inadequacy (30-50 nmol/L) n (%)	Sufficient (50-75 nmol/L) n (%)	More than sufficient (>75 nmol/L) n (%)	
Mistissini	5 (2.66)	77 (41.0)	96 (51.1)	10 (5.32)	<0.01
Wemindji	7 (4.96)	55 (39.0)	65 (46.1)	14 (9.93)	<0.01
Eastmain	3 (2.68)	41 (36.6)	53 (47.3)	15 (13.4)	<0.01
Waskaganish	16 (14.6)	63 (57.3)	30 (27.3)	1 (0.91)	<0.01
Chisasibi	10 (5.43)	77 (41.9)	64 (34.8)	33 (17.9)	<0.01
Whapmagoostui	10 (9.26)	37 (34.3)	40 (37.0)	21 (19.4)	<0.01
Waswanipi	3 (2.91)	26 (25.2)	48 (46.6)	26 (25.2)	<0.01
All communities	54 (5.71)	376 (39.8)	396 (41.9)	120 (12.7)	<0.01

1. Chi-square analyses

With reference to Table 4.2.2, it is interesting to note that in Mistissini, Wemindji, Eastmain and Waskaganish the 25(OH)D serum concentrations in men did not differ by age. In Waswanipi, there was no difference between older and younger women; in Mistissini, Wemindji, Waskaganish and Chisasibi, men had higher levels than women and this was also true of all communities combined.

In pairwise comparisons between communities (Table 4.2.2), the women 15-50 in Waswanipi had higher serum vitamin D than in all other communities; in Eastmain, Wemindji, Chisasibi, Whapmagoostui and Mistissini, they were of comparable magnitude. By comparison, women 51 and older in Whapmagoostui had the highest serum vitamin D, with Chisasibi and Eastmain exceeding those in Waskaganish. In men 15-50, the Waswanipi and Eastmain concentrations were higher than in Waskaganish, while those in Mistissini and Waskaganish were the lowest.

Additional details about the Vitamin D findings and further interpretative analysis, including assessments of the prevalence and risk factors of vitamin D insufficiency, are provided in a separate report (Riverin et al., 2013).

4.2.3 Omega-3 fatty acids and trans fats in blood as they relate to traditional and market food intake

Among the women in Waskaganish, long-chain *n*-3 fatty acids [EPA plus DHA, expressed as a percent of total fatty acids in erythrocyte (red blood cell) membranes] were highly associated with the consumption frequency of fish and weakly related to traditional food consumption (averaged over the entire past year) (see Table A7.4.2A). Interestingly, for men in Waskaganish no such associations were observed.

In Chisasibi women, *n-3* fatty acids were most highly associated with the past-year total traditional food and fish consumption with weaker relationships to reports of spring consumption (Table A7.4.2B). Again, the correlations for men were less robust. For Chisasibi children, only spring consumption of fish was weakly related to these fatty acids. By contrast, for women in Whapmagoostui (Table A7.4.2C), there were no or only weak correlations; in men, there were strong associations for past-year total traditional food and fish consumption, and summer consumption of total traditional foods. In adolescents, the long chain *n-3* fatty acids were strongly related to past year and summer reports of traditional food and fish intake.

In Waswanipi (see Table A7.4.2D), good correlations to past-year and summer consumption of both fish and total intake of traditional foods occurred for women. In men, only total traditional food intake showed a relationship for both the past year and summer. In adolescents, fish consumption (past year) and summer fish and traditional food consumption were highly correlated to the erythrocyte levels of the long-chain n-3 fatty acids (EPA plus DHA).

Younger individuals in all communities consistently had lower levels of the long chain *n-3* fatty acids in their erythrocyte membranes (see Table 4.2.4). In Chisasibi, men had the highest values followed by women and then children. Based on correlations between the concentrations of the long chain fatty acids EPA and DHA, it is concluded that women were better able to report (qualitatively speaking) their traditional food intake compared to men and children (Table 4.2.5).

Correlations between total n-3 and trans-fatty acid concentrations showed weak associations in Chisasibi and Whapmagoostui, but none in Waskaganish and Waswanipi (see Table A7.4.3). Comparing these fatty acids with intakes of high-sugar drinks and high-fat foods (based on the market food frequency questionnaire) indicated overall weak, but significant relationships, for the last four communities surveyed. Analyses combining dietary data for all individuals in all seven communities yielded no relationship between total n-3 and trans-fatty acid levels. Correlating these fatty acids with high-sugar drinks and high-fat foods for all communities revealed an overall weak, but significant, relationship (Table 4.2.6).

TABLE 4.2.4 RELATIVE CONCENTRATIONS OF EPA+DHA (% BY WET WEIGHT OF TOTAL FATTY ACIDS) IN ERYTHROCYTE MEMBRANES BY COMMUNITY[1]

Community	Children 9-18 y		Women ≥19 y		Men ≥19 y	
	n	% EPA+DHA±SD	n	% EPA+DHA±SD	n	% EPA+DHA±SD
Mistissini	60	3.15±0.70[a]	103	4.24±1.22[b]	64	4.02±1.01[b]
Wemindji	35	3.04±0.47[a]	72	3.92±1.06[b]	58	4.03±1.19[b]
Eastmain	36	3.15±0.49[a]	61	4.10±1.11[b]	34	3.81±1.13[b]
Waskaganish	38	3.01±0.77[a]	54	3.87±1.33[b]	40	3.86±1.97[b]
Chisasibi	55	3.15±0.53[a]	95	4.05±1.13[b]	64	4.56±1.51[c]
Whapmagoostui	51	3.25±0.64[a]	44	4.82±1.40[b]	36	4.40±1.40[b]
Waswanipi	41	3.09±0.39[a]	47	3.78±0.78[b]	37	3.76±0.93[b]
All communities	316	3.13±0.59[a]	476	4.10±1.18[b]	333	4.10±1.35[b]

1. Superscripts with different letters were significantly different on pairwise comparisons in ANOVA ($p < 0.05$)

TABLE 4.2.5 PEARSON CORRELATION COEFFICIENTS (*R*) BETWEEN TRADITIONAL FOOD CONSUMPTION AND OMEGA-3 (*N*-3 AS EPA AND DHA) FATTY ACIDS AS % OF TOTAL FATTY ACIDS IN ERYTHROCYTE MEMBRANE PHOSPHOLIPIDS FOR ALL SEVEN COMMUNITIES[1]

Average Daily Frequency	Past year traditional food consump.	Past year fish consump.	Spring traditional food consump.	Spring fish consump.	Summer traditional food consump.	Summer fish consump.
Adult Men ≥19 y (n = 333)	0.22^{***}	0.22^{***}	0.19^{***}	0.20^{***}	0.19^{***}	0.19^{***}
Adult Women ≥19 y (n = 476)	0.37^{***}	0.37^{***}	0.27^{***}	0.20^{***}	0.39^{***}	0.36^{***}
Children 9-18 y (n = 316)	0.16^{***}	0.20^{***}	0.10^{*}	0.08	0.10^{*}	0.15^{***}
All (n = 1125)	0.28^{***}	0.27^{***}	0.22^{***}	0.21^{***}	0.27^{***}	0.29^{***}

1. Significance:* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

TABLE 4.2.6 PEARSON CORRELATION COEFFICIENTS (R) OF TOTAL N-3 AND TRANS-FATTY ACIDS AND HIGH-SUGAR AND HIGH-FAT FOODS FOR ALL SEVEN COMMUNITIES[1]

	Total n-3 and trans-fatty acids[2]	Trans-fat and high-fat foods[3]	Total n-3 and high-sugar drinks	Total n-3 and high-fat foods[3]
Adult men ≥19 y (n = 332)	-0.03	-0.04	-0.14**	-0.08
Adult women ≥19 y (n = 479)	-0.01	-0.05	-0.19***	-0.13***
Children 9-18 y (n = 309)	0.14*	-0.05	-0.02	-0.01
All (n = 1120)	0.00	-0.04	-0.22***	-0.16***

1. Significance: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

2. Measured in erythrocyte membranes

3. Assessed from market food frequency questionnaire

4.2.4 Discussion

The dietary data provide valuable background information on the dietary habits and nutritional status of the communities and give a context to evaluate and manage benefits and risks pertaining to dietary habits and traditional food consumption. The intakes are sufficient for animal foods that are good sources of iron and zinc, but low intake of fruits and vegetables point to low magnesium, folate, and fibre intake. We suspect that the estimated vitamin C intake may be derived in part from fortified beverages. Low intake of milk products led to low calcium and vitamin D intakes as these are the main sources of these nutrients. Given the importance of magnesium in protecting against cardiovascular risk (Del Gobbo et al., 2012) and its likely role in preventing type-2 diabetes (Champagne, 2008), future community consultations need to emphasize the many aspects of nutrition and promote the many benefits of healthy diets.

Analyses of food and energy intake highlight that interventions targeting the consumption of soft drinks and other sugared drinks as well as snack foods, fast foods and baked goods would reduce the caloric intake without reducing the intake of important nutrients. All of these foods constitute an optional part of a total diet, and in the current study represent as much as 40-50% of the energy intake of consumers participating in the health study. If intake of these food items were underestimated, as indicated by the energy intake/basal metabolic rate ($EI:BMR_{est}$) ratios of less than 1.5, there is even more cause for concern. The finding of high-sugar drink consumption is particularly worrying and worthy of discussion with community members. Each can of high-sugar drink (carbonated beverage, or sweetened drink) provide approximately 155 kilocalories. Provided that all other dietary intake represents that needed to maintain one's weight, the daily addition of one can of pop drink per day to one's diet predicts a 16-pound weight gain over a one-year period. Simple changes like replacing a can of pop with water over a lifetime could result in a remarkable improvement in achieving a healthy body weight and in promoting overall health and well-being.

In children, we have found an excessive consumption of high-sugar and high-fat foods, but low fruit and vegetable intake in combination with low traditional food consumption. This leads to the concern that low quality foods may be replacing more nutrient-rich foods (Bou Khalil et al., 2010). Traditional food is nutrient-rich and it consistently leads to higher intakes of important nutrients such as protein, vitamin D and iron (Johnson-Down et al., 2013). Low consumption of traditional food seems to be a trend for younger individuals.

4.3 Physical Activity *(Louise Johnson-Down and Grace Egeland)*

4.3.1 Findings

A total of 89 adult participants (≥18 years) in Waskaganish provided valid (usable) physical activity questionnaire information (IPAQ, 2005a,b). Their mean age was 35.3±12.2 years, and 57.3% of the individuals were women. In Chisasibi, the number of adult participants was 146 with a mean age of 40.4±15.7 and 61% were women; in Whapmagoostui, 78 participants (mean age of 39.4±16.0 and 60.3% were females); and in Waswanipi, 83 (mean age of 40.9±16.8 and 55.4% being women).

In Mistissini the results indicated that dedicated walkers (defined as individuals with greater than 1 hour per day for at least 6 days a week) enjoyed the health benefits of their physical activity and that, in general, such activity improved the health status in *Eeyouch* (Egeland et al., 2008). Because of the relatively low participation rate in some communities, statistical power could not be achieved for other single communities; only the combined results for all the *Eeyou Istchee* communities are thus explored.

Significant inverse correlations were observed between the IPAQ total metabolic equivalent (MET) score and % body fat ($r = -0.08$, $p < 0.05$) and waist circumference ($r = -0.08$, $p < 0.05$). The IPAQ vigorous MET score and % body fat exhibited the strongest correlation ($r = -0.13$, $p < 0.001$) with the inverse association between the physical activity scores and % body fat being strongest among the 527 individuals with a BMI > 30 kg/m2 ($r = -0.13$, $p < 0.01$ for total MET score; $r = -0.17$, $p < 0.0001$ for vigorous MET score) (see Table 4.3.1).

When total MET scores were evaluated as quartiles and vigorous MET scores expressed as tertiles, men were more vigorously active compared to women (Chi-square for differences in proportion by tertile of vigorous activity $p < 0.0001$) (Table 4.3.1). Similar to the results of the MET scores, the total MET quartiles and vigorous MET tertiles were inversely related to % body fat in univariate analyses (Table 4.3.1). Lastly, dedicated walkers defined as individuals with greater than 1 hour per day for at least 6 days a week had a lower BMI, percent body fat and waist circumference (Table 4.3.1).

TABLE 4.3.1 MEANS ± STANDARD DEVIATIONS OF ANTRHOPOMETRIC INDICES, AGE, AND GENDER BY TOTAL MET QUARTILES AND VIGOROUS MET TERTILES IN ADULT *EEYOUCH*[1]

Activity score	Age	% Women	BMI	% Body fat	Waist circumference
		Total MET quartiles (n = 745)			
1 (n = 186)	41.8±16.3	57.5	34.3±7.01	41.0±9.66*	113±14.6
2 (n = 185)	36.1±12.6	60.5	34.5±6.87	41.0±9.30	112±16.4
3 (n = 188)	38.3±14.7	62.8	33.5±6.60	40.1±9.43	111±15.2
4 (n = 186)	38.7±15.0	58.1	33.2±6.98	39.2±9.59	110±15.5
		Vigorous MET tertiles (n = 745)			
1 (n = 257)	40.3±16.5	69.7***	34.1±7.10	41.6±9.09**	112±14.9
2 (n = 237)	36.9±13.4	58.5	34.0±6.74	40.5±9.47	112±16.3
3 (n = 251)	38.8±14.1	49.8	33.4±6.77	38.8±9.79	111±15.1
Walking					
None – Moderate (n = 508)	39.8±14.8	60.6	34.5±6.77***	41.3±9.09***	113±15.2***
6-7 days and ≥60 min/day (n = 237)	36.5±14.6	57.8	32.1±6.74	38.3±10.0	108±15.5

1. T-test, Chi-square or ANOVA: *p-value < 0.05; **p-value < 0.01; ***p-value < 0.001

In pairwise comparisons of ranks of total MET scores by gender, there were no statistical differences for men, but women in Wemindji ranked higher than women in Chisasibi, Whapmagoostui and Waswanipi. Similar comparisons for ranks of vigorous MET scores again showed no differences for men, with women in Wemindji ranking higher than all other communities. No differences were evident for moderate MET scores by community. Chi-square analyses yielded significant differences in the number of dedicated walkers reported across communities and pairwise comparisons by ANOVA showed that Waskaganish and Wemindji reported more dedicated walkers than Mistissini, Eastmain, Whapmagoostui and Chisasibi.

Preliminary pedometer data from Waskaganish, Chisasibi, Whapmagoostui and Waswanipi is presented in Table 4.3.2. The data was validated by eliminating all individuals with missing or no data, as well as removing all individuals with less than 1000 steps per day as recommended (Tudor-Locke et al. 2011a,b). Maximum numbers were divided by 100 to judge whether they were physically meaningful. Because the number of adolescents with valid pedometer data was small, only the data for adults are reported and used.

Quartiles of the pedometer steps showed a weak, but significant, relationship for walkers identified as dedicated. Quartiles of steps per day were inversely correlated with BMI ($r = -0.35$, $p < 0.0001$), waist circumference ($r = -0.26$, $p < 0.0001$), percent body fat ($r = -0.37$, $p < 0.0001$) and age ($r = -0.15$, $p < 0.01$). When analyses were stratified by sex, correlations were similar in women and men for BMI ($r = -0.37$, -0.20, $p < 0.05$), waist circumference ($r = -0.28$, -0.21, $p < 0.05$), percent body fat ($r = -0.31$, -0.22 $p < 0.05$), and age ($r = -0.16$, -0.15, $p < 0.10$). Both women and men in Waskaganish recorded more steps per day than in other communities.

TABLE 4.3.2 MEAN NUMBER OF STEPS PER DAY RECORDED ON A PEDOMETER FOR ADULTS

	Community	n	Number of steps/day ± SD	Minimum	Maximum
Women	**Waskaganish**	42	7,610±5,224	1,074	23,555
	Chisasibi	44	5,903±3,992	1,203	16,023
	Whapmagoostui	32	4,249±2,089	1,358	9,702
	Waswanipi	38	5,969±3,780	1,090	16,737
Men	**Waskaganish**	32	10,148±5,622	1,496	24,289
	Chisasibi	33	9,018±4,889	1,776	22,537
	Whapmagoostui	28	6,971±3,789	1,962	15,206
	Waswanipi	28	8,081±5,443	1,489	24,410

4.3.2 Summary of implications

The results indicate that dedicated walkers are enjoying the health benefits of their physical activity and in general it can improve health status in *Eeyouch*. The results also indicate that the IPAQ has potential as a surveillance and research tool in *Eeyou Istchee* communities. The Canadian Population Health Initiative 2004 recommendation for eliciting health benefits from physical activity is to perform more than 60 minutes of measured physical activity per day (Raine, 2004). Since the IPAQ sums all activities that occur during a week without considering specific days, it is difficult to determine the extent to which Canadian physical activity recommendations were followed in the community using the IPAQ questionnaire. Modifying the questionnaire to make it more sensitive to assessing whether Canadian guidelines are followed would be worthwhile from a public health perspective.

4.4 Smoking Status *(Louise Johnson-Down and Grace Egeland)*

TABLE 4.4.1 NUMBER OF SMOKERS AND INDIVIDUALS SMOKING IN THE HOME

	Community	n	Current smokers n (%)	Occasional smoker n (%)	Smokers with >10 cigarettes per day n (%)	Former smokers n (%)	Never smoked n (%)	Individuals with smoking in home n (%)
Women	**Oujé-Bougoumou**	63	NA	NA	NA	NA	NA	12 (19.1)
	Nemaska	28	NA	NA	NA	NA	NA	3 (10.7)
	Mistissini	152	45 (29.6)	20 (13.2)	16 (24.6)	42 (27.6)	45 (29.6)	4 (2.63)
	Wemindji	90	29 (32.2)	14 (15.6)	7 (16.3)	37 (41.1)	10 (11.1)	5 (5.56)
	Eastmain	80	34 (42.5)	7 (8.75)	8 (19.5)	26 (32.5)	13 (16.3)	20 (24.7)
	Waskaganish	72	21 (29.2)	8 (11.1)	8 (27.6)	29 (40.3)	14 (19.4)	8 (10.8)
	Chisasibi	120	52 (43.3)	19 (15.8)	15 (21.1)	28 (23.3)	21 (17.5)	15 (12.5)
	Whapmagoostui	73	33 (45.2)	8 (11.0)	10 (24.4))	18 (24.7)	14 (19.2)	6 (8.22)
	Waswanipi	69	20 (29.0)	9 (13.0)	5 (17.2)	22 (31.9)	18 (26.1)	10 (14.5)
	All communities	656	234 (35.7)	85 (13.0)	69 (21.6)	202 (30.8)	135 (20.6)	83 (11.1)
Men	**Oujé-Bougoumou**	67	NA	NA	NA	NA	NA	14 (20.9)
	Nemaska	26	NA	NA	NA	NA	NA	4 (15.4)
	Mistissini	97	23 (23.7)	12 (12.4)	13 (37.1)	27 (27.8)	35 (36.1)	4 (4.12)
	Wemindji	80	21 (26.3)	11 (13.8)	12 (37.5)	34 (42.5)	14 (17.5)	5 (6.25)
	Eastmain	53	23 (43.4)	1 (1.89)	11 (45.8)	15 (28.3)	14 (26.4)	5 (9.43)
	Waskaganish	62	19 (30.7)	8 (12.9)	12 (44.4)	18 (29.0)	17 (27.4)	10 (15.6)
	Chisasibi	99	26 (26.3)	14 (14.1)	19 (47.5)	33 (33.3)	26 (26.3)	10 (10.1)
	Whapmagoostui	58	26 (44.8)	9 (15.5)	12 (34.3)	11 (19.0)	12 (20.7)	5 (8.62)
	Waswanipi	57	14 (24.6)	7 (12.3)	11 (52.4)	20 (35.1)	16 (28.1)	6 (10.5)
	All communities	506	152 (30.0)	62 (12.3)	90 (42.1)	158 (31.2)	134 (26.5)	63 (10.4)

For the most part, *Eeyouch* do not smoke in their homes. Over 30% of the participants reported smoking currently, with former smokers representing over 30%. Heavy smoking of more than 10 cigarettes per day was reported more frequently by men (42%) than women (22%, $p < 0.0001$).

Our assessment indicates that *Eeyouch* are aware of the damaging effects of second-hand smoke, are actively limiting smoking in their homes, and report that a sizable proportion in all communities has quit this habit.

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5. EXPOSURE TO ENVIRONMENTAL CONTAMINANTS

(Evert Nieboer, Ian Martin, Pierre Ayotte, and Suzanne Côté)

5.1 Overview

5.1.1 Context

In the previous reports in this series (Bonnier-Viger et al., 2007, 2011), the focus in terms of elements (i.e., metals and non-metals) was on the following: selected toxic metals (cadmium, mercury and lead in whole blood; also mercury in hair), the essential elements selenium (whole blood and nail) and iodine (urine), as well as organochlorine compounds (OCs) in blood plasma (namely PCBs, pesticides and similar chemicals), organobromine fire retardants, and organofluorine surfactants. Collectively, these organohalogen chemicals are referred to as persistent organic pollutants (POPs), because they reside in the environment and the human body for long periods of time (having removal or turnover times in years, and in some cases longer than a decade).

Although not reported to date, but quantified for each community, are the toxic elements arsenic (in urine and hair), cobalt and nickel in whole blood, as well as three essential elements in whole blood (copper, molybdenum and zinc). The summary statistics and findings presented in this chapter include reports on these additional elements. The primary focus is on the results for all seven communities in the *Nituuchischaayihtitaau Aschii* study and Oujé-Bougoumou and Nemaska when feasible. Nevertheless, throughout, some emphasis will be given to the findings for the four communities surveyed in 2008 (Waskaganish and Chisasibi) and 2009 (Whapmagoostui and Waswanipi), since for them no separate document has previously been published as was done for Oujé-Bougoumou and Nemaska (Dewailly et al., 2005), Mistissini (Bonnier-Viger et al., 2007) and Eastmain and Wemindji (Bonnier-Viger et al., 2011).

5.1.2 Data Summaries

The blood data for Waskaganish, Chisasibi, Whapmagoostui and Waswanipi are presented in Tables A8.1.1-A8.1.4 (cadmium); A8.1.5-A8.1.8 (lead); A8.1.9-A8.1.10 (mercury); A8.1.13-A8.1.14 (selenium); and in Tables A8.1.11-A8.1.12 (mercury in hair), A8.1.15 (selenium in nails) and A8.2.1-A8.2.6 (POPs). Summary statistics for all the elements and all communities are provided in Tables 5.1.1 (whole blood), 5.1.2 (hair, urine and nails), and 5.1.3 (POPs).

TABLE 5.1.1 SUMMARY STATISTICS FOR THE OBSERVED CONCENTRATIONS OF 10 ELEMENTS IN WHOLE BLOOD FOR THE *EEYOU ISTCHEE* COMMUNITIES (AGE >14 Y; BOTH SEXES)

	Community	n	Median	Geo. Mean	Mean	S.E. of Mean	Min	Max
Cadmium (nmol/L)	Mistissini	229	5.250	6.584	15.446	1.205	0.20	77.40
	Wemindji	170	5.600	5.796	10.862	0.921	0.20	64.00
	Eastmain	134	7.850	6.746	14.320	1.345	0.20	65.00
	Waskaganish	140	4.350	5.891	12.893	1.244	0.20	59.00
	Chisasibi	221	7.500	6.830	13.377	0.930	0.20	73.00
	Whapmagoostui	135	10.000	7.990	13.181	0.963	0.60	50.00
	Waswanipi	128	4.350	5.064	9.556	0.986	0.20	65.00
	Oujé-Bougoumou	190	12.005	12.946	18.902	1.163	2.67	77.39
	Nemaska	82	19.125	14.649	23.065	2.110	1.78	83.62
Mercury (nmol/L)	Mistissini	229	21.440	21.325	48.668	4.774	0.25	498.53
	Wemindji	170	11.000	10.094	32.296	4.315	0.25	410.00
	Eastmain	134	7.350	6.683	19.199	2.775	0.25	200.00
	Waskaganish	140	7.800	7.296	19.827	2.466	0.25	190.00
	Chisasibi	221	11.000	9.547	25.452	2.937	0.25	300.00
	Whapmagoostui	135	17.000	17.857	49.336	7.106	0.30	630.00
	Waswanipi	128	13.500	13.614	41.636	7.323	0.30	650.00
	Oujé-Bougoumou	190	19.941	20.657	37.721	3.506	0.70	374.89
	Nemaska	82	10.469	12.052	31.389	7.541	0.70	538.41
Lead (µmol/L)	Mistissini	229	0.082	0.091	0.126	0.008	0.02	0.68
	Wemindji	170	0.110	0.126	0.210	0.018	0.02	1.80
	Eastmain	134	0.086	0.096	0.142	0.013	0.02	0.99
	Waskaganish	140	0.120	0.124	0.183	0.015	0.02	1.00
	Chisasibi	221	0.150	0.156	0.244	0.017	0.02	1.60
	Whapmagoostui	135	0.250	0.262	0.420	0.038	0.03	2.50
	Waswanipi	128	0.050	0.060	0.082	0.007	0.02	0.46
	Oujé-Bougoumou	190	0.097	0.106	0.152	0.012	0.02	1.59
	Nemaska	82	0.082	0.094	0.137	0.016	0.02	0.77
Selenium (µmol/L)	Mistissini	229	2.030	2.143	2.183	0.031	1.39	4.94
	Wemindji	170	2.150	2.179	2.195	0.022	1.70	3.70
	Eastmain	134	2.100	2.118	2.132	0.022	1.70	3.10
	Waskaganish	140	2.000	2.036	2.046	0.018	1.50	2.80
	Chisasibi	221	2.100	2.107	2.124	0.019	1.30	4.20
	Whapmagoostui	135	2.100	2.083	2.097	0.021	1.60	2.90
	Waswanipi	128	2.200	2.258	2.295	0.040	1.80	4.90
	Oujé-Bougoumou	190	2.546	2.551	2.572	0.024	1.74	4.19
	Nemaska	82	2.292	2.271	2.296	0.038	1.36	3.34
Cobalt (nmol/L)	Wemindji	170	1.800	1.964	2.514	0.223	0.47	33.00
	Eastmain	134	3.400	3.592	3.811	0.136	2.00	15.00
	Waskaganish	140	3.150	3.303	3.615	0.154	2.00	13.00
	Chisasibi	221	4.000	4.195	4.442	0.113	2.00	13.00
	Whapmagoostui	135	4.500	4.617	4.759	0.113	3.10	12.00
	Waswanipi	128	4.600	5.002	6.715	1.761	3.70	230.00
	Oujé-Bougoumou	190	2.400	3.182	3.490	0.130	2.40	13.58
	Nemaska	82	2.400	2.835	3.039	0.163	2.40	10.18

	Community	n	Median	Geo. Mean	Mean	S.E. of Mean	Min	Max
Copper (µmol/L)	Wemindji	170	16.000	15.640	15.820	0.188	10.00	27.00
	Eastmain	134	16.000	16.150	16.360	0.236	11.00	27.00
	Waskaganish	140	14.000	14.690	14.840	0.183	10.00	25.00
	Chisasibi	221	14.000	14.290	14.400	0.120	10.00	22.00
	Whapmagoostui	135	15.000	15.520	15.670	0.192	11.00	24.00
	Waswanipi	128	15.000	15.520	15.650	0.183	12.00	24.00
	Oujé-Bougoumou	190	15.150	15.500	15.730	0.212	10.00	31.00
	Nemaska	82	15.890	16.020	16.220	0.296	9.00	27.00
Molybdenum (nmol/L)	Wemindji	170	5.600	5.791	6.182	0.195	2.40	26.00
	Eastmain	134	5.450	5.638	6.158	0.282	2.50	26.00
	Waskaganish	140	7.550	7.548	8.201	0.289	2.00	23.00
	Chisasibi	221	5.300	5.142	5.665	0.169	0.50	21.00
	Whapmagoostui	135	4.900	4.806	5.204	0.191	1.00	17.00
	Waswanipi	128	5.850	5.971	6.485	0.249	2.00	19.00
	Oujé-Bougoumou	190	18.762	18.343	18.784	0.303	10.40	37.50
	Nemaska	82	14.593	14.286	14.847	0.462	8.30	27.10
Nickel (nmol/L)	Wemindji	170	20.500	21.665	24.298	1.150	7.80	110.00
	Eastmain	134	25.000	25.102	25.590	0.544	19.00	79.00
	Waskaganish	140	23.000	19.573	21.366	0.625	3.00	37.00
	Chisasibi	221	22.000	22.642	22.968	0.272	14.00	46.00
	Whapmagoostui	135	8.000	6.938	7.704	0.265	2.50	20.00
	Waswanipi	128	7.000	6.897	8.098	0.518	2.50	49.00
	Oujé-Bougoumou	190	13.630	12.494	13.575	0.422	7.20	40.90
	Nemaska	82	7.229	8.714	9.202	0.426	7.20	30.70
Zinc (µmol/L)	Wemindji	170	96.000	94.330	95.212	0.997	65.00	130.00
	Eastmain	134	92.000	91.922	92.701	1.068	66.00	150.00
	Waskaganish	140	91.500	90.621	91.693	1.185	63.00	130.00
	Chisasibi	221	96.000	93.302	94.231	0.863	46.00	130.00
	Whapmagoostui	135	92.000	89.586	90.830	1.264	54.00	120.00
	Waswanipi	128	96.000	93.632	94.906	1.378	60.00	150.00
	Oujé-Bougoumou	190	93.282	91.476	92.539	0.993	54.66	130.90
	Nemaska	82	85.936	85.234	86.362	1.540	56.86	127.90
Magnesium (mmol/L) whole	Whapmagoostui	88	1.600	1.572	1.583	0.020	1.20	2.20
	Waswanipi	91	1.600	1.553	1.558	0.014	1.30	1.80
Magnesium (mmol/L) in RBC	Whapmagoostui	95	2.617	2.609	2.632	0.037	1.92	3.85
	Waswanipi	90	2.577	2.579	2.592	0.027	1.97	3.37

TABLE 5.1.2 SUMMARY STATISTICS FOR HAIR, URINE AND NAIL CONCENTRATIONS OF SELECTED ELEMENTS IN THE *EEYOU ISTCHEE* COMMUNITIES

Sample: metal	Community	n	Median	Geo. Mean	Mean	S.E. of Mean	Min	Max
Hair analysis: Mercury (nmol/g)	Mistissini	273	3.30	2.76	8.28	0.82	0.25	101.00
	Wemindji	188	0.97	1.28	5.07	0.80	0.25	68.58
	Eastmain	136	0.77	1.07	3.58	0.57	0.25	36.99
	Waskaganish	156	0.50	0.58	1.59	0.25	0.05	25.00
	Chisasibi	248	0.98	1.01	3.26	0.48	0.05	80.00
	Whapmagoostui	151	2.80	2.93	9.09	1.67	0.10	210.00
	Waswanipi	153	2.40	2.13	7.80	1.26	0.05	98.00
	Oujé-Bougoumou	218	4.49	4.55	9.96	0.89	0.70	69.30
	Nemaska	97	1.99	2.21	4.75	0.74	0.70	43.87
Hair analysis: Arsenic (µg/g)	Wemindji	146	0.03	0.04	0.05	0.01	0.01	0.44
	Eastmain	121	0.03	0.03	0.04	0.00	0.01	0.22
	Waskaganish	117	0.03	0.03	0.04	0.00	0.01	0.22
	Chisasibi	190	0.04	0.04	0.06	0.01	0.01	0.81
	Whapmagoostui	126	0.02	0.04	0.62	0.19	0.01	15.00
	Waswanipi	122	0.05	0.05	0.07	0.01	0.01	0.38
	Oujé-Bougoumou	180	0.05	0.05	0.11	0.01	0.01	1.48
	Nemaska	78	0.05	0.04	0.06	0.01	0.01	0.26
Nail analysis: Selenium (µg/g)	Mistissini	209	0.73	0.72	0.73	0.01	0.39	1.20
	Wemindji	158	0.75	0.75	0.76	0.01	0.48	1.10
	Eastmain	122	0.77	0.79	0.80	0.01	0.54	1.50
	Waskaganish	120	0.74	0.76	0.77	0.02	0.45	2.10
	Chisasibi	176	0.76	0.75	0.78	0.02	0.30	3.40
	Whapmagoostui	120	0.86	0.84	0.85	0.01	0.51	1.20
	Waswanipi	117	0.93	0.95	0.97	0.02	0.45	1.70
Urine analysis: Inorganic Arsenic (µmol/L)	Wemindji	171	0.05	0.06	0.08	0.01	0.05	0.47
	Eastmain	134	0.05	0.06	0.07	0.00	0.05	0.31
	Waskaganish	136	0.05	0.06	0.06	0.00	0.05	0.62
	Chisasibi	219	0.05	0.07	0.08	0.01	0.05	0.57
	Whapmagoostui	132	0.03	0.04	0.05	0.00	0.03	0.31
	Waswanipi	127	0.05	0.05	0.06	0.01	0.03	0.98
	Oujé-Bougoumou	185	0.07	0.07	0.08	0.00	0.01	0.39
	Nemaska	81	0.09	0.09	0.11	0.01	0.01	0.41
Urine analysis: Iodine (µmol/L)	Wemindji	170	0.90	0.91	1.12	0.06	0.14	3.80
	Eastmain	134	1.05	0.96	1.23	0.07	0.12	4.50
	Waskaganish	107	0.85	0.87	1.18	0.10	0.10	4.90
	Chisasibi	184	0.85	0.79	0.99	0.05	0.05	6.90
	Whapmagoostui	107	0.95	0.84	0.99	0.05	0.15	2.80
	Waswanipi	102	0.86	0.80	1.05	0.09	0.05	6.10

TABLE 5.1.3 SUMMARY STATISTICS OF THE CONCENTRATIONS OF POPS WITH DETECTION FREQUENCIES ≥70% IN THE *EEYOU ISTCHEE* COMMUNITIES (AGE >14 Y; BOTH SEXES)

POP	Community	n	Median	Geo. Mean	Mean	S.E. of Mean	Min	Max
Aroclor 1260 (µg/L)	Mistissini	189	5.19	5.57	22.24	3.26	0.14	334.88
	Wemindji	142	5.45	4.51	15.87	2.10	0.14	150.00
	Eastmain	111	2.00	1.92	6.01	1.01	0.14	67.00
	Waskaganish	109	0.59	0.76	2.08	0.48	0.14	44.00
	Chisasibi	184	3.40	3.64	12.65	1.71	0.14	180.00
	Whapmagoostui	108	4.30	4.02	12.36	1.94	0.14	120.00
	Waswanipi	103	1.70	1.89	7.40	1.16	0.14	53.00
	Oujé-Bougoumou	169	5.81	6.62	21.76	2.93	0.26	221.68
	Nemaska	71	2.71	2.78	9.88	2.38	0.14	125.56
PCB 118 (µg/L)	Mistissini	189	0.09	0.12	0.51	0.08	0.01	8.35
	Wemindji	142	0.09	0.10	0.34	0.06	0.01	4.40
	Eastmain	111	0.04	0.05	0.14	0.03	0.01	1.40
	Waskaganish	109	0.02	0.03	0.06	0.01	0.01	1.50
	Chisasibi	184	0.06	0.08	0.30	0.05	0.01	7.30
	Whapmagoostui	108	0.09	0.09	0.28	0.05	0.01	3.00
	Waswanipi	103	0.02	0.06	0.17	0.03	0.01	1.30
	Oujé-Bougoumou	169	0.13	0.16	0.63	0.11	0.01	10.06
	Nemaska	71	0.04	0.06	0.19	0.04	0.01	2.04
PCB 138 (µg/L)	Mistissini	189	0.28	0.31	1.16	0.16	0.01	15.25
	Wemindji	142	0.30	0.27	0.87	0.12	0.01	9.60
	Eastmain	111	0.11	0.12	0.37	0.06	0.01	4.20
	Waskaganish	109	0.04	0.05	0.13	0.03	0.01	2.80
	Chisasibi	183	0.20	0.21	0.74	0.10	0.01	11.00
	Whapmagoostui	108	0.28	0.24	0.73	0.11	0.01	7.00
	Waswanipi	103	0.08	0.12	0.43	0.07	0.01	3.00
	Oujé-Bougoumou	169	0.33	0.38	1.24	0.17	0.02	13.88
	Nemaska	71	0.14	0.16	0.52	0.12	0.01	6.41
PCB 153 (µg/L)	Mistissini	189	0.70	0.76	3.12	0.47	0.01	49.15
	Wemindji	142	0.78	0.63	2.26	0.30	0.01	20.00
	Eastmain	111	0.27	0.24	0.79	0.13	0.01	8.70
	Waskaganish	109	0.08	0.09	0.27	0.06	0.01	5.80
	Chisasibi	184	0.45	0.49	1.69	0.23	0.02	24.00
	Whapmagoostui	108	0.57	0.53	1.65	0.26	0.01	17.00
	Waswanipi	103	0.23	0.24	0.99	0.16	0.01	7.20
	Oujé-Bougoumou	169	0.79	0.89	2.95	0.39	0.03	28.75
	Nemaska	71	0.38	0.38	1.37	0.34	0.02	17.73
PCB 170 (µg/L)	Mistissini	189	0.14	0.16	0.68	0.11	0.01	12.87
	Wemindji	142	0.17	0.15	0.52	0.07	0.01	4.50
	Eastmain	111	0.06	0.07	0.18	0.03	0.01	2.00
	Waskaganish	109	0.02	0.03	0.07	0.02	0.01	1.40

POP	Community	n	Median	Geo. Mean	Mean	S.E. of Mean	Min	Max
	Chisasibi	184	0.11	0.12	0.40	0.06	0.01	6.20
	Whapmagoostui	108	0.15	0.14	0.46	0.07	0.01	4.20
	Waswanipi	103	0.05	0.07	0.24	0.04	0.01	1.80
	Oujé-Bougoumou	169	0.17	0.20	0.70	0.10	0.01	7.94
	Nemaska	71	0.07	0.09	0.33	0.09	0.01	4.33
PCB 180 (μg/L)	Mistissini	189	0.52	0.56	2.60	0.40	0.01	44.45
	Wemindji	142	0.56	0.51	1.99	0.27	0.01	18.00
	Eastmain	111	0.22	0.19	0.64	0.11	0.01	7.50
	Waskaganish	109	0.06	0.08	0.24	0.05	0.01	4.50
	Chisasibi	184	0.37	0.37	1.43	0.20	0.01	21.00
	Whapmagoostui	108	0.47	0.42	1.54	0.26	0.01	14.00
	Waswanipi	103	0.17	0.19	0.81	0.13	0.01	5.70
	Oujé-Bougoumou	169	0.55	0.61	2.28	0.31	0.02	25.36
	Nemaska	71	0.24	0.25	1.09	0.30	0.01	15.65
PCB 187 (μg/L)	Mistissini	189	0.19	0.21	0.89	0.14	0.01	15.15
	Wemindji	142	0.22	0.19	0.71	0.09	0.01	5.80
	Eastmain	111	0.08	0.08	0.24	0.04	0.01	2.30
	Waskaganish	109	0.02	0.04	0.09	0.02	0.01	2.00
	Chisasibi	184	0.14	0.15	0.54	0.07	0.01	7.80
	Whapmagoostui	108	0.16	0.17	0.54	0.08	0.01	4.40
	Waswanipi	103	0.06	0.09	0.32	0.05	0.01	2.20
	Oujé-Bougoumou	169	0.23	0.26	0.88	0.12	0.01	9.31
	Nemaska	71	0.11	0.11	0.41	0.10	0.01	5.24
p,p-DDE (μg/L)	Mistissini	189	0.99	1.36	3.91	0.48	0.08	35.02
	Wemindji	142	1.25	1.42	3.25	0.37	0.08	21.00
	Eastmain	111	1.10	0.98	1.92	0.24	0.08	13.00
	Waskaganish	109	0.48	0.57	1.07	0.17	0.10	14.00
	Chisasibi	184	0.89	1.14	2.64	0.33	0.10	39.00
	Whapmagoostui	108	1.15	1.11	2.43	0.38	0.08	33.00
	Waswanipi	103	0.65	0.78	1.96	0.27	0.08	15.00
	Oujé-Bougoumou	169	1.35	1.67	4.49	0.65	0.14	50.86
	Nemaska	71	0.85	0.95	1.94	0.35	0.14	20.23
PBDE 47 (μg/L)	Wemindji	142	0.03	0.03	0.06	0.01	0.02	0.52
	Eastmain	111	0.04	0.04	0.05	0.00	0.02	0.24
	Waskaganish	109	0.04	0.04	0.06	0.01	0.02	0.96
	Chisasibi	183	0.05	0.04	0.06	0.00	0.02	0.39
	Whapmagoostui	108	0.05	0.05	0.08	0.01	0.02	1.20
	Waswanipi	103	0.06	0.07	0.11	0.01	0.02	0.82

5.2 Findings and Their Interpretation

5.2.1 Lead

Figure 5.2.1 depicts the observed concentrations of lead in whole blood by age group and community (also see Tables A8.1.5 and A8.1.6). Lead levels in persons 15 years and over in Whapmagoostui are clearly higher than in any of the other communities. There is a general upward trend with age, with Chisasibi, Nemaska, Wemindji and Whapmagoostui showing higher levels for the over 40 group. Exceedances of the 0.48 µmol/L guideline are depicted in Figure 5.2.2 and Table A8.1.8 (see Appendix 6 for health effects of concern). The critical windows in this figure are those for children (<8 y and 8-14 y) and women of reproductive age (15-39 y), for whom the guideline is an action level. For the latter group, the follow-up needed was minimal in most communities although more considerably so in Whapmagoostui. For adult males and females 40 y old and over, the multiple exceedances above the guideline (it constitutes a concern level for them) serve to illustrate that there is merit in identifying lead sources and pursuing exposure reduction. Such effort, as shown in the next paragraph, would likely also curtail the exposure of children and women of reproductive age. This is important because recent studies suggest that concentrations below the 0.48 µmol/L guideline can have measurable detrimental effects for them. For this reason, some jurisdictions have (or are) considering lowering the lead guideline for women of reproductive age and children (or more specifically for pregnant women in one jurisdiction) to 0.24 µmol/L (OME, 2007; Ettinger et al., 2010; Sanders et al., 2012). Consequently, the clinical algorithm provided in Appendix 6 for managing chronic lead exposure may need to be revised. Only a few ‘other’ adults (males 15 and older, and females ≥40 years) exceeded the 1 µmol/L action level. Twelve individuals in Whapmagoostui and 3 each in Wemindji and Chisasibi exceeded this level.

A detailed statistical analysis revealed that the dependence on community of blood lead levels was important and statistically significant ($p < 0.001$); in other words, exposure to this toxic metal differed between communities. Consideration of the individual questionnaire question “Do you use lead shot?” indicated that the answer “*yes*” correlated with higher blood lead concentrations ($p < 0.001$; also see Table A8.1.7 and Section 5.2.8). An estimate of the relative risk (hunters using lead shot *versus* those who did not) of elevated blood lead (>0.5 µmol/L) was 2.9 ($p \leq 0.05$). Although the use of the gun alone can result in exposure to lead fumes (more specifically particulates; Tsuji et al., 2008a,b), it is reasonable to suspect that consumption by hunters and their families of game killed with lead shot constitutes a unique dietary source of this toxic metal. It is well established that meats from harvested animals contain lead pellets and lead pellet fragments (Tsuji et al., 1999, 2002, 2008a,b). Furthermore, abdominal X-rays of Cree residing in James Bay West Coast communities have identified the presence of lead pellets (Tsuji and Nieboer, 1997).

It is pertinent to mention that normal sources of lead for the general population include: the normal food supply (current calculated intakes are quite low); tap water, due to leaching from plumbing (generally low, but of special concern for older homes built before the 1950s; water exiting from treatment facilities generally has low lead levels); and indoor and house dust (especially homes with lead-containing paint) (Health Canada, 2011). This is borne out in a recent lead-isotope study of children in St. John's, NL, in which drinking water (~40%), dust (~30%) and soil (~30%) were most frequently the closest source media that matched the observed lead-isotope ratios seen in whole blood (Bell, 2012). Similarly in a recently conducted Montreal study of 1-5 y-old children, tap-water lead was the largest contributor to blood lead levels (BLLs), followed by paint-lead and windowsill dust loading (Nueguta and Levallois, 2012).

FIGURE 5.2.1 MEAN CONCENTRATIONS (± 95% C.I.) OF LEAD IN WHOLE BLOOD BY AGE GROUP AND COMMUNITY (AGE GROUPS ARE IN LEFT-TO-RIGHT ORDER)

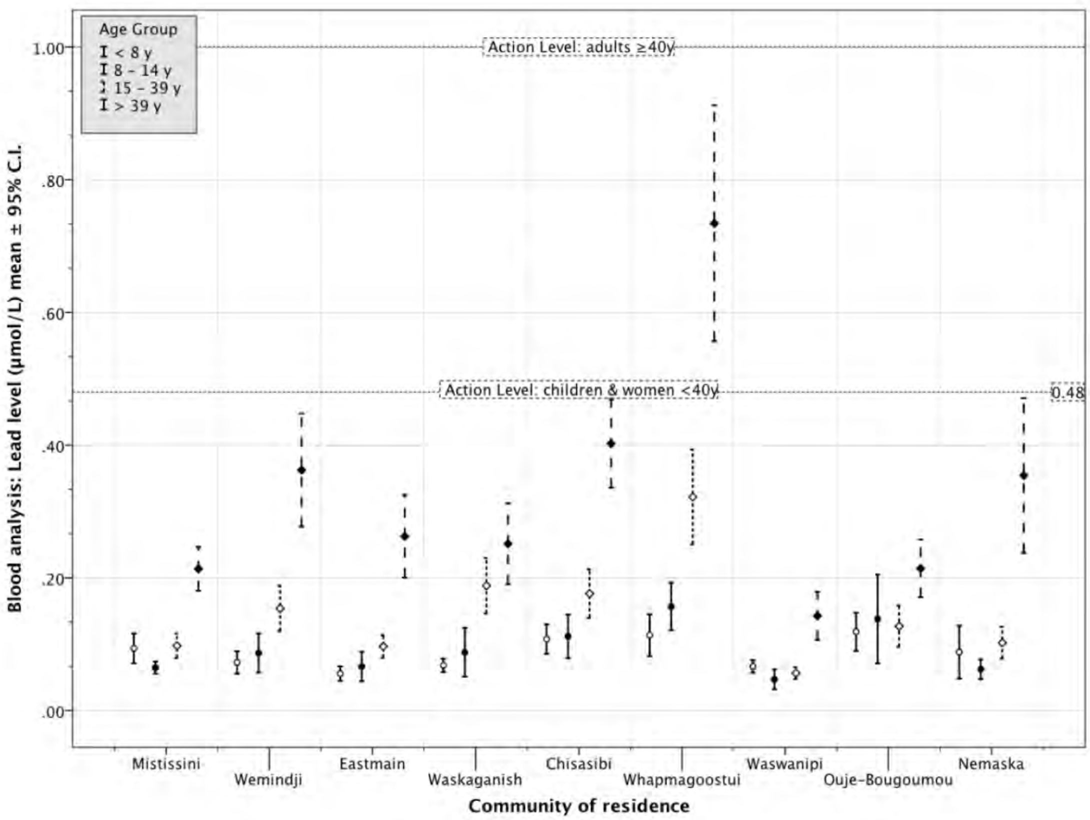
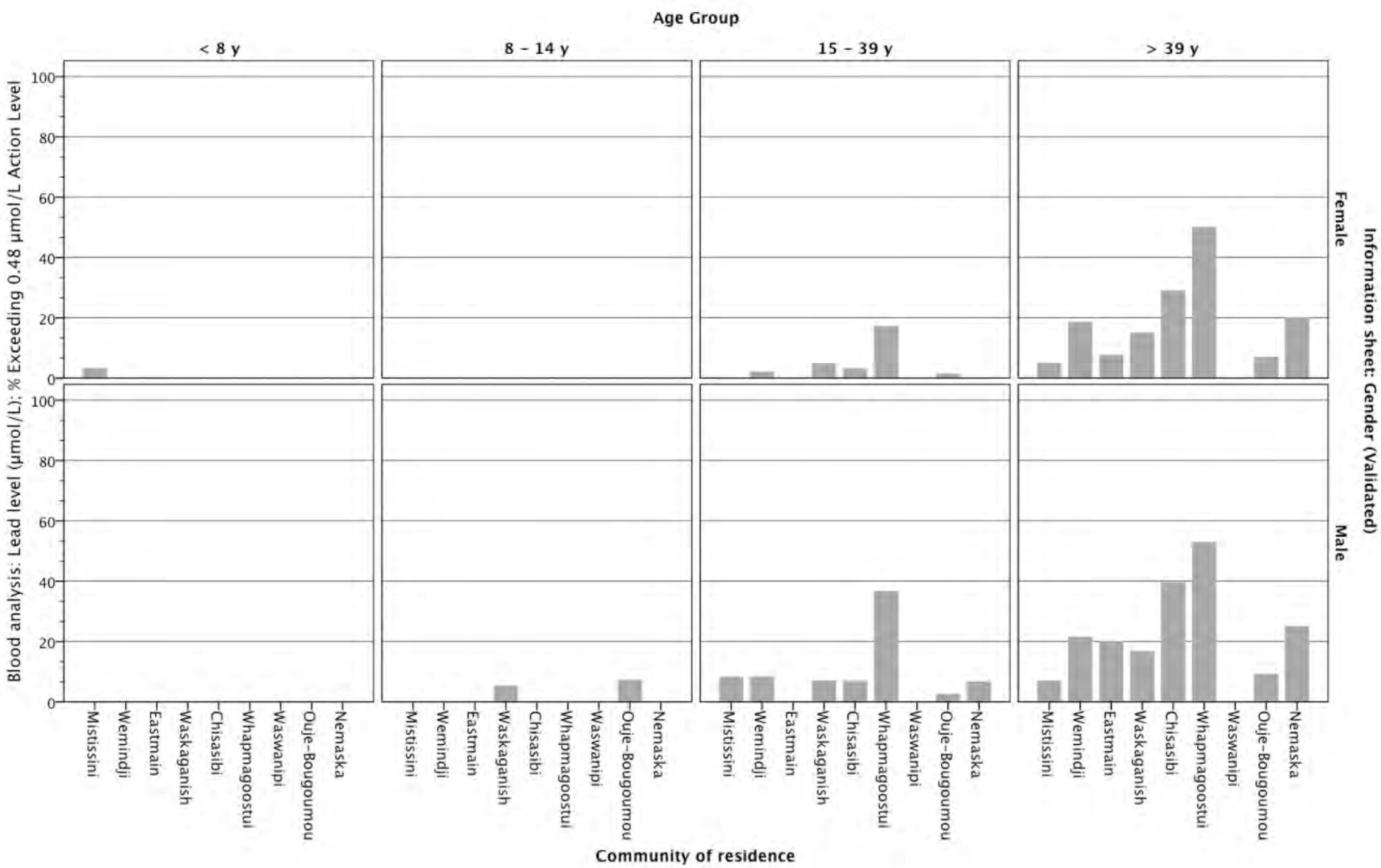


FIGURE 5.2.2 EXCEEDANCES OF WHOLE BLOOD LEAD CONCENTRATIONS ABOVE THE 0.48 µMOL/L GUIDELINE BY AGE GROUP AND COMMUNITY



5.2.2 Mercury

It is evident from the summaries in Tables A8.1.9 and 5.1.1 and Figure 5.2.3 that the observed mercury concentrations in blood varied with age, gender and community. This was confirmed statistically by an analysis of variance (ANOVA), with $r^2 = 0.29$ (adjusted, $p \leq 0.001$). A 2.6-fold difference is seen in the mean blood levels (Table 5.1.1) compared to 6-fold for hair (see Tables 5.1.2 and A8.1.11). The association between these two exposure indices was robust ($r^2 = 0.856$, $p < 0.0005$), and the hair-to-blood concentration ratio varied with age, gender and community with overall means ranging from 179 (Chisasibi) to 304 (Oujé-Bougoumou). A value of 250 is often used to convert hair concentrations to blood values or *vice versa* (e.g., Legrand et al., 2010). Because of the wide variation in this ratio between individuals, we need to examine this aspect more closely.

Blood mercury concentration is currently the preferred exposure index and we will limit our deliberations to it. Compared to the concentrations reported in the *Canadian Health Measures Survey* (CHMS): *Cycle 1, 2007 to 2009* (Statistics Canada, 2010; Wong et al., 2008), the *Nituuchischaayihtitaau Aschii* study blood mercury levels by age (all nine communities combined) are higher. The median concentrations in the two studies for the five CHMS age groups in nmol/L were: 1.4 & *4.3* (6-11 y group); 1.6 & *5.9* (12-19 y); 3.8 & *12.0* (20-39 y); 5.6 & *33.0* (40-59 y); and 4.8 & *110.1* (60-79 y), with the *Nituuchischaayihtitaau Aschii* study concentrations given in italics. The findings for the *Eeyou Istchee* communities are consistent with mercury concentrations reported for other indigenous peoples living at northern latitudes (AMAP, 2009). The clear increase with age (Figure 5.2.3) likely reflects higher consumption of traditional foods, especially fish (see Sections 5.2.8 and 5.2.9.3). In addition, there is evidence that the turnover of mercury in the human body slows down as the body burden increases, resulting in longer half-lives than the 50-70 days normally quoted (Stern, 2005; Yaginuma-Sakurai et al., 2012; Bernhoft, 2012).

Generally there is good evidence that mercury levels are decreasing in arctic biota (AMAP, 2011) and indigenous peoples living in northern regions of the world (AMAP, 2009). However there are some inconsistencies. Even though reductions in North American emissions of mercury have taken place, the levels of this toxic metal in the Canadian Arctic are not yet uniformly decreasing in all marine species (AMAP, 2011). It is difficult to compare the current findings for mercury in hair with those published previously by Dumont et al. (1998) because of improved detection limits (12.5 *versus* 0.41 nmol/g). When comparing the 1993/1994 Dumont et al. (1998) data for the nine *Eeyou Istchee* communities with our own, there has been an apparent increase in the proportion of individuals (all age groups) with low mercury hair levels (<12.5 nmol/g), and thus a shift away from higher concentrations (>12.5 nmol/g): a change in % from 71.5 to *86.9*(<12.5 nmol/g); 16.4 to *8.10* (12.6-29.5 nmol/g); 9.3 to *4.6* (29.6-74.5 nmol/g); 2.7 to *0.4* (74.6-149.5 nmol/g); and 0.1 and

0.1 (>149.5 nmol/g), with the proportions for the combined 2005-2009 *Nituuchischaayihtitaau Aschii* and the 2002 Oujé-Bougoumou and Nemaska data set in italics.

Figures 5.2.3 and 5.2.4 depict that there were exceedances of both the declarable level (also referred to as the concern level) and the action level that apply to children and women of reproductive age (see Appendix 6 for guideline and management details). This is most clearly indicated for the latter in Figure 5.2.4. It shows that only a small number of exceedances occurred for the most susceptible female population and none among children. However Health Canada, like other jurisdictions, is now recommending new blood guidelines. Specifically, 40 nmol/L for pregnant women, women of reproductive age, and children (Legrand et al., 2010; also see Appendix 6). The 100 nmol/L level of concern and the 500 nmol/L action level for 'other' adults have not been changed. Fortunately, only a few 'other' adults exceeded the 500 nmol/L, action level.

FIGURE 5.2.3 MEAN CONCENTRATIONS (± 95% C.I.) OF MERCURY IN WHOLE BLOOD BY AGE GROUP AND COMMUNITY (AGE GROUPS ARE IN LEFT-TO-RIGHT ORDER; AGE GROUP <8 Y ONLY AT WASKAGANISH)

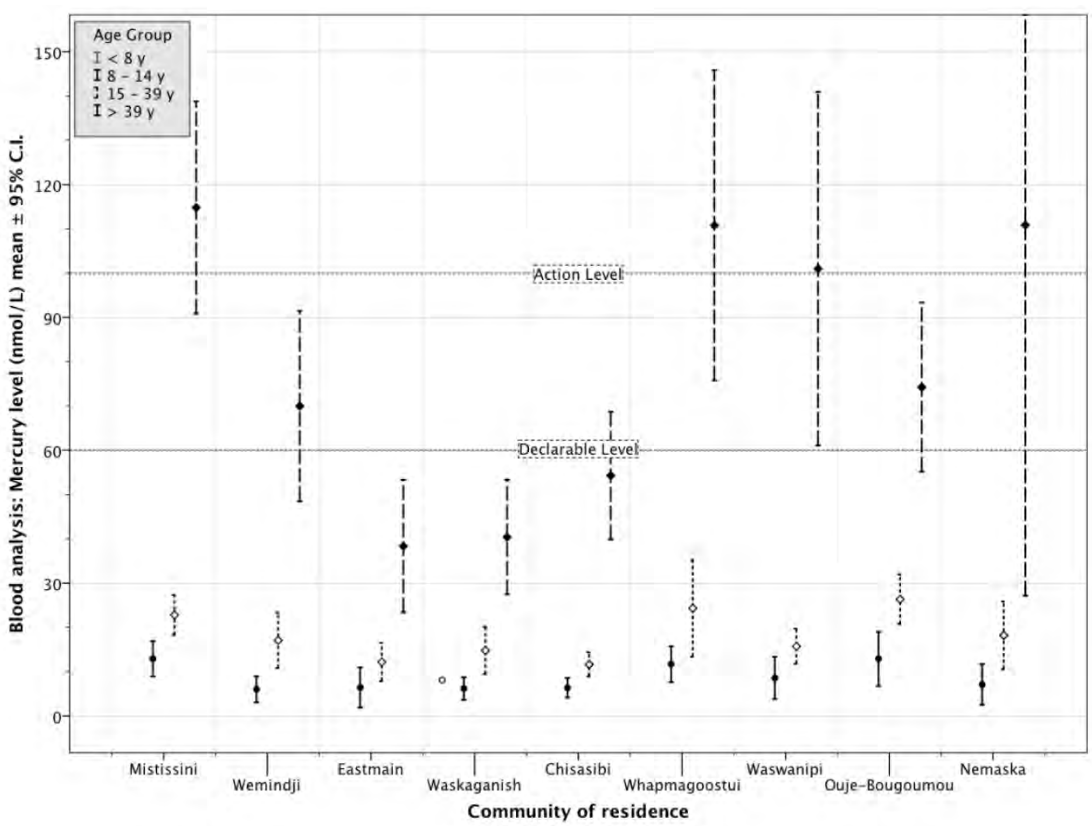
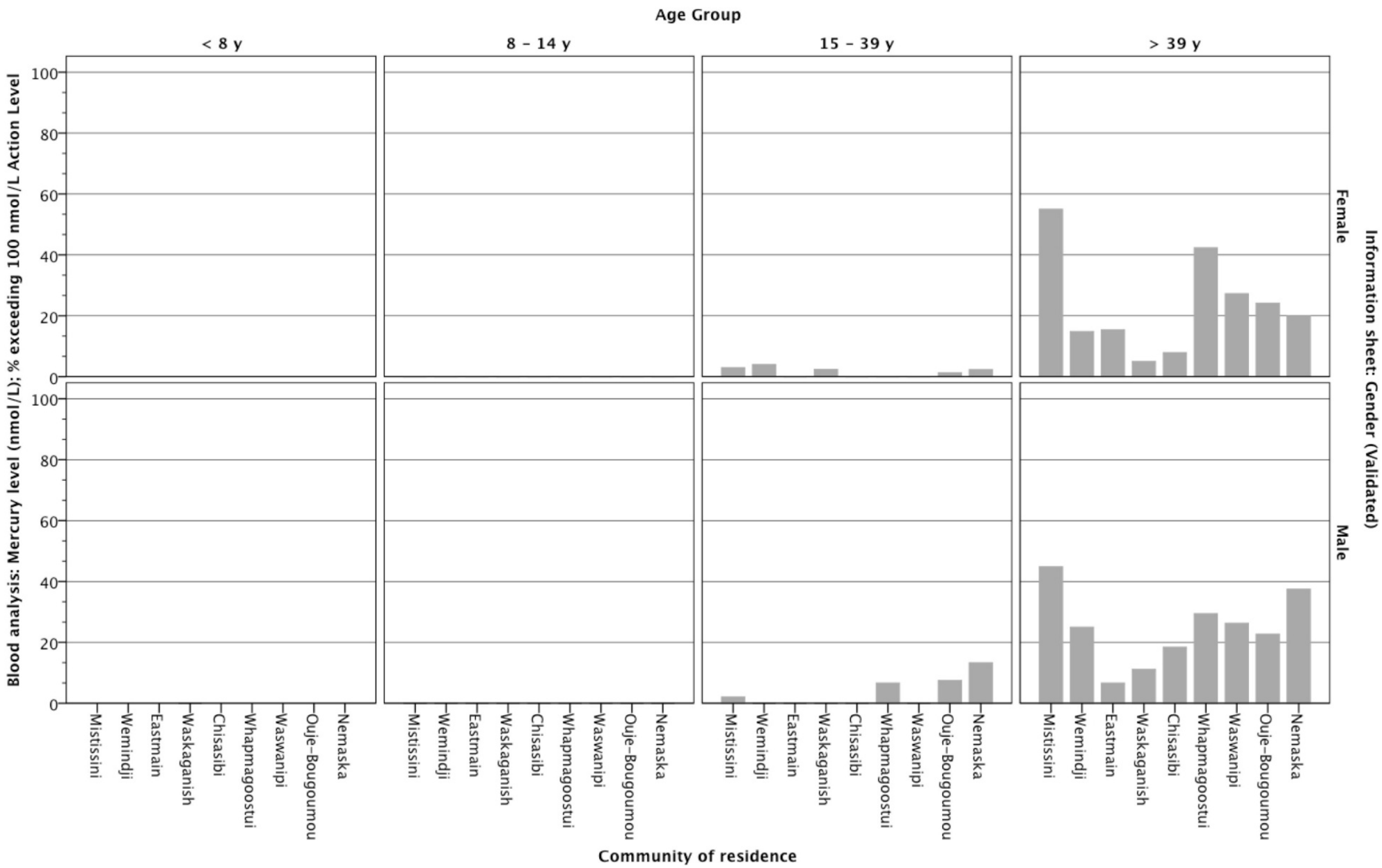


FIGURE 5.2.4 EXCEEDANCES OF WHOLE BLOOD MERCURY CONCENTRATIONS ABOVE GUIDELINES BY AGE GROUP AND COMMUNITY



5.2.3 Cadmium

The age-dependence pattern evident in Tables A8.1.1 and Figure 5.2.5 for cadmium in blood is quite different from that seen for lead and mercury, with the middle age group having the highest concentrations. Cadmium is severely toxic to the kidneys, and the 45 nmol/L in blood constitutes an occupational action level to protect against this (ACGIH, 2007). It is clear from Figure 5.2.6 that there were exceedances in all age groups and both genders, except for the <8 y-olds (also see Tables A8.1.3 and A8.1.4). The plots in Figure 5.2.7 and the data in Table A8.1.2 compare the blood cadmium concentrations for smokers and non-smokers. It is clear that smoking strongly increases blood cadmium concentration. The evidence that smoking is largely responsible is reinforced by the correspondence analysis described in Section 5.2.8. Smoking as the primary exposure source of cadmium for the general public and its impact on kidney function is well established (ATSDR, 2008; also see Appendix 6). As noted in the Nieboer et al. (2011, p.102), dietary sources of exposure to cadmium such as the consumption of internal organs (e.g., kidneys and liver) appear not to be associated with blood cadmium in these two communities. This conclusion is also supported by the lack of correlation between blood cadmium and traditional food consumption in the correspondence analysis described in Section 5.2.8.

FIGURE 5.2.5 MEAN CONCENTRATIONS (± 95% C.I.) OF CADMIUM IN WHOLE BLOOD BY AGE GROUP AND COMMUNITY (AGE GROUPS ARE IN LEFT-TO-RIGHT ORDER; AGE GROUP <8 Y ONLY AT WASKAGANISH)

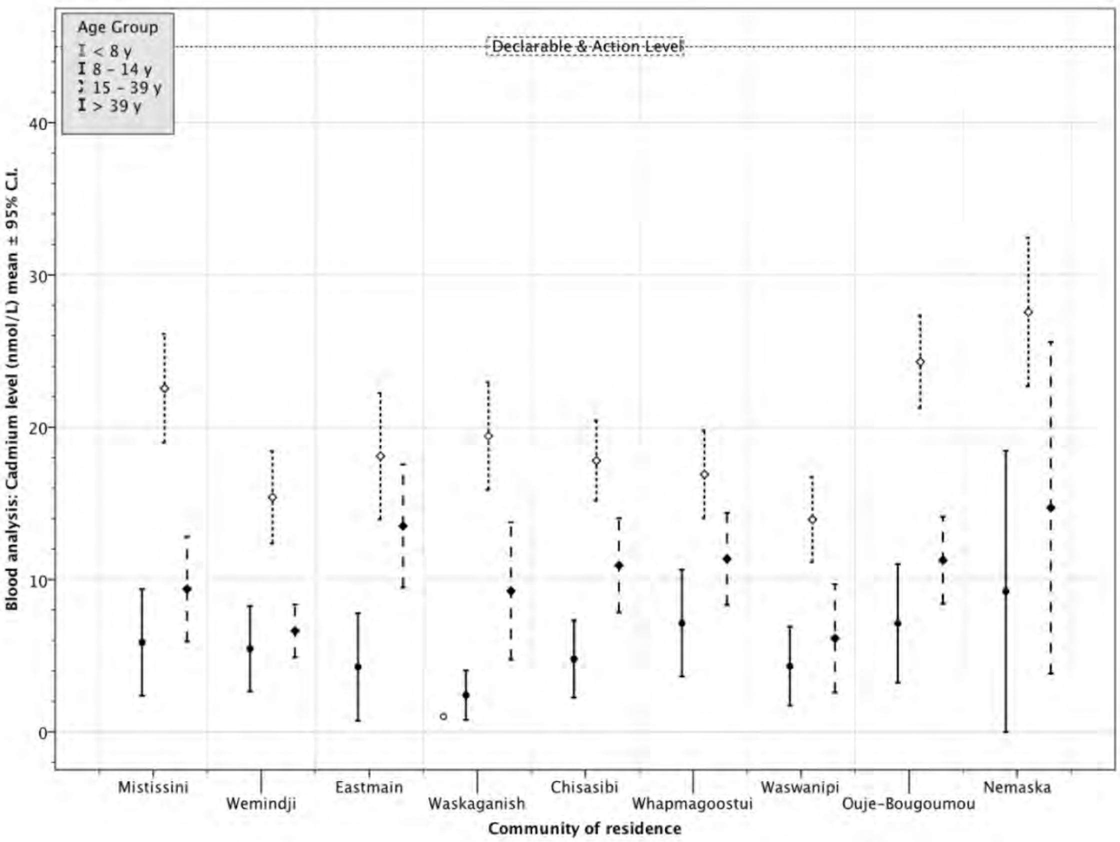


FIGURE 5.2.6 EXCEEDANCES OF WHOLE BLOOD CADMIUM CONCENTRATIONS ABOVE THE 45 NMOL/L DECLARABLE AND ACTION LEVEL BY AGE GROUP AND COMMUNITY

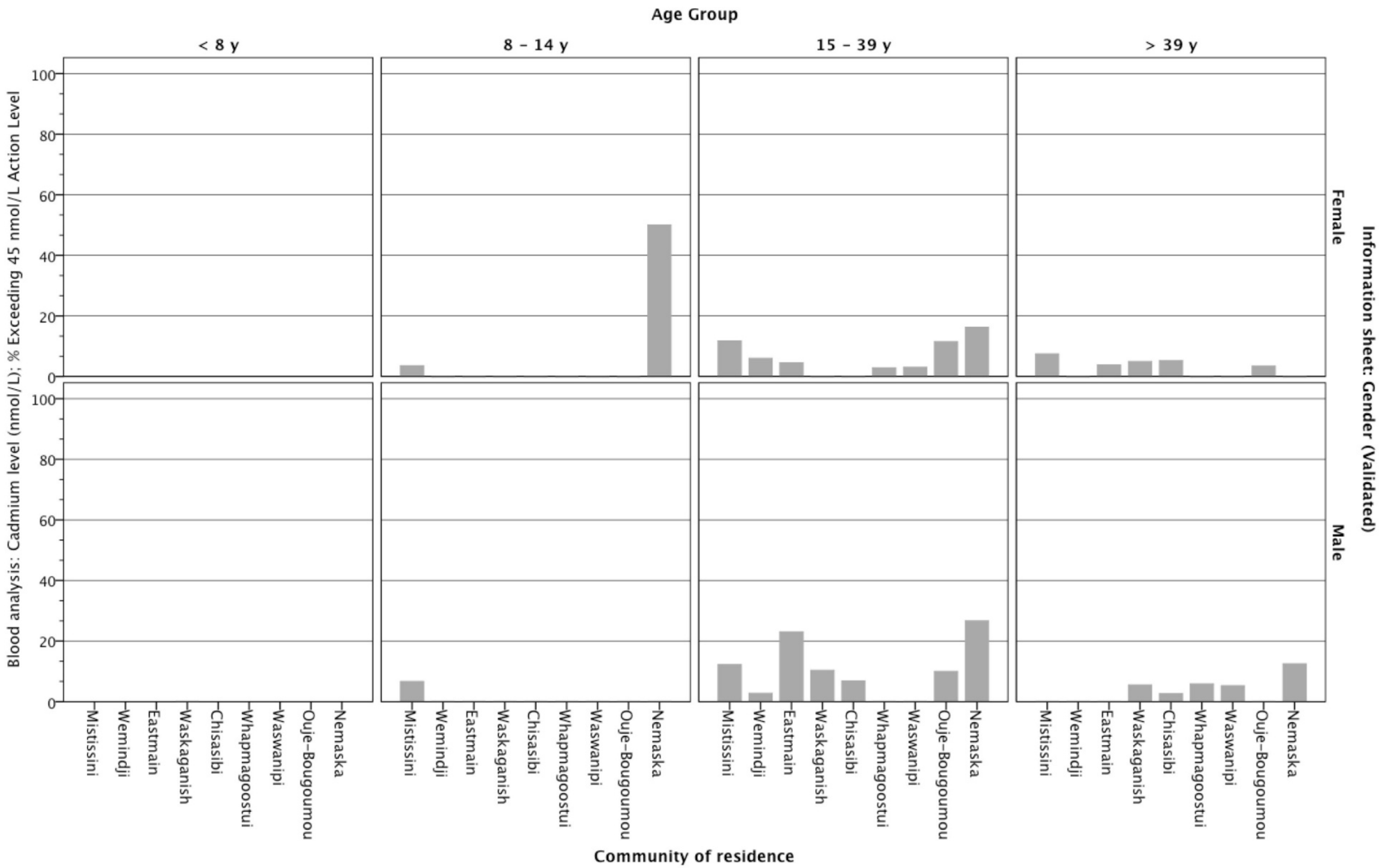
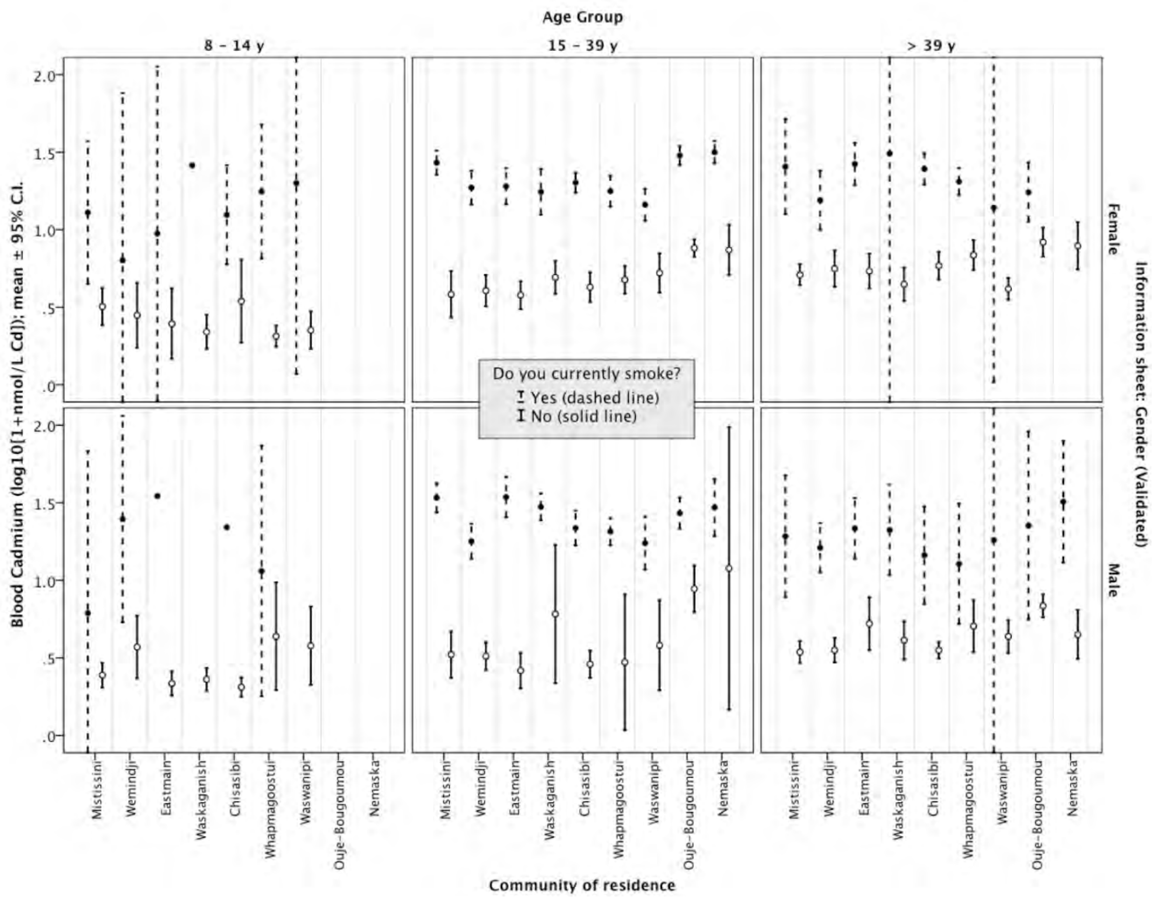


FIGURE 5.2.7 COMPARISON OF WHOLE BLOOD CADMIUM CONCENTRATIONS FOR SMOKERS AND NON-SMOKERS BY AGE GROUP AND COMMUNITY (NON-SMOKERS: OPEN SYMBOLS; SMOKERS: CLOSED SYMBOLS)

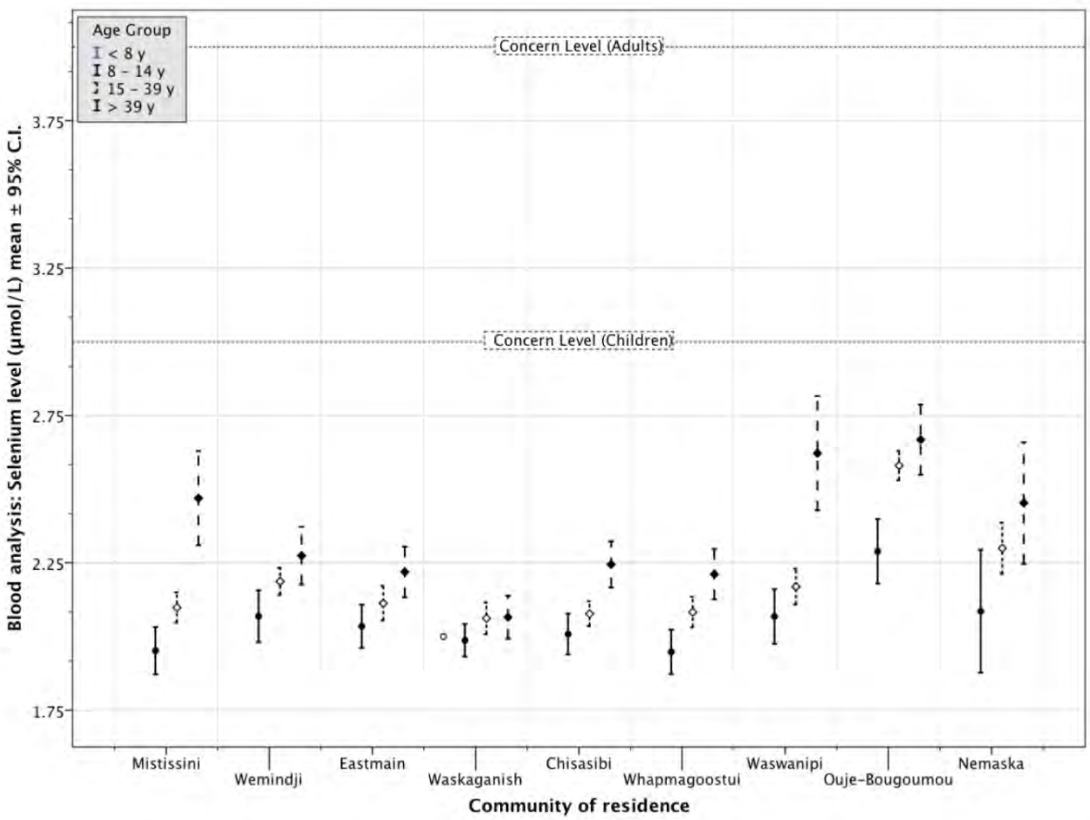


5.2.4 Selenium

Selenium is an important essential element. It is involved in protein and enzyme biochemical processes that are crucial to proper immune and thyroid function, and protection against oxidation (Shenkin et al., 2006; Fairweather-Tait et al., 2011). It also seems to be protective by mitigating the toxicity of mercury (Berry and Ralston, 2008). Wheat, cereal products, and especially fish constitute good sources of selenium (Brantsaeter et al., 2010). Selenium toxicity in humans is rare, and concentrations up to levels reaching 8.5 µmol/L were not associated with any clinical symptoms in a previous study conducted in people living in selenium rich (seleniferous) areas (Longnecker et al., 1991). In the current study, the maximum concentration observed was 4.94 µmol/L (see Tables 5.1.1 and Figure 5.2.8; also Tables A8.1.13 and A8.1.14), only 6 adults exceeded the 4 µmol/L level of concern (data not shown) and no children were above their level of concern of 3 µmol/L. This indicates that selenium exposure is not an issue of concern; neither is selenium dietary deficiency. The 4 µmol/L corresponds to the upper limit of selenium concentration observed in the southern Québec population (4 µmol/L) and to the U.S. level of concern, while the

3 µmol/L concern level for children was derived from a childhood poisoning incident with the chemical selenious acid (see Bonnier-Viger et al., 2011 for details). In general, selenium levels were higher than those observed in the southern Québec population (LeBlanc et al., 2004 a), as can be expected for a fish-eating population. Selenium was also measured in nails. The latter was significantly correlated ($p = 0.020$) with the whole blood levels, but the overall Pearson correlation was low ($r = 0.073$), indicating only a weak association in the 1014 individuals for whom both measurements were available.

FIGURE 5.2.8 MEAN CONCENTRATIONS (± 95% C.I.) OF SELENIUM IN WHOLE BLOOD BY AGE GROUP AND COMMUNITY (AGE GROUPS ARE IN LEFT-TO-RIGHT ORDER; AGE GROUP <8 Y ONLY AT WASKAGANISH)



5.2.5 Arsenic

Inorganic arsenic, rather than *total arsenic*, was measured in urine because total arsenic contains forms of this element that are not toxic. It is evident from published concentrations that the summary data in Table 5.1.2 for arsenic in urine and hair are mostly what is expected. For example, in the U.S. population Survey of 2003-2004, the urinary mean and 95th percentile was 0.245 (0.21-0.31) µmol/L (Caldwell et al., 2009). Similar concentrations were reported in the 2003 survey of the greater Québec City area (LeBlanc et al., 2004a). We took the 95th percentile of 0.30 µmol/L observed in this survey as the *level of concern*; in this INSPQ study (LeBlanc et al., 2004a,b), the mean + 3 standard deviations was 0.4 μmol/L and thus lower than the *Laboratory Reporting Threshold* in the Province of Québec of 0.5 μmol/L. The latter constitutes the American Conference of Government Industrial Hygienist (ACGIH) *Biological Exposure Index (BEI)* (ACGIH, 2001), and serves as a suitable action level since it was formulated to protect workers against the carcinogenic effects of arsenic (see Appendix 6 for more detail). Considering all nine communities, one person was at this action level, and two were just above it.

The medium hair arsenic concentrations observed in eight communities ranged from 0.031-0.051 μg/g (see Table 5.12), and are of comparable magnitude as the reference concentrations proposed by Goullé et al. (2005), namely a median of 0.05 μg/g and 5^{th}-90^{th} percentile of 0.05-0.08 μg/g. It is well established that interpretation of hair arsenic concentrations is complicated by an inability to distinguish that excreted from the blood into hair and that due to external contamination (reviewed in Nieboer, 2002). This is illustrated by comparing the mean hair and urine arsenic levels for Whapmagoostui. For this community the mean hair value was the highest (0.62 μg/g) for the 8 communities surveyed (mostly due to a few extreme outliers), but its mean urine concentration was the lowest (0.050/L). Not surprisingly, there was no evidence for a relationship between urine and hair arsenic concentrations (Pearson $r = -0.05$, $p > 0.05$; all 8 communities). An obvious external source is pressure-treated wood (PTW) which historically contained arsenic, which is known to leach from it (Lew et al., 2010). Exposure to arsenic as a result of contact with PTW structures has been established based on analysis of hand washings of children playing on PTW structures compared to those who did not (Lew et al., 2010). These authors presented data that demonstrates that contact with PTW playground structures "is not likely to significantly contribute to the overall arsenic exposure in children", and that "other sources such as dietary arsenic may be a main contributor to their overall exposure". The urinary and hair data in Table 5.1.2 support this conclusion. Close scrutiny of homes in Whapmagoostui confirms the past use of PTW in the construction of homes (external siding; outside stairs, decks and railings). It is important to avoid burning PTW as arsenic fumes are given off and these can be inhaled.

5.2.6 Cobalt and nickel

Cobalt and nickel are important metals and diet provides the primary source (Barceloux, 1999a,b). Of these, nickel is most common, as it is an important component of stainless steel (chromium being the other). Contact with stainless steel appliances and resulting intake by hand-to-mouth activity seems a plausible source of nickel, and nickel can also be present in drinking water when taps are not flushed (nickel is a common component of faucets). Neither metal has essential functions in humans, although diet-derived vitamin B12 which contains cobalt is an essential molecule. Relative to cadmium, lead and mercury, cobalt and nickel have rather low toxicities and do not pose a health threat to the general population other than a capability of inducing contact dermatitis. Skin contact with jewelry is the most common cause in case of nickel. Additional details are provided in the short toxicological profiles provided in Appendix 6.

Proposed reference concentrations for nickel in whole blood are 36 nmol/L (median) and 5-70 nmol/L (range) (Goullé et al., 2005). In the Québec City area survey, serum nickel in the general population was determined to be <100 nmol/L, with 250 nmol/L being the laboratory reporting threshold concentration (LeBlanc et al., 2004a,b). [As a first approximation, serum (or plasma) concentrations are comparable to those in whole blood (Goullé et al., 2005; also see Appendix 6)].Thus the nickel levels are consistent with previously reported background values.

It is evident from the data in Table 5.1.1 that whole blood concentrations of cobalt are considerably lower than nickel. Concentrations of 4.3 nmol/L (median) and 0.7-11 nmol/L (range) (Goullé et al., 2005); in the Québec City area survey, normal concentrations were designated to be <10 nmol/L, with 17 nmol/L the laboratory declarable level (LeBlanc et al., 2004a,b; Sanfaçon et al., 2004). Like for nickel, the observed blood cobalt concentrations in the *Nituuchischaayihtitaau Aschii* study constitute normal background exposure.

5.2.7 Other essential elements (copper, iodine, magnesium, molybdenum and zinc)

These elements are referred to as essential because they are required for good health (Shenkin et al., 2006). Copper has many important biochemical functions and is present in many enzymes/proteins that are involved in the use of molecular oxygen and thus in the generation of energy for living (i.e., electron transfer); it is also a crucial component of enzymes that have antioxidant functions. Its blood level is very tightly regulated (see below), and diet is the primary intake source. Although copper toxicity is rare, there are congenital disorders that involve either copper deficiency or its systematic accumulation in multi-body tissues resulting in dysfunction of multiple body processes. Copper is usually measured in plasma or serum, and normal ranges for this medium are reported in clinical chemistry textbooks (e.g., Roberts et al., 2006). A comparison of the current data (a narrow mean concentration range of 14.4-16.4 µmol/L considering both children >14 y and adults) to these reference ranges indicates that the blood copper concentrations are comparable in magnitude to serum levels. In the present study and as expected, female participants were found to have 13.0% higher blood copper concentrations than males (considering all ages). Although there are few publications reporting copper in whole blood, the data summarized in Table 5.1.1 are in good agreement with published values (Minoia et al., 1990; Seifert et al., 2000; Hansen et al., 2011).

Zinc, like copper, is a crucial element for good health and has minimal toxicity when in excess. It is present in numerous enzymes that play significant roles in gene expression, basic biochemical processes involved in digestion, immunity, growth and healing, among others. Like copper, zinc is usually measured in serum or plasma. It appears that the blood levels are more than five times higher than serum levels. The concentrations reported in Table 5.1.1 are consistent with values reported by others (Minoia et al., 1990; Rollin et al., 2009; Hansen et al., 2011).

Magnesium is an essential metal that is crucial to many biochemical processes, especially those involved with the generation, storage and use of energy in our bodies. The observed concentrations in red blood cells are in the normal range, and those in whole blood are consistent with it and the expected plasma concentrations (Enders and Rude, 2006).

Molybdenum deficiency has not been well documented in healthy individuals, and it too has relatively low toxicity. It plays an important role as a co-factor in a number of complex enzymes and thus body chemistry. The observed concentrations (Table 5.1.1) appear to be in line with those reported by Goullé et al. (2005) and others (e.g., Rudge et al., 2011; Hansen et al., 2011).

Iodine intake is essential for proper thyroid function. The World Health Organization uses iodine in urine as a measure of its intake status for an individual and populations. Urinary iodine median concentrations in the range 0.78-1.57 µmol/L are designated as "adequate intake" (WHO, 2007). Based on the observed median levels of 0.85-1.05 µmol/L summarized in Table 5.1.2 for the six communities for which this clinical chemistry indicator was measured, iodine intake appears satisfactory. A more detailed analysis of these data in the context of thyroid function is presented in Chapter 6 (Section 6.8).

5.2.8 Correspondence analysis of elemental concentration data

To supplement standard regression analysis (single or multivariate) methods, a helpful way of dealing with multiple variables is to use factor analysis techniques such as principal component analysis (PCA) and correspondence analysis (CA). They involve mathematical approaches in which the number of variables (e.g., frequency of specific food items consumed, blood concentrations of multiple contaminants, or lifestyle factors) are reduced to fewer independent variables, referred to as "factors" or "axes" (see Sections 2.5 and 4.1.2.3). This approach reduces an original large set of inter-related variables into a smaller uncorrelated set that captures much of the variation in the original variables.

Table 5.2.1 features four axes resulting from examination by correspondence analysis (CA) of the blood elemental data. Together they explain nearly 90% of the variation in the original 9 metals variables. The plot in Figure 5.2.9 of CA-2 versus CA-1 illustrates the placement of individual participants' CA-1 and CA-2 values of three age groups (>7 y) into a two-dimensional space. Clearly, the coordinates for the essential elements copper, molybdenum, selenium and zinc, as well as for cobalt and nickel, cluster together in matrix space having similar scores (indicated by the placement of chemical symbols for these elements); in matrix space, cadmium is quite different from all the other elements, while those for lead and mercury are spatially closer to each other than to the others. This suggests that cadmium, lead and mercury have quite distinct features (likely exposure sources) from the other elements placed closer to the origin of the plot. The greatest relative blood contamination of cadmium occurs in the 15-39 y age group for both males and females, as is indicated by the dominance of this age group in the upper right quadrant close to the coordinates for cadmium (+ symbol, Figure 5.2.9). By contrast, the oldest age group (>39 y) have coordinate scores concentrated in the upper left quadrants of the plots for either sex (solid symbol), indicating that lead and mercury are the dominant metal contaminants for this age group, whilst children (8-14 y) have coordinate scores most often in the bottom right quadrants of the plots for both sexes (signifying low levels of contamination from mercury, lead, and cadmium, when compared to concentrations of essential elements; open symbol).

The data for an ANOVA analysis of the effect of hunting and smoking on the observed elemental concentrations are summarized in Table 5.2.2. Based on the relative magnitudes of the F-ratio and corresponding p-values, it is evident that the concentration of lead in blood is more influenced by hunting than is the concentration of cadmium. Clearly, hunting as a source of lead is confirmed by the strong negative loading of CA-1 (see Table 5.2.1) and this too is corroborated by the results of the ANOVA (Table 5.2.2). The context and evidence for the association between hunting and blood lead was documented in Section 5.2.1. Since most hunters also fish and consume fish, the concomitant strong negative loading of CA-1 for blood mercury makes sense (see Section 5.2.2). It is also clear from Table 5.2.2 that smoking contributes more strongly to blood cadmium concentration than does hunting activity, and considerably less so to blood lead. The CA-2 axis is also most strongly associated with this activity. As indicated in Section 5.2.3, smoking is well established as the primary cadmium exposure source for the general public (including second hand smoke). There is also good support in the literature that smoking constitutes a limited source of lead (Health Canada, 2011).

Partial correlations (controlled for age) are summarized in Table 5.2.3 between the metal CA axes and selected traditional food items, as well as with the dietary principal component axes (PC-1 to PC-6) introduced in Section 4.1.2.3. Negative CA-1 scores in Table 5.2.3 are correlated with negative scores for the consumption of traditional foods and of the traditional food axis PC-1, and thus correlate with lead and mercury (have negative loadings on CA-1). As indicated above, CA-2 which has a positive cadmium loading is strongly influenced by smoking. Since many smokers also consume alcohol, the positive correlation for PC-5 in Table 5.2.3 makes sense. Market vegetable and salad consumption is negatively associated with lower lead, cadmium, and cobalt (i.e., lower CA-2 and CA-4 values to which these 3 elements contribute positively).

TABLE 5.2.1 CORRESPONDENCE ANALYSIS (CA) OF 9 ELEMENTS IN WHOLE BLOOD SAMPLES FROM PARTICIPANTS >7 Y (ALL COMMUNITIES)[a]

Metal, as log10 (1+nmol/L)	**CA-1** (42.8%)	**CA-2** (28.1%)	**CA-3** (10.8%)	**CA-4** (7.8%)
Cadmium (Cd)	**0.1849**	**0.3714**	0.0015	-0.0173
Mercury (Hg)	**-0.4203**	0.0698	-0.0338	-0.0212
Lead (Pb)	**-0.4663**	**0.2166**	**0.5550**	**0.1214**
Selenium (Se)	0.0204	-0.0502	-0.0142	0.0119
Cobalt (Co)	0.0612	-0.0594	0.0464	**0.1987**
Copper (Cu)	0.0457	-0.0699	0.0045	0.0267
Molybdenum (Mo)	0.0591	-0.0561	**-0.1860**	-0.0137
Nickel (Ni)	0.0838	**-0.1127**	0.0941	**-0.1290**
Zinc (Zn)	0.0375	-0.0604	0.0140	0.0158

a. The percentages indicated for the four CA axes correspond to the explained variability, and the scores in bold-face type indicate those with a high relative score on a given CA axis.

TABLE 5.2.2 TWO-WAY ANOVA OF EFFECT OF HUNTING AND SMOKING ON WHOLE BLOOD CONCENTRATIONS OF ELEMENTS FOR PARTICIPANTS >14 Y (ALL COMMUNITIES)

Source	Dependent Variable[a]	Type III SS	df	Mean Square	F-ratio	p-value[b]
Do you hunt? (Y/N)	CA-1 (42.8%)	1.4040	1.980	1.4040	58.4935	**<u>0.000000</u>**
	CA-2 (28.1%)	0.0360	1.980	0.0355	4.2099	**0.040455**
	CA-3 (10.8%)	0.0760	1.980	0.0763	9.3460	**<u>0.002295</u>**
	CA-4 (7.8%)	0.0190	1.980	0.0195	3.5688	0.059171
	Cadmium	0.3640	1.980	0.3636	5.2683	**0.021927**
	Lead	0.1860	1.980	0.1856	32.8530	**<u>0.000000</u>**
Do you currently smoke? (Y/N)	CA-1 (42.8%)	6.0500	1.980	6.0497	252.0516	**<u>0.000000</u>**
	CA-2 (28.1%)	7.3330	1.980	7.3332	869.1323	**<u>0.000000</u>**
	CA-3 (10.8%)	0.0200	1.980	0.0202	2.4723	0.116195
	CA-4 (7.8%)	0.0000	1.980	0.0003	0.0501	0.822984
	Cadmium	99.7080	1.980	99.7083	1444.8351	**<u>0.000000</u>**
	Lead	0.0300	1.980	0.0302	5.3439	**0.021002**
Smoke x hunt interaction	CA-1 (42.8%)	0.0260	1.980	0.0261	1.0854	0.297760
	CA-2 (28.1%)	0.0150	1.980	0.0147	1.7459	0.186696
	CA-3 (10.8%)	0.0000	1.980	0.0003	0.0327	0.856485
	CA-4 (7.8%)	0.0150	1.980	0.0151	2.7733	0.096166
	Cadmium	0.2640	1.980	0.2639	3.8239	0.050809
	Lead	0.0000	1.980	0.0004	0.0720	0.788512

a. Scores from CA of 9 elements; element concentrations log10(x+1) transformed

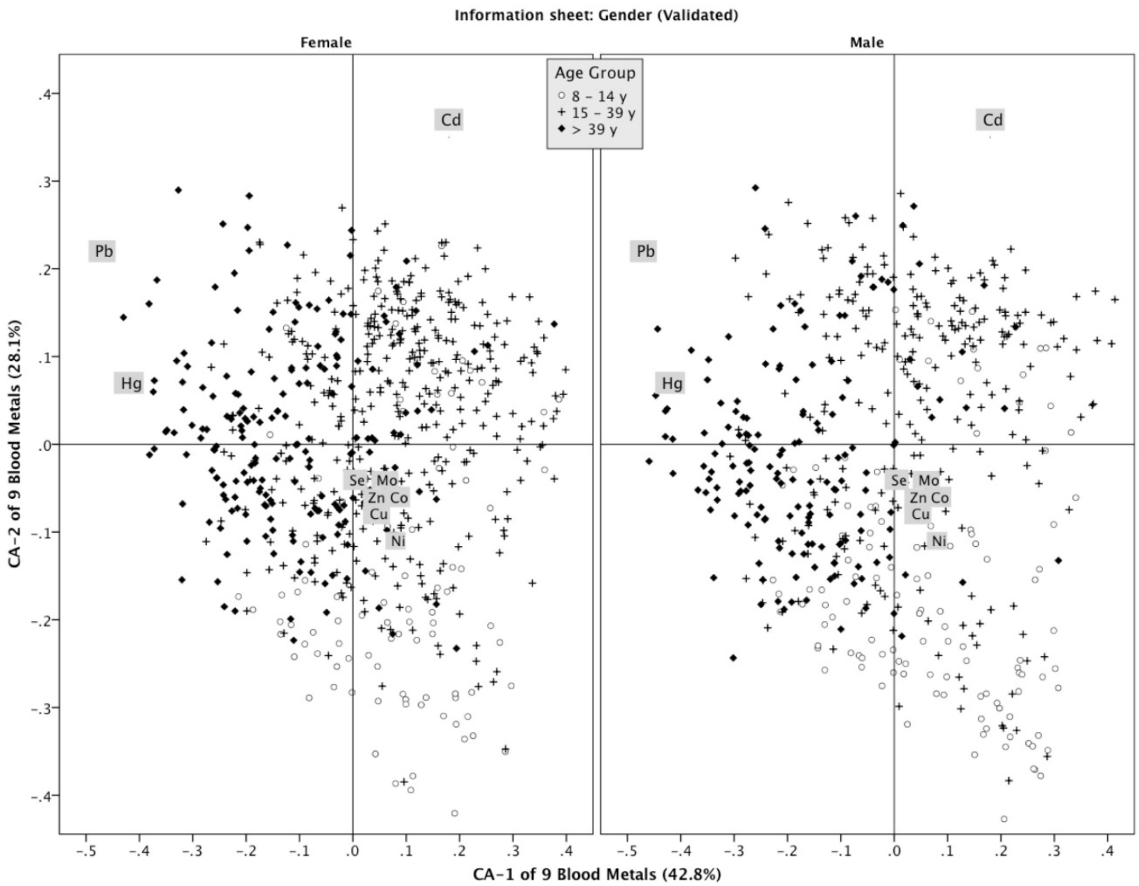
b. Bold entries, $p < 0.05$; bold underscore entries, $p < 0.01$

TABLE 5.2.3 PARTIAL CORRELATIONS[a] (CONTROLLING FOR AGE) BETWEEN SIMPLE DIETARY FREQUENCY SUMS, DIETARY FREQUENCY PC VARIABLES, AND MEASURES OF ELEMENTS IN WHOLE BLOOD (ALL COMMUNITIES)

			Mean Daily Frequency over Year for:					PCA of Dietary Frequency Data:					
CA of 9 Blood Metals	**Positive Scoring**	**Negative Scoring**	**Mammal Meats**	**Fish**	**Birds**	**Organ Meats (mammal, bird)**	**Wild Berries, jam**	**PC-1 (9.8%) (+ trad. foods)**	**PC-2 (4.7%) (+ snacks , deep fried)**	**PC-3 (3.5%) (+ veget-ables)**	**PC-4 (3.4%) (+ moose meat)**	**PC-5 (2.9%) (+ alcohol, lard)**	**PC-6 (2.8%) (- bear meat)**
CA-1 (42.8%)	(+ Cd)	(- Pb, Hg)	-	-	-	-	ø	-	ø	ø	ø	ø	-
CA-2 (28.1%)	(+ Cd, Pb)	(- Ni)	ø	ø	ø	ø	ø	ø	ø	-	ø	+	+
CA-3 (10.8%)	(+ Pb)	(- Mo)	ø	+	+	+	ø	ø	-	ø	-	+	ø
CA-4 (7.8%)	(+ Co, Pb)	(- Ni)	+	ø	+	ø	+	ø	ø	-	+	ø	ø

a. Correlations are flagged as significant positive (+), significant negative (-), or non-significant (ø); $p < 0.05$

FIGURE 5.2.9 PLOT OF CORRESPONDENCE VARIABLES CA-1 VERSUS CA-2 SCORES FOR FEMALES AND MALES IN 3 AGE GROUPS, AND CONCENTRATIONS OF SELECTED ELEMENTS IN WHOLE BLOOD (CD, CADMIUM; CO, COBALT; CU, COPPER; HG, MERCURY; PB, LEAD; MO, MOLYBDENUM; NI, NICKEL; SE, SELENIUM; ZN, ZINC)



5.2.9 Persistent organic pollutants (POPs)

5.2.9.1 Observed Concentrations

It is evident from Table A8.2.1 that none of the organohalogen compounds was present in all blood plasma samples analyzed. In fact, some were not present at all or in only a few samples. The observed concentrations of those POPs most commonly observed (detected in ≥70% of participants) are summarized in Table 5.1.3, as is the concentration of the sum of PCBs (Aroclor 1260).

There are strong dependencies on community and age for PCBs and organochlorine pesticides (OCPs), with the older *Eeyouch* exhibiting the highest blood plasma concentrations (Figures 5.2.10-5.2.12). For the sum of PCBs, there is a 10.3-fold difference between the maximum spread in mean concentrations observed between Oujé-Bougoumou and Waskaganish (5.3-fold between geomeans), and a 3.8-fold difference for the means of the sum of OCPs (2.4-fold for the geomeans). Similarly for PCBs measured as Aroclor 1260 (see Table 5.1.3), the maximum spread was 10.7-fold (mean) and

8.7-fold (geomean) between Mistissini and Waskaganish. [Aroclor was one of the industrial mixtures of PCBs which was manufactured prior to the PCBs' ban in 1977.] The dependence on age is clearly illustrated in Figures 5.2.10 and 5.2.12, and for community differences in Figure 5.2.11. The robust associations depicted in these plots between the PCBs and OCPs attest to similar sources. By contrast, the sum of polybrominated diphenyl ethers (PBDEs) *versus* either the sum of 12 PCB congeners (Figure 5.2.13) or 11 OCPs (Figure 5.2.14) shows the absence of a comparable relationship. Consequently, different sources are implicated (see below). Note that some of the high concentrations of PBDEs occurred among the youngest participants (8-14 years; also peruse Table A8.2.2).

The observed concentration ranges of OCPs and PCBs are comparable to those reported for adult indigenous populations in Canada (mostly Inuit), Greenland (mostly Inuit) and Russia (multiple ethnic groups) (AMAP, 2009), and are considerably higher (roughly 2-20 fold, depending on age) than for non-indigenous groups (e.g., Hansen et al., 2010; Rylander et al., 2012). In terms of the brominated halogen compounds, the concentrations reported for women of reproductive age were either higher (PBDE-147, 100, 153; see Tables A8.2.2, A8.2.5 and A8.2.6) or lower (PBB-153; Table A8.2.2) than Danish women (Frederiksen et al., 2010); while for older women (>39 years), they were generally somewhat lower than indicated for menopausal females living in Quebec City (Sandanger et al., 2007). Compared to Oujé-Bougoumou (data not shown in Table 5.1.3), plasma levels of PBDEs were lower in Fort Albany and Peawanuck Cree communities (West coast of James Bay; Liberda et al., 2011). Exposure to these compounds in some *Eeyou Istchee* communities appears somewhat lower than reported for the Inuit of Nunavik (Dallaire et al., 2009).

Organofluorine compounds are considered to be a family of emerging persistent chemicals. From the summary data for perfluorooctane sulfonate (PFOS) compiled in Table A8.2.4 for Waskaganish, Chisasibi, Whapmagoostui, and Waswanipi, it appears that the observed plasma concentrations show some dependence on age and community, but less so than for OCs. Also summarized in Appendix 8 (Table A8.2.3) are the plasma concentrations of dioxin-like compounds. Dioxin is considered one of the most toxic organohalide contaminants, and a separate *in vitro* assay was employed called Calux as described in Section 4.5.1.4 of the E&W Report (Bonnier-Viger et al., 2011). The strong age and community dependencies exhibited by the data in Table A8.2.3 are not surprising, since PCBs that have chemical reactivity that is similar to dioxin itself contribute to the observed levels.

The data presented in Figure 5.2.10 indicate that a few exceedances of the 20 μg/L level of concern occurred for women of reproductive age, and of the 100 μg/L guideline by older adults. Because many of the PCBs and OCs have rather long half-lives in humans, it is difficult to manage high exposures by treatments that reduce their body burden (as is done for lead and other toxic metals).

Reported half-lives range from 5-15 years (Grandjean et al., 2008; Ritter et al., 2011; Wimmerova et al., 2011). This implies that without additional exposures, it would take 25 to 75 years for the body to get rid of these contaminants by natural processes. This slow release is one of the factors responsible for the observation that body burdens increase with age. The other is that the consumption of traditional foods by *Eeyouch* is higher in individuals over 40 years of age, as these foods constitute an important dietary source of OCs (see Sections 5.2.9.2 and 5.2.9.3). Counselling concerning dietary preferences such as consumption of lean fish and low fat intake constitute important exposure-reduction measures, especially during the reproductive years of females (see Appendix 6). Although even less is known about the toxicity of brominated and fluorinated compounds than for OCs, the same advice seems prudent.

FIGURE 5.2.10 COMPARISON OF THE OBSERVED SUM OF PCBS (MEASURED AS AROCLOR 1260) TO THE HEALTH CANADA GUIDELINE OF 20 µG/L (BY AGE AND GENDER; ALL NINE COMMUNITIES)

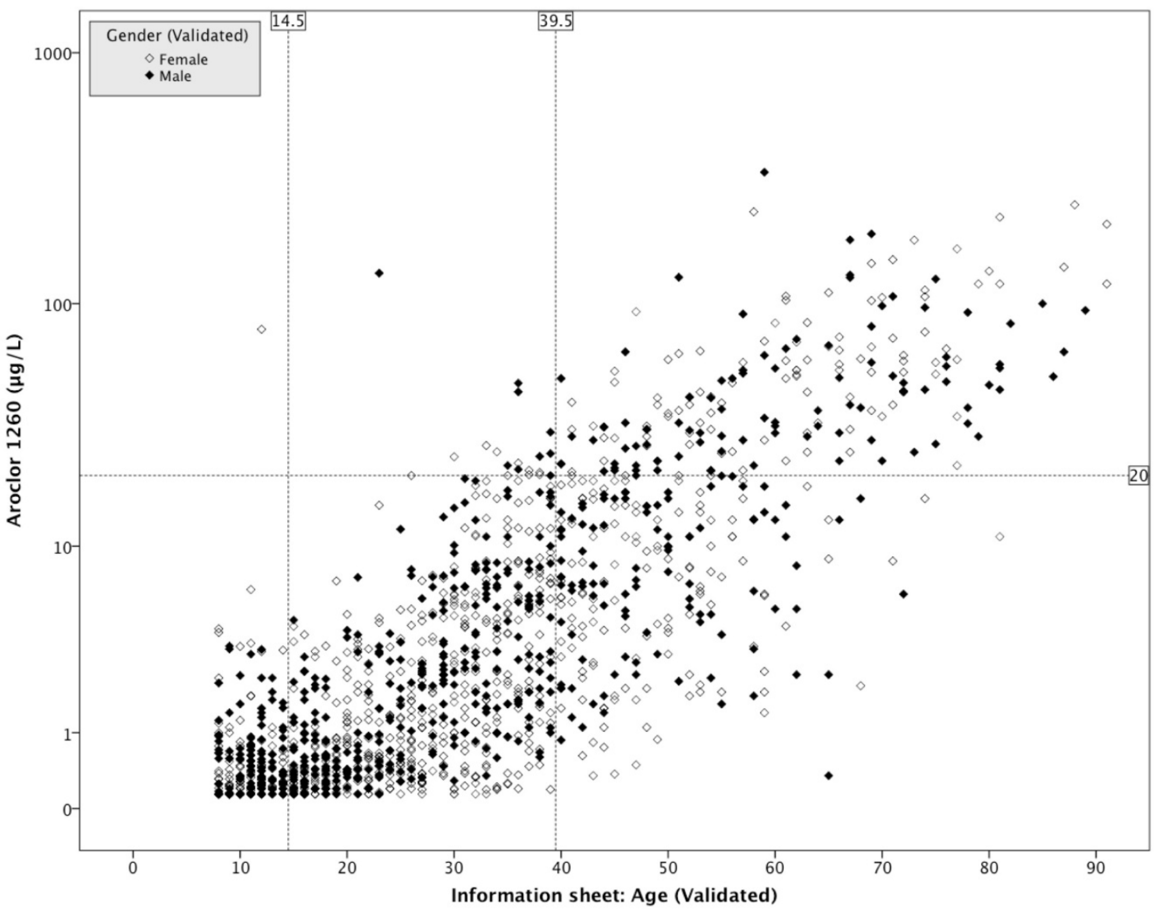


FIGURE 5.2.11 COMPARISON BY COMMUNITY OF THE OBSERVED PLASMA CONCENTRATIONS OF SUMS OF OCPS AND PCB CONGENERS (ALL NINE COMMUNITIES)

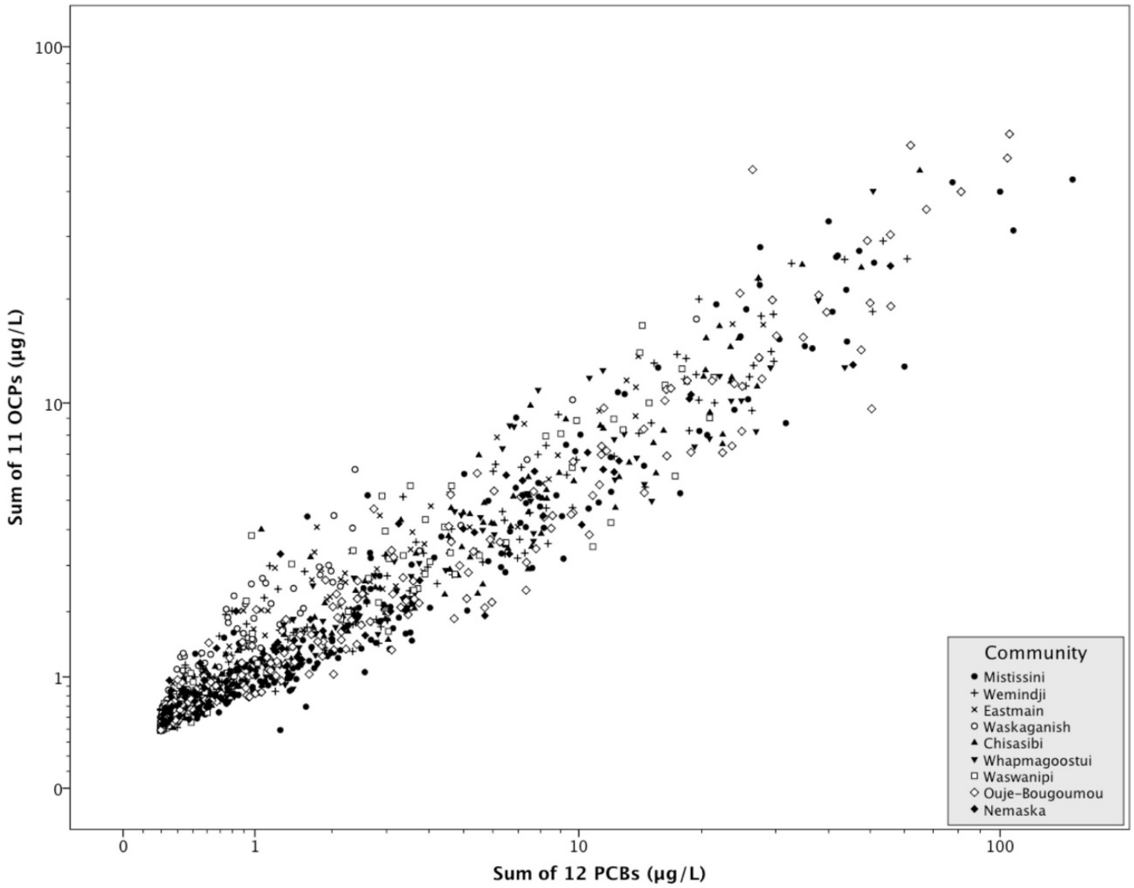


FIGURE 5.2.12 COMPARISON BY AGE GROUP OF THE OBSERVED PLASMA CONCENTRATIONS OF SUMS OF OCPS AND PCB CONGENERS (ALL NINE COMMUNITIES)

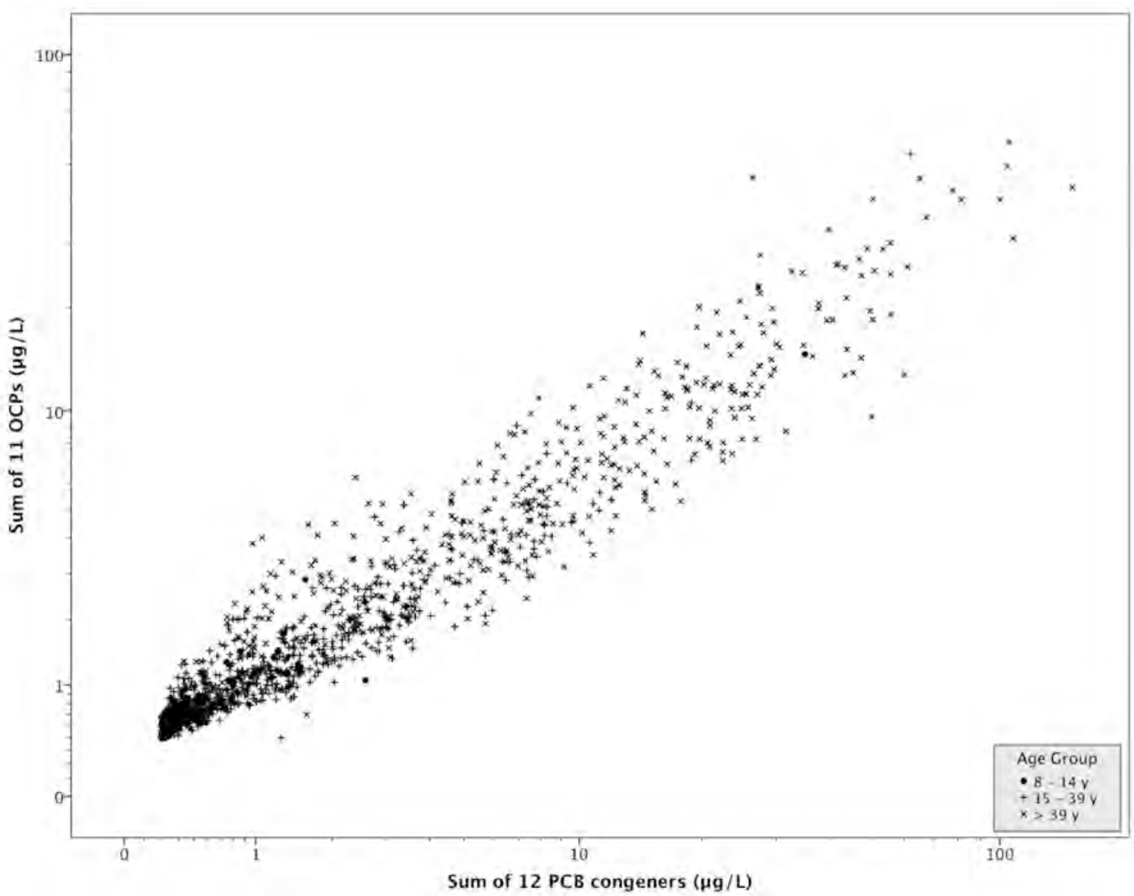


FIGURE 5.2.13 COMPARISON BY AGE GROUP OF THE OBSERVED PLASMA CONCENTRATIONS OF SUMS OF PBDES AND PCB CONGENERS (SIX COMMUNITIES; SEE TABLE 5.1.3 FOR SUMMARY STATISTICS)

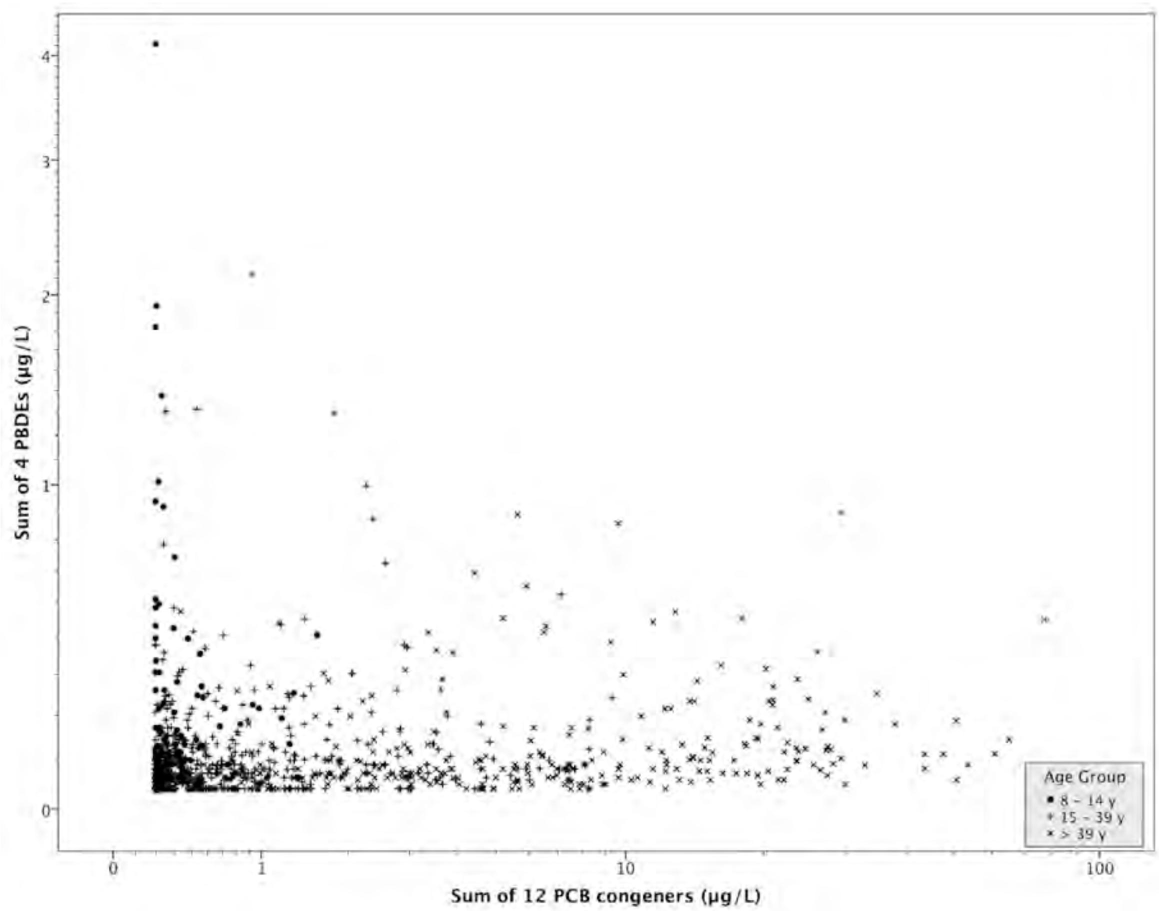
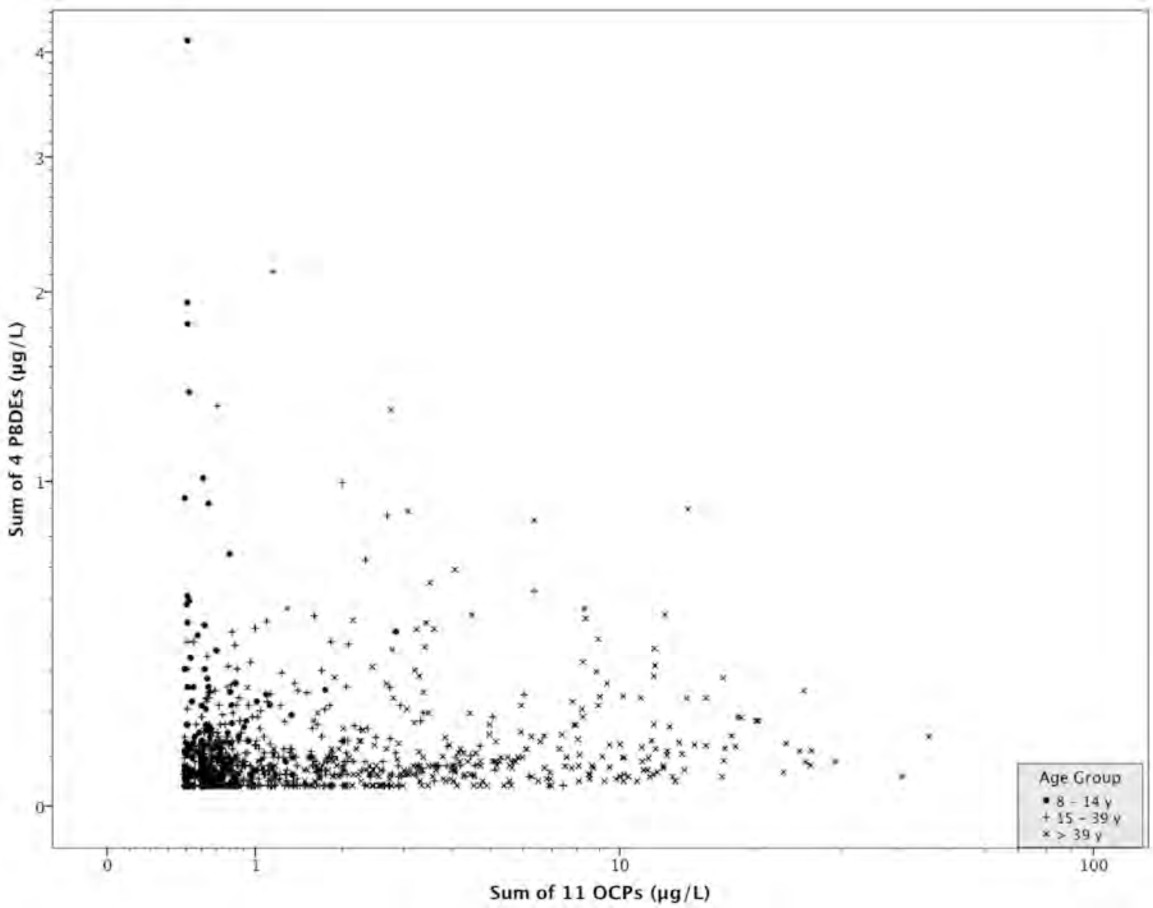


FIGURE 5.2.14 COMPARISON BY AGE GROUP OF THE OBSERVED PLASMA CONCENTRATIONS OF SUMS OF PBDES AND OCPS (SIX COMMUNITIES; SEE TABLE 5.1.3 FOR SUMMARY STATISTICS)



5.2.9.2 Established sources of POPs

Lipohilic (fat soluble) POPs are known to biomagnify in the Arctic food webs (Letcher et al., 2010). Although there is evidence of a general decline of concentrations of the historical POPs in air and animal tissues in northern and arctic regions (Hung et al., 2010) – which parallels a reduction in long-range transport – some POPs are on the increase such as PFOS (Hung et al., 2010; Butt et al., 2010) and certain brominated compounds (deWit et al., 2010). The same patterns are evident or are expected in humans (AMAP, 2009). In terms of traditional foods, Tsuji et al. (2007, 2008c) have shown (based on chemical analyses of game bird tissues harvested in the Western James Bay region) that consumption of water fowl constitutes a potential source of PCBs and p,p'-DDE, including dabbling ducks and Canada geese. The study also showed that POP contaminants from consumption of these migratory waterfowl could be markedly reduced if skin and fat tissues were removed before consumption. This source also makes some contribution for PBDEs (Liberda et al., 2011). Generally speaking, harvested traditional foods constitute a primary source of the more traditional POPs. This is not so for emerging contaminants.

The chemical stability and surface tension/levelling properties of PFOS and related compounds have led to multiple uses, including: inks, varnishes, waxes, fire fighting foams, metal plating and cleaning, coating formulations, lubricants, water and oil repellents for leather, paper and textiles, and insecticide raw material. Since PBDEs are ubiquitous in household products (including common food items, upholstery, textiles, building materials, kitchen appliances, plastic products and electronics), exposure to PBDEs through house dust is significant, especially for toddlers who ingest more dust than adults (Frederiksen et al., 2009, 2010). This is consistent with our observation mentioned earlier that high blood levels of PBDEs occur among young children. By contrast, household goods and materials are not a prominent source of traditional POPs.

5.2.9.3 Correspondence analysis

Four of the most prominent new summary variables generated from the POP concentrations are shown in Table 5.2.4. Most PCB congeners and mirex had relatively large positive scores on CA-1, whereas p,p'-DDT, p,p'-DDE and hexachlorobenze (HCB) had relatively large negative scores. This is graphically illustrated in Figure 5.2.15. Generally speaking, the relative concentrations of PCBs and mirex increase with age relative to OCPs. Thus in younger people, OCPs (mostly p,p'-DDE and HCB) contribute relatively more to the plasma OC levels than PCBs and mirex. This suggests an age-dependent source difference for these 2 contaminant groups. Clearly CA-1 can be considered a POP axis. The interpretation of the other 3 axes is more difficult because correspondence analysis considers more than simple variation in plasma concentration, such as, the detection frequency (i.e., the % of samples in which a contaminant is detected), age and community of residence, as illustrated if Figure 5.2.15.

The analysis summarized in Table 5.2.5 explores the relationship between contaminant variables and the dietary principal component axes (derived in Section 4.1.2.3 for the combined market and traditional diet frequency data; based on the answers on the food intake questionnaires). Clearly, the measured sum of PCBs, sum of OCPs, Aroclor 1260 concentrations and the CA-1 variable (from Table 5.2.4) showed significant positive correlation with the traditional food axis PC-1 when controlling for age. Negative relationships were evident for these parameters with the vegetables axis (PC-3), and either little or negative correlations were seen for PC-2, PC-4 and PC-6; the correlation with PC-5 was also positive for Aroclor and CA-1, presumably because of the use of lard in the preparation of traditional meat items. Collectively, this analysis reinforces the evidence that traditional foods constitute a source of OCs. By contrast, PBDE plasma levels show no comparable link to the traditional food PC-1 axis. However, in a separate correlation analysis using consumption frequencies for specific traditional food items, birds constituted a likely source for OCs, PCBs and PBDEs. These findings are consistent with the documented sources described in the previous section. A more detailed analysis is in progress to obtain a clearer understanding of the contributions of specific traditional food items to the body burden of OCs, including community dependence. Based on an analysis of variance (ANOVA) involving the PC-1 traditional food variable and the CA-1 of 18 POPs, there is a strong suggestion that consumption of traditional foods and the associated OC levels are higher for inland than coastal communities ($p = 0.00025$).

FIGURE 5.2.15 CORRESPONDENCE ANALYSIS: CA-1 SCORES FOR 18 POPS BY AGE GROUPS AND GENDER (ALL COMMUNITIES)

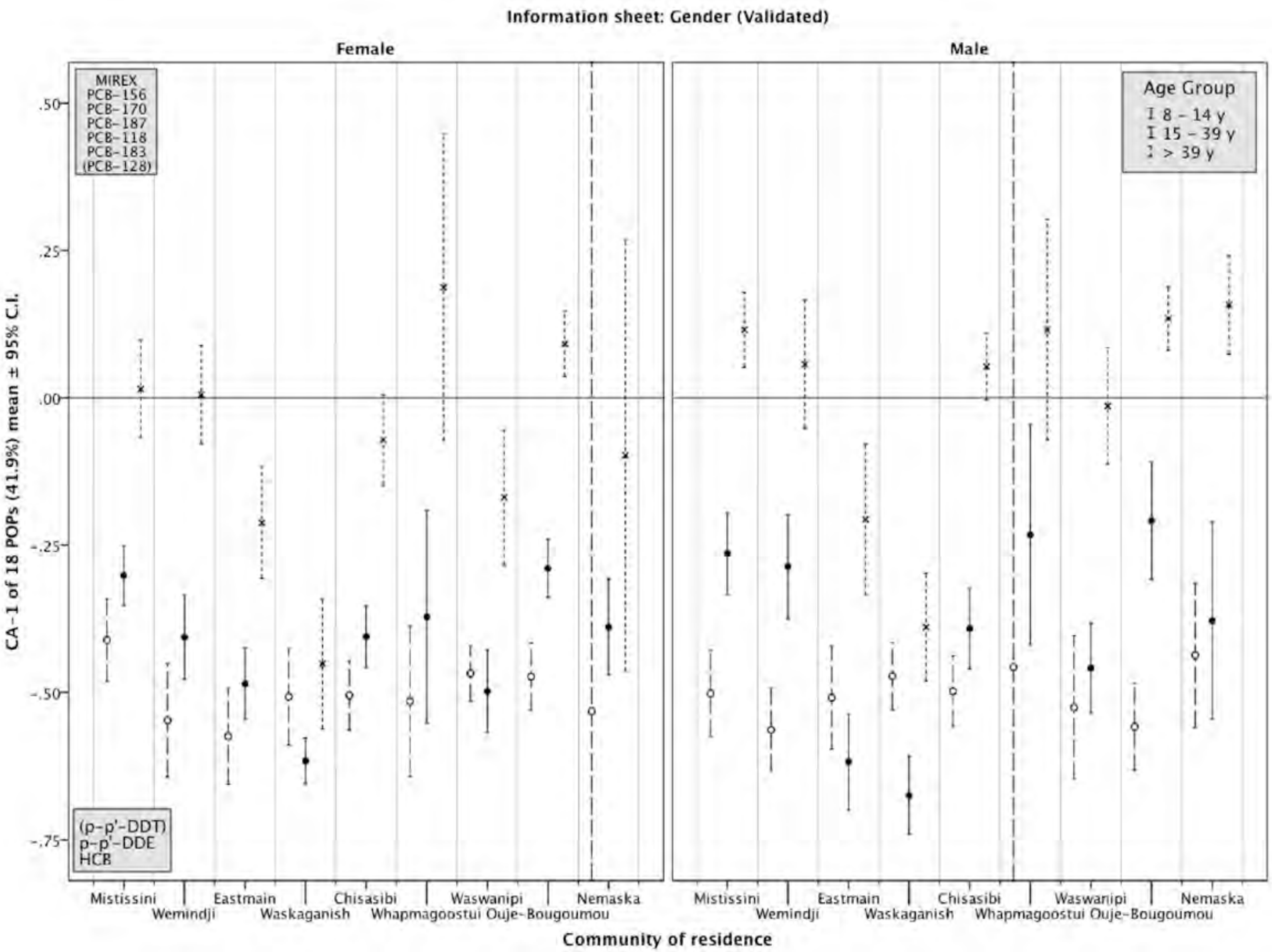


TABLE 5.2.4 CORRESPONDENCE ANALYSIS (CA)[a] SCORES OF POPS IN BLOOD PLASMA[b] (ALL COMMUNITIES)

POPs	CA-1 (41.9%)	CA-2 (28.3%)	CA-3 (11.0%)	CA-4 (6.5%)
CB 99	0.1194	0.2194	0.0600	**-0.2232**
CB 105	-0.0097	**0.4789**	0.2269	**-0.2186**
CB 118	**0.1946**	0.1600	0.0779	**-0.2448**
CB 128	**0.1466**	**1.5142**	**-0.5370**	**0.2242**
CB 138	0.1142	-0.0380	-0.0469	-0.1001
CB 153	0.0344	-0.1156	-0.1042	-0.0256
CB 156	**0.2692**	0.0584	0.0996	0.0985
CB 170	**0.2415**	-0.0280	0.0140	0.0826
CB 180	0.1125	-0.1383	-0.0830	0.0645
CB 183	**0.1870**	0.1445	0.0904	-0.0657
CB 187	**0.2087**	-0.0515	-0.0043	0.0196
cis-Nonachlor	-0.0477	0.2118	**0.4132**	0.0687
p,p-DDE	**-0.4095**	-0.0378	-0.0382	-0.0021
p,p-DDT	**-0.9249**	**0.5020**	**0.4268**	**0.2469**
Hexachlorobenzene	**-0.2463**	0.0912	**0.3001**	0.0390
Mirex	**0.2848**	-0.0829	0.1427	**0.2001**
oxy-Chlordane	0.0400	0.1360	0.2525	0.0482
trans-Nonachlor	0.1111	0.0277	0.2029	0.0137

a. Thioulouse J., Chessel D., Dolédec S., & Olivier J.M. (1997)

b. All POP concentrations were log (1 + µg/L) and detectable in >10% of participants; bold entries designate substantial scores

TABLE 5.2.5 PARTIAL CORRELATIONS[a] (CONTROLLING FOR *AGE*) BETWEEN DIETARY FREQUENCY PC VARIABLES AND MEASURES OF BLOOD PLASMA CONCENTRATIONS OF POPS (ALL COMMUNITIES)

			Market & Traditional Diet (PCA Loadings)					
Contaminant Variable	**Positive scores**	**Negative scores**	**PC-1 (+ traditional foods)**	**PC-2 (+ snack foods, deep fried)**	**PC-3 (+ vegetables)**	**PC-4 (+ moose meat)**	**PC-5 (+ alcohol, lard)**	**PC-6 (- bear meat)**
Log (Aroclor 1260 [µg/L])	Aroclor	n/a	+	-	-	ø	+	ø
Sum of PBDEs (µg/L)	PBDE congeners	n/a	ø	ø	-	ø	ø	ø
Sum of 12 PCB congeners (µg/L)	PCB congeners	n/a	+	ø	-	-	ø	-
Sum of 11 OCPs (µg/L)	Chlorinated Pesticides	n/a	+	-	-	-	ø	-
CA-1 of 18 POPs (41.9%)	(+ Mirex, PCBs 156, 170, 187, 118, 183, 128)	(- DDT, DDE, HCB)	+	-	-	ø	+	ø

a. Correlations are flagged as significant positive (+), significant negative (-), or non-significant (ø); $p < 0.05$

5.3 Concluding Remarks

Statistical power of a study concerns the ability to detect an effect or a difference deemed important between two study groups (e.g., among age or gender subgroups). Such ability depends strongly on sample size (i.e., the number of participants). The *Nituuchischaayihtitaau Aschii* study amply illustrates this. For the contaminants report outlined in this chapter, the maximum participant number was 1405 (or 1730 when including Oujé-Bougoumou and Nemaska), while it was 640 and 288 respectively for the Eastmain & Wemindji and Mistissini study reports (Bonnier-Viger et al, 2007, 2011). This constitutes the primary reason for our ability not only to confirm the link between blood lead levels and the use of leaded ammunition (and the implied consumption of lead-contaminated harvested food), but also assign a relative risk for hunters using lead shot and those who do not. Similarly, we were able to show conclusively that traditional foods contribute little to blood cadmium levels, with smoking being the primary source. By contrast, traditional food consumption is linked to mercury blood levels. It is well established that fish and fish-eating birds are sources of this toxic metal, and we are confident that more detailed statistical analyses of our multi-community data will add to this understanding. With PBDEs and perhaps also PFOS as exceptions, the additional sample size has strengthened the conclusion that consumption of traditional food items is linked to plasma concentrations of POPs; both show a strong link with age and dependence on community. It appears that both consumption of traditional foods and the associated plasma OC levels are lower for coastal communities. Clearly, the multi-community design of the *Nituuchischaayihtitaau Aschii* study avoids over interpretation of observations seen in a single community, and the observed trends and patterns across the communities afford new insight. And finally, when all communities were considered, the opportunity to observe high plasma concentrations of PBDEs in young children supported published findings that house dust is suspected as an important exposure medium for this contaminant.

Generally speaking, it is encouraging that minimum follow-up was needed in response to exceedances of guidelines in the case of blood lead and mercury levels. It is clear that compared to the mid-1990s, mercury exposure is declining in *Eeyou Istchee*. In terms of lead, additional efforts to reduce the use of leaded ammunition would reduce lead exposure (and thus blood lead) to what is seen in the general Canadian population. The latter is evident from the relatively low blood lead concentrations seen in some of the *Eeyou Istchee* communities, especially Waswanipi. There is no doubt that a reduction in smoking would reduce blood cadmium levels, and this may be a trend occurring in older residents since peak cadmium levels were observed in younger adults (15-39 y).

In terms of toxic inorganic arsenic, our findings suggest that there is a source in the communities. A comparison of hair and urine levels suggests that this toxic element was not internalized. Since pressure-treated wood until recently contained arsenic and has been used in external home construction, its burning in any situation should be avoided. The concentrations in blood of the essential elements copper, molybdenum, and zinc were in the normal range, and the toxic metals cobalt and nickel were at background concentrations.

Globally, the environmental levels of POPs are declining in northern regions (arctic and subarctic) and this is reflected in reported blood plasma levels of animals and humans. Because of their long residence times in the human body, the higher levels seen in the over 40 y age group will decline slowly. However in the context of the general global decline mentioned, the relatively low concentrations seen in the <40 y age group and children in the *Nituuchischaayihtitaau Aschii* study suggest considerably lower life-time exposure for these groups. However, exposures to emerging contaminants [i.e., the brominated (e.g., PBDEs) and fluorinated (e.g., PFOS) compounds] need continued monitoring in *Eeyou Istchee* as elsewhere in Canada and other countries.

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6. Heart Disease Risk Factors, Diabetes, Bone Health and Thyroid Disorders

(Éric Dewailly, Marie-Ludivine Château-Degat, Suzanne Côté, and others)

The main objective of this section is to report results on chronic diseases or their risk factors which are: 1) of interest for the *Eeyou Istchee* communities, and 2) associated in the scientific literature with exposure to environmental contaminants.

6.1 High Blood Pressure (Hypertension)

6.1.1 Among adults

Information on hypertension (HTN) was obtained from two sources, namely medical files and onsite measurements. Table 6.1 summarizes the comparison between both assessments (also see Tables A9.1A-F). About one third of all adults in the study had high blood pressure (HBP), which for one in six was either undiagnosed or uncontrolled if already diagnosed. Among adults with HBP, 57% had it under control. The prevalence of diagnosed and undiagnosed hypertension and of controlled hypertension was similar for men and women. Differences between communities in the prevalence of HBP and its control should be interpreted with caution, since they might be due to sampling shortcomings (e.g., size and selection bias; see footnote "f" of Table 6.1).

Table 6.1 Prevalence of diagnosed, controlled, uncontrolled and undiagnosed, and overall hypertension among adults (≥18 years) by community[a,b,c,d,e,f]

Community	n	Diagnosed HTN (a)	Controlled HTN (b)	Undiagnosed HTN (c)	Overall HTN (d)	Uncontrolled and undiagnosed HTN (e)
Mistissini	165	26.7	52.3	4.8	31.5	17.6
Eastmain	95	31.6	70.0	6.3	37.9	15.8
Wemindji	126	28.6	72.2	7.1	35.7	15.1
Waskaganish	87	19.5	82.4	4.6	24.1	8.0
Chisasibi	149	29.5	70.5	2.0	31.5	10.7
Whapmagoostui	81	34.6	82.1	7.4	42.0	13.6
Waswanipi	86	23.3	60.0	10.5	33.7	19.8
All communities[f]	789	27.8	68.5	5.7	33.5	14.4

a. Prevalence of diagnosed HTN: diagnosed hypertension in medical chart

b. Prevalence of controlled hypertension: diagnosed hypertension in medical chart with normal blood pressure during the study

c. Prevalence of undiagnosed hypertension: elevated blood pressure (above or equal to 140/90mmHg) measured during the study but with no mention of hypertension in the medical chart

d. Prevalence of overall hypertension

e. Prevalence of uncontrolled and undiagnosed HTN: people with diagnosed hypertension in medical chart with abnormal blood pressure during the study plus people with elevated blood pressure (above or equal to 140/90 mmHg) measured during the study with no mention of hypertension in the medical chart)

f. For Oujé-Bougoumou and Nemaska, the medical file data were not consulted. Consequently, estimated prevalences of elevated blood pressure only measured during the study should not be directly compared with those for participants from the other communities. In Oujé-Bougoumou, prevalence of blood pressure measured at the time of the study (above 140/90 mmHg) was 28.5% and no gender differences were discernible (26% among women *versus* 32.8% among men; p-value = 0.37). In Nemaska, among 61 participants sampled, 14.75% had elevated blood pressure and women clearly presented a higher prevalence than men (4.7% *versus* 38.9; p-value = 0.002).

6.1.2 Among children and adolescents

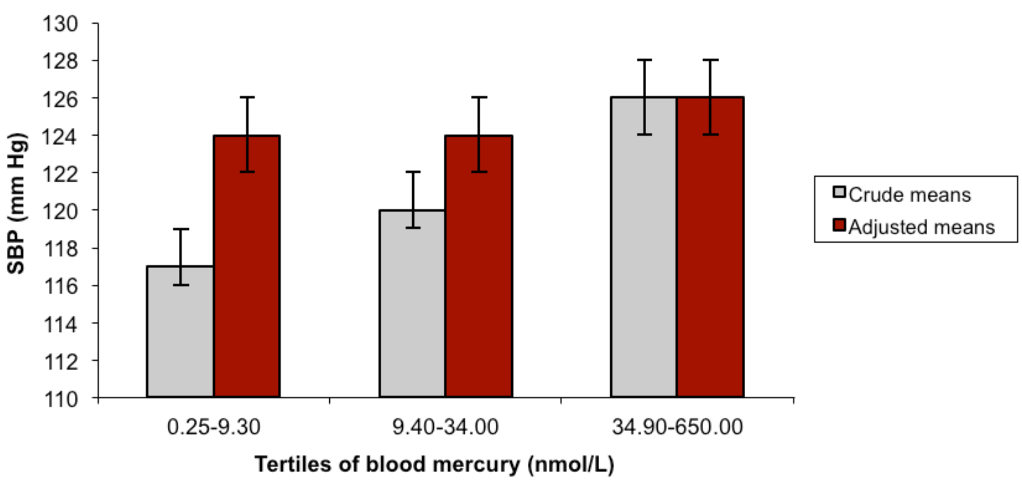
Among children and adolescents (8-17 years), the estimated prevalence of HTN was ascertained from information gathered from medical files or onsite measurements. In the latter case, hypertension was defined as having an average systolic blood pressure (SBP) and/or diastolic blood pressure (DBP) above the 95th percentile for gender, age, and height.

We combined all nine communities (n = 358, of which 262 had BP measures) in order to draw a global profile of all youths with elevated BP. Overall, in the nine Cree communities visited, 30 (11.5%) of the 262 youths met the criteria of having elevated blood pressure.

6.1.3 Association between blood mercury and blood pressure among adults (≥18 years)

The effect of mercury on BP was studied by pooling the data collected in the seven communities surveyed during 2005-2009, and thus excludes Oujé-Bougoumou and Nemaska. In Figure 6.1, we present the unadjusted and adjusted means of systolic blood pressure (SBP) by tertiles of blood mercury concentrations. BP increased across tertiles of blood mercury concentrations, but the differences did not reach statistical significance after adjusting for confounders (similar results occurred for DBP).

FIGURE 6.1 SYSTOLIC BLOOD PRESSURE ACCORDING TO TERTILES OF MERCURY BLOOD CONCENTRATIONS (SEVEN COMMUNITIES)[a,b]



a. Significant difference occurred between tertile 1 mean (unadjusted) and unadjusted SBP means in tertile 2 ($p < 0.05$) and tertile 3 ($p < 0.05$)

b. Means and 95% CIs shown were adjusted for age, gender, LDL-cholesterol, HDL-cholesterol, triglycerides, waist circumference, fasting glucose, smoking, physical activity, anti-hypertensive treatment, total n-3 fatty acids, selenium, lead and PCB 153

We did not observe significant associations between blood mercury and BP after adjusting for common BP risk factors, as well as concentrations of n-3 polyunsaturated fatty acids (n-3 PUFAs) in red blood cell (RBC) membranes, selenium and lead in blood, and PCB 153 in plasma. These results are not in line with most previous studies, and some important differences must be discussed. Some studies conducted among adults have reported a positive association between mercury and SBP, DBP and pulse pressure (Pedersen et al., 2005; Fillion et al., 2006; Choi et al., 2009; Valera et al. 2009). However, they were conducted in populations with higher mercury levels than those detected here. It has been suggested that n-3 PUFAs and selenium could have a protective effect on BP. However, in our sample, neither n-3 PUFAs nor selenium were significantly associated with SBP or DBP in the final statistical models. This is in line with the results of a previous study conducted in this population in which no protective effect of n-3 PUFAs on BP was observed (Dewailly et al. 2002).

6.2 Blood Lipids and Fatty Acids

6.2.1 Blood lipids

As participants from Oujé-Bougoumou and Nemaska were not all under fasting conditions, their results for plasma triglycerides, HDL-C and the elevated total cholesterol/HDL ratio were excluded from the computational analyses. The lipid results by community are presented in Tables A9.2A-F, and for all nine communities combined in Table 6.2.

Among the participating adults (≥18 years), elevated total cholesterol (≥5.2 mmol/L) was found in 25.0%, LDL-C (>3.4 mmol/L) in 14.8%, and low HDL-C in 50.3%, with an elevated total cholesterol/HDL ratio (≥5.0) in 18.2%. Elevated blood triglycerides (>1.7 mmol/L) was found in 28.6% of participants. In all adults, the blood lipid profile was markedly related to obesity status. Gender and age influence were less consistent (see Table 6.3).

Among children (8 to 17 years old), we used the modified Cook criteria (Cook et al., 2003) to estimate risk factors in this paediatric population. Overall, elevated triglycerides (>1.2 mmol/L) were detected in 55 of 232 children tested. Notice that missing values exceed 35% for this measure. No gender difference was observed among the children with elevated triglycerides, and most of them (76.0%) had an elevated body mass index (BMI) (i.e., it exceeded the 95th percentile when adjusted for age and gender).

For low HDL-C when combining data from all nine communities, one in five children had low HDL-C and no gender differences were found. Most of them (79.0%) had an elevated BMI. The results among children have not been adjusted for any lipids medication.

TABLE 6.2 PLASMA LIPID CONCENTRATIONS ACCORDING TO AGE AND GENDER IN ALL NINE *EEYOU ISTCHEE* COMMUNITIES[a]

	Overall				Male				Female			
	15-39 years n = 759		**≥40 years** n = 426		**15-39 years** n = 299		**≥40 years** n = 193		**15-39 years** n = 460		**≥40 years** n = 233	
Total Cholesterol (C) (mmol/L)[b]	4.4	(0.9)	4.8	(1.0)	4.5	(0.9)	4.8	(1.1)	4.3	(0.8)	4.8	(0.9)
C/HDL-C[b]	3.8	(1.1)	3.9	(1.4)	4.0	(1.2)	4.3	(1.8)	3.6	(1.1)	3.6	(0.9
HDL-C (mmol/L)[c]	1.2	[1.1-1.2]	1.2	[1.2-1.3]	1.2	[1.1-1.2]	1.1	[1.1-1.2]	1.3	[1.3-1.4]	1.3	[1.2-1.4]
LDL-C (mmol/L)[b]	2.4	(0.7)	2.8	(0. 7)	2.7	(0.8)	2.9	(0.9)	2.4	(0.7)	2.7	(0.7)
Triglycerides (mmol/L)[c]	1.4	[1.3-1.4]	1.4	[1.3-1.5]	1.4	[1.3-1.5]	1.4	[1.3-1.6]	1.2	[1.1-1.2]	1.3	[1.4-1.5]

a. As participants from Oujé-Bougoumou and Nemaska were not all under fasting conditions, their results were excluded from the analyses presented in the text on triglycerides, HDL and the elevated total cholesterol/HDL ratio.

b. Arithmetic mean (SD)

c. Geometric mean [95% CI]

TABLE 6.3 PREVALENCE (%) OF ABNORMAL CARDIOMETABOLIC FACTORS AMONG ADULTS (≥18 YEARS) ACCORDING TO BMI STATUS IN ALL *EEYOU ISTCHEE* COMMUNITIES*

BMI (kg/m^2)	**HBP** (a)	**C** (b)	**LDL-C** (c)	**HDL-C** (d)	**C/HDL-C** (e)	**TG** (f)	**Diabetes** (g)			**Met. Synd.** (h)
							Norm.	**IFG**	**T2D**	
Total (n)										
<24.9 (n = 105)	16.2	12.4	6.7	22.7	5.1	10.3	86.6	3.1	10.3	8.6
25-29.9 (n = 225)	25.8	31.3	19.4	32.8	13.8	26.4	82.2	8.6	9.2	33.1
30-39.9 (n = 557)	32.7	27.4	17.0	48.7	16.8	36.7	64.7	16.0	19.3	61.3
≥40 (n = 177)	39.6	18.1	7.4	64.5	15.6	40.4	58.9	18.4	22.7	75.9
Male (n)										
<24.9 (n = 60)	15.0	14.3	8.7	24.6	8.7	15.8	86.0	3.5	10.5	6.3
25-29.9 (n = 113)	26.6	28.3	22.1	21.3	18.0	30.3	86.5	5.6	7.9	26.9
30-39.9 (n = 226)	32.8	38.0	27.9	33.3	27.5	42.3	56.3	21.6	22.1	65.5
≥40 (n = 30)	53.3	23.3	16.7	52.0	36.0	36.0	68.0	12.0	20.0	84.0
Female (n)										
<24.9 (n = 45)	17.8	9.8	3.9	20.0	0	2.5	87.5	2.50	10.0	12.1
25-29.9 (n = 112)	25.0	34.2	16.5	44.7	9.4	22.3	77.7	11.8	10.6	39.5
30-39.9 (n = 331)	27.8	20.3	9.6	60.0	8.6	32.5	71.0	11.8	17.3	58.2
≥40 (n = 147)	36.7	17.1	5.5	67.2	11.2	41.4	56.9	19.8	23.3	74.1

*As participants from Oujé-Bougoumou and Nemaska were not all under fasting conditions, their results for triglycerides, HDL-C and elevated total cholesterol/HDL ratio, glucose and metabolic syndrome were excluded from the analyses.

a. ≥140 (syst.) – 90 (diast.) mmHg, or medication;

b. >5.2 mmol/L;

c: ≥3.4 mmol/L;

d. ≤1.03 (♂); 1.3 mmol/L (♀);

e. C/HDL ≥5;

f. ≥1.7 mmol/L;

g. Fasting glucose: normal <6.1 mmol/L, IFG (impaired fasting glucose): 6.1-6.9 mmol/L, T2D >6.9 mmol/L;

h. Metabolic syndrome according to the Internationl Diabetes Federation (IDF) is defined as: waist >88 cm for women and >94 cm for men plus two of the following: high blood pressure (systolic ≥130 mmHg or diastolic ≥85 mmHg) or HTN medication, Trig ≥1.7 mmol/L, HDL<1.03 mmol/L (men) or <1.29 mmol/L (women), fasting glucose ≥5.6 mmol/L or total cholesterol/HDL >5 mmol/L.

6.2.2 Fatty Acids (FA)

Relative concentrations of FA in RBC membranes are reported in Tables A9.3A-D for the four communities surveyed in 2008-2009; the comparable Mistissini data are provided in Table 5.4.6 of the Mistissini report (Bonnier-Viger et al., 2007), and for Eastmain and Chisasibi in Tables 5.4.4A-B of Bonnier-Viger et al., 2011. The abbreviations employed in this and the following sections are: EPA (eicosapentaenoic acid), DHA (docosahexaenoic acid), DPA (docosapentaenoic acid), PUFA (polyunsaturated fatty acids), MUFA (monounsaturated fatty acids), SFA (saturated fatty acids) and TFA (trans fatty acids); also see footnotes to Tables A9.3A-D.

When considering the seven communities surveyed in 2005-09, the total n-3 polyunsaturated fatty acids (n-3 PUFAs) mean concentrations measured in red blood cell (RBC) membranes of participants were compared between communities and age categories. Total n-3 PUFAs accounted for 6.13% of total FA (95% CI: 6.05-6.21), while EPA, DHA and DPA accounted for 96% of total n-3 PUFAs (EPA+DHA ≈ 62% and DPA ≈ 34%). However, the relative mean concentrations of total n-3 PUFAs and EPA+DHA (3.82%, 3.75-3.89) highly differed between age categories and between communities. Indeed, coastal residents tended to have higher EPA, DHA and DPA levels, and lower (n-6)/(n-3) ratios than inland residents. They also had lower TFA levels than inland residents ($p < 0.0001$).

Analysis restricted to adults aged 18-74 y showed that relative mean concentrations of n-3 PUFAs, EPA and DHA, adjusted for community and gender, strongly increased (p trend <0.0001) with age, while adjusted means of n-6 PUFA and the (n-6)/(n-3) ratio decreased (p trend <0.0001). TFA and n-3 PUFAs showed opposite trends, with participants aged ≥40 y having higher n-3 PUFAs (approx. 1.3 times, p-trend <0.0001) and lower TFA (approx. 1.2 times; p-trend = 0.0441) levels than those aged 15-39 y and 8-14 y. The average level of TFA was 0.69% (0.65-0.72) and differed significantly between the communities within each age group ($p < 0.0001$). The differences remained significant after the community of Mistissini was removed from the analysis, even though it had a unique trans-fat profile compared to the other communities (age and gender-adjusted mean TFA levels were 3.2 times higher on average).

RBC levels of n-3 PUFAs found among participants of the *Eeyou Istchee* communities surveyed in 2005-09 were approximately half the values found among Nunavik Inuit in 2004 (9.25%), but still remained about 2-3 times higher than reported for the general population of Québec (Dewailly et al., 2001; Proust and Dewailly, 2009; Lucas et al., 2010). n-3 PUFAs are indicative of fish and game consumption. The particularly high proportion of DPA among participants of all ages may reflect the importance of game (meat) species in their diet. Furthermore, it increased with age. By contrast the (n-6)/(n-3) ratio (which is indicative of the generational nutritional transition and a major determinant of the risk of CVD) and TFA levels (a biomarker of deleterious dietary intake associated with processed foods), showed an opposite pattern in most communities. Thus, the promotion of the traditional *Eeyou* diet based on fish and game food is still pertinent, as it provides the communities with the cardioprotective effects of n-3 PUFA and also helps to reduce intake of store-bought foods.

6.2.3 The situation of TFA in youth of Mistissini

TFA concentrations in RBC membranes were assessed in all *Eeyou Istchee* communities from 2005 to 2009, and data from Mistissini in 2005 appeared to be much higher than in any of the other *Eeyou Istchee* communities (approx. 3.2-fold), particularly among young people aged 8-18 yrs old. This finding identified the importance of assessing the extent to which *Eeyouch* are exposed, and also the need to reassess the TFA levels in youth of this community. Subsequently, we decided to re-evaluate the TFA profile in RBC membranes of children and adolescents in Mistissini aged 8 to 18 in 2011, and to compare it with the 2005 profiles.

In 2005, 61 young *Eeyouch* from Mistissini aged 8-18 had their FA measured including TFA. The FA composition of RBC membrane phospholipids was again measured using the standard method currently used at the Lipid Research Centre (Québec). In 2011, 36 children and adolescents aged 8-18 y participated in a re-evaluation study in Mistissini, of whom 25, aged 8-14, had not participated in the 2005 survey ("new subjects") and 11, aged 14-18, had done so previously. Concentrations of FA (including TFA) were again measured in RBC membranes employing the same standardized method as in 2005.

In 2005, the *Eeyou* children and adolescents aged 8-18, living in Mistissini, had a much higher relative mean concentration of TFA in their RBCs (1.66%, 95% CI: 1.58-1.74, n = 61) than any other of the communities surveyed between 2005 and 2009, the difference between Mistissini and other communities being highly significant ($p < 0.0001$). The highest TFA levels were observed in young individuals 9-10 y (1.85%) and 17-18 y (1.63%). In 2011, the mean RBC TFA levels among young *Eeyouch* of the same age (9-18 y) were dramatically reduced to 0.42% (0.39-0.44, n = 36; $p < 0.0001$ when compared to 2005), and thus were within the TFA range for all the communities visited in 2007-2009 (0.22-0.72%).

These results raise several questions about the presence of larger amounts of TFA in store-bought foods and restaurants in 2005 than in 2011, different dietary choices in 2011, or other factors affecting the findings. For example, the Canadian average intake of TFA has probably declined between 2005 and 2011. In December 2005, the Government of Canada required that the content of TFA be listed on the labels of pre-packaged foods. In June 2007, further actions were taken by Health Canada to reduce TFA concentrations to less than 2% of the total fat content. Nevertheless, actions directed to improving the food supply in the James Bay Cree communities should be encouraged.

6.3 Atherosclerosis and Contaminants

Atherosclerosis can be defined as a thickening and hardening of arteries due to the accumulation of white blood cells (macrophage), fatty materials (cholesterol), and waste products from cells, calcium and fibrin. This can result in the impairment of blood flow and causes myocardial infarction (heart attack), stroke or other ischemic heart diseases. The natural phenomenon of atherosclerosis increases with age and known risk factors (e.g., high blood pressure, diabetes, smoking, obesity, and dyslipidemia). However an increasing number of studies suggest that mercury (Hg) exposure and also persistent organic pollutants (POPs) may increase the risk of cardiovascular diseases (CVDs) such as atherosclerosis.

In this study, we use carotid intima-media thickness (CIMT) measurements as a surrogate marker of atherosclerosis to describe the atherosclerotic status of the James Bay Cree sample of population and try to explain its major determinants including some environmental contaminants. The CIMT measure reflects plaque build-up inside arteries.

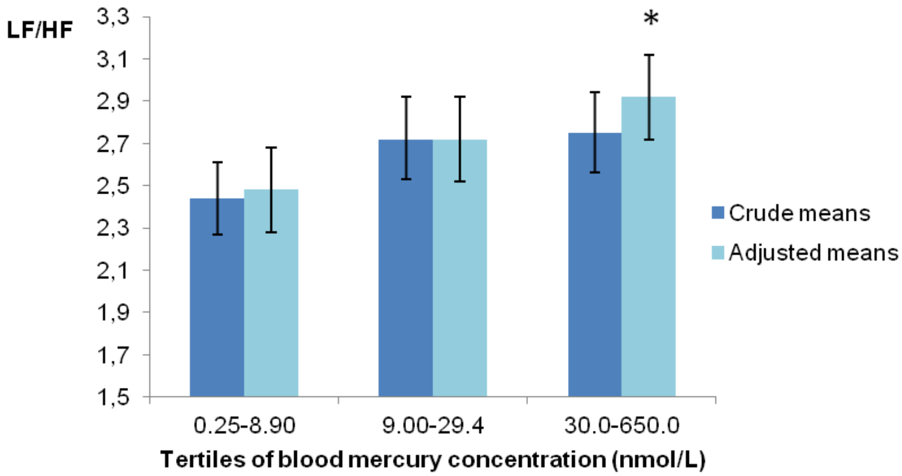
Among adults ≥40 years old, we studied 320 people in seven communities with a mean age of 54 years. In those communities, we found that the mean CIMT did not differ between communities but did with gender ($p < 0.0001$); it was higher in men [0.82 mm (0.80-0.84)] than in women [0.76 mm (0.75-0.78)]. CIMT increased significantly with age [0.09 mm in mean per 10 years of age (0.08-0.10), $p < 0.0001$], and was associated with abnormal fasting glucose blood levels (i.e., >6.1 nmol/mL, $p = 0.002$) when we adjusted for age and gender. We found a significant difference in CIMT between obese and young adults with normal body mass index (i.e., BMI <25 with CIMT = 0.53 *versus* 0.56 for BMI >30, $p = 0.005$). A significantly higher CIMT was noticed in young adults affected by blood lipid impairment ($p = 0.001$), or with abnormal fasting glucose blood levels ($p = 0.04$). A slightly increasing CIMT was observed in young adults affected by HBP ($p = 0.06$) when we adjusted for age and gender.

Preliminary results to determine if an association between mercury or POPs (PCB 153) and atherosclerosis can be detected were not conclusive in our population. It was probably due to an important correlation between these two contaminants ($r = 0.70$) and to a non-linear relationship between them and CIMT. It may be possible that these contaminants interact with age as CIMT increases. More investigations and statistical modeling need to be done to understand these interdependencies in our analysis. We also need to take into account the observed variability in contaminant levels across the communities. The potential roles of mercury and POPs on CIMT are still unclear but further analyses are ongoing.

6.4 Heart Rate Variability (HRV) and Mercury

Epidemiological evidence suggests a detrimental impact of mercury on cardiovascular risk factors such as heart rate variability (HRV). The objective was to assess the impact of this toxic metal exposure on resting heart rate (HR) and HRV among adult *Eeyouch*. Data were collected among 791 adults ≥18 years old living in the seven communities. Blood mercury and hair levels were used, respectively, as biomarkers of recent and more long-term exposure. HRV was derived from a 2-hour Holter monitoring assessment. After adjusting for confounders, blood mercury was associated with HRV parameters such as low frequency (LF) ($\beta = 0.21$, $p = 0.0002$), high frequency (HF) ($\beta = 0.15$, $p = 0.004$) and LF/HF ($\beta = 0.06$, $p = 0.003$) (see Figure 6.2). Similar associations were observed with hair mercury. As found in Nunavik Inuit, mercury exposure negatively affects HRV.

FIGURE 6.2 MEANS OF LF/HF RATIO ACROSS TERTILES OF BLOOD MERCURY CONCENTRATIONS[a,b,c]



a. LF (low frequency) and HF (high frequency) are spectral analysis parameters; a decrease in HRV is indicated by a high LF/HF ratio.

b. Trend was significant (p = 0.02) for both the crude and adjusted means.

c. Means were adjusted for age, sex, waist circumference, triglycerides, fasting glucose, smoking, physical activity, selenium, PCB 53, total n-3 PUFAs, and lead.

*Significant difference from tertile 1 (p = 0.02).

6.5 New Cardiovascular Risk Factors

6.5.1 Inflammation

Low-grade systemic inflammation is now recognized as an important risk factor for cardiovascular disease (CVD). Among the adult *Eeyouch* in the study (≥18 years), 16.0% of participants had high-sensitivity C-reactive protein (hs-CRP) concentrations in blood plasma below 1 mg/L, 38.9% between 1 and 3 mg/L, and 45.1% exceeding 3 mg/L, respectively associated with a low-risk, moderate-risk and high-risk of CVD. The prevalence of hs-CRP concentrations >3 mg/L among *Eeyouch* is almost twice as high as in Canadians of European origin (25.0%). Similar to our results, a high prevalence (54.8%) of hs-CRP concentrations >3 mg/L has been reported for First Nation individuals from the Six Nations Community in Ontario (Anand et al., 2004).

Table 6.4 shows the generally high levels of inflammatory biomarkers observed in plasma for adult *Eeyouch*. More specifically, women had higher hs-CRP, interleukin (IL)-6 and tumor necrosis factor-alpha (TNF-α) concentrations than men (all $p < 0.03$). The inflammatory profile also differed according to weight status defined as normal weight (BMI < 25 kg/m^2), overweight (BMI = 25-29 kg/m^2) and obese (BMI ≥ 30 kg/m^2). Obese individuals had higher hs-CRP and IL-6 concentrations than normal weight and overweight individuals (all $p < 0.05$). Similar results (not shown) were obtained when stratifying subjects according to the presence of abdominal obesity (defined as waist circumference ≥102 cm in men and ≥88 cm in women). hs-CRP and IL-6 concentrations were also higher in the presence *versus* the absence of type 2 diabetes (hs-CRP levels of 3.8±7.6 *versus* 3.2±7.9 mg/L with p = 0.006; and IL-6: 3.3±5.1 *versus* 2.8±5.4 pg/mL, p = 0.0006). Inflammatory biomarker concentrations did not differ by age. In summary, our observations suggest that adult *Eeyouch* are characterized by a high prevalence of low-grade systemic inflammation. Consistent with observations in previous studies (Rogowsky et al., 2008), being female and obesity emerge as two key predictors of the observed pro-inflammatory profile.

TABLE 6.4 MEAN INFLAMMATORY BIOMARKER PLASMA CONCENTRATIONS AMONG SEVEN *EEYOU ISTCHEE* COMMUNITIES ACCORDING TO SEX, AGE, AND WEIGHT STATUS[a]

		Sex		Age (years)[b]		BMI (kg/m^2)[c]		
Biomarker	**All communities**	**Men**	**Women**	**18-39**	**40+**	**<25**	**25-29**	**≥30**
hs-CRP (mg/L)	3.3±7.8 (n = 745)	2.8±7.3 (n = 333)	3.9±7.9[d] (n = 412)	3.4±8.5 (n = 429)	3.2±6.8 (n = 316)	1.7±6.0 (n = 66)	2.5±7.0 (n = 161)	3.9±7.7[e,f] (n = 494)
IL-6 (pg/mL)	2.9±5.4 (n = 846)	2.6±5.7 (n = 358)	3.3±4.9[d] (n = 488)	2.9±5.5 (n = 488)	3.0±5.1 (n = 358)	1.8±3.5 (n = 68)	2.5±5.8[e] (n = 173)	3.2±5.1[e,f] (n = 579)
TNF-α (pg/mL)	3.0±8.4 (n = 842)	2.8±7.8 (n = 358)	3.2±8.7[d] (n = 484)	3.0±9.1 (n = 486)	3.0±7.3 (n = 356)	3.2±8.1 (n = 69)	2.7±6.8 (n = 172)	3.2±8.9 (n = 575)

a. Abbreviations: BMI, body mass index; hs-CRP, high-sensitivity C-reactive protein; IL-6, interleukin-6; TNF-α, tumor necrosis factor-alpha. Values are means ± SD. For hs-CRP, values above 10 mg/L (n = 112) were excluded as they are indicative of an active acute infection. For IL-6 and TNF-α, values with two standard deviations above the mean were also excluded for the same reason.

b. Difference between age groups: $p \geq 0.36$ for hs-CRP, IL-6 and TNF-α (adjusted for community of residence).

c. Difference between weight status groups: $p < 0.0001$ for hs-CRP and IL-6 and $p = 0.40$ for TNF-α (adjusted for community of residence).

d. $p < 0.03$ between sexes, adjusted for community of residence.

e. Significantly different from the normal weight group (BMI <25 kg/m2), $p < 0.05$.

f. Significantly different from the overweight group (BMI 25-29 kg/m2), $p < 0.05$.

6.5.2 Low density lipoprotein size

An interesting new marker of CVD is particle size of plasma LDL. Small, dense LDL particles are considered to be a risk factor of atherosclerosis. In part, they are formed as a response to elevation of triglycerides. It is considered that LDL peak particle sizes of less than 255 Å (Angströms; 10^{-8}cm) are associated with an increased risk for CVD. In Québec City, an average of 257 Å was found in healthy men, and 255 Å in patients with heart disease. Participants of all communities had an average LDL size of 254.6 Å with no difference between communities. LDL peak particle size was significantly associated with age and a deterioration of the glucose profile (increasing risk), and also tended to be associated with BMI and diabetes status.

6.5.3 Discussion of risk factors for CVD

In all communities visited, we observed a similar pattern for the risk factors of CVD. We found a relatively high prevalence (around 30%) of hypertension compared to that for the Nunavik Inuit (19%). Metabolic disturbances such as low HDL-C and elevated triglycerides were also detected in more than one third of adult participants. However, we concomitantly noticed a lower than expected prevalence of elevated LDL-C, total cholesterol and total cholesterol/HDL-C ratio. All these risk factors were positively associated with general and abdominal obesity. The influence of gender varies from one risk factor to another except for HDL-C concentrations, which were higher among women (as expected).

As already shown in numerous population-based studies, all previous biological parameters such as hypertension, low HDL-C, high triglycerides, abdominal obesity and diabetes, drastically increase the risk of cardiovascular diseases and related complications.

This descriptive analysis highlighted the tight relationship between obesity (global and abdominal), hypertension, HDL-C and gender. Explanatory analyses including lifestyle and environmental data (such as dietary profile, social context, contaminants, etc.) should be investigated further in order to complement public health strategies already in place in various Cree communities.

Preliminary analyses between contaminants and CVD risk factors are inconclusive. We were not able to observe an association between blood pressure and mercury as found in Inuit of Nunavik. The lower level of Hg exposure might be responsible for this. However, we found an association between mercury exposure and heart rate variability. This finding echoes our previous observations and those by teams studying other populations (Valera et al., 2008; Lim et al., 2009; Yaginuma-Sakurai et al., 2009; Valera et al., 2011), and the association seems to be robust. The exact significance of decreased HRV is not clinically evident, but certainly impacts the CVD health of the Cree nation.

Our preliminary analysis of the association between contaminant exposure and the development of atherosclerosis summarized here is not conclusive, and further analyses are needed to explore possible associations in greater detail.

6.6 Obesity, a Significant Risk Factor for Type 2 Diabetes (T2D)

6.6.1 Estimated prevalence of obesity, insulin levels and other risk for T2D

We defined obesity as BMI ≥ 30kg/m^2 or a waist circumference (WC) ≥102 cm in men and ≥88 cm in women. After pooling all data for the nine communities, the prevalence of obesity defined by BMI was 69.1%, and when WC-based it reached 91.4% (abdominal obesity; women 94.1% and men 87.4%). For both measures, women displayed the higher proportion ($p < 0.0001$). Fat mass was also higher in women (45.2 kg *versus* 33.0 kg) and, as expected, fat-free mass tended to be higher in men (49.6 *versus* 92.1 kg, $p = 0.07$). Moreover, BMI and age were correlated (ß = 0.04, $p = 0.002$) after adjustment for gender. Data for individual communities are presented in Tables A9.4A-F.

When participants were categorized according to BMI status, all cardiovascular factors considered (blood pressure, high-LDL cholesterol, low-HDL cholesterol, high triglycerides, diabetes and metabolic syndrome) follow a dose-response relationship with BMI status (except for LDL-C in women).

Obesity has a key role in the development of T2D. Thus, we examined its distribution in participants already diagnosed with a T2D. When we combined seven communities, the vast majority of participants (81%) with diabetes were obese (i.e., BMI ≥ 30 kg/m^2). Furthermore, most of the participants (83%) with blood glucose levels (measured during the study) in the diabetes range (≥7.0 mmol/L) were obese.

Hyperinsulinemia is a known precursor to pre-diabetes and diabetes. We examined the measured plasma insulin concentrations by BMI categories, gender and age**.** In order to increase precision of this analysis, we merged the data from the seven communities surveyed in 2005-2009. Although not reported (but see Tables 6.3 and 6.5), compared to males, higher insulin levels were observed in women across all BMI categories ($p = 0.009$). Globally, insulin levels were positively associated with BMI in both adults and children ($p < 0.0001$).

Fasting insulin concentrations were also analyzed according to glycaemia status, age and gender. Generally, a positive gradient was observed between glycaemia and insulinemia. However, even those participants classified as having normal glycaemia still had high levels of insulin (even children), and are therefore at increased risk of developing diabetes (Table 6.6). The evaluation of T2D prevalence data summarized in this table were evaluated in the following ways: 1) analysis of blood samples collected during the onsite research study clinical session; and 2) information collected in the medical files of participants. Participants were advised to fast for at least eight hours prior to blood sampling. Both blood glucose and insulin were evaluated. The Canadian Diabetes Association's cut-off levels were used to classify the study population according to blood glucose levels. The data in Tables A9.5A-D compare both assessments in each of the 2005-2009 communities surveyed. Through blood sampling we found that overall 10% of adult *Eeyouch* had blood plasma glucose levels in the at-risk-of-diabetes range (6.1-6.9 mmol/L). Prevalence of undiagnosed T2D, defined as having a blood glucose level in the diabetes range (≥7.0 mmol/L) without mention of the disease in their medical file, was only 4.0%. This proportion was quite similar across the communities except in Waswanipi, where more cases were identified. We also found that on average close to one of five participants with T2D adequately controlled their blood glucose level.

TABLE 6.5 PLASMA INSULIN CONCENTRATIONS (PMOL/L) BY GENDER AND AGE ACCORDING TO BLOOD GLUCOSE CATEGORIES IN SEVEN *EEYOU ISTCHEE* COMMUNITIES VISITED

	Female						Male					
Blood fasting glucose	**8-17 years n = 153**		**18-39 years n = 299**		**≥40 years n = 199**		**8-17 years n = 199**		**18-39 years n = 198**		**≥40 years n = 199**	
	Median	**[IQR][a]**	**Mean**	**[95% CI]**	**Mean**	**[95% CI]**	**Mean**	**[95% CI]**	**Mean**	**[95% CI]**	**Mean**	**[95% CI]**
Normal (<6.1 mmol/L)	116.0	101.0	146.0	108.0	121.0	78.0	107.5	79.0	99.5	84.5	116.0	88.0
Suspected IFG (6.1-6.9 mmol/L)	-[b]	-	209.0	111.0	173.0	80.0	266.0	79.0	222.5	205.0	171.0	126.0
Suspected DM (≥7.0 mmol/L)	576	682	229.0	158.0	178.0	137.0	-		149.0	83.0	184.0	136.0

a. Due to the large distribution of the variable for this age group, the median and their IQR interquartile range (difference between the 25 and the 75[th] percentile) are presented.

b. Only one person in this category.

TABLE 6.6 PREVALENCE OF DIAGNOSED, UNDIAGNOSED AND UNCONTROLLED T2D AMONG ALL ADULTS (18 YEARS AND OVER) IN SEVEN *EEYOU ISTCHEE* COMMUNITIES

Community	Sample size[a]	Prevalence (%) of diagnosed T2D[b]	Prevalence (%) of controlled[c] T2D	Prevalence (%) of undiagnosed[d] T2D	Prevalence (%) of overall T2D[e]	Prevalence (%) of at risk of T2D[f]
Mistissini	170	23.5	12.5	2.4	25.9	9.4
Eastmain	95	28.4	7.4	2.1	30.5	5.3
Wemindji	129	16.3	19.0	3.9	20.2	7.0
Waskaganish	91	9.9	0.0	4.4	14.3	12.1
Chisasibi	150	14.0	4.8	2.0	16.0	12.0
Whapmagoostui	83	13.3	27.3	2.4	15.7	12.0
Waswanipi	86	24.4	23.8	14.1	38.5	12.8
All communities	804	18.7	13.3	4.0	22.7	10.0

a. Sample size: All records with valid medical chart review.

b. Prevalence of diagnosed T2D indicated in medical charts.

c. Prevalence of diagnosed T2D with normal fasting plasma glucose (≤6 mmol/L) during the study.

d. Prevalence of undiagnosed T2D (no mention of T2D in medical charts) with elevated fasting plasma glucose (≥7 mmol/L) during the study.

e. Total prevalence of diagnosed T2D indicated in medical charts + undiagnosed T2D (no mention of T2D in medical charts) with elevated fasting plasma glucose (≥7 mmol/L) during the study.

f. Prevalence (%) of undiagnosed T2D (no mention of T2D in medical charts) with fasting plasma glucose between 6.1-6.9 mmol/L during the study.

6.6.2 Discussion obesity and diabetes

Extremely high prevalences of abdominal obesity, based on waist circumference, were observed for adult participants in the nine *Eeyou Istchee* communities visited; all averages were above 85%, except in Waskaganish where it was slightly lower. Similarly, global rates of obesity defined by BMI above 30 kg/m^2 were also alarmingly high with prevalences of more than 70%; Waskaganish again was the exception, where it was 54%. These obesity proportions are considerably higher than among the Inuit (22%) and in the general Canadian population (14%) (Mongeau et al., 2005; Dewailly et al., 2007). We also observed elevated plasma insulin concentrations, particularly in women and young girls. Similar levels of fasting insulin have been reported in girls from an Oji-Cree community in north-western Ontario (Retnakaran et al., 2006a,b). These observations for children are of particular concern since for them hyperinsulinemia and obesity can be predictive of diabetes in adulthood. In light of these results, community-based intervention programs should be intensified in order to address the high prevalence of these metabolic risk factors in Cree children.

Even if the study was not designed to address the surveillance of type 2 diabetes in the *Eeyou Istchee* population, we determined the prevalence of this disease among adult participants from the seven communities visited in 2005-2009. The data for Oujé-Bougoumou and Nemaska were excluded because we did not collect information from the medical files there. Nevertheless, our findings are consistent with previous diabetes screenings in the *Eeyou Istchee* communities by the CBHSSJB (Kuzmina et al., 20007). In the latter study, the age-adjusted prevalence for the entire adult population was 25.5% *versus* 22.7% in our *Nituuchischaayihtitaau Aschii* study. This consistency reassured us concerning the results obtained for undiagnosed T2D, which was 4.0% for the entire region.

As observed in other studies, including Kuzmina et al. (2007), women had a higher prevalence of T2D than men. Our results also show that women had a higher prevalence of diabetes risk factors, such as obesity and hyperinsulinemia. Tentative explanations include the higher rate of obesity among women and possibly genetic susceptibility. These results imply that a particular effort should be made to focus on prevention programs for young women and girls.

In conclusion, the significant morbidity associated with the high rates of obesity documented in our study call for an intensification of existing programs to reduce obesity in *Eeyou* adults and children. Considering the influence of obesity as a risk for developing T2D and the associated macrovascular complications, we can anticipate that CVD is likely to increase in the future. Whether or not contaminants play a significant role in this epidemic needs to be shown.

6.7 Osteoporosis

In total, 254 women aged between 35 and 74 years were investigated for bone quality. The mean age was 48. Forty-one percent of the participants were postmenopausal and only 3% of them were taking hormonal medication; 59% were peri-menopausal, of whom 25% used oral contraceptives. Age was the main risk factor that explained roughly 32% of bone density variations in participating *Eeyou* females.

Z-and T-scores were used to compare bone density. A Z-score is a comparison of a person's bone density to what is normal, adjusting for age and sex. The proportion of women with low Z-scores was 17% in women aged 50 and over, and 15% in those younger than 50. While a Z-score alone is not used to diagnose osteoporosis, low Z-scores (-1.0 or less) can sometimes be a hint to look for other osteoporosis risk factors. A T-score is a comparison of a person's bone density with that of a healthy 30-year-old of the same sex. A T-score of -2.5 or lower in postmenopausal women qualifies as high-risk of osteoporotic fracture. The prevalence of postmenopausal women at high fracture risk in our sample was 14%. T-scores or Z-scores cannot be used interchangeably and cannot be compared. These results suggest that bone quality in *Eeyou* women is satisfactory and is comparable with that reported for women living in the southern part of Québec (Côté et al., 2006).

Concerning the multivariate analysis performed on data from the seven *Eeyou Istchee* communities, three factors were significant ($p < 0.05$) and negatively associated to ultrasound (QUS) parameters: age, tobacco use and height. In the broadband attenuation (BUA in dB/mHz) multivariate model, two variables were significant: namely, age (as a risk factor) and weight (a protective factor).

6.8 Thyroid Hormones

An imbalance in iodine nutritional status can lead to thyroid diseases. Our aim was to evaluate iodine status and thyroid function in our *Nituuchischaayihtitaau Aschii* study.

Among the 1751 participants of the cohort, 1211 were aged 15 or over. Spot urine samples for iodine analysis were obtained along with blood plasma samples for assessing thyroid stimulating hormone (TSH), as well as information on their personal history of thyroid disease through the clinical questionnaire. We measured urinary iodine concentrations using the ICP-MS technique. To evaluate iodine nutritional status according to WHO standards, we calculated the median value of urinary iodine concentrations according to sex, age and community. Frequencies of strict euthyroidism (0.4 mU/L ≤ TSH < 4.0 mU/L), thyroid dysfunction (TSH ≥ 4.0 mU/L or TSH < 0.4 mU/L), elevated TSH (≥ 4.0 mU/L) or low TSH (TSH < 0.4 mU/L) were evaluated. Subclinical hypothyroidism was defined as high TSH (5-20 mU/L) and normal free T4 (9-25 pmol/L).

Among participants who provided information on their personal history of thyroid disease (n = 910), goiter was reported by 4 participants, hypothyroidism by 30 participants (22 women and 8 men), and hyperthyroidism by 11 (7 women and 3 men). Urinary iodine analyses were carried out for the remaining 746 individuals. The overall median urinary iodine concentration was 111 µg/L, with values of 114 µg/L for men and 110 µg/L for women. For women, the median concentrations by age were as follows: 152 µg/L, 108 µg/L and 108 µg/L, respectively for ages 15-17 (n = 37), 18-49 (n = 302), and 50 and over (n = 108). Among men, similar results were observed: medians of 120 µg/L among 15-17 year olds (n = 39), 104 µg/L for ages 18-49 (n = 208), and 127 µg/L among those over 50 (n = 77). Interpretation of these medians relative to WHO classification indicated optimal urinary iodine, indicating adequate iodine intake across all age groups. Assessment of thyroid function was done among a subgroup of 1181 individuals. Subclinical hypothyroidism (high TSH and normal free T4) was found in 4.6% (n = 5) of individuals aged 15-17, in 3.1% (n = 26) of those between 18-49, and 9.3% (n = 23) of individuals over 50.

According to the present study, the population of *Eeyou Istchee* communities appears iodine replete, with adequate iodine intakes across generations and similar medians of urinary iodine concentration between men and women. A high frequency of subclinical hypothyroidism was evidenced among individuals over 50, but this is usual for this age group.

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7. ZOONOSES

(Hugues Sampasa-Kanyinga, Benoit Lévesque, Elhadji Anassour-Laouan-Sidi, and others)

7.1 Introduction

The traditional eating habits of the Cree are based on everything that nature offers in their territory including a range of game meats, fish and wild berries. However their dietary regime has changed dramatically in the past 25 years, mainly due to hydroelectric and other northern development activities. Despite this, the Cree remain attached to their traditional practices of hunting, fishing and trapping. These activities keep them in close contact with wildlife but also expose them to the potential risk of zoonotic diseases.

Zoonoses are important public health concerns. It has recently been estimated that 75% of emerging infectious diseases in humans during the last 10 years were caused by pathogens from animals or animal products (WHO, 2004). ***Thus it is important*** to periodically monitor the prevalence of some zoonotic pathogens in the Cree communities. The pathogens targeted for the study were chosen based on the long-term persistence of antibodies, permitting past infections, as well as known or likely epidemiological risks, to be documented. The selection of zoonoses for inclusion in the study was made in collaboration with Québec public health authorities in *Eeyou Istchee*.

From 2005 to 2009, four different datasets were collected in seven Cree communities in Québec. The data for Mistissini (Bonnier-Viger, 2007; Lévesque et al., 2007) and for Eastmain and Wemindji (Bonnier-Viger et al 2011; Campagna et al., 2011) have already been published. The objectives of the current chapter are to describe the results of the four last communities investigated (Chisasibi, Waskaganish, Waswanipi, Whapmagoostui) and to provide an overview of the seroprevalence for the targeted zoonoses in all communities investigated. The data for these four communities are provided in Appendix 10.

7.2 Methods

Data were collected in seven of the nine Cree communities in the province of Québec at four different time points: Mistissini in 2005, Eastmain and Wemindji in 2007, Chisasibi and Waskaganish in 2008, and Waswanipi and Whapmagoostui in 2009. Except for the Mistissini study, which focused on hunters and their wives, samples in other investigations were selected from the general population. People aged 18 years or older were eligible for inclusion, except in Eastmain/Wemindji where the age criterion was 15 years or older. After providing written informed consent, participants answered three questionnaires. The information gathered focused on demographic characteristics (age, sex, education, community of residence, occupation), presence of pets at home and characteristics related to hunting and trapping (fur and meat handling, wearing gloves, number of years of hunting activities, camping activities, forest activities, species and number of animals killed or captured over the last year).

The zoonoses targeted included three bacterial infections (*Coxiella (C.) burnetii*, *Francisella (F.) tularensis*, *Leptospira* sp.) and four parasitic infections (*Echinococcus (E.) granulosus*, *Toxocara (T.) canis*, *Toxoplasma (T.) gondii*, *Trichinella* sp.). The *Sin Nombre* virus was also targeted in Mistissini and Eastmain/Wemindji along with two viruses of the California serogroup, specifically the Jamestown Canyon (JC) and Snowshoe hare (SSH). They were also screened for in the other four communities.

Immunoglobulin G (IgG) antibodies against *Trichinella* sp., *T. canis*, *E. granulosus* (SCI Inc., Carlsbad, CA), *T. gondii* (AxSYM, Abbott Diagnostics, Abbott Park, IL), *Leptospira* sp. and *C. burnetii* (Virion / Serion; Serion Immundiagnostica GmbH, Würzburg, Germany) were detected by enzyme-linked immunosorbent assay (ELISA). Antibodies against *F. tularensis* were detected by tube agglutination testing (Stewart, 1981; Snyder, 1980). For California serogroup viruses in Eastmain/Wemindji, non-commercial ELISAs were undertaken to detect IgM and IgG (Martin et al., 2000). The presence of JC- and SSH-specific antibodies in ELISA-positive samples was confirmed by plaque reduction neutralization tests (PRNT). The same methods were employed in Chisasibi/Waskaganish, but IgM was not tested. Finally after protocol modifications at the National Microbiology Laboratory, only in Waswanipi and Whapmagoostui was PRNT conducted directly to detect IgG antibodies against the California serogroup viruses. Samples with PRNT titers ≥20 were deemed to be positive, and when serum was positive for both viruses (JC and SSH), exposure was attributed to the virus with the highest titers; lower titers were considered indicative of cross-reactions. If equal titers (≥1:20 dilution) were found for both viruses, the subject was considered positive for the California serogroup with unspecified viral type. IgG ELISA sensitivity to California viruses was evaluated by comparison to PRNT testing for 60 samples (40 positive and 20 negative), selected randomly from Waswanipi and Whapmagoostui (approximately equal numbers from each community). Criteria for the interpretation of the serologic analyses are presented in Table 7.2.1.

TABLE 7.2.1 CRITERIA FOR THE INTERPRETATION OF SEROLOGIC ANALYSES

Pathogens	Criteria		
	Negative	Equivocal	Positive
Optical density			
Trichinella sp.	<0.25	≥0.25 to <0.35	≥0.35
Toxocara canis	<0.25	≥0.25 to <0.35	≥0.35
Echinococcus granulosus	<0.35	≥0.35 to <0.45	≥0.45
Sin Nombre virus (IgG-IgM): serum diluted 1:400	<0.30	≥0.30 to <1.0	≥1.0
IgG (IU/ml)			
Leptospira sp.	<5	≥5 to ≤9	>9
Coxiella burnetii	<20	≥20 to <30	≥30
Toxoplasma gondii	<2	≥2 to <3	≥3
Titers			
Francisella tularensis	<1/20	-	≥1/20
California serogroup[a]	<1/20	-	≥1/20

a. Serology for Snowshoe hare and Jamestown Canyon viruses. These titers correspond to confirmatory serology by PRNT on serum samples diluted 1:400; IgG-IgM for Eastmain/Wemindji and IgG only for Chisasibi/Waskaganish. Only PRNT was performed to detect IgG antibodies against California serogroup viruses in serum diluted 1:2 for Waswanipi/Whapmagoostui.

The medical records of all subjects with one or more positive serology results were reviewed to identify clinical manifestations potentially related to zoonotic exposure(s). Records were audited according to presumed antibody persistence: the last five years, for persons with serology tests positive for *C. burnetii*, *Leptospira* sp., and *Trichinella* sp., and 10 years, for those who tested positive for *F. tularensis*, *T. canis*, *T. gondii*, *E. granulosus* and California serogroup viruses.

Given the importance of timing in zoonoses, the seroprevalence data were stratified by year of collection and by community. For the data concerning the last four communities (2007 and 2009), proportions of selected characteristics (questionnaire and seroprevalence data) were compared between the two communities for each study year using the Chi-square test or Fisher's exact test as appropriate (i.e., Chisasibi versus Waskaganish and Whapmagoostui versus Waswanipi). The seroprevalence data were stratified by community. A variable "zoonosis" was created to describe results positive for any of the pathogens tested and to verify the global effect of independent variables on seropositivity for at least one pathogen. Zoonoses with overall seroprevalence ≥5% in the two paired communities were included. Any comparison between the two paired communities with $p \leq 0.05$ values resulted in a parallel analysis in each community. For zoonoses with seroprevalence ≤5% overall but >5% in one community, analysis was restricted to that community. Relationships between seropositivity for zoonotic infections and both socio-demographic and wildlife exposure variables were assessed by univariate logistic regression. Variables with $p \leq 0.1$ values were included in a multivariate logistic regression model. The statistical significance threshold for multivariate models was set at 0.05. The results are reported as odds ratios (ORs). To present an overview of the results of the seroprevalence data for all the communities, the prevalence of exposure to the different pathogens and their 95% confidence intervals (95% CI) were calculated.

7.3 Results

7.3.1 Chisasibi and Waskaganish

A total of 267 participants, 18 years old and over, provided blood samples for this study: 166 from Chisasibi and 101 from Waskaganish. For this age group, participation rates were 32.5% and 31.1% among residents of Chisasibi and Waskaganish, respectively. The average age of all participants was 39±15 years (range: 18-87). Ninety-eight women (mean age: 38±15 years, range: 18-87) and 68 men (mean age: 44±16 years, range: 18-81) were from Chisasibi, and 59 women (mean age: 37±14 years, range: 18- 81) and 42 men (mean age: 36±13 years, range 18-66) were from Waskaganish.

Table A10.1 reports the frequency of key variables in both communities. Overall, it is noteworthy that the study population of Chisasibi was slightly older ($p = 0.05$). Very few were cat owners, but owning a cat was more common in Waskaganish ($p < 0.01$). Several activity variables indicated that participants from Chisasibi had more contact with wildlife (handling animals other than herbivores, staying in the forest during the last year) than those from Waskaganish.

Table A10.2 presents the results of serological analyses. Overall, 54% of participants showed serologic signs of at least one zoonosis. The most prevalent pathogens were *Leptospira* sp. (23%), *F. tularensis* (18%), California JC virus (17%) and *T. gondii* (9%). The overall seroprevalence rate for California SSH virus was 4%, but no participants manifested evidence of exposure to both JC and SSH viruses. Seroprevalence rates for the bacterium *C. burnetii* and the parasite *T. canis* were both below 5%. Less than 1% (0.7%) had *E. granulosus*, and none tested positive for *Trichinella* sp. in either community.

Table A10.3 summarizes data from the medical records of participants with ≥1 positive serology. Clinical manifestations consistent with exposure, suggested by serology results, were documented for *C. burnetii*, *Leptospira* sp., *F. tularensis* and *T. canis* in a small number of subjects. By contrast, the medical records of patients seropositive for *E. granulosus*, *T. gondii* and California serogroup viruses did not reveal any history of symptoms or signs suggestive of infection.

Statistically significant differences in seroprevalence rates between the two communities were apparent for *Leptospira* sp., *T. canis*, *T. gondii* and JC virus (Table A10.2). *Leptospira* sp. and *T. gondii* seropositivity was higher in Chisasibi, while participants from Waskaganish appeared to have had more exposure to *T. canis* and JC virus. Analysis of seroprevalence rates by sex and age group in each community indicated that women were more exposed to *F. tularensis* in Waskaganish (women, 31%; men, 10%; $p = 0.02$), while men were more exposed to JC virus in Chisasibi (women, 8%; men, 20%; $p = 0.02$). There was statistically significant interaction between age and community for *Leptospira* sp. ($p < 0.01$) and *F. tularensis* seropositivity ($p = 0.02$). *Leptospira* sp. seroprevalence was higher among people over 40 years old (<40 years, 22%; ≥40 years, 32%) in Chisasibi, but lower in the same age group in Waskaganish (<40 years, 22%; ≥40 years, 5%). This relationship was inverse for *F. tularensis* seropositivity: prevalence was higher among those 40 years and older (<40 years, 18%; ≥40 years, 29%) in Waskaganish, and lower in the same age group in Chisasibi (<40 years, 19%; ≥40 years, 12%).

Table A10.4 reports the significant predictive variables identified by multivariate analysis for the two communities, combined or stratified by community, based on the analytical criteria.

7.3.2 Waswanipi and Whapmagoostui

In total, 180 participants (Waswanipi: 91; Whapmagoostui: 89) provided blood samples for this part of the study. The average age of all participants was 41.2±16.8 years, ranging from 18 to 89 years. Fifty women (mean age: 41.0±17.0 years; range: 18-77 years) and 41 men (mean age: 42.8±17.3 years; range: 18-78 years) were from Waswanipi, and 51 women (average age: 38±15years; range: 18-81 years) and 38 men (mean age: 39±16.9 years; range: 18-89 years) were from Whapmagoostui. Participation rates were 28.5% in Waswanipi and 39.4% in Whapmagoostui among residents aged 18 years and older. Table A10.5 describes the frequency of key variables in both communities. Overall, there was not much difference between the two communities, except that more participants from Waswanipi practiced hunting and trapping as their main activity in the woods during the spring ($p = 0.05$) and had more contact with large predators ($p = 0.02$). Table A10.6 summarizes the serology results on 9 zoonotic infections. Among the 180 participants, 142 (79%) tested positive for at least one pathogen: 75 (38 women, 37 men) in Waswanipi and 67 (39 women, 28 men) in Whapmagoostui. The most prevalent pathogens were *F. tularensis* (31%), California serogroup virus SSH (28%) and JC (21%), *Leptospira* sp. (13%) and *T. gondii* (12%). Overall prevalence of the California viruses (JC, SSH and an unidentified serogroup) was 55% (98/179), with a higher global prevalence in Waswanipi (p < 0.01). *E. granulosus*, *T. canis* and *Trichinella* sp. seroprevalence rates were below 5%, and no subject tested positive for *C. burnetii* in either community. The prevalence of infection by California SSH virus was significantly different statistically between the two communities (p < 0.01) (Table A10.6). SSH virus seropositivity was higher in Waswanipi. Participants from Whapmagoostui seemed to be more exposed to *F. Tularensis,* but the difference was not statistically significant (p = 0.06).

Table A10.7 summarizes data from the medical records of participants with a positive serology. Clinical manifestations consistent with exposure, indicated by the serologic results, were documented for *Leptospira* sp., *F. tularensis* and *T. gondii*. The records of patients with serology positive for *E. granulosus* and California serogroup viruses showed no signs or symptoms suggesting infection.

Table A10.8 reports significant predictive variables identified by multivariate analysis for both communities combined, and stratified according to the analytical criteria. Some risk factors were associated with zoonoses investigated in this study. Overall, age (older) was the only variable linked with evidence of exposure to at least one pathogen (zoonosis). Handling wolves was the only variable linked to *F. tularensis*. Nevertheless, the width of the confidence interval indicates a problem concerning the precision of this relationship. Younger people and women appeared to be protected from toxoplasmosis, whereas handling small predators was associated with this infection. Factors such as coming from Waswanipi and the failure to wear gloves when handling animals were connected with California SSH virus.

7.3.3 The seven communities combined

Table 7.3.1 presents the results of serologic analyses for all the communities. Participation rates of the total adult populations (18 years or older for all studies, except in Eastmain/Wemindji, where the criterion was 15 years or older) ranged from 28.5% to 60.1% (57.5% in Eastmain, 60.1% in Wemindji, 32.5% in Chisasibi, 31.1% in Waskaganish, 28.5% in Waswanipi, and 39.4% in Whapmagoostui). Overall, participants who had serologic evidence of at least one zoonosis ranged from 42% in Wemindji to 82% in Waswanipi. Variations in seroprevalence rates were relatively high for the different pathogens, particularly for SSH virus (1-42%), *F. tularensis* (14-37%), *Leptospira* sp. (10-27%), JC virus (9-24%), *C. burnetii* (0-18%), *T. gondii* (4-12%), and *T. canis* (0-10%). Seroprevalence rates of less than 5% were observed for *E. granulosus* (0-4%) and *Trichinella* sp. (0-1%). As a whole, seroprevalence rates were lower for the parasitic zoonoses. No subject showed serologic evidence of Sin Nombre virus exposure in the three communities where it was investigated.

TABLE 7.3.1 SEROPREVALENCE (PERCENTAGE WITH 95% CONFIDENCE INTERVAL) OF ZOONOSES IN *EEYOU ISTCHEE*

	Waswanipi/Whapmagoostui 2009		**Chisasibi/Waskaganish** 2008		**Eastmain/Wemindji** 2007		**Mistissini** 2005
	Waswanipi (n = 91)	**Whapmagoostui** (n = 89)	**Chisasibi** (n = 166)	**Waskaganish** (n = 101)	**Eastmain** (n = 111)	**Wemindji** (n = 140)	(n = 50)
Coxiella burnetii	0	0	6 (2.5-10.2)	2 (0.2-7.0)	1 (0.02-4.9)	2 (0.5-6.2)	18 (8.6-31.4)
***Leptospira* sp.**	10 (3.8-16.0)	19 (9.1-24.6)	27 (20.2-34.3)	16 (9.43-24.7)	21 (13.6-29.5)	25 (18.2-33.2)	14 (5.8-26.7)
Francisella tularensis	24 (15.4-33.0)	37 (27.0-47.1)	16 (10.6-22.4)	22 (14.3-31.4)	20 (12.9-28.5)	14 (9.1-21.5)	26 (16.0-43.5)
Echinococcus granulosus	4 (0.1-8.6)	3 (0.0-7.1)	1 (0.02-3.4)	1 (0.0-5.4)	4 (1.5-10.2)	3 (0.8-7.2)	0
Toxocara canis	6 (0.0-10.2)	0	1 (0.02-3.4)	10 (4.9-17.5)	5 (2.0-11.4)	1 (0.2-5.1)	4 (0.5-13.7)
Toxoplasma gondii	12 (6.2-20.6)	12 (6.3-21.0)	12 (7.7-18.3)	4 (1.1-9.9)	5 (2.0-11.4)	5 (2.0-10.0)	10 (3.3-21.8)
***Trichinella* sp.**	0	1 (0.0-3.3)	0	0	0	2 (0.5-6.2)	0
California serogroup[1]	65 (55.0-74.7)	44 (33.9-54.7)	17 (11.1-23.0)	29 (20.2-38.6)	10 (3.8-14.8)	9 (5.0-15.4)	–
JC virus	19 (10.7-26.7)	24 (14.8-32.4)	13 (8.6-19.6)	23 (15.0-32.2)	10 (3.8-14.8)	9 (4.5-14.5)	–
SSH virus	42 (31.6-51.9)	14 (6.4-20.6)	3 (1.0-7.0)	6 (2.2-12.5)	3 (0.2-6.4)	1 (0.2-5.1)	–
***Sin Nombre* virus**	–	–	–	–	0	0	0
Zoonosis[2]	82 (74.6-90.2)	75 (66.3-84.2)	51 (45.4-60.7)	60 (55.6-74.4)	50 (41.0-59.9)	42 (34.1-50.8)	46 (31.2-60.5)

1. Serology tested for Snowshoe hare (SSH) and Jamestown Canyon (JC) viruses

2. Results positive for any of the pathogens tested.

Table 7.3.2 compares the IgG ELISA and PRNT results on California viruses for inhabitants from Waswanipi and Whapmagoostui. Forty positive (JC or SSH) and 20 negative samples on PRNT were tested by IgG ELISA. The 20 negative sera remained negative upon retesting by both PRNT and IgG ELISA. Of 21 PRNT-confirmed JC samples, 18 were positive on IgG ELISA (85.7%). Of 19 PRNT-confirmed SSH exposures, 13 were positive on IgG ELISA (68.4%). Overall, the California virus (JC+SSH) IgG ELISA had a sensitivity of 77.5%.

TABLE 7.3.2 COMPARISON FOR WASWANIPI AND WHAPMAGOOSTUI OF IGG ELISA AND PRNT[1] SENSITIVITY FOR CALIFORNIA VIRUS

Antibody Confirmation		IgG ELISA + n	IgG ELISA – n	Total n
PRNT +	JC[2]	18	3	21
	SSH[3]	13	6	19
PRNT -	(JC+SSH)[4]	0	20	20
Total n		31	29	60

1. PRNT: plaque reduction neutralization technique

2. JC IgG ELISA sensitivity = 18/21 = 85.7%

3. SSH IgG ELISA sensitivity = 13/19 = 68.4%

4. California virus IgG ELISA sensitivity (JC+SSH) = 31/40 = 77.5% and (JC + SSH) IgG ELISA specificity of 20/20 = 100%

Table 7.3.3 summarizes data from the medical records of participants with ≥1 positive serologic test. Clinical manifestations consistent with exposure, as suggested by serologic results overall, were documented primarily for bacterial infections (*F. tularensis*, *Leptospira* sp., *C. burnetii*). Few compatible clinical manifestations were documented for infections by parasites or viruses.

TABLE 7.3.3 COMPATIBLE CLINICAL MANIFESTATIONS FOUND IN MEDICAL RECORDS OF PARTICIPANTS WITH POSITIVE SEROLOGY FOR INFECTIONS IN *EEYOU ISTCHEE* (2005-2009)[1]

	Waswanipi/Whapmagoostui 2009	**Chisasibi/Waskaganish** 2008	**Eastmain/Wemindji** 2007	**Mistissini** 2005
Coxiella burnetii[2]	No symptoms or signs (n = 0)	Atypical pneumonia (5/11; 45.5%)	Atypical pneumonia (1/4; 25.0%)	Atypical pneumonia (1/9; 11.1%)
***Leptospira* sp.**[2]	Conjunctivitis (1/24; 4.2%)	Uveitis (1/60; 1.7%)	Uveitis (3/58; 5.2%)	No symptoms or signs (n = 7)
	Subconjunctival hemorrhage (1/24; 4.2%)	Flu-like syndrome (1/60; 1.7%)	Influenza-like illness (1/58; 1.7%)	
Francisella tularensis[3]	Conjunctivitis (3/55; 5.5%)	Conjunctivitis (3/48; 6.3%)	Conjunctivitis (3/42; 7.1%)	Infected inguinal lymph node (1/13; 7.7%)
	Pharyngitis (1/55; 1.8%)	Pharyngitis (4/48; 8.3%)	Pharyngitis (6/42; 14.3%)	
	Atypical pneumonia (3/55; 5.5%)	Atypical pneumonia (2/48; 4.2%)	Adenopathy (1/42; 2.4)	
	Skin ulcers (2/55; 3.6%)			
	Adenopathy (1/55; 2.0%)			
Echinococcus granulosus[3]	No symptoms or signs (n = 7)	No symptoms or signs (n = 2)	No symptoms or signs (n = 9)	No symptoms or signs (n = 0)
Toxocara canis[3]	No symptoms (n = 5)	Eosinophilia (2/11; 18.2%)	No symptoms or signs (n = 8)	No symptoms or signs (n = 2)
Toxoplasma gondii[3]	Flu-like syndrome (1/22; 4.6%)	No symptoms or signs (n = 24)	No symptoms or signs (n = 13)	No symptoms or signs (n = 5)
***Trichinella* sp.**[2]	Eosinophilia (1/1; 100%)	No symptoms or signs (n = 0)	Abdominal pain and eosinophilia (1/2; 50.0%)	No symptoms or signs (n = 0)
California serogroup virus[3]	No symptoms or signs (n = 98)	No symptoms or signs (n = 56)	Intense long-lasting headache (1/24; 4.2%)	--[4]

1. Clinical manifestations are shown (i.e., number of cases/number of seropositive participants; %). When there was no history of symptoms or signs suggesting infection, the number of seropositive participants (n) was provided;
2. Verified for the last 5 years;
3. Verified for the last 10 years;
4. California serogroup virus was not verified in Mistissini.

7.4 Discussion

7.4.1 The four last communities surveyed

7.4.1.1 General comment

The study sample was selected as being representative of the general Chisasibi, Waskaganish, Waswanipi and Whapmagoostui populations. However, because participation rates were 32.5% in Chisasibi, 31.1% in Waskaganish, 28.5% in Waswanipi and 39.4% in Whapmagoostui, the results presented here should be interpreted with caution relative to the entire population.

The samples from Chisasibi and Waskaganish differed slightly in the age of participants and their overall relationship with wildlife; those from Chisasibi were older and more exposed to wildlife (Table A10.1). These differences between the two communities may explain some variations in seroprevalence rates for the various pathogens. Only a few differences were observed in potential risk factors between Waswanipi and Whapmagoostui [specifically, handling of large predators was more frequent in Waswanipi ($p = 0.02$) and spring hunting was higher ($p = 0.05$) in Whapmagoostui (Table A10.5)].

More than half of the participants from Chisasibi and Waskaganish (54%) were seropositive for at least one of the zoonotic organisms studied (variable zoonosis). This proportion, which is lower than the 79% documented among participants in Waswanipi and Whapmagoostui, was mainly related to the high prevalence of infection by California serogroup viruses (especially SSH). Only in the latter two communities was the PRNT detection technique employed, which is more sensitive than IgG ELISA. We will discuss this methodological issue in the section dedicated to the discussion for all seven communities.

7.4.1.2 Comments on the different pathogens investigated

Gender (women) was the only variable associated with exposure to *F. tularensis* ($p < 0.01$) in Chisasibi and Waskaganish (Table A10.4). This relationship may be linked to culinary activities (e.g., food preparation, meat manipulation). The significant interaction between age and community observed in this study is difficult to explain, but participants from these two communities were very different with respect to age and exposure to wildlife (Table A10.4). In Waswanipi and Whapmagoostui, however, we documented linkage between handling wolves and evidence of exposure to *F. tularensis* (Table A10.8). The width of the confidence interval indicates an issue concerning the precision of this relationship, given that only 10 participants (5.6%) reported that they handled wolves. Nevertheless, some evidence suggests that wolves may indeed be potential sources of infection (Zarnke et al., 2004; Zarnke and Ballard, 1987). The relatively benign clinical histories of participants seropositive for *F. tularensis* (Tables A10.3 and A10.7) may imply that the Cree are exposed to the less virulent subspecies holartica (type B) (Tarnvik, 1989; Eigelsbach and McGann, 1984).

Leptospira sp. seropositivity also showed significant interaction between age and community ($p < 0.01$), for unclear reasons, in Chisasibi and Waskaganish. Community was also a significant variable in *Leptospira* sp. seroprevalence ($p = 0.01$), as participants from Chisasibi were more exposed than those from Waskaganish. Moreover, this study identified rabbit handling as a risk factor associated with *Leptospira* sp. seropositivity

(Table A10.4). Shotts et al. (1971) reported 77% seroprevalence of leptospirosis in a population of 50 rabbits captured in Mississippi. When stratified by community, our analysis suggests that wearing gloves when handling carcasses has a protective effect against infection in Chisasibi. In Waskaganish, younger participants seem to be more exposed to *Leptospira* sp. infection. In the absence of good data on antibody persistence, this finding is hard to interpret in a cross-sectional study. A history of spring hunting tended to be coupled with infection in Waskaganish, but the data are very imprecise. Spring hunting activities focus on birds and involve frequent contact with water, possibly explaining the association with leptospirosis. Indeed, it is well-known that leptospirosis is associated with aquatic activities (Mumford, 1989). We noted one case of a flu-like syndrome, one case of uveitis (Table A10.3), one case of conjunctivitis and a history of subconjunctival hemorrhage without any trauma (Table A10.7) in people positive for *Leptospira* sp. Martins et al. (1998) reported 19% prevalence of subconjunctival hemorrhage among 21 patients with clinical and laboratory (IgM ELISA) diagnoses of leptospirosis during its acute phase. Moreover, the incidence of ocular signs was found to vary from 2 to 90% during the acute systemic phase of leptospirosis. However, ocular manifestations may be subtle and easily overlooked in this infection (Rathinam, 2005).

Being older was identified as a risk factor for infection by *T. gondii* in Chisasibi, Waskaganish, Waswanipi and Whapmagoostui (Tables A10.4 and A10.8). This association with age is consistent with the lifelong persistence of circulating antibodies in people exposed to *T. gondii* (Bouhamdan et al., 2010; Tenter et al., 2000). We also documented a tendency of stronger *T. gondii* exposure in those who had handled ducks during the last year in Chisasibi and Waskaganish (Table A10.4). Some data suggest that ducks may be potential sources of infection (Boehringer et al., 1962; Bartova et al., 2009). Moreover, women appeared to be protected from toxoplasmosis, whereas handling small predators was associated with this infection in Waswanipi and Whapmagoostui (Table A10.8). Women were less exposed than men to *T. gondii*, probably because the latter were more involved in hunting activities. Of the 104 individuals engaged in hunting and trapping, 70 (67%) were men. The literature suggests that some small predators, such as otter and mink, may be potential sources of infection (Henriksen et al., 1994; Jones et al., 2006; Conrad et al., 2005; Dubey et al., 2003). Among all 66 people seropositive for *T. gondii*, the medical records revealed only one case of flu-like syndrome (Table A10.7).

In Chisasibi/Waskaganish, wearing gloves when handling game animals seemed to be protective against infection by JC virus (Table A10.4). Presumably, wearing gloves when handling carcasses, which are likely to attract mosquitoes, could prevent JC virus transmission. In Chisasibi, hunting in the fall tends to be linked with infection, an association that is hard to explain and may be a chance finding considering the precision of the estimate. Moreover, in the context of the current study, we could not identify risk factors of JC virus seroprevalence in Waswanipi and Whapmagoostui.

Even when considering the variation of methods, SSH virus seroprevalence seems to be particularly high in Waswanipi (Table A10.8). The exposure rate to California viruses can be quite high, especially in areas where many outdoor activities take place in the forest and particularly during the mosquito season. Furthermore, the

SSH virus has many vectors, including Aedes, Culex and Culiseta mosquito species. They infect a wide variety of animals, including squirrels, chipmunks, hares, deer, moose, cattle, horses and pigs (Collier, 2000). In Alaska, small mammals (voles, squirrels, rabbits) have been identified as risk factors associated with SSH virus seroprevalence (Walters et al., 1999). Participants from Waswanipi and those who handled animals without gloves were more exposed to the California SSH virus (Table A10.8). Considering the similar relationship documented for JC virus, the protective nature of wearing gloves is interesting.

Despite the high seroprevalence of California viruses in these four communities, there was no evidence of clinical manifestations compatible with these infections in the medical records (Tables A10.3 and A10.7). Besides encephalitis, which is uncommon, infection by California viruses is often asymptomatic or may cause nonspecific febrile syndrome (Meier-Stephenson et al., 2007), which may go unnoticed.

No antibodies against *C. burnetii* have been detected in the populations of Waswanipi and Whapmagoostui, but the seroprevalence was 4% in Chisasibi/Waskaganish. We identified age (older) as a risk factor associated with *C. burnetii* in Chisasibi (Table A10.4). Such linkage has also been reported in France (Tissot Dupont et al., 1992; Raoult et al., 2000). Pneumonia is a common clinical manifestation of Q fever (Marrie et al., 1985). Interestingly, nearly half of the 11 seropositive participants in Chisasibi/Waskaganish had a history of documented pneumonia (Table A10.3).

The proportion of people exposed to *T. canis* was higher in Waskaganish than in Chisasibi (Table A2). Dogs are the main reservoir of *T. canis* (Mandarino-Pereira et al., 2010; Glickman and Schantz, 1981; Barriga, 1988; Wolfe and Wright, 2003), but only four of 11 participants seropositive for *T. canis* in Chisasibi and Waskaganish declared owning a dog. However, it is possible that the presence of stray dogs may increase the risk of exposure. Although our study identified manipulation of caribou as a risk factor for *T. canis* exposure in Waskaganish, the relative lack of statistical power must be considered. Two of the seropositive individuals from Chisasibi and Waskaganish had histories of unexplained eosinophilia documented without other signs or symptoms indicative of the disease (Table A10.3). No subject tested positive for *T. canis* in Whapmagoostui, but five presented evidence of infection in Waswanipi (Table A10.7). We did not find either signs or symptoms suggestive of toxocariasis in the medical records of these people.

In total, nine people had *E. granulosus*-positive serology; one each in Chisasibi and Waskaganish versus four in Waswanipi and three in Whapmagoostui (Tables 7.3.1, A10.3 and A10.7). We did not find either signs or symptoms suggestive of echinococcosis in the medical records of these nine seropositive individuals.

No evidence of antibodies against *Trichinella* sp. was detected in the populations of Chisasibi, Waskaganish and Waswanipi (Tables A10.2 and A10.6), and only one case in Whapmagoostui (Table A10.6) with presentation of hypereosinophilia (Table A10.7). These data indicate infrequent exposure to this parasite.

A high proportion of participants were positive for at least one pathogen. Serologic evidence of exposure to one or more pathogens (variable zoonosis) in Waswanipi and Whapmagoostui appeared to be greater among older people (Table A10.8). This association with age is probably due to the persistence of antibodies in blood for most infections, as well as prolonged exposure in the elderly. However, we did not find any factor relating to the variable zoonosis in Chisasibi and Waskaganish (Table A10.4).

7.4.2 The seven communities

Given the varying participation rates in these different studies, which can influence the external validity of results, comparisons between the documented prevalence rates should be interpreted with caution. Nevertheless, data from such studies can help to estimate the relative importance of the findings reported here, and we believe that the current paper provides a contemporary portrait of zoonotic infections in the major Cree communities.

More than three-quarters of the total population studied was seropositive for at least one of the zoonotic organisms among participants, as much as 75% in Whapmagoostui and 82% in Waswanipi. The rate in Waswanipi was significantly higher than in other communities, except Whapmagoostui. In turn, the rate for the latter was significantly higher than in Chisasibi, Eastmain, Wemindji and Mistissini. The high rates in Waswanipi and Whapmagoostui were mainly related to the high prevalence of infection by California serogroup viruses (especially SSH) using PRNT, which is more sensitive than IgG ELISA. Based on the comparative data shown in Table 7.3.2, the JC IgG ELISA used was only slightly less sensitive than PRNT, while the SSH IgG ELISA would have missed ~ 30% of the positive samples. Overall, our IgG ELISA screening protocol may have missed ~ 20% of positive California serogroup participants, making comparison of global seroprevalence rates difficult between the different communities. When the California viruses were excluded from the computation, 47% and 54% tested positive for at least one pathogen in Waswanipi and Whapmagoostui respectively. These results are more comparable to those from other Cree communities.

Of the infections investigated in this study, leptospirosis, tularemia, Q fever, trichinellosis, hantavirus infection and the encephalitides caused by arthropods are all notifiable diseases in the province of Québec. Our serologic results suggest that many participants from the Cree communities under study had been exposed to one or more of these pathogens (*Leptospira* sp., *F. tularensis*, JC and SSH viruses, *C. burnetii* and *Trichinella* sp.). However, not a single case of any of these infections had been reported from the Cree territories between 1990 and 2006 (Carlin 2007), indicating that: individuals had experienced few or no symptoms, had not sought care, and/or had not been appropriately diagnosed. Our review of their medical records occasionally revealed a clinical illness consistent with the implicated infection. Unfortunately, it is impossible to assess or assign causality with certainty retrospectively.

Even when the methods for detecting California viruses were modified, the rates of JC virus seroprevalence were comparable between studies, although the sample size was small. The higher prevalences in

Whapmagoostui (24%) and Waskaganish (23%) suggest an environment for encountering mosquitoes and/or deer. Evidence of exposure to SSH virus was particularly high in Waswanipi (42%). Seroprevalence rates were lower and comparable between other communities (range 1-14%). The latter low range is likely due (at least in part) to the diagnostic methods used in Waswanipi and Whapmagoostui, namely the higher sensitivity of PRNT versus IgG ELISA for the SSH virus. Nevertheless, the overall exposure rate to the California viruses in these communities appeared to be quite high.

Despite the high seroprevalence of California viruses in Cree communities, there was only one case with a history of any compatible clinical manifestations; namely, intense headache lasting many days in the Eastmain/Wemindji study (Table 7.3.3). However infection by California viruses is only rarely overtly symptomatic and, most commonly, causes nonspecific febrile syndrome (Meier-Stephenson et al., 2007) that may go unnoticed.

Exposure to *F. tularensis* in Whapmagoostui was relatively high, and statistically different from seroprevalence rates for this bacterium in Chisasibi and Wemindji. In general, pharyngitis, pneumonia of unknown etiology and conjunctivitis were the most frequently reported compatible clinical manifestations found in the medical records of seropositive people for *F. tularensis*. These clinical presentations are quite common in Cree communities but, as already stated, we cannot be sure that any such cases were caused by *F. tularensis* given the limitations of our study design. Pneumonia is among the most dangerous presentations of tularemia (Gill and Cunha, 1997; Thomas and Schaffner, 2010); it can occur either as a primary process from direct inhalation, or as a secondary manifestation of ulceroglandular or typhoidal disease. Large numbers of pharyngeal disease have been reported recently in a large case series, including an outbreak of 145 cases in Turkey (Meric et al., 2008). By contrast, conjunctivitis in tularemia is thought to be quite uncommon (Steinemann et al., 1999). It may be a result of autoinfection from another infection site, through transfer of the bacteria present there (for example, by the patient's own hands or oral secretions; Barut and Cetin, 2009). As already stated, the absence of clinical manifestations compatible with severe tularemia in *Eeyou Istchee* suggests that less virulent subspecies such as holartica (type B) might be involved.

Leptospira sp. seropositivity was comparable in all communities, although the rates documented in Chisasibi (27%) and Wemindji (25%) were statistically higher than that of Waswanipi, which had the lowest seroprevalence. Ocular signs (uveitis, conjunctivitis and subconjunctival hemorrhage) were the most frequent clinical symptoms documented in the medical records of participants seropositive for *Leptospira* sp. Martins et al. (1998) reported an incidence of ocular signs varying from 2 to 90% during the acute systemic phase of leptospirosis. However, ocular manifestations may be subtle and easily overlooked in this infection (Rathinam, 2005).

Exposure to *C. burnetii* was high among the trappers of Mistissini. Although Waswanipi is geographically relatively close to Mistissini, no antibodies against *C. burnetii* were detected in the Waswanipi population. Therefore, greater exposure of the Mistissini hunters to fauna probably explains the difference. Lévesque et al. (1995) noted a similar seroprevalence rate for *C. burnetii* (15%) among 165 trappers and an equal number of controls in the Québec City area of southern Québec; the latter population was more exposed to domestic and farm animals, known vectors of bacterial infection (Lévesque et al., 1995). Review of the medical records revealed a history of pneumonia for many of the individuals seropositive for *C. burnetii* but, again, causal links were impossible to confirm. A particularly high proportion of the seropositive subjects with this history were observed in Chisasibi and Waskaganish (5 out of 11). In Nova Scotia, Canada and the Basque region of Spain, pneumonia was a predominant manifestation of Q fever (Marrie et al., 1985; Montejo et al., 1985).

The seroprevalence rates of *T. gondii* were statistically comparable in all communities, ranging from 4-12%. These figures are significantly lower than the 59.8% recently reported in the population of Nunavik (Messier et al., 2009), and are even lower than (or in the same range as) those documented in several industrialized countries (Tenter et al., 2000; Nash et al., 2005). Whapmagoostui is located in the same area as the Inuit community of Kuujjuarapik, where seroprevalence was 87% (Messier et al., 2009), yet antibodies to *T. gondii* were found in only 12% of Whapmagoostui residents. The difference in prevalence estimates between the Nunavik and Cree communities is most likely explained by different eating and culinary habits. Inuit consume raw meat regularly, which markedly increases their risk of exposure. Only one person seropositive for *T. gondii* had a flu-like syndrome documented in their medical records.

Globally, *T. canis* seroprevalence was comparable among all sites. However, there were some differences between communities. The proportion of people exposed to *T. canis* was clearly higher in Waskaganish than in Chisasibi and Whapmagoostui. Dogs are the main reservoir of *T. canis* (Mandarino-Pereira et al., 2010; Glickman and Schantz, 1981; Barriga, 1988; Wolfe and Wright, 2003). Two seropositive individuals out of 11 in Chisasibi/Waskaganish had histories of unexplained eosinophilia without other signs or symptoms suggestive of toxocariasis.

Overall, *E. granulosus* seroprevalence was generally below 5% in the Cree territories of Québec. Although a recent study found a higher incidence of echinococcosis among people living north of the 55th parallel (2.9 per million per year) (Gilbert et al., 2010), we could identify only a single published case in the literature among the *Eeyouch* of Québec (in 1955; Begin et al., 1956). A seroprevalence of 3% in a sample of hospitalized Cree patients from several communities was reported during the 1980s by Tanner et al. (1987), and Messier et al. (2007) have noted a relatively high seroprevalence (8%) among the Inuit of Nunavik.

Antibodies against *Trichinella* sp. were not detected in the populations of Waswanipi, Chisasibi, Waskaganish, and Mistissini. Only one seropositive subject was identified in Whapmagoostui and two in Wemindji. These data indicate infrequent exposure to this parasite among the Cree. As noted above, there were two histories of unexplained eosinophilia in our review of the medical records, one of which was associated with abdominal pain that resolved spontaneously.

7.5 Conclusion

The serologic data assembled here strongly suggest that a large proportion of the Cree population of Québec has been exposed to at least one of the targeted zoonotic agents. The *Eeyouch* and the medical staff living in these regions should be aware of these diseases. Greater awareness would help to decrease exposure and assure that suitable diagnostic testing is carried out. Physicians should consider these infectious agents when confronted with difficult or confusing diagnoses, or otherwise unexplained non-specific symptoms such as severe headache (arboviral infections), unexplained or prolonged fevers (tularemia, leptospirosis, Q fever), atypical pneumonias (Q fever, tularemia), long-lasting pharyngitis (tularemia), or severe ocular pathologies (tularemia, leptospirosis).

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8. DRINKING WATER
(Elizabeth Robinson)

8.1 Introduction

Traditionally *Eeyouch* drew water for drinking and washing from rivers, lakes and springs, community wells, or melted snow. It was only in the 1980s, after the signing of the *James Bay and Northern Quebec Agreement* in 1975, that community water and sewage systems brought running water and flush toilets into people's homes. Even today, unlike most communities or societies in Québec, a considerable number of *Eeyouch* spend several days, weeks or months, each year, in hunting camps in the bush, where traditional water sources or bottled water are likely used.

Drinking water contaminated with microbes can lead to severe gastroenteritis, hepatitis A and other illnesses, especially among elders and young children. Surface water (from lakes and rivers) is almost always contaminated with microbes from animal feces, while underground water, from wells, or coming to the earth's surface as springs, is usually (but not always) free of microbes. Community tap water systems use either surface water (from a lake or river) or water from an underground well depending on what is locally available[13]. All surface water used in community water systems has to be treated to kill microbes, either with chlorine or one of several newer methods. Tap water can sometimes be contaminated with microbes, but in the past 10 to 15 years, regular (weekly) testing has been carried out by the Cree Nation Councils, and microbes are rarely found. No outbreaks of infectious disease due to contaminated water have been reported to the CBHSSJB Public Health Department during this period.

Through the *Nituuchischaayihtitaau Aschii* study, the Public Health Department was interested in learning what proportion of people drink tap water and water from various other sources. People had often been heard to say they preferred water from natural sources because of its taste, and that tap water turned tea black. Tap water is usually safe, whereas water from traditional sources can be contaminated by disease-causing microbes unless it is boiled for one minute before using. Commercial bottled water is usually safe, but throw-away bottles and transport from the south make it an environmentally unfriendly choice; perhaps cost is also an issue. Public health dentists consider adding fluoride to community drinking water systems to be an effective measure for preventing dental caries, but it is important to know how many children drink tap water before promoting this measure. (No *Eeyou Istchee* community adds fluoride to their water system at the present time.)

The *Nituuchischaayihtitaau Aschii* study questionnaires included items about sources of drinking water consumed in the community and the bush. (Stores in some communities bottle their own water, but the questionnaire did not differentiate between locally bottled water and bottled water brought in from outside the

[13] At present community water systems in Chisasibi, Wemindji and Waskaganish distribute chlorinated surface water, while the other communities use underground sources (which usually are not chlorinated; source: Alan Penn, Cree Regional Authority).

region.) In Mistissini, Wemindji and Eastmain, a team of researchers from Laval University used new testing methods to look at microbes in the lakes, streams and springs people took drinking water from, as well as in the containers used for storing this water in homes.

8.2 Sources of Drinking Water while *Eeyouch* are Staying in the Community and Bush Camps

Table 8.1 shows that fewer than one quarter of people in Mistissini, Wemindji, Eastmain and Waswanipi reported drinking tap water "all or most of the time." In these communities, over half reported drinking bottled water "all or most of the time." In Chisasibi, Waskaganish and Whapmagoostui, more people – but still only between 40 and 50% – reported drinking tap water "all or most of the time." Bottled water was a second choice in these communities, except in Whapmagoostui where over half of the study participants said they drank water from a spring "all or most of the time." As expected, tap water was not a prominent source when in the bush (all communities), nor was bottled water, except in Waswanipi (57.9% replied "all or most of the time"); while in the bush, drinking spring water was most common in Wemindji, Chisasibi, and Waswanipi (ranging from 40.5-56.2%). In the community, use of lake/river water was registered as a minimal source in most communities, except Mistissini (23.2%) and Whapmagoostui (29.9%), with a mean of 10.8% use for all seven communities combined; in the bush, the use of this source increased substantially (40.9% for all communities combined). The drinking of rain water and melted ice or snow was very low, or did not occur at all in the communities, except rain water in Eastmain (9%); in the bush, ice or snow use was more substantial, especially in Wemindji (30%), Eastmain (40.2%), Chisasibi (22.8%) and Waskaganish (38.4%), with rain water consumption low but reaching 9% in Eastmain.

Oujé-Bougoumou and Nemaska, studied in 2002, reported the highest proportion of people (over two-thirds) drinking tap water "all or most of the time." But the question was asked in a different way in those two communities (see Footnote c of Table 8.1), and this may have influenced the answers.

- I only drink tap water when in the community
- I drink tap water most of the time
- I drink tap water only occasionally
- I never drink tap water

TABLE 8.1 SOURCES OF DRINKING WATER WHILE PEOPLE 8 YEARS OF AGE AND OLDER ARE STAYING IN THE COMMUNITY (OR IN THE BUSH)

	Tap water[a]		Bottled water[a]	From a spring[a]	From a lake/river[a]	Melted ice or snow[a] [or rain][b]
Community and year surveyed[c]	**All or most of the time** %	**Rarely or never** %	**All or most of the time** %	**All or most of the time** %	**All or most of the time** %	**All or most of the time** %
Oujé-Bougoumou – 2002 n = 225	68	n/a	n/a	n/a	n/a	n/a
Nemaska – 2002 n = 100	92	n/a	n/a	n/a	n/a	n/a
Mistissini – 2005 n = 249	14.8 (0.4)	61.5 (91.9)	55.4 (11.3)	33.0 (30.0)	23.2 (69.7)	0.4 (1.6) [n/a]
Wemindji – 2007 n = 170	20 (4.1)	48.8 (89.4)	71.8 (17.6)	21.8 (47.1)	2.4 (23.5)	0.6 (30.0) [0 (4.2)]
Eastmain – 2007 n = 134	22.4 (5.2)	60.5 (90.3)	61.9 (20.9)	35.0 (24.6)	2.2 (5.9)	2.2 (40.2) [9.0 (9.7)]
Chisasibi – 2008 n = 219	47.5 (3.2)	32.4 (91.8)	38.8 (19.6)	33.8 (56.2)	7.8 (51.1)	1.0 (22.8) [0 (3.6)]
Waskaganish – 2008 n = 138	48.5 (15.9)	18.8 (68.1)	33.3 (16.6)	2.1 (10.9)	0.7 (11.6)	0.7 (38.4) [0.7 (5.7)]
Whapmagoostui – 2009 n = 134	41.8 (0.7)	26.8 (95.5)	14.9 (2.2)	54.5 (25.4)	29.9 (85.1)	0 (9.7) [0 (0)]
Waswanipi – 2009 n = 126	23.0 (11.1)	48.4 (69.1)	64.3 (57.9)	20.6 (40.5)	3.2 (12.7)	0 (0.8) [0.8 (0.8)]
Last 7 communities – 2005-2009	30.5 (5.1)	43.7 (86.5)	49.1 (19.5)	29.2 (35.1)	10.8 (40.9)	0.7 (19.3) [1.5 (4.0)]

a. Main entry is the "in the community response," and "in the bush" percentage is given in parentheses; n/a, not available.

b. Rain water use is given in square parentheses.

c. 2002 Question used in Oujé-Bougoumou and Nemaska: *Q18 - Do you drink water from the tap in your house?*

2005-2009 questions used in all the other communities: Q11 – When in the community, how often do you drink water from these different sources? Q12 – While in the bush, how often do you drink water from these different sources?

- All the time
- Most of the time
- Sometimes
- Rarely
- Never

Tap water, as the drinking water source by age, is summarized in Table 8.2. We can see that there is a slight tendency in most communities for the younger group to drink tap water more than the older people.

TABLE 8.2 *EEYOUCH* REPORTING DRINKING TAP WATER ALL OR MOST OF THE TIME, BY AGE AND COMMUNITY

Community (year surveyed)	**8 to 29 years old**	**30 years old and older**
Oujé-Bougoumou – 2002 n = 190	70.6%	66.7%
Nemaska – 2002 n = 82	92.6%	89.3%
Mistissini – 2005 n = 249	17.4%	12.7%
Wemindji – 2007 n = 170	25.4%	16.2%
Eastmain – 2007 n = 134	23.7%	21.3%
Chisasibi – 2008 n = 219	42.7%	55.6%
Waskaganish – 2008 n = 138	44.4%	50.0%
Whapmagoostui – 2009 n = 134	47.1%	35.9%
Waswanipi – 2009 n = 126	23.4%	22.6%
All 9 communities	41.3%	36.8%
Last 7 communities – (2005-2009)	31.8%	29.3%

8.3 Testing for Microbes in Drinking Water from Natural Sources Used by Residents of Mistissini, Wemindji and Eastmain

For more information on the findings described below, the reader is referred to the appropriate sections of the technical reports for Mistissini (Boissinot et al., 2007) and Eastmain and Wemindji (Huppé V et al., 2011).The study in Mistissini was also published in a peer-reviewed scientific journal (Bernier J-L et al., 2009).

Twelve local water sources (six lakes and six rivers) around Mistissini and 24 plastic containers (5-gallon capacity) in people's homes were tested in the summer of 2005. The water sources were chosen with the help of community members, and 74 samples were collected from the 12 sites on different days for testing. All samples contained some total coliforms (TC) and 68% of samples contained *E. coli* (EC) – all 12 sites had EC at least once. And 16 out of 21 water containers tested contained TC, but only two contained EC. It was interesting that among the 12 sites tested, the two most favoured by the community were also the two that had the lowest levels of contamination. This could explain in part why barely 10% (2/21) of household containers tested positive for *E. coli*.

Indicators of fecal contamination in drinking water

The most common indicators used for testing whether drinking water is bacteriologically safe are: total coliforms (TC) and *E. coli* (EC). These are the two indicators used by the Cree Nation Councils to test the community drinking water every week. For the study, water samples were tested for these two indicators, as well as a third one, Enterococci (EI) using two different methods. The presence of a few TC does not necessarily mean that the water is unsafe to drink. The presence of any amount of EC in a community's water distribution system on even just a single test would lead to an advisory to the community to boil their water before drinking it.

In Wemindji, 29 samples from four local water sources (three springs and one surface water source) were analyzed as well as 20 plastic household containers. TC were found in most tests from all four water sources, and EC were found in low counts in two sources [no EC found in nine samples each at kilometer (Km) 5 and 12].

In Eastmain, three local water sources and 11 household containers were tested. One of the three sites tested, a well-protected well at Km 381, had neither TC or EC, but had one of five tests positive for Enterococci (EI). The other two sites had EC in two out of three tests.

In both coastal communities, no EC (which are more of a public health concern than TC) were found in the domestic containers, but many contained TC, and a few contained Enterococci.

8.4 Conclusions and Recommendations

Except for Oujé and Nemaska, over half of the people studied report drinking water all or most of the time from a source other than tap water – either bottled water or natural springs, lakes or rivers – while they were living in the community. Oujé and Nemaska were studied earlier than the other communities, and a different question was used. Overall, there was no pronounced difference in the reported frequency of drinking tap water between people under 30 and those older. More people may drink tap water in Mistissini now than in 2005, since the source of the community drinking water system is no longer the lake, but an underground well. It is possible that people might use different sources of water for making tea than they do for drinking a glass of water. For example, they might use bush water to make tea and bottled water when drinking a glass of water. The questionnaire did not make this distinction, and thus may have led to some confusion.

Natural water sources used by people in Mistissini, Wemindji and Eastmain were tested for microbes that could cause disease. Some coliform contamination was found in all natural water sources (springs, lakes, rivers), and *E. coli* were found at least once in 16 out of 19 water sources tested. Among samples taken on different days from the same source, there was considerable variation in the findings, so it is not possible to be sure that any one source will always be safe to drink from.

The natural sources in the study that were found to be the least contaminated seemed to be the same ones that people preferred. Perhaps because of this, there was less contamination in the domestic containers than in the natural sources.

It is impossible to tell by looking at water from a natural source whether it contains disease-causing microbes. Because harmful bacteria were found at least once in 84% of natural water sources, water used to make tea should be boiled for one whole minute before being poured into the teapot or cup. Similarly when used for drinking or making juice, it should also be boiled for one minute, and then allowed to cool down. Domestic water containers need to be cleaned regularly with dish soap, rinsed, and then rinsed again with 4 cups (1 liter) of boiled or tap water to which 1 tsp. of chlorine bleach has been added.

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9. EDUCATIONAL ACTIVITIES

(Laura Atikessé, Alanah Heffez, Reggie Tomatuk, and others)

9.1 Summary

The Educational Activities component of the *Nituuchischaayihtitaau Aschii* project had three broad objectives:

1. To create visibility and public outreach opportunities that would bridge the gap between the project team and the community.
2. To give something back to the host communities by providing stimulating, hands-on, culturally-relevant science and health-science education, and to hire local youth.
3. To encourage Cree youth to pursue careers related to science, with the long-term objective of meeting the CBHSSJB's need for local health and science professionals.

The 2005 evaluation of the Mistissini pilot project (Bonnier-Viger et al., 2007) process proposed several guidelines for improving the educational components of the *Nituuchischaayihtitaau Aschii* project.

1. **Develop and implement a communication strategy** employing diverse methods known to be effective in the community, including collaboration with Cree authorities and local organizations, and begin promoting the project in the community several months before the arrival of the full study team. Improve local understanding of the project by providing accessible background documentation about the research questions and hypotheses, ensuring that the sampling method is well-communicated, and involving the study's principal investigators in communications with the community;
2. **Expand the educational component of the program** by involving interested people in the school system as fully as possible, engaging high-school and elementary students in curriculum-related science activities during the school year and expanding opportunities for youth to be employed within the project team.

These recommendations guided the approach to educational activities employed in the six other communities visited. The Cree Board of Health opened a temporary full-time position for an Educational Activities Coordinator.

In each community, youth were mainly targeted through environmental workshops, summer camps and visits to the project's clinical facilities. Depending on the material or facilities available in each community, other activities were planned. For more details, the technical report for Mistissini (Bonnier-Viger et al., 2007) and the technical report for Eastmain and Wemindji (Bonnier-Viger et al., 2011) are available online (see reference list for links). More details about the educational activities which took place in 2008 in Chisasibi and Waskaganish, and in 2009 in Whapmagoostui and Waswanipi can be found in Appendix 11.

The educational activities also included focus groups and workshops with local teachers in order to gather information about existing measures, to promote science within each community, and identify needs related to science education. Bonds established with the school staff before the study's arrival in the community facilitated the implementation of educational activities. All the activities were not necessarily directly related to the

Nituuchischaayihtitaau Aschii project, but were linked to general environment and health topics, such as nutrition, botany, physics, electricity, ecology, anatomy, etc. The activities were adapted for each targeted grade.

Employment was provided for nine local teenagers, as Science Activities Assistants. The selected candidates received training on the subjects of science, health and the environment, and ways to develop their communication and leadership skills.

The educational activities were greatly appreciated by youth and local organizations that were involved in this project. In total, more than a 1,000 participants were met.

Activities	Number of participants	Communities involved
Science workshops and laboratory visits	874	All
Summer camps	90	Chisasibi, Waskaganish and Whapmagoostui
Activities at day care centres	69	Chisasibi, Waskaganish and Whapmagoostui
Job training opportunities for young adults	9	All except in Waswanipi
Total participants	1,042	

9.2 Opening Ceremonies

An official opening ceremony, organized by the assistant coordinator of the *Nituuchischaayihtitaau Aschii* project, took place in each community in collaboration with some representatives from local organizations:

Community	Date	Local organizations involved	Number of participants
Mistissini	July 4th, 2005	Mistissini Chief and Council and his Public Health Services Department	About 60 community members
Wemindji	June 4th, 2007	Public Health Officer and Deputy Chief of the Cree Nation of Wemindji Local CHB Director	About 75 people (150 people at the feast)
Eastmain	August 2nd, 2007	Local Project Coordinator Eastmain Deputy Chief	About 40 people
Waskaganish	June 1st, 2008	Waskaganish cultural council	Over a hundred
Chisasibi	June 21st, 2008	Elders Council of the Cree Nation of Chisasibi	Over a hundred
Whapmagoostui	August 1st, 2009	MSDC Elders in Whapmagoostui	About 60 community members
Waswanipi	August 23rd, 2009	Culture Department of Waswanipi	Over a hundred

These ceremonies were an opportunity to meet community members and discuss the project and its objectives. The Opening Ceremonies in the communities were all different: the aim was to present Cree culture and bring together people from all walks of life living in the community. Teachers, professionals from the Cree School Board, the Cree Regional Authority, the Cree Health Board, and community members joined in the opening of the study.

Opening speeches were made by at least one representative from each community, followed by a representative from the research team who presented the main goals of the study. Then, project staff introduced themselves and their roles. On each occasion, the ceremony ended with a traditional feast.

In several communities, we introduced the feast-kit challenge by promoting recycling and a garbage-free environment, after observing the amount of garbage produced during previous Environment-and-Health Opening Ceremonies. This gave us a good opportunity to change our habits and be kinder towards the environment by not producing garbage at local celebrations.

Events took place thanks to the participation and collaboration of the communities: during the feast-kit challenge, unexpectedly, people actually made their own cutlery, wooden cups and plates. This challenge showed us that the communities can make a difference when everyone participates in events such as this.

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10. CONCLUSIONS

10.1 Regional and Community Contexts of the Study

To provide general context for the *Nituuchischaayihtitaau Aschii* Multi-community Environment-and-Health Study, the recent history of human settlement (*Eeyou*, Inuit and non-aboriginal) of the James Bay region of Québec is briefly reviewed in Chapter 3. Pertinent aspects of the geological background and geography are also mentioned, and a brief summary of the mining, forestry, and hydro-electric developments in the territory, and the Cree hunting culture are described. Features of the changing demographics of the Cree communities themselves and of the region as a whole are then examined, followed by short descriptions of the location, history, demographics, employment, economic sectors and activities, food sources, and participation in hunting for each of the nine communities.

10.2 Foods and Physical Activity Issues

Traditional foods are a good source of many important nutrients. In *Eeyou* adults, past-day traditional foods contributed 10% of energy and fat, 18% of iron and 15% of vitamin D. Based on the results of both the food frequency and the 24-hour recall questionnaires, and compared to younger adults and children, traditional food intake was higher in adults 40 years of age and older. It is a concern that younger individuals are not consuming foods that have traditionally been important in the *Eeyou* diet. Negative correlations between high-sugar and high-fat foods and the total omega-3 fatty acids in red blood cell membranes suggest that participants are replacing nutrient-dense traditional foods with less healthy choices.

Rates of obesity were high in adults based on body mass index (BMI), waist circumference and percent body fat, with women showing higher rates than men. The children and youth had lower rates of BMI-determined obesity, indicating a clear transition to higher body weights in adulthood. Obesity points to a long-term overconsumption of energy.

Percentage energy from foods not included in one of the four Canada's Food Guide (CFG) groups—especially fats such as oils, butter and margarine, as well as candy, cakes, cookies and sugar-sweetened drinks—on average, was over 23% for all communities, and as much as 40-50% in some consumers. Although some of these foods are required for a balanced diet, many could be eliminated or replaced by CFG group foods, thereby reducing the over-consumption of energy. One example of such a strategy is the already implemented "Drop the Pop" campaign. One can of sweetened carbonated beverage supplies 150 kilocalories, and thus a reduction of just one can a day could potentially eliminate 15 lbs of excess weight in one year.

More than 67% of adults were above the acceptable macronutrient distribution ranges (AMDR) for percent energy as fat, whereas this was true for only 14-21% of children 9-18 years of age. Nutrients at greatest risk of inadequacy are vitamins A and D, calcium and magnesium. It is important to note that the northern latitudes where the *Eeyouch* reside put them at higher risk of vitamin D deficiency because of reduced annual sun exposure. Furthermore, almost 40% of individuals aged 15 years and over showed insufficient amounts of vitamin D in their blood. The best sources of calcium are dairy products and the best sources of magnesium are vegetables and whole grains. Fiber intake was also very low. However, it should be emphasized that absolute nutrient intakes must be interpreted with caution due to under-reporting.

Physical activity was consistently inversely correlated with BMI, % body fat and waist circumference. Dedicated walkers, defined as those walking at least one hour per day for at least six days per week, enjoy greater health benefits. Increased activity can contribute to correcting the energy imbalance found in *Eeyou Istchee* communities.

The dietary data collected provide valuable background information on the nutritional habits and status in *Eeyou Istchee,* and provide a context for evaluating and managing benefits and risks pertaining to dietary habits including the consumption of traditional food. It is imperative to identify culturally-appropriate ways to encourage good health.

10.3 Environmental Contaminant Exposure and Sources

Levels of the toxic metal lead increased with age and depended on the community of residence; they were higher in persons based on the answer "yes" to the questionnaire questions "do you hunt" or "do you use lead shot," and slightly higher in smokers (*versus* non-smokers). Only a few children and women of reproductive age needed follow-up based on current public health guidelines, although in some communities adult males and females 40 years old and over exceeded their "level of concern." These findings merit ongoing efforts for hunters to switch to ammunition that does not contain lead. Because lead is toxic even at low levels, especially in children, this campaign is deemed of utmost importance.

Evidence is presented that, compared to mercury hair measurements in 1993/4, there has been a shift to lower blood mercury concentrations. The clear increase with age likely reflects higher consumption of traditional foods, especially fish. Although there were exceedances of the Province of Québec declarable level and the current action guidelines, only a small number of exceedances occurred for women of reproductive age and none among the children.

The age-dependence for cadmium in blood is quite different from that seen for lead and mercury, with the younger adults (15-39 years) having the highest concentrations. Clear evidence is presented that smoking strongly increases the blood cadmium concentration, and constitutes the major exposure source. Dietary sources such as the consumption of internal organs (e.g., kidneys and liver) appear not to be associated with blood cadmium. Exceedances of the safe occupational health guideline occurred in all age groups but the youngest (<8 y), and reached 20% among males in the middle age group in some communities. Cadmium is severely toxic to the kidneys, and this health outcome constitutes yet another health risk of smoking.

The toxic element arsenic was measured in urine and hair. Based on the hair analysis, there was some evidence of exposure to it, although the observed urine levels indicated no internal exposure. Contact with pressure-treated wood (PTW) is suspected, since historically it contained arsenic and this toxic element is known to leach from it. Cobalt and nickel, which are metals considerably less toxic than cadmium, mercury and lead, were found in blood to be in the normal non-toxic range. A number of elements that are essential to good health, namely copper, iodine, magnesium, molybdenum and zinc, were also present in the normal range.

Levels of persistent organic pollutants (POPs) were measured in blood plasma. They persist in the environment and our bodies for a long time (months to years). Historically, these included pesticides (such as DDE, which was introduced into the environment as DDT; mirex and others), and transformer oils (PCBs); and more recently, fire retardants (oganobromine compounds) and related surface-tension stabilizers (organofluorine compounds) referred to as "emerging contaminants." Strong dependencies on community and age were observed for PCBs and pesticides with the older *Eeyouch* exhibiting the highest blood plasma concentrations. The observed concentration ranges are comparable to those reported for adult indigenous populations in Canada (mostly Inuit), Greenland (mostly Inuit) and Russia (multiple ethnic groups), and are considerably higher (roughly 2-20 fold, depending on age) than for non-indigenous groups. It is difficult to assign measureable health impacts at the observed concentrations, although there are some genuine concerns. Generally speaking, harvested traditional foods (especially fish, but also to a lesser degree migratory waterfowl) constitute a primary source of the more traditional POPs. By contrast, dust derived from goods and materials treated with fire retardants in our homes and in other settings appear to be a primary source of emerging POPs. In the context of the general global decline of traditional POPs, the relatively low concentrations seen in the current study among the < 40y age group and children suggest considerably lower life-time exposure for these groups. Exposures to the emerging contaminants need continued monitoring in *Eeyou Istchee,* as elsewhere in Canada and other countries.

The comprehensive documentation of contaminant exposures established in the *Nituuchischaayihtitaau Aschii* study should serve as a baseline for future developments in *Eeyou Istchee,* such as those proposed in Québec's Plan Nord.

10.4 Health Findings

The main objective of the health section is to report results on chronic diseases or their risk factors which are: 1) of interest for the *Eeyou Istchee* communities, and 2) associated in the scientific literature with exposure to environmental contaminants.

Extremely high prevalences of abdominal obesity, based on waist circumference, were observed for adult participants in the nine *Eeyou Istchee* communities visited; all were above 85%, except in one community where it was slightly lower. Similarly, global rates of obesity defined by body mass index (BMI) above 30 kg/m^2 were also alarmingly high with prevalences of more than 70%. Metabolic disturbances such as low HDL-C and elevated triglycerides were also detected in more than 1/3 of the adult participants. All these risk factors were positively associated with general and abdominal obesity. However, we concomitantly noticed a lower than expected prevalence of elevated LDL-C, total cholesterol and of the total cholesterol/HDL-C ratio.

Furthermore, levels of n-3 polyunsaturated fatty acids (n-3 PUFAs) in red blood cell membranes found among the participants of the *Eeyou Istchee* communities surveyed in 2005-09 were approximately half the values found among the Nunavik Inuit in 2004, but still remained about 2-3 fold higher than reported for the general population of Québec. Long-chain n-3 PUFAs are indicative of fish and/or game consumption and considered to be protective of good health.

Preliminary analyses between contaminants and cardiovascular disease (CVD) risk factors are inconclusive. We were not able to observe an association between blood pressure and mercury as found in Inuit of Nunavik. The lower level of mercury (Hg) exposure might be responsible for this. However, we found an association between mercury exposure and heart rate variability. This finding echoes our previous observations and those by teams studying other populations, and the association seems to be robust. The exact significance of a decreased heart rate variability (HRV) is not clinically evident, but certainly impacts the CVD health of the Cree Nation.

The age-adjusted prevalence of type 2 diabetes (T2D) for the entire adult study sample was 22.7% in our *Nituuchischaayihtitaau Aschii* study, with undiagnosed T2D at 4.0% for the entire region. We also observed elevated plasma insulin concentrations, particularly in women and young girls. The significant morbidity associated with the high rates of obesity documented in our study call for an intensification of existing programs to reduce obesity in *Eeyou* adults and children. Considering the influence of obesity as a risk for developing T2D and the associated macro-vascular complications, we can anticipate that CVD is likely to increase in the future.

Explanatory analyses including lifestyle and environmental data (such as dietary profile, social context, contaminants, etc.) should be investigated further in order to complement public health strategies already in place in various Cree communities targetting CVD and T2D.

It can also be concluded that members of the *Eeyou Istchee* communities have adequate iodine intake across generations, with similar medians of urinary iodine concentration for men and women.

10.5 Transfer of Disease from Animals to Humans

The Cree communities of James Bay are at risk of contracting infectious diseases conveyed by wildlife. Evidence of exposure to *Trichinella* sp., *Toxoplasma (T.) gondii*, *Toxocara (T.) canis*, *Echinococcus (E.) granulosus*, *Leptospira* sp., *Coxiella (C.) burnetii* and *Francisella (F.) tularensis* was verified in all seven communities, whereas antibodies against *Sin Nombre* virus and California serogroup viruses (Jamestown Canyon and Snowshoe hare) were evaluated in three and six communities, respectively. Seroprevalence rates varied widely between communities: Snowshoe hare virus (1-42%), *F. tularensis* (14-37%), *Leptospira* sp. (10-27%), Jamestown Canyon virus (9-24%), *C. burnetii* (0-18%), *T. gondii* (4-12%), *T. canis* (0-10%), *E. granulosus* (0-4%) and *Trichinella* sp. (0-1%). No subject had serologic evidence of *Sin Nombre* virus exposure. These data suggest that large proportions of the Cree population have been exposed to at least one of the targeted zoonotic agents. Even if the design of the study does not permit to assign clinical diseases to the infections investigated, the review of medical records of seropositive subjects revealed very few on-going or historical health events compatible to one or other zoonoses. Nevertheless, the Cree population, particularly those most heavily exposed to fauna, as well as the medical staff living in these regions, should be aware of these diseases. Greater awareness would not only help to decrease exposures but would also increase the chance of appropriate diagnostic testing.

10.6 Sources of Drinking Water

The study asked people about the water they drink. In addition, several natural sources used by people living in Mistissini, Wemindji and Eastmain, were tested for harmful bacteria.

Over half report drinking water all or most of the time from a source other than tap water – either bottled water, or water from natural springs, lakes or rivers – while living in the community.

Results for the three to nine test samples collected from each of the 19 popular local water sources showed that almost all sources contained harmful bacteria in at least one test.

Because it is impossible to tell by looking at water from a natural source whether it contains disease-causing microbes, all water for making tea should be boiled for one minute before being poured into the teapot or cup. When used for drinking or making juice, water should also be boiled for one minute, and then allowed to cool down. Domestic water containers need to be cleaned regularly with dish soap, rinsed, and then rinsed again with 4 cups (1 liter) of boiled or tap water to which 1 tsp. of chlorine bleach has been added (for additional details see CDC, 2013).

10.7 Educational Programs

10.7.1 Educational Activities in Mistissini (2005) and Eastmain and Wemindji (2007)

The educational activity components of the *Nituuchischaayihtitaau Aschii Study* were launched to create visibility for the project and to reach out to the communities, with a special focus on interaction with youth to foster interest in science and science careers. After the Mistissini experience (Bonnier-Viger et al., 2007), the program was strengthened around two guiding principles to emphasize: (i) development and implementation of an effective communication strategy, and (ii) expansion of the educational aspects of the program. Subsequent to the Eastmain and Wemindji field work during the summer of 2007 (for details see Bonnier-Viger et al., 2011), community-specific adjustments were made in June/July of 2008 for Waskaganish and Chisasibi and in August/September of 2009 for Whapmagoostui and Waswanipi. Brief summaries are provided below.

10.7.2 Educational Activities in 2008 in Waskaganish and Chisasibi

Educational workshops about science, the environment and nutrition were carried out in collaboration with local partners, including the schools, daycares and Band Council, in each community. The activities were greatly appreciated by all these partners and over 450 children, mostly aged 4-12, took part in at least one activity. Three local youths also received job training through assisting in the educational activities. However, the long-term impact of the educational activities and training opportunities, as well as concrete links with the environment-and-health study, were limited due to the compressed timeframe of the field work in 2008.

10.7.3 Educational Activities in 2009 in Whapmagoostui and Waswanipi

As in the previous year, the environment, nutrition and science workshops were carried out with comparable partners, and attracted the participation of 300 youths in at least one activity. Following the recommendation of the 2008 project, emphasis was placed on creating links with the environment-and-health study team, and on developing more culturally-relevant, curriculum-based activities for older students (Grades 4-10).

With the goal of promoting science education in the long-term, an extra-curricular activities pilot project was developed with Youth Fusion, a non-profit organization that tackles absenteeism and drop-out rates in Québec high schools, including two schools in *Eeyou Istchee*. This link offers a promising possibility for the Educational Activities to have a lasting impact in all the communities visited over the course of the *Nituuchischaayihtitaau Aschii* Project.

10.8 Final Thoughts

As mentioned in the Acknowledgments, the *Nituuchischaayihtitaau Aschii* study required cooperation, support and efforts from many individuals, institutions and governing bodies. From this perspective, it is therefore important to maximize the applications of the findings described and information provided. Thus, even though the current technical report brings formal closure to our study, the scientific endeavor of the project will continue for some time through the publishing of scientific papers based on its extensive database. This will also require ongoing consultations with the communities. And finally, the comprehensive documentation provided should serve as a reference for the planning and implementation of future environment-and-health studies or surveys in *Eeyou Istchee*.

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