Nituuchischaayihtitaau Aschii

Multi-community Environment-and-health Longitudinal Study in Iiyiyiu Aschii: Mistissini

Technical report: summary of activities, results and recommendations

2007

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Multi-community Environment-and-health Longitudinal Study in Iiyiyiu Aschii: Mistissini

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1. SUMMARY

This pilot-study was conducted in the James Bay Cree Territory of Quebec, in the community of Mistissini. Sample collection took place from July 4 until August 13, 2005. A total of 282 individuals participated in the study and answered questions about their health and activities. All age groups were represented: 54 participants were between 0 and 7 years old, 45 between 8 and 14 years old, 115 between 15 and 39 years old and 68 were 40 years old and over. For some aspects of the study, only specific age groups were targeted and some tests or questionnaires were administered to sub-groups of the recruited participants. The part of the study about dietary habits included 228 persons (all participants over 7 yrs. old). As well, 170 participants agreed to have their heart beat monitored for a 2-hour period (all participants over 15 yrs. old were solicited). Fifty women had their heel bone strength measured by ultrasound (all women between 35-74 yrs. old were solicited) and neck artery thickening due to cholesterol deposits was assessed using ultrasound for 57 participants between 40 and 74 yrs. old. Finally, 68 persons had an oral glucose tolerance test.

Dietary habits: Traditional food is frequently enjoyed by adults over 40 years of age. They eat 2-4 times more game, fish, birds and berries than younger adults or children. These foods are an excellent source of good, healthy, natural fats and proteins. However, the study showed that in general, people in Mistissini eat too much non-natural, unhealthy fat (including trans fats from store-bought baked goods). Blood levels of a good type of fat (Omega-3 fatty acids) reflect the consumption of wild animals (fish and game), and increased with age, which is consistent with the higher consumption of traditional food observed in older age groups. On the other hand, unwanted industrial trans fats (in fries, industrially prepared and packed foods, etc.) showed the opposite trend, with higher levels found in the younger age groups. Also, a high proportion of children (65%) reported consuming sweet drinks, with an average of 2.2 cans per day accounting for as much as 14% of energy intake. The fact that teenagers have higher levels of trans fats in their bodies and a high intake of sugar suggests that they are at increased risk of developing heart diseases and diabetes in the future. Finally, the average daily consumption of fibre and vegetables is low, which could increase the risk of chronic diseases such as diabetes and cancer of the bowel. Also, since fruit and vegetable consumption is low, some vitamin and mineral intakes are too low based on the diet of study participants. **Therefore, this pilot study showed that despite the fact that healthy traditional food is still part of the diet (especially in older age groups), a transition toward a more unhealthy diet high in sugar, saturated fat and trans fat is observed, especially in young people; this could have negative health impacts in the future.**

Physical activity: Physical activity was assessed using a questionnaire. The results showed that increased physical activity was related to a lower percentage of body fat. **Therefore, the results suggest that the dedicated walkers are enjoying the health benefits of their physical activity and that physical activity in general can improve health status in Iiyiyiuch.**

Environmental contaminants: The environment is contaminated with different chemicals originating from human activities. Some of these contaminants are called "persistent organic pollutants" (POPs). They accumulate in fatty tissues of animals and humans, are difficult to break down and are transported long distances by water and air. Consequently, they are found in environments where they are not initially released, such as in the North. Examples of POPs are PCBs, organochlorine pesticides (a class of pesticides formerly used but now banned since the late 70s-80s), some industrial by-products/waste such as dioxins, and other types of domestic or industrial chemicals such as water and stain repellents or fireproofing agents that tend to leach out of plastics and textiles or from electronic devices. The environment is also contaminated with toxic metals, which tend to accumulate in the liver and kidneys as well as in the flesh of animals and humans, rather than in fatty tissues. These include mercury (mainly methylmercury, the organic form of mercury), cadmium and lead. All of these contaminants (POPs and metals) are found in the food chain (i.e., in fish and fish-eating birds, as well as in other wild animals) and because of their persistence, they tend to accumulate in higher concentrations in predators and older animals.

Concentrations of POPs and toxic metals were measured in the blood (plasma) of the Mistissini study participants. Since older adults (40 yrs. old and over) have consumed more wild animals during their lifetime, they generally show higher concentrations of PCBs, organochlorine pesticides and mercury in their bodies. However, these contaminants represent a health concern mainly for pregnant women and their babies, and young children. Fortunately, women of childbearing age and young children had relatively low levels of mercury, and levels of PCBs and organochlorine pesticides were not a health concern for the majority of participants. Regarding other metals, lead exposure is not a big issue in Mistissini. Cadmium exposure (toxic to the kidneys in older age groups) is mostly related to smoking, an avoidable source of exposure. Since some participants exceeded levels of concern for cadmium exposure, especially teens and young adults, this reinforces the fact that people should quit smoking to avoid adverse health effects. Exposure to other industrial contaminants such as stain repellents, fireproofing agents and dioxins is similar to levels observed in other First Nation communities elsewhere in Canada, and shows similar associations with fish/game consumption and age, except for fireproofing agents and pentachlorophenol, which showed no association with age, nor with the

consumption of fish, suggesting other sources of exposure unrelated to traditional food consumption. **Nonetheless, the results of this pilot phase suggest that exposure to environmental contaminants through the consumption of traditional foods is observed in the Mistissini population. The concentrations observed are not yet alarming but warrant further investigation with regards to their potential health effects. Monitoring of environmental contaminants should also continue in order to track changes in contaminant levels associated with large development projects. However, given the known benefits of traditional food consumption, this practice should still be encouraged. Further investigation on sources of exposure could help in providing guidelines to decrease exposure while maintaining traditional diets.**

Health status: In this study, many clinical tests were carried out in order to provide a "snapshot" of the Mistissini population health status, with an emphasis on certain chronic diseases or health conditions that may be related to lifestyle habits as well as the environment. Osteoporosis is a condition that appears mostly in post-menopausal women which increases the risk of bone fractures. Fortunately, the bone ultrasound measurements indicated that the risk of breaking a bone appears to be relatively low among Cree women in Mistissini compared to Quebec City women. Issues related to thyroid hormones could not be fully investigated with the data collected, but according to the clinical screening carried out, men seem to suffer from mild hypothyroidism (under-active thyroid gland) more frequently than women. In general, thyroid problems do not seem to be a major health concern in the Mistissini population, but additional data from medical files would be necessary to draw firm conclusions regarding this issue.

Thickening of the arteries (atherosclerosis) is a condition responsible for heart attacks and stroke. It was estimated in 63 participants aged 40 years and older by measuring the thickness of the carotid artery (neck artery) by ultrasound. This analysis showed that artery thickness increased with age for both men and women, but overall, this measurement was lower in Cree people than in other aboriginal people, and similar to the Inuit people of Quebec. According to the questionnaire data, 17% of people declared suffering from high blood pressure, but only 4% of the population showed high blood pressure during the clinical examination, which suggests that this condition is adequately diagnosed and stabilized for most people. High blood pressure was more frequent in older people, those showing abdominal obesity, and in those most exposed to mercury. For blood lipids (fats), total cholesterol was high in only a small portion of the population, but the good cholesterol (HDL) concentrations could be improved relatively to the bad cholesterol (LDL) levels, especially in older women. Therefore, high blood pressure and thickening of the arteries are risk factors for cardiovascular disease that does not seem to be of

great concern to the Cree people, but some preventive actions could be undertaken to improve blood lipid profiles and increase the amount of good blood lipids.

However, issues related to overweight and diabetes need specific attention and immediate action in the Mistissini population. Very few self-declared cases of cardiovascular disease were found in Mistissini based on questionnaire data, but it was found that 15.7% of participants reported suffering from diabetes, which is approximately three times more frequent than in the rest of Canada. Based on blood tests (not all participants), 14.4% of the participants may be considered diabetic, 4% of whom are newly diagnosed cases (i.e., people who were not aware of their condition). Additionally, 11% of screened participants are at risk for developing diabetes (showed abnormally high levels of insulin), and this affected women and young girls more than men. These results show that diabetes is a matter of concern in the Mistissini population and screening should be intensified. In the Mistissini population, diagnosed diabetes was always related to obesity or overweight. Indeed, 80% of all participants may be considered overweight, with 54% being obese. Abdominal obesity, which increases the risk of cardiovascular disease and diabetes, was also very frequent (68%) and affected women more than men. **Obesity and diabetes are unhealthy conditions that lead to other medical problems, morbidity and premature death. It is known that high-fat and high-sugar diets, coupled with low physical activity are linked to these medical conditions. Therefore, promotion of a healthy diet and increased physical activity are urgently needed to prevent the onset of these conditions, especially in younger age groups.**

Zoonoses: In this study, we looked at some diseases that could be transmitted from animals to humans (zoonoses). When somebody is infected by a germ (bacteria, a parasite or a virus), it is often possible to find traces of past infections in the blood (antibodies measured as serologic evidence of infections) even many years after the acute infection episode is over. During the study, these "traces" were measured in the blood of 50 active hunters/trappers and their spouses selected for their known exposure to wild animals. The lack of serologic evidence for the *Sin Nombre* virus and the few positive results for three out of the four parasites investigated (*Echinococcus granulosus, Trichinella* species*, Toxocara canis*) indicate no or infrequent exposure to these pathogens. On the other hand, exposure to *Toxoplasma gondii* and zoonotic bacteria appears to be more common. For *Toxoplasma gondii*, seroprevalence is comparable to reported rates in various industrialized countries. **In general, the results of this study component show no alarming rates of zoonotic infections nor any need for immediate action. However, when considering all pathogens together, the positive results observed are related to fishing, hunting and trapping activities. Hunters and trappers should therefore**

be made aware of the sickness symptoms of these infections, as well as safe procedures for handling dead animals in order to reduce risks of infection.

Water*:* During this study, we also assessed potential contamination of surface water with germs (bacteria, parasites, viruses). Water samples from lakes and rivers of the Mistissini area used for drinking water were analysed. Some tests showed that water samples contained different types of potentially harmful germs, as evidenced by the presence of bacterial indicators of fecal contamination as well as nucleic acids (DNA) from unwanted (pathogenic) parasite species. These germs probably originate from animals and not necessarily from human fecal contamination, which would be more problematic. **However, since these analyses showed that surface water used for drinking may contain some unwanted pathogenic germs (as is the case for raw water collected in most natural environmental settings), it is generally accepted that as a simple preventive measure, surface water from natural sources should be boiled for at least one minute before drinking.**

In conclusion, contaminants are not a major concern for the CBHSSJB, even though they are present in the food chain. Because of the environmental changes imposed by large development projects, we must continue monitoring these contaminants. However, being overweight and eating an unbalanced diet are by far more important health concerns that seem to require prompt preventive action. Based on the findings summarized above, the important messages are: do not smoke, be physically active, include vitamin-rich foods in your diet, keep eating traditional food items as they are healthy, and reduce eating foods known to be unhealthy such as high-sugar, high-fat industrially-prepared foods.

2. ABBREVIATIONS AND GLOSSARY OF CREE TERMS

2.1 Agency and Program Abbreviations

AMAP:	Arctic Monitoring and Assessment Program
FAPAQ:	Société de la faune et des parcs du Québec
CBHSSJB:	Cree Board of Health and Social Services of James Bay
CHUL:	Centre de recherche du Centre hospitalier de l'Université Laval
CHUQ:	Centre hospitalier Universitaire de Québec
CINE:	Centre for Indigenous People's Nutrition and Environment
CRA:	Cree Regional Authority
CRI:	Centre de recherche en Infectiologie
INSPQ:	Institut national de santé publique du Québec
IUPAC:	International Union of Pure and Applied Chemistry
MADO:	Maladies à déclaration obligatoire
NCP:	Northern Contaminants Program
URSP:	Unité de recherche en santé publique
USEPA:	United States Environmental Protection Agency
WHO:	World Health Organization

2.2 Cree Terms

Nituuchischaayihitaau Aschii	Learn about us and our earth
Iiyiyiu	Cree person
Iiyiyiuch	Cree persons
Iiyiyiuyimuwin	Cree language
Iiyiyiu Aschii	Cree Territory (Category 1, 2 and 3 lands)
Awash	Child
Uschiniichisuu	Youth
Chishaayiyuu	Adult and elder
Miyupimaatisiiwin	State of health and well-being

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)

2.3 Abbreviations

AI: adequate intake
AMDR: acceptable macronutrient distribution range
ApoA-I: apolipoprotein A-I
ApoB: apolipoprotein B
ASPE: automated solid-phase extraction method
BDEs: brominated diphenyl ethers
BMD: bone mass densitometry
BMI: body mass index
BMRest: basal metabolic rate
BP: blood pressure
BUA: broadband ultrasound attenuation
CA: correspondence analysis
CFU: colony-forming unit
CINDI: Countrywide Integrated Non-communicable Disease Intervention
CRP: C-reactive protein
CVD: cardiovascular disease
DBP: diastolic blood pressure
DDE: dichloro-diphenyl-dichloroethylene
DDT: dichloro-diphenyl-trichloroethane
DHA: docosahexanoic fatty acid
DL: detection limit
DLCs: dioxin-like compounds
DM: diabetes mellitus
DMSO: dimethyl sulfoxide
DNA: nucleic acids
DR-CALUX: dioxin-receptor chemically-activated luciferase-expression bioassay
DRI: dietary reference intake
EAR: estimated average recommendation
EC: *E. coli*
EI: electronic impact ionisation, energy intake, enterococci
ELISA: enzyme-linked immunosorbent assay

EPA: eicosapentaenoic fatty acid
EUPASS: European Physical Activity Surveillance System
EUROHIS: European Health Interview Survey
FA: fatty acids
FAME: fatty acid methyl esters
FFQ: food frequency questionnaire
F/H/T: fishing/hunting/trapping
FID: flame ionization detector
GLC: gas-liquid chromatography
GC-MS: gas chromatography-mass spectrometry
HCB: hexachlorobenzene
HCH: hexachlorocyclohexane
HDL: high-density lipoprotein (so-called “good” cholesterol)
HF: high frequency
HRGC-HRMS: high resolution gas chromatography/high resolution mass spectrometry
HRGC-MS: high-resolution gas chromatography-mass spectrometry
HRV: heart rate variability
ICP-MS: inductively coupled plasma mass spectrometry
IFBG: impaired fasting blood glucose
IGT: impaired glucose tolerance
IHD: ischemic heart disease
IL-6: interleukin-6
IMT: intima-media thickness
IPAC: International Physical Activity Questionnaire
IQ: insufficient quantity
IQR: interquartile range
IUPAC: International Union of Pure and Applied Chemistry
LC-MS-MS: liquid chromatography-tandem mass spectrometry
LDL: low-density lipoprotein (so-called “bad” cholesterol)
LF: low frequency
mEI: membrane-enterococcus indoxyl- β-D-glucoside
METs: metabolic equivalents

MF: membrane filtration

mmIMT: mean maximum intima-media thickness

MPN: most probable number

MUFA: monounsaturated fatty acids

NA: not applicable

NCI: negative chemical ionisation

NI: non interpretable

NN: median of all RR intervals

OCs: organochlorines

OCPs: organochlorine pesticides

OGTT: oral glucose tolerance test

PBDE: polybrominated diphenyl ether

PCA: principal component analysis

PCBs: polychlorinated biphenyls

PCR: polymerase chain reaction

PFOA: perfluoroctanoate

PFOS: perfluoroctane sulfonate

PFHxS: perfluorohexanesulfonate

pNN50: percentage of the absolute differences between successive normal RR intervals that exceed 50 msec

POPs: persistent organic pollutants

PTH: parathyroid hormone

PUFAs: polyunsaturated fatty acids

QUS: quantitative ultrasound

RBC: red blood cell

RDA: recommended daily allowance

R_f: relative mobility

rMSDD: mean squared differences of successive RR intervals

RR interval: interval between R-wave peaks

RV: reference value

QUS: quantitative ultrasound parameters

SBP: systolic blood pressure

SD: standard deviation
SDANN: standard deviation of the average normal RR intervals
SDNN: standard deviation of the normal RR intervals
SFA: saturated fatty acids
SI: stiffness index
SIDE: Software for Intake Distribution Estimation
SOS: speed of sound
T3: thyroid hormone
T4: thyroid hormone
TC: total cholesterol and total coliforms
TCDD: 2,3,7,8-tetrachlorodibenzo-p-dioxin
TDI: tolerable daily intake
TEQs: toxic equivalent concentrations
TG: triglycerides
TNF-a: tumour necrosis factor
TNF-α: tumour necrosis factor
TPOAb: thyroid antibody
TSH: thyroid stimulating hormone
VLF: very low frequency
WC: waist circumference
WHS: World Health Survey

3. PROJECT BACKGROUND, OBJECTIVES AND SCOPE

3.1 Background

Environmental health recognizes the close link between a healthy environment and a healthy population. This is especially true for human populations living in close contact with their environment or depending on it very closely for food sources. Hunting and fishing are activities that are part of the traditional lifestyle of Iyiyiuch and the consumption of traditional food has many advantages with regard to cultural and health aspects. Indeed, it is now well documented that the loss of traditional lifestyle causes distress in populations undergoing such a cultural transition, and a decrease in the amount of traditional foods consumed will result in negative health consequences (NCP, 2003). Traditional foods are reported to be lower in total fat, lower in saturated fats, have lower levels of sucrose, and are excellent sources of omega fatty acids, selenium, vitamins A, C, D and E, iron, zinc, copper, magnesium and manganese, as compared to non-traditional store-bought foods. Absence of trans fats is another advantage. These attributes are associated with lower risks of, and protection against, illnesses such as cardiovascular disease, certain cancers (e.g., colorectal and prostate), obesity and type-2 diabetes. However, some traditional food items may be contaminated by environmental pollutants such as toxic metals and various organic chemicals from anthropic sources. Wild animals may also transmit certain diseases (called zoonoses) to humans either through the manipulation or consumption of infected specimens. Therefore, an assessment of risks and benefits associated with a traditional diet is needed in order to promote healthy lifestyles and integrate traditional habits into changing cultural lifestyles. In order to achieve this, adequate information needs to be gathered regarding current dietary habits, as a quantitative assessment of nutritional intake and status is not yet available for the Iiyiyiuch. This information gap is therefore addressed in the dietary component of this study.

It is also important to note the gap in data on the health status and exposure to contaminants of the Iiyiyiuch. Programs such as the Northern Contaminants Program (NCP, 2003) and the Arctic Monitoring and Assessment Program (AMAP, 1998, 2003) have been developed to conduct surveys and research on northern aboriginal groups such as the Inuit, Dene and Métis, but little research has been done on the more southerly, mid-north Iiyiyiu people. For example, the relatively high concentrations of polychlorinated biphenyls (PCBs) and *p,p'*-DDE (a metabolite of the insecticide *p,p'*-DDT) found in the plasma of residents of Oujé-Bougoumou was unexpected (Dewailly and Nieboer, 2005). Even within the NCP and AMAP programs, gaps are

still identified such as knowledge about or activities related to: health consequences of not eating traditional food; sources of organochlorines (OCs) and other persistent environmental contaminants; regular monitoring or surveillance of contaminants in humans; assessment of traditional food consumption patterns and regional variations and trends; toxic effects of contaminants on northern people and related health problems; effects of nutrients such as fatty acids, selenium and Vitamin E on methylmercury metabolism and toxicity; research data enabling the review of Tolerable Daily Intakes (TDI) for northern peoples; and further research to better formulate benefit-risk messages for the consumption of traditional foods, especially for women of reproductive age (NCP, 2003). These gaps in knowledge hinder an adequate risk/benefit assessment of traditional lifestyle and traditional food intake and need to be filled for adequate recommendations to be provided to native populations.

This study therefore aims at providing quantitative information that will allow these issues in Iiyiyiu Aschii to be addressed, and this document reports on the results of the pilot phase of this study. This large-scale environmental-health study was set up in response to the Mercury Agreement (2001) (section 3.1.1) in an effort to provide a follow-up to two previous studies carried out in Iiyiyiu Aschii: the Oujé-Bougoumou/Nemaska study (section 3.1.2) and the Needs and Feasibility Study (section 3.1.3). The complete study will be implemented in all communities of Iiyiyiu Aschii over a seven-year period. The first community visited was Mistissini (summer 2005) and constituted the pilot phase of the complete study. Results from this pilot phase are reported here and serve as a basis for adjustments to be made for the following communities.

3.1.1 The Mercury Agreement

The dual objectives of the 2001 Mercury Agreement set out a global vision for promoting fisheries restoration within the context of protecting the health of the population[1]. The role of the Public Health Authorities is explicitly described in Section 5 in relation to protecting the health of the population, and implicitly understood in relation to some of the provisions in Section 6 for the restoration of the fisheries.

The first and second Mercury Agreements in 1986 and 2001 were developed in recognition that the construction of the La Grande Project (phase 2), the EM-1 and the proposed EM-1a and Rupert Diversion projects, are associated with certain economic development and environment-and-health concerns. The Agreements recognize the need to economically maintain and restore Iiyiyiu fisheries within a context that addresses potential environment-and-health concerns. The 1986 Agreement committed a total of $18.5 million to health and environment monitoring and studies, preventive and remedial measures and socio-cultural aspects of mercury and monitoring. The health research proportion was set at $4.1 million. The 2001 Agreement committed a total of $24 million, including $16 million for fisheries restoration and $8 million for health-and-environment studies. With similar objectives for health and environment studies to the 1986 Agreement, it is written in much greater detail and sets out a more elaborate management plan [Section 5.2.1] for some types of activities.

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[1] The dual intent of the 2001 Mercury Agreement is spelled out in the first two objectives:

"to support Public Health Authorities in the development and delivery of programs designed to manage the risks associated with human exposures to mercury, in a manner consistent with this Agreement, with the technical and other information they would request or which would be significant in relation to this Agreement"; and

"to restore and strengthen the Cree fisheries in ways which respond to Cree aspirations and needs, but which also adequately take into account the health risks associated with human exposure to mercury and other contaminants and which deal in a responsible and reasonable manner with the management and conservation of fish resources in the James Bay Region."

The 2001 Agreement supports two classes of health studies and related activities.

1) The first class falls within the elaborated management plan [Section 5.2.1] set in the Agreement.

From Section 5.2.3:

- a) “Monitoring of Iiyiyiu exposure to mercury and other contaminants;
- b) Epidemiological and toxicological studies of Iiyiyiuch;
- c) Investigation of the pattern of Iiyiyiu exposure to mercury;
- d) Studies of the health benefits of fish consumption;
- e) Investigation of patterns of fish consumption in Iiyiyiu society.”

From Section 5.3.2:

- a) “Monitoring of mercury levels in fish, wildlife or other food consumed by the Iiyiyiuch”; and
- b) “Determination of contaminants, other than mercury, in fish, wildlife or other foods consumed by the Iiyiyiuch”.

2) The second group of studies/activities is managed by simple proposal and board decision, and include: a) literature reviews, investigations of risk perception and evaluation of risk-assessment approaches, pertinent to mercury and other contaminants; and b) studies of fish harvesting and distribution, information campaigns to support and implement consumption advisories, attendance at conferences, support for nutrition and health registries and assistance in creating health-related data bases [Section 5.2.4].

Although, the role of the Public Health Authorities is only recognized in relation to Section 5, their involvement is also implicated, although not mentioned, in relation to several types of activities described in Section 6 of the Agreement, which deals with fisheries restoration and development, specifically:

- Wildlife enhancement schemes;
- Enhancement of camp sites for fishing purposes;
- Technical training to establish local expertise in the types of measures contemplated herein;
- The perpetuation of traditional knowledge of fishing and related activities.

For example, a wildlife enhancement scheme must involve a thorough understanding of zoonoses; enhancement of camp sites has implications for maintaining water quality; technical training will obviously include provisions for monitoring and understanding the monitoring of contaminant levels in different lakes, species and sizes of fish, and in animals and humans; and the perpetuation of traditional knowledge of fishing and related activities will happen, as stated in the Agreement's second objective, within the context of protecting the population from mercury and other contaminants.

In summary, the Agreement sets out a global vision for promoting fisheries restoration within the context of promoting and protecting the health and well-being of the population. The role of the Public Health Authorities, and thus the CBHSSJB, is explicitly implied in Section 5 and implicitly understood in relation to some of the provisions in Section 6 for the restoration of fisheries.

3.1.2 Oujé-Bougoumou/Nemaska study

The core component of the multi-community study outlined below is based on the Oujé-Bougoumou/Nemaska study "Exposure and Preliminary Health Assessment of the Oujé-Bougoumou Cree Population to Mine Tailings Residues" (Dewailly and Nieboer, 2005). The latter was conducted primarily to determine whether Oujé-Bougoumou residents were at risk of taking in contaminants related to mine tailings, namely arsenic, copper, zinc, and selenium. An array of clinical chemistry and other measures that relate to aspects of individual and community health were also conducted. The observed measures were related to information obtained in a detailed questionnaire about the type and quantity of traditional foods consumed and other personal factors such as age, sex, living in the bush, participation in hunting, smoking habits and occupation among others. An unexpected finding was the high concentrations of PCBs and OC pesticides observed in blood plasma samples of Iyiyiuch, especially for the oldest participants (the over-40 group). This study raised concerns among community members regarding environmental quality and possible effects on human health and called for a follow-up, which led to the needs and feasibility study outlined below.

3.1.3 Needs and feasibility study

Eight of the nine Iiyiyiu Communities (except Nemaska) and a number of Iiyiyiu entities were visited during the period from the end of November 2003 to the end of March 2004. The purpose was to share with them recent developments within the CBHSSJB to reconstitute the Mercury Working Group, the objectives and findings of the Oujé/Nemaska study and to introduce core

components of the proposed multi-community study described herein and to determine their interest and willingness to participate in it. The information and direction received during the community consultation was to be used to develop a more detailed project proposal (which led to the current project). In the communities, meetings were held with the Band Councils and feedback from individual community members was obtained in open house style meetings (in Waswanipi, Waskaganish, Eastmain and Wemindji) and by way of a radio phone-in show (Chisasibi and Whapmagoostui). Such a public meeting was neither planned nor held in Oujé-Bougoumou and could not be arranged during our short visit in Mistissini. On the whole, good support was received in all communities and from Iiyiyiu entities.

The most common special local environment-and-health concerns noted by the communities and the Iiyiyiu entities were: addressing food safety issues such as contaminants and parasites in wild meats; assessing the quality of community drinking water; the importance of including PCBs and other organic contaminants in the screening due to the results found in the Oujé/Nemaska study; and respiratory issues related to the occurrence of high levels of blowing dusts and indoor air quality (especially the presence of moisture and moulds).

3.2 Objectives and Scope

Because of the New Mercury Agreement, the CBHSSJB has reconstituted its Mercury Program in the context of a more comprehensive environment-and-health program. One of the goals of the CBHSSJB is to set up long-term monitoring and surveillance activities[2] focusing on exposure to and intake/body burden of mercury and other contaminants in the Iiyiyiu communities. These activities are to be done in a manner that promotes community interest, and involvement on environment-and-health issues.

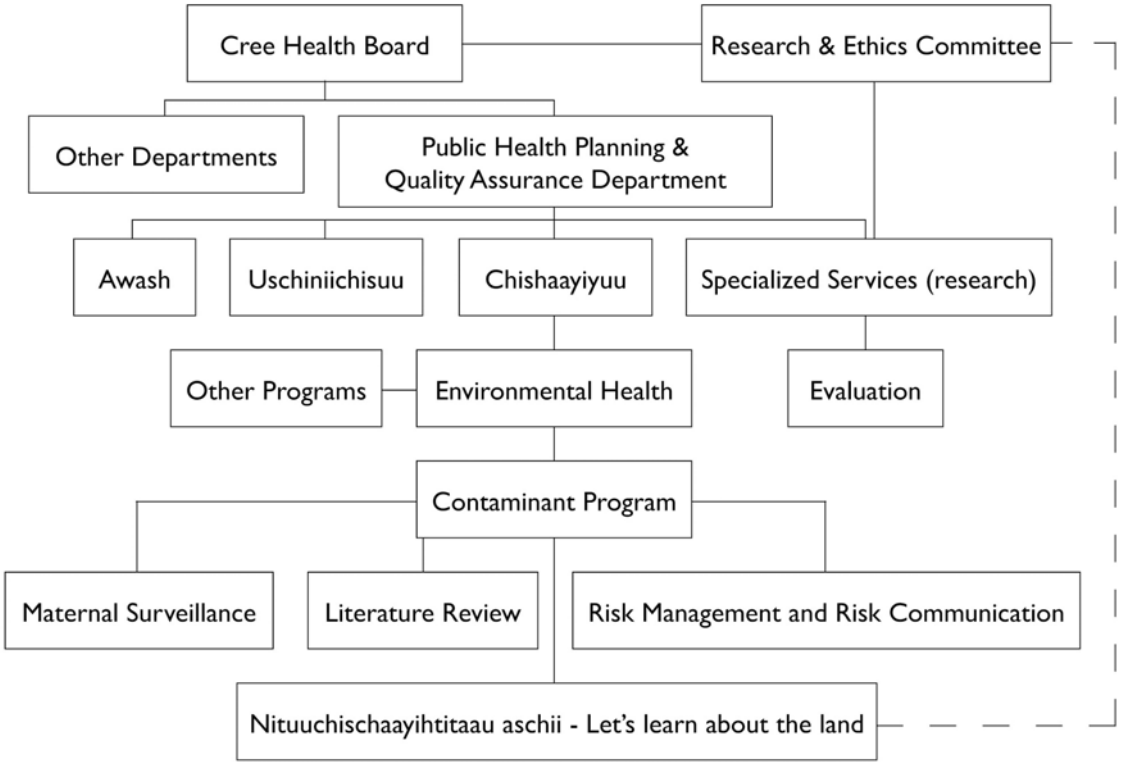
This project proposes to address several environmental-health issues as part of a core project, mainly based on the issues raised during the two previous studies, but also on the basis of known research gaps. It will be implemented over a seven-year period and and the work from first year (2005) in Mistissini constitutes its pilot phase.

[2] Monitoring or screening is for collecting data for the purpose of assessing individual exposure and intervention. In contrast, surveillance means the acquisition of data at the community level for reference and determining trends and distribution patterns and changes therein, in relation to control measures. The present study is designed to conduct both.

3.2.1 Objectives, organization and logistics

Environmental health is one of six domains of public health in which regional public health departments are expected to develop programs and services as outlined in Quebec's National Public Health Program 2003-2012. Activities to prevent or reduce health effects of air and water pollution and of major development projects must be initiated, as well as programs to prevent exposure to heavy metals such as mercury and lead. The Public Health Department (PHD) and other workers in the CBHSSJB are also active in chronic disease prevention (diabetes, heart disease, osteoporosis, etc.) through the promotion of healthy lifestyles and environments, including the promotion of traditional and healthy diets. The organizational chart illustrated in Figure 3.1.1 shows where the current project fits into the environment-and-health mandate of the Public Health Department within the CBHSSJB. This project is clearly an important component of its contaminants program.

FIGURE 3.1.1 PLACEMENT OF THE MULTI-COMMUNITY STUDY WITHIN THE PUBLIC HEALTH DEPARTMENT OF THE CBHSSJB

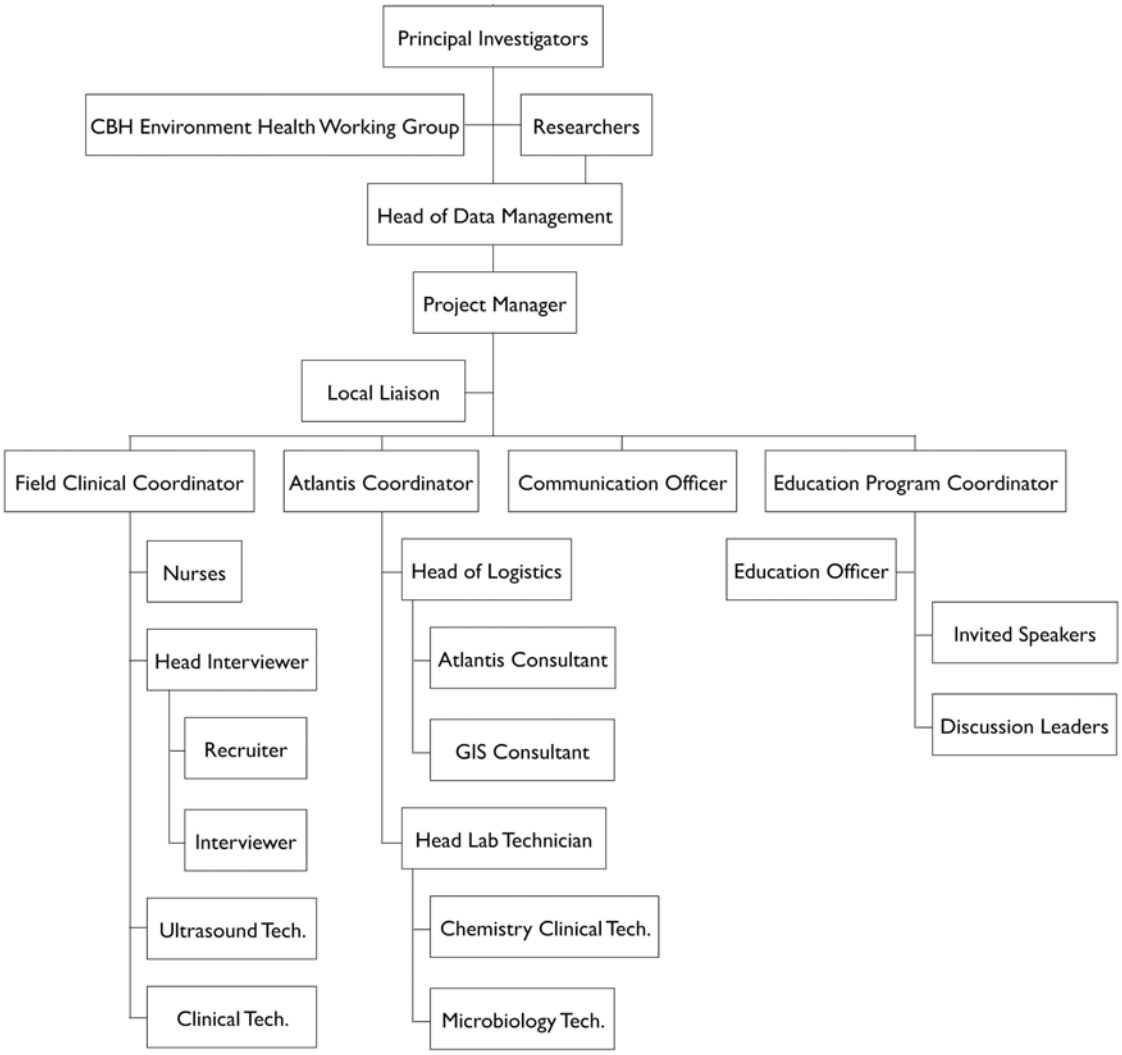


The main objectives of the project are to: assess consumption patterns of traditional and store-bought foods and their role in dietary adequacy; establish a baseline (for each community) for the exposure to mercury and other contaminants and related clinical biochemistry parameters; as well as facilitate community awareness about contaminants and their monitoring. Specific objectives of the project may be itemized as follows:

1) *Assess exposure to environmental contaminants and nutrient intake in relation to diet:*
    - Investigation of consumption patterns of traditional and store-bought foods;
    - Assessment of environmental contaminant concentrations in blood/hair of Iiyiyiu people and in traditional food items;
    - Assessment of concentrations of some essential nutrients in traditional food items and estimation of intake in the traditional Iiyiyiu diet (e.g., selenium and fatty acids);
    - Assessment of the risks and benefits of the traditional diet with regards to contaminant versus nutrient content/intake.
    - Evaluation of the contribution of traditional food to dietary adequacy.
2) *Investigate health effects in relation to lifestyle and environmental contaminants exposure:*
    - Diabetes and fish/game and carbohydrates consumption;
    - Diabetes and environmental contaminant exposure;
    - Cardiovascular health, environmental contaminants and nutrition;
    - Osteoporosis in relation to exposure to persistent organic pollutants;
    - Endocrine effects in relation to environmental endocrine disruptors.
3) *Investigate the links between wildlife health, quality of aquatic environments and human health:*
    - Assess the risk of human exposure to zoonotic agents in relation to wildlife health status;
    - Investigate the contamination of freshwater ecosystems, the risks to human health and/or wildlife health.

To achieve the project's goals, a multi-institutional, multi-disciplinary and collaborative team has been constituted, and several sub-committees have or will be constituted, to take charge of the different aspects of the project (Figure 3.1.2).

FIGURE 3.1.2 PROJECT TEAM ORGANIZATION



With this partnership comes the expertise needed to design and conduct a study that integrates a large number of multidisciplinary activities. These include: bringing a research team along with mobile laboratories (Atlantis) into one of the communities for up to four months each year, thereby visiting all communities over a 7-year period; administering questionnaires concerning exposure, lifestyle, health, and traditional and store-bought food intake; clinical measurements and biological specimen collections; addressing community environment-and-health concerns such as parasites in traditional foods and worries about drinking water safety; information and technology transfer on the community level; and community involvement in the project design including the use of focus groups. This approach is proposed to best incorporate sensitivity to the integrative life-and-world view of the Iiyiyiu people, namely that there is no distinction between the well-being of the environment and human health.

The following sections describe in more detail each of the specific areas of research that are addressed in the project, including a rationale for specific research hypotheses to be addressed, as well as background information for each of the sections, when relevant.

3.2.2 Socio-demographic information

General socio-demographic parameters are important determinants of the health status of a given population. In order to be able to analyze and interpret the results obtained on environmental contaminants exposure assessment, nutritional status of individuals and general health status, information is needed about the participants, including: general socio-demographics (e.g., gender, age, family size, etc.), residency and household property information (e.g., places and duration lived there, age of present house, type of building materials, etc.), occupational details (job responsibilities, physical aspects, potential contaminant exposure), outdoor activities and hobbies (time spent outside, hunting details, play areas for youngsters, etc.), lifestyle issues (concerning exercise, smoking, alcohol use, etc.) stress and psychological well-being, as several of these parameters may affect the studied outcomes in one way or another. Furthermore, this information is also needed for framing public health messages in a manner that will promote overall nutritional health and food safety in the communities. This information is gathered with specifically designed questionnaires (mainly the individual and clinical questionnaires, see section 4.3 and Appendix 1).

3.2.3 Dietary habits, nutritional status and lifestyle habits

Diet affects human health in several ways. Inadequate nutrient intake, excessive intake of fats and sugar, intake of harmful food additives and/or contaminants are all factors that may lead to adverse health effects. The environmental-health study carried out here includes a strong dietary component, since exposure to environmental contaminants occurs mainly through dietary intake. Moreover, several health endpoints that are considered in this study may be affected by dietary habits, and therefore the latter need to be documented. Since there are no recent quantitative assessments of nutritional intake and status for Iiyiyiuch, this study proposes to document these important lifestyle aspects.

Dr. Grace Egeland and her colleagues at the Center for Indigenous Peoples' Nutrition and Environment (CINE, McGill University) were therefore asked to join the team and design, coordinate and implement the nutritional/dietary/physical activity component of the study. This key study component includes an assessment of the intake frequencies and amounts of traditional foods, some market foods, macronutrients and selected micronutrients in relation to

recommended daily allowances for individual consumption, and to determine the number of individuals having intakes below estimated average recommendations (EAR) or adequate intakes (AI), as defined by the Dietary Reference Intakes (DRI) (IOM 2000a). This assessment is carried out through structured interviews and specifically designed dietary questionnaires (food frequency for market and traditional foods, 24-hour recall, see section 4.3 and Appendix 1).

3.2.4 Environmental contaminants

Toxic metals (lead, mercury, cadmium) and organochlorines (polychlorinated biphenyls, DDT, chlordane, mirex, etc.) are ubiquitous environmental contaminants that have been detected in biological samples from people throughout the world, and especially in aboriginal populations living at northern latitudes (Van Oostdam et al. 2005). In these populations, exposure to environmental contaminants mainly originates from the consumption of contaminated wild food, since these chemicals have often contaminated the food chain. In addition to these legacy contaminants, new compounds of interest have emerged in recent years, including halogenated phenolic compounds (e.g., hydroxylated metabolites of PCBs, chlorophenols) (Sandau et al, 2000), brominated flame retardants (polybrominated diphenyl ethers, polybrominated biphenyls) (Birnbaum and Staskal, 2004) and perfluorinated compounds such as perfluoroctane sulfonate (PFOS), which was used as a water/stain repellent (Houde et al., 2006). Exposure to environmental contaminants was also reported in Cree people of the Oujé-Bougoumou and Nemaska communities of Quebec (Dewailly and Nieboer, 2005; Bussières et al. 2004). Therefore, one objective of this study was to characterize exposure of the Iyiyiuch of all communities to environmental contaminants, identify dietary sources of exposure and study possible relations with health endpoints.

In order to characterize the body burden of toxic metals and OCs in Iiyiyiuch from Mistissini, participants were asked to donate a blood sample for the analysis of lead, mercury and cadmium in whole blood and the analysis of the 14 most prevalent PCB congeners and 11 common chlorinated pesticides and metabolites in plasma. In addition, a hair sample was obtained for mercury analysis, and nail samples for selenium analysis. In order to measure the concentration of dioxin-like compounds (DLCs) in plasma samples of Iiyiyiuch from Mistissini, we used an *in vitro* bioassay referred to as DR-CALUX (the dioxin-receptor chemically-activated luciferase expression bioassay). This reporter-gene bioassay uses cells that express luciferase in response to the activation of the Ah receptor by dioxin-like compounds (DLCs). In presence of luciferin (luciferase substrate), the cells emit light proportionally to their exposure to DLCs (Ayotte et al., 2005; Pauwels et al, 2000). This method allows for the determination of DLCs at a fraction of

the cost of the usual analytical method (HRGC-HRMS). We also tested the relationship between DLC concentrations measured by the bioassay and plasma PCB concentrations determined by HRGC-MS, since most of the dioxin-like toxic equivalents in plasma are contributed by PCBs (Ryan et al., 1997).

We also set out to determine the concentrations of 86 persistent organic pollutants (POPs) in pooled plasma samples of Iiyiyiuch, in order to better characterise their body burden of old and emergent compounds of interest, and investigate the relationship of body burden to gender, age and fish consumption. Pooled samples were constituted for men and women, according to age (five categories) and fish consumption (three categories). We used a semi-automated extraction and purification procedure that yields several fractions containing the various analyses from a single plasma sample (5 mL). Fractions were analysed by high-resolution gas chromatography-mass spectrometry (HRGC-MS) (Dumas et al. 2006). This analysis on pooled samples was done as part of the pilot phase only, and results obtained are to serve as a decision tool to determine the suite of environmental contaminants to assess in blood collected in other communities participating in the study.

3.2.5 Prevalence of selected biochemical, morphometric and medical outcomes.

3.2.5.1 Metabolic syndrome, cardiovascular disease and diabetes

Chronic diseases are most often related to multifactorial causes, some of them preventable if the risk of developing a disease is identified early enough. The metabolic syndrome is a condition associated with several genetic, lifestyle and environmental determinants (Zimmet, Alberti et al. 2001) and represents a growing health concern since it precedes the onset of type II diabetes as well as the development and progression of atherosclerosis and other cardiovascular diseases. It is mainly characterised by a general resistance of glucose and lipid metabolism to the action of insulin (termed insulin resistance), abdominal obesity, dislipidaemia (blood lipid imbalance) and hypertension (Zimmet, Magliano et al. 2005).

In the last thirty years, socio-cultural and political changes along with large development projects have deeply affected the way of life of the Iiyiyiuch of Northern Quebec. According to the results of a health survey performed among the Iiyiyiuch in 1982-1984 (Foggin et al, 1988), obesity, arterial hypertension and diabetes mellitus have now been added to the list of major health problems while they were almost unknown in the past. The Iiyiyiuch run a very high risk of obesity, hypertension and diabetes mellitus and further in-depth studies of chronic conditions in these communities are needed. Preliminary results from studies carried out in the Inuit of Nunavik suggest that the coexistence of a traditional native diet rich in omega-3 fatty acids and

the consumption of store-bought junk food made of refined carbohydrates (chocolate, soft drinks…) might be a risk factor for the development of insulin resistance or diabetes among natives. These changes in risk-factor patterns are recent and are also expected in other native populations, such as the Iiyiyiuch, due to the westernization of traditional diets. If these initial findings are confirmed in the Iiyiyiuch, major discussions and decisions will have to take place in communities regarding dietary recommendations and food market policies.

Recently, some research groups have suggested that it is possible that exposure to some environmental contaminants may be involved in the development of a metabolic syndrome in which endocrine disruption affects glucose and lipid metabolism (Heindel 2003; Grun and Blumberg 2006; Tabb and Blumberg 2006), even if such environmental exposure is not the main determinant of this condition (genetic background and lifestyle habits being important determinants of the metabolic syndrome). Also, the possibility that serum levels of PCBs and dioxin-like compounds could be causally related to the development of diabetes has been suggested, based on the observation that diabetics show higher than average concentrations of OCs in their serum when compared to non-diabetics in several populations exposed through different routes (Henriksen, Ketchum et al. 1997; Pesatori, Zocchetti et al. 1998; Calvert, Sweeney et al. 1999; Cranmer, Louie et al. 2000; Longnecker and Michalek 2000; Longnecker and Daniels 2001; Steenland, Calvert et al. 2001; Remillard and Bunce 2002; Fierens, Mairesse et al. 2003; Glynn, Granath et al. 2003; Rylander, Rignell-Hydbom et al. 2005; Vasiliu, Cameron et al. 2006). An alternative interpretation of the latter observation was that diabetes alters pharmacokinetics and consequently, OC serum concentrations (reverse causation) (Longnecker et al, 2001; Fierens et al, 2003), but evidence for the causal relationship of POPs to diabetes was brought forward in a recent study carried out in Michigan in which the diabetes status was related to exposure levels prevailing before the onset of the disease, hence rendering the possibility of reverse causation unlikely (Vasiliu, Cameron et al, 2006). These findings warrant further studies and may have special relevance for Iiyiyiuch.

One aim of the present component of the Nituuchischaayihitaau Aschii program is therefore to evaluate various risk factors related to cardiovascular disease (CVD), namely obesity, dyslipidemia, fasting hyperinsulinemia and glycemia, in relation to n-3 PUFAs measured in erythrocyte membranes. These analyses are carried out in order to assess the possible effects of increased dietary carbohydrate intake, combined with elevated n-3 PUFAs from fish consumption, on the development of the metabolic syndrome. Another aim of this study's component is to assess the possible relationship of environmental contaminant exposure to diabetes, obesity and the metabolic syndrome.

3.2.5.2 Endocrine disruption

Exposure to environmental contaminants has also been related to disruption of several endocrine functions, namely disruption of steroid hormones (sex hormones) (De Rosa et al., 1998; Sonnenschein and Soto, 1998) and thyroid hormones (Langer, 2005). In the current study, the set-up unfortunately does not allow a thorough evaluation of sex-hormone disruption (including the seriated sampling of urine and blood for hormonal cycle determinations, etc.), but one health endpoint related to sex-hormone disruption is being investigated in peri-menopausal women (osteoporosis) since it has been related to OC exposure in an earlier study (Côté et al, 2006). Additionally, the status of thyroid hormone homeostasis is investigated in men and women because disruption of thyroid hormones has been reported in experimental studies (Brouwer et al, 1998; Schuur et al, 1998a; 1998b, 1998c; Cheek et al, 1999) as well as in human populations (Koopman-Esseboom et al., 1994).

3.2.6 Exposure to microbial and zoonotic agents

3.2.6.1 Food safety: exposure to zoonotic agents

The aim of this study component was to determine the seroprevalence of eight zoonoses in Iiyiyiu hunters and trappers to verify their exposure to different microorganisms. Due to their non-specific presentation, most of the infections investigated in this study are under-reported and often go unnoticed. With the agreement of the Cree Board of Health, data were collected in the summer of 2005 from 50 subjects (active hunters/trappers and their spouses) in Mistissini. The eight zoonotic infections within the scope of this pilot study where toxoplasmosis (*Toxoplasma gondii*), leptospirosis (*Leptospira* sp.), Q fever (*Coxiella burnetii*), hantavirus *Sin nombre*, echinococcosis (*Echinococcus granulosus*), toxocariasis (*Toxocara canis*), trichinosis (*Trichinella* sp.) and tularemia (*Francisella tularensis*). Hantavirus infection has been included in the study following a first-reported case in Mauricie. The other infections have been documented in the province of Québec (Lévesque et al., 1995; Curtis, 1998; Tanner et al., 1987) and northern Canada (Lantis, 1981).

Leptospirosis, Q fever, trichinosis, tularemia, and more recently hantavirus infection, are included in Québec's Epidemiological Surveillance System for Mandatory Reportable Diseases (Maladies à déclaration obligatoire - MADO). However, from 1985 to 2005, none of these diseases was reported to the public health authorities in the Cree Territories (i.e., the Cree Board of Health).

3.2.6.2 Water microbiology

In the field of water microbiology, there is a need for more rapid, sensitive, specific, and affordable tests to improve water safety, since this medium is an important route of transmission for many of the most widespread and debilitating diseases that afflict humans (Reiff et al., 1996). It is vital to test the microbiological quality of drinking and environmental water used by members of Iiyiyiu communities for consumption. Two types of samples have been studied to evaluate the risk posed to human health: environmental samples, from sites suggested by community officials, and water from storage containers with which community members collect water from natural sites. Microbial targets, including fecal contamination indicators and selected human pathogen microorganisms, have been tested primarily by classical culture-based methods (whenever possible), but also by more rapid, specific, and adaptable molecular amplification methods.

3.3 Ethics and Confidentiality

This project involves a partnership between specific Iiyiyiu First Nations, the CBHSSJB, the Institut national de santé publique du Québec, Université Laval, McGill University, and McMaster University. The project partners will also closely collaborate with the Traditional Pursuits Department of the CRA, the Cree Trappers Association and the Cree School Board. The project partnership will be formalized through an adapted version of the standard research agreement/memorandum of understanding used by the CBHSSJB. The parties to the agreement will be the CBHSSJB, the participating Iiyiyiu First Nation, the INSPQ, CHUQ, Université Laval, McMaster University and McGill University. This agreement will have a mechanism for including other Iiyiyiu First Nation partners in subsequent years.

The proposal for the pilot study was submitted and accepted by the Research Ethics Boards of Université Laval and McGill University and shared with that of McMaster University, as well as the Ethics Committee of the CBHSSJB.

Community consent for the project was obtained through a formal Band Council Resolution inviting Iiyiyiu First Nations to participate in the project. The community involved in the study authorized in writing its identification in any report published for an audience outside of Iiyiyiu Aschii.

Separate consent forms, and corresponding information sheets, were prepared for the following groups: children aged 0-7, 8-14, 15-17 years and adults aged 18 years and older (see Appendix 5). Individuals (or guardians in the case of children) signed informed consent forms to participate in the study. Any reporting and publication of the results must exclude personal identifiers.

All information concerning participants is kept strictly confidential. An alphanumeric code to catalogue and identify questionnaires and biological samples is used to ensure confidentiality. The participant's name does not appear on any documentation except on master sheets that link these data records to the names of individuals. At the end of the completed project, these master sheets will be destroyed, unless they are kept under a new research agreement (which complies with Quebec law and the Tricouncil Policy Statement on Research Ethics with Human Subjects) for a longitudinal follow-up of this study.

All questionnaires and test results are kept at the CBHSSJB. After the study, researchers will only maintain access to the data after signing a new agreement with the CBHSSJB. Each participant is asked to authorize the principal investigators to send abnormal blood results and other medical tests to his/her community health center as a preventive measure. An agreement has been made so that individuals concerned are duly advised by letter to consult their health center concerning these abnormal results.

4. FIELD STUDY AND STATISTICAL METHODS

4.1 Overview

This chapter presents the various protocols employed in the fieldwork. Although the methods used for each study component are described in separate sections, the details about recruitment, participation, various questionnaires (but one), and of the statistical treatments used are presented in an integrated fashion.

4.2 Study Population, Recruitment, Ethics and Confidentiality

4.2.1 Study population and sampling for the complete study

The complete study will primarily focus on 7 of the Iiyiyiu communities: Mistissini (pilot study reported on in this report), Wemindji, Eastmain, Waswanipi, Waskaganish, Chisasibi, and Whapmagoostui. Wemindgi and Eastmain are the two target communities for 2007. As Oujé-Bougoumou and Nemaska were the study groups in the Oujé/Nemaska study, sufficient participants have already been sampled in Oujé-Bougoumou with an additional 50 anticipated for Nemaska. However, both of these communities need to be revisited as more parameter measurements have been added to the present proposed study than were assessed during the Oujé/Nemaska study (specifically, dioxins, furans and emerging contaminants).

The sample size targeted for the complete study has been estimated in two ways. First, using general data of urinary arsenic determinations obtained from the Laboratoire de Toxicologie de l'INSPQ. The arithmetic mean (0.25 μmol/L) and the standard deviation (0.11) of arsenic concentration in urine of non-exposed people (standard) have been used, with a statistical power of 80% (a 0.20 risk of type II error), and a 0.05 risk of type I error (two-sided test). Based on these data, it was estimated that 200 exposed (Oujé-Bougoumou) and 100 non-exposed (Nemaska) participants would allow us to detect significant differences in metal concentrations between groups. Second, using the same power and type 1 error conditions for Aroclor 1260, a geometric mean of 1.32 μg/L and a standard deviation of 1.09 μg/L (corresponding to 134 Caucasian females living in the western Canadian arctic), a minimum of 20-30 individuals in each age/gender group are required to detect a two-fold difference. On this basis, and the actual Oujé/Nemaska study experience, a minimum of 150 individuals will be sampled in the smallest community (Eastmain) and 300 in the largest (Chisasibi). More specifically, the following are the target numbers: 150 (Eastmain), 160 (Whampagoostui), 200 (Wemindji and Waswanipi), 250 (Waskaganish) and 300 (Mistissini and Chisasibi). In addition, 50 more samples are to be collected in Nemaska (since only 100 were collected in the Oujé/Nemaska study. This brings the total to 1,610.

4.2.2 Sampling and recruitment in Mistissini

The community of Mistissini was visited during the summer of 2005 within the context of the pilot study. For this community, sampling of the population followed a stratified sampling design considering the following age categories: children between 0 and 7 years old, children between 8 and 14 years old, adults between 15 and 39 years old, and adults over 40 years old. The selection of participants within each age stratum was done using simple random sampling without replacement in order to build the lists of potential participants to be contacted by recruiters. Weights were attributed for each stratum in order to ensure population representation.

A first list of 300 participants was selected for recruitment. The latter participants were all contacted first, then, based on refusals, a second backup list of participants was randomly selected and used to continue recruitment in order to meet the target number of participants in each age category. An additional sub-group of 50 hunters/trappers, and their spouses, was selected for the seroprevalence of zoonoses.

The recruitment was facilitated employing the Iiyiyiu Beneficiaries Lists, which was used to randomly select potential participants. These lists were updated, as needed, by qualified local research assistants, who worked as recruiters. These persons were fluent in Iiyiyiuyimuwin and English and were selected directly from the community of Mistissini. Local radio announcements and local publicity were employed to generate and maintain public interest in the project. The local recruiters were responsible for the phone contacts and inviting the randomly selected residents to participate in the research project; they also arranged and supervised appointments. All of these steps were supervised by a field coordinator and the head interviewer.

TABLE 4.2.1 TOTAL POPULATION SIZE AND PARTICIPANTS IN THE CREE COMMUNITY OF MISTISSINI (STRATIFIED BY AGE)

Age group	Population	Invited	Participants
0-7 years	514	75	54
8-14 years	422	62	45
15-39 years	1 221	278	115
≥ 40 years	660	126	68
Total	2 817	541	282

A total of 541 Iiyiyiu of Mistissini were contacted, of which 282 participated (52%) as volunteers and completed the study (Table 4.2.1). The recruitment and participation details are summarized in Table 4.2.2. Among the participants recruited, some tests were targeted only to subgroups: Iiyiyiu women between 35 to 74 years old were invited to do an ultrasound bone densitometry (n = 49), and for those 40 to 74 years old an ultrasound of the carotid was done (n = 57). Heart rate variability was measured for participants 15 years old and over (n = 171).

TABLE 4.2.2 RECRUITMENT AND PARTICIPATION DETAILS FOR THE COMMUNITY OF MISTISSINI (STRATIFIED BY AGE)

Age group	Contacted	Out of the village	Refused	Other reason[1]	Withdrawn	Participant
	n	n	n	n	n	n
0-7 years	75	9	10	2	-	54
8-14 years	62	1	16	0	-	45
15-39 years	278	53	68	35	7	115
≥ 40 years	126	15	28	14	1	68
Total	541	78	122	51	8	282

1 Deceased, pregnant, unknown

4.3 Questionnaires

Many parameters related to lifestyle affect the relationship between environmental contaminants and diet to health endpoints, and need to be documented within the framework of an environmental-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. Then, dietary habits were documented using specially designed questionnaires.

4.3.1 Individual questionnaire

An individual exposure/lifestyle questionnaire was designed and adapted for the specific purpose of this study. Questions were asked of participants 8 years old and over about the following issues: general socio-demographics (e.g., gender, age, level of schooling, etc.), residency/household information (e.g., number of bedrooms, etc.), occupational details (e.g., working status, potential contaminant exposure, etc.), outdoor activities and hobbies (e.g., hunting and fishing details, etc.), lifestyle issues (drinking water, smoking, etc.) and physical activity. This questionnaire was administered by a local interviewer, either in Iiyiyiuyimuwin or in English, and the average time of administration was thirteen minutes. The physical activity questionnaire is a previously validated tool to estimate physical activity (IPAC). It is described in more detail in section 4.8. A copy of the individual questionnaire is provided in Appendix 1.

4.3.2 Clinical questionnaire

A clinical questionnaire was designed and adapted for the specific purpose of this study. It was administered to participants 8 years old and over. It covered topics such as personal medical history, women's health and the perception of environmental pollution. This questionnaire was administered by a research nurse in English, assisted by a local interpreter if the questionnaire was administered in Iiyiyiuyimuwin. The average time of administration for this questionnaire was seven minutes. A copy of the clinical questionnaire is provided in Appendix 1.

4.3.3 Dietary questionnaires

Dietary intake was assessed using two semi-quantitative food frequency questionnaires (FFQ) of traditional foods, taking into account seasonal variations and market food items. In addition, one 24-hour recall and repeat recalls on non-consecutive days for a 20% sub-sample were also attempted in early to mid summer in order to model usual daily intake to evaluate adequacy (IOM 2003). Interviewers/translators were selected from local communities and received appropriate training in dietary assessment techniques. As a quality control measure, all completed questionnaires were reviewed by research team members to ensure all questions were answered adequately and appropriately. Copies of the questionnaires are provided in Appendix 1.

4.4 Interviews and Biological Sample Collection

Sample collection in Mistissini took place from July 4th until August 13th 2005. The randomly selected participants were contacted, informed about the study and their participation was requested. If consent to participate was granted, the participant was given instructions to fast overnight and an appointment was scheduled within the next days. The local interviewers assisted each participant in completing the appropriate written consent form, which was available in English, and all the questionnaires (Appendix 1). If the participant was under 18 years of age, one of the parents or the guardian was invited to sign the informed consent form.

For participants 0 to 7 years old, blood sampling was carried-out for the measurement of lead concentrations and hair sampling for mercury body burden assessment. For all participants over 8 years of age, body weight, height, waist and hip circumferences, as well as sitting height were measured and recorded by the research nurse using standardized techniques (see section 4.6). The research nurse also collected blood, toenail and hair samples, and blood pressure/pulse and body impedance were measured. For a subset of the participants, a second blood test was taken 2 hours after the clinical appointment as part of the oral glucose tolerance test (OGTT) initiated

during the clinical appointment. Following the blood test, a meal/snack was provided to all participants. Oral temperature was taken only if participants were included in the sub-group for the analyses of zoonoses. An ultrasound bone densitometry was carried-out on women 35 to 74 years old, an ultrasound of the carotid was carried out on participants 40 to 74 years old, and the heart rate variability was measured on participants 15 years old and over. This visit lasted approximately two and a half hours, and it was possible to schedule it either during the morning or the afternoon. All blood samples were taken under fasting condition. A time-reimbursement was provided to the participants at the end of their visit, and few visits were done at home for participants who asked for it or for whom it was not possible to come to the clinic (e.g., seniors). All clinical tests are summarized in table 4.4.1, and a fuller description of morphometric measurements and clinical tests is provided in section 4.6.

Ten vacutainers of blood for a total of 57 mL were collected from each participant aged 15 years and over. The vials of blood were collected for the determination of the contaminants of concern, for biochemistry, and CVD markers. The zoonoses analyses were done only for a sub-group of hunters/trappers and their wives. For the participants 7 years old and younger, one vacutainer of 3 mL was collected for lead determination only. For the participants 8 to 14 years old, a total of 29 mL was collected for the determination of the contaminants of concern, and glucose/insulin in plasma (see Appendix 3 for details). Some of the blood specimens were analysed for OCs and mercury in hair, on site in the Atlantis mobile laboratory. Other biological samples (whole blood and plasma) were stored in a freezer at either -20^{o}C or -80^{o}C in the Atlantis mobile laboratory. All biological samples that were not analyzed aboard the mobile laboratory were shipped to Quebec City, where they were kept in a freezer, at ≤ -80^{o}C, at the Public Health Research Unit, Université Laval Medical Research Center, CHUQ, Quebec. Assays of samples were restricted to information contained in the consent form.

For the hair samples, strands (about the length of a pen) were cut close to the scalp from the occipital region of the head by the research nurse. A haemostatic clamp was used to squeeze the hair sample to avoid any movement when cutting and when inserting the specimen into a plastic bag. The latter was stapled to avoid any movement during transportation and handling and was tagged with the participant's identification number, his or her birth date and the sampling date. The proximal end of the hairs (near the scalp) was clearly identified to allow the identification of the segments to be analyzed. Hair samples were obtained from every age group. A summary of biochemical and chemical analyses carried out on biological samples is provided in Table 4.4.2 and fuller descriptions of laboratory methods are provided in section 4.5.

TABLE 4.4.1 SUMMARY OF CLINICAL TESTS BY AGE GROUP

	Informed consent form	Individual questionnaire	Clinical questionnaire	Zoonosis questionnaire	Dietary questionnaires	Environmental contaminants	Clinical biochemistry	Hair sampling	Toenail sampling
0-7 years old	√					Lead only		√	
8-14 years old	√	√	√		√	√	√ [a]	√	√
≥ 15 years old	√	√	√		√	√	√	√	√
Trappers/hunters and their wives subgroup				√					

a Only plasma glucose and insulin, and fatty acid profile (including omega-3)

	Blood pressure/pulse	Height/weight Circumferences waist/hip, Sitting height	Impedance	2-hour Holter	Ultrasound bone densitometry	Ultrasound carotid	Oral temperature	Zoonotics[a]	OGTT[b]
0-7 years old									
8-14 years old	√	√	√						
≥ 15 years old	√	√	√	√	√ if a woman and ≥35-74	√ if ≥40-74			√
Trappers/hunters and their wives subgroup							√	√	

a If the participant is not on the sampling list, we will only take a blood sample and temperature and administer the zoonosis, individual and traditional food frequency questionnaires.

b Participants should be fasting (8-hour fast) for OGTT (not to be done for diabetics) blood lipids and insulin.

TABLE 4.4.2 SUMMARY OF CLINICAL BIOCHEMISTRY AND ENVIRONMENTAL CONTAMINANTS ANALYSES

	Lead (whole blood)	Cadmium (whole blood)	Selenium (whole blood, toenail)	Total mercury (whole blood)	Total mercury (hair)	OCs (PCBs, pesticides)	[a]Emergent POPs and toxaphenes (ASPE method)	[b]Dioxins/Furans (HRGC-HRMS and DR-Calux) Dioxin-like compounds (DR-Calux)
0 years old and over	√				√			
8 years old and over		√	√	√		√	√	√

a 30 pools

b 11 pools

	Blood lipids (Chol, HDL, LDL, TC) and LDL phenotype	Glucose[a]	Insulin[a]	Thyroid hormones T3, T4, TSH	Inflammatory markers (TNF-a, CRP, IL-6, homocystein)	Oxidized LDL	OGTT [b]	Apoproteins (Apo A1, Apo B, Apo C-III)
8-14 years old		√	√					
15 years old and over	√	√	√	√	√	√	√	√

a Homa index, the samples are to be collected after 8-hour fast

b Sub-sampling, after 8-hour fast

	Fatty acids, trans fat in erythrocyte membranes	Vitamins C, D, E, B-carotene	GSH, GPx, GR	Zoonotics *(Francisella turalensis, Coxiella burnetii, Leptospira sp, Hantavirus, Trichinella sp, Echinococcus, Toxocara, Toxoplasma gondii)*
8-14 years old	√			
15 years old and over	√	√	√	Hunters/trappers and their wives

4.5 Laboratory Analyses

4.5.1 Environmental contaminant determinations

Toxic metals (lead, mercury, cadmium) and organochlorines (polychlorinated biphenyls, dioxins, DDT, chlordane, mirex, etc.) are ubiquitous environmental chemicals that have been detected in biological samples from people throughout the world. In addition to these "old" contaminants, new compounds of interest have emerged in recent years, including halogenated phenolic compounds (e.g., hydroxylated metabolites of PCBs, chlorophenols), brominated flame retardants (polybrominated diphenyl ethers, polybrominated biphenyls) and perfluorooctane sulfonate and related fluorinated compounds. In order to characterise the body burden of toxic metals and OCs in Iiyiyiuch from Mistissini, participants donated a blood sample for the analysis of lead, mercury and cadmium in whole blood and the analysis of the 14 most prevalent PCB congeners and 11 common chlorinated pesticides and metabolites in blood plasma. A hair sample was also obtained for mercury analysis, and nail samples for selenium analysis. Additionally, the concentrations of dioxin-like compounds (DLCs) in individual plasma samples of Iiyiyiuch from Mistissini were assessed using a reporter-gene cell-based assay, the dioxin-receptor chemically-activated luciferase expression assay (DR-CALUX) (Ayotte et al., 2005; Pauwels et al, 2000). This method allows the determination of DLCs at a fraction of the cost of the usual analytical method (HRGC-HRMS). Finally, in order to assess exposure to emerging contaminants, we set out to determine the concentrations of 86 persistent organic pollutants (POPs) in pooled plasma samples of Iiyiyiuch to better characterise their body burden of old and emergent compounds of interest, and investigate the relationship of body burden to gender, age and fish consumption. The following describes the detailed analytical methods for contaminant measurements in different matrices used.

Analyses were carried out by the INSPQ Human Toxicology Laboratory, which is accredited ISO 17025 by the Standards Council of Canada. The Toxicology Laboratory is also an international leader in analytical toxicology applied to human and environmental studies and a reference institution for interlaboratory comparison programs in heavy metals and POP measurements. Some of the analyses were carried out in the analytical toxicology module of the Atlantis Mobile Laboratory, which is operated by the staff from the INSPQ Human Toxicology Laboratory. The DR-CALUX assay was performed in the Biomarker Research Laboratory of the INSPQ, which is located in the Human Toxicology Laboratory of the INSPQ.

4.5.1.1 Toxic metal analyses on individual samples

Lead (Pb), mercury (Hg) and cadmium (Cd) concentrations were determined in whole blood samples from individual participants by inductively coupled plasma mass spectrometry (ICP-MS), which allows the simultaneous determinations of several metals in their elementary form in various matrices. Blood samples are diluted in ammonium hydroxide and metals are brought to their elementary form by passing through argon plasma before being identified by mass spectrometry. All samples were analysed on a Perkin Elmer Sciex Elan 6000 ICP-MS (DRC II for Hg) instrument. Detection limits are 0.001 µmol/L for lead, 0.49 nmol/L for mercury, and 0.42 nmol/L for cadmium.

Mercury (Hg) concentrations were also determined in hair samples. Two 1-cm segments were analysed. Hair mercury was determined by cold vapour atomic absorption spectrometry on a Mercury Monitor Model 100 from Pharmacia. Each hair segment was chopped and microwave-digested using nitric acid. An aliquot was used for the analysis. Accuracy and precision are measured using reference materials from the Toxicology laboratory's Interlaboratory Comparison Program. Also, external comparison is assessed within the "Programme de comparaison interlaboratoire du mercure dans les cheveux, Santé Canada, Ottawa". The detection limit with this method is 0.41 nmol/g.

Selenium concentrations were also determined in toe nails by ICP-MS. Samples were digested in concentrated nitric acid and then diluted twenty fold with deionised water. An internal standard is added for improved precision. Calibration is performed under aqueous conditions. The detection limit is 0.09 µg/g with a relative coefficient of variation of 14%.

4.5.1.2 Organochlorine analyses in individual plasma samples

Concentrations of fourteen (14) PCB congeners and eleven (11) organochlorine compounds were determined in individual plasma samples. This traditional suite of persistent organic pollutants (PCBs IUPAC #: 28, 52, 99, 101, 105, 118, 128, 138, 153, 156, 170, 180, 183, 187, aldrin, α-chlordane, γ-chlordane, cis-nonachlor, *p,p'*-DDE, *p,p'*-DDT, hexachlorobenzene, mirex, oxychlordane, transnonachlor, β-HCH) were measured in plasma by GC-MS (INSPQ method E-347-H) according to the following protocol. Blood samples (10 mL) collected in a vial containing EDTA were centrifuged (10 min, 5,000 rpm) and the plasma was transferred into pre-cleaned glass vials and frozen until further processing. Samples were thawed and organochlorines were extracted from a 2-mL aliquot with hexane (three extraction steps). The extract was then evaporated and cleaned-up on Florisil columns, then taken to a final volume of 100 µL. Organochlorines were separated and quantified by GC-MS on a HP-5890 series II gas

chromatograph. Percent recovery ranged from 75% to 90%. The detection limit for Aroclor 1260 is 0.2 µg/L, 0.125 µg/L for PCB-28, 0.05 µg/L for *p,p'*-DDT, *p,p'*-DDE and β-HCH, and 0.02 µg/L for all other PCB congeners and other organochlorine compounds.

4.5.1.3 Determination of dioxin-like activities in plasma by the DR-CALUX assay

Organochlorines were extracted from plasma using a solid phase extraction protocol described in section 4.5.1.4. Part of the extract was further purified on an acid-silica column and reconstituted with 5 µL dimethyl sulfoxide (DMSO). The H4IIE-Luc cell line is stably transfected with the dioxin-responsive element promoter ahead of the luciferase gene. When these cells are exposed to dioxin-like chemicals, they produce luciferase, which enables them to produce light in the presence of the substrate luciferine. The cells are plated at a density of $8x10^4$ cells/well in 24-well plates. After incubating for 5 hours, 2,3,7,8-TCDD dioxin standards and plasma extracts are added to the cells for 24 hours. The cells are washed and lysed in lysis buffer (Promega). Luciferase activity (light emission) is determined with a luminometer (LMax, Molecular Devices). Luciferase activity measured in plasma samples is compared to the TCDD standard curve and toxic equivalent concentrations (TEQs) are determined for plasma extracts.

4.5.1.4 Contaminant analyses on pooled plasma samples

Samples were classified into groups according to gender, five age categories (15-19 year-olds, 20-29 year-olds, 30-39 year-olds, 40-49 year-olds and over) and three categories of fish consumption. Pooled plasma samples were constituted using an equal volume of each individual sample included in a given pool of 5 mL. A minimum of four individual samples per pool were used. Based on this classification, 30 pools should have been constituted, but only 23 pools could be created since 7 groups did not comprise enough individual samples (see Table 4.5.1). The 23 pooled samples were then analysed by a novel analytical method, the Automated Solid Phase Extraction Method (ASPE), allowing the simultaneous detection of 86 analytes, including several parent compounds and their metabolites (Dumas et al, 2006).

TABLE 4.5.1 DESCRIPTION OF POOLED PLASMA SAMPLES

Pool #	n individual samples	Gender	Fish consumption	Age group
111	11	Female	Low	15-19
121	22	Female	Low	20-29
122	4	Female	Moderate	20-29
131	12	Female	Low	30-39
132	12	Female	Moderate	30-39
133	5	Female	High	30-39
142	11	Female	Moderate	40-49
143	7	Female	High	40-49
151	4	Female	Low	50+
152	9	Female	Moderate	50+
153	22	Female	High	50+
211	5	Male	Low	15-19
212	4	Male	Moderate	15-19
221	6	Male	Low	20-29
222	7	Male	Moderate	20-29
223	7	Male	High	20-29
231	5	Male	Low	30-39
232	7	Male	Moderate	30-39
233	4	Male	High	30-39
242	6	Male	Moderate	40-49
243	6	Male	High	40-49
252	7	Male	Moderate	50+
253	15	Male	High	50+

Extraction and purification were completed on a RapidTrace Automated SPE Workstation (Caliper Life Science Hopkinton, MA, USA) and evaporation was performed on a Labconco evaporator (Labconco Corp., Kansas city, MO). Plasma samples were extracted on an Oasis HLB (540 mg, Waters Corp.) solid phase extraction column according to the method described in Sandau et al (2003). The sample was mixed with internal standards and formic acid and applied onto the column. After drying the column, the sample was extracted with methanol: dichloromethane (1:9), evaporated to dryness and dissolved in n-hexane. The extract was separated into two equal parts: one for the DR-CALUX assay and the other for the POP determination.

The ASPE method is based on a fractionation of the plasma extract leading to three fractions (F1, F2, F3), followed by different purification and derivatization methods on F1, F2 and F3, that respectively contain non-polar, non-planar compounds (F1), semi-polar, planar compounds (F2) and polar compounds (F3). The F1 fraction containing PCBs, OC pesticides and BDEs is eluted with hexane:dichloromethane (5:1), the F2 fraction containing methylsulfones is eluted with hexane:acetone (4:1) and the F3 fraction containing hydroxylated PCBs and phenolic compounds is eluted with dichloromethane:methanol (5:1). The F3 fraction is then derivatised with diazomethane in hexane according to Sandau et al (2000). Fractions F2 and F3 are then combined and cleaned up on silica/acidified silica columns. Using this sample preparation, PCBs, OC pesticides and brominated compounds such as brominated diphenyl ethers (BDEs), as well as other compounds, can then be measured by mass spectrometry (GC-MS using negative chemical ionisation (NCI) or electronic impact ionisation (EI). More details on mass spectrometry methods and equipment are provided in Dumas et al (2006). The extraction method theoretically allows the separation of up to 145 analytes. However, the measurement and quantification of the latter require different mass spectrometry procedures and some of the analytes have proven more difficult to integrate without interference than others. Additionally, several analytes have been shown to be frequently undetected in human blood. Based on these observations, the INSPQ laboratory has refined the method and adapted it to human studies by selecting the most relevant compounds to analyse. The final list of compounds includes 86 analytes: 29 PCB congeners (IUPAC # 74, 99, 101, 105, 118, 128, 138, 146, 153, 156, 157, 163, 167, 170, 172, 177, 178, 180, 183, 187, 189, 194, 195, 196, 201, 203, 206, 208, 209) and Aroclor 1260, 16 other OCs (pesticides, phenolic compounds and industrial pollutants) and 26 of their metabolites (15 hydroxy metabolites and 11 methylsulfones), 2 toxaphene congeners (Parlar # 26 and 50) and 12 brominated compounds including PBB-153, Tetrabromobisphenol A (TBBPA), 4 BDE congeners (IUPAC # 47, 99, 100 and 153) and brominated metabolites. The complete list of analytes as well as detection limits and % recovery for all the analytes are presented in Appendix 2 (Table A2.1).

Analyses of perfluorooctane sulfonate (PFOS) were also carried out according to a method recently developed by the INSPQ human toxicology laboratory. This method is based on alkaline extraction of PFOS, perfluorooctanoate (PFOA) and perfluorohexanesulfonate (PFHxS) with methyl-tert butyl ether and tetrabutylammonium hydrogen-sulfate, followed by electrospray LC-MS-MS analysis. Quantification is carried-out using isotope-labelled internal standards. This analytical method has a detection limit of 0.1 µg/L for all analytes. Recovery for PFOS at a concentration of 3 µg/L is 87%.

4.5.2 Clinical biochemistry

4.5.2.1 Blood profile & inflammation.

A selection of blood chemistry parameters relevant to cardiovascular health and diabetic status has been analyzed in the 60 mL of blood taken from each participant. We analyzed plasma lipids such as total cholesterol, high-density lipoprotein cholesterol (HDL-Chol), low-density lipoprotein cholesterol (LDL-Chol) and triacylglycerols (triglycerides), apolipoproteins such as apolipoprotein-A1 and apolipoprotein-B, as well as LDL phenotype and oxidized LDL. Associated CVD markers were also measured such as CRP, IL-6, and TNF-α, and dietary protective factors such as vitamin D. Target values of lipids, glucose and insulin for individuals at high risk of cardiovascular disease and diabetes respectively are presented in table 4.6.1.

4.5.2.2 LDL sizing

Non-denaturing 2 to 16% polyacrylamide gradient gel electrophoresis was performed using a modification of procedures described previously (St-Pierre et al, 2001). LDL particle size was determined using 8 x 8 cm polyacrylamide gradient gels prepared in batches in our laboratory. Aliquots of 3.5 mL of whole plasma samples were mixed 1:1 with a sampling buffer containing 20% sucrose and 0.25% bromophenol blue and loaded onto the gels. A 15-min pre-run at 75V preceded the electrophoresis of plasma samples at 150V for 3 hrs. Gels were stained for 1 hour with Sudan black (0.07%) and stored in a 0.81% acetic acid, 4% methanol solution until analysis using the Imagemaster 1-D Prime computer software (Amersham Pharmacia Biotech, Baie d'Urfé, PQ, Canada). LDL size was extrapolated from the relative mobility (R_f) of 4 plasma standards of known diameter. The estimated diameter for the major peak in each scan was identified as the LDL peak particle size. An integrated (or mean) LDL diameter was also computed. This integrated LDL particle size corresponded to the weighed mean size of all LDL subclasses in one individual. It was calculated as a continuous variable and was computed as the sum of the diameter of each LDL subclass multiplied by its relative area. Analysis of pooled plasma standards revealed that measurement of LDL peak and mean particle size was highly reproducible with an interassay coefficient of variation < 2% (St-Pierre et al, 2001).

4.5.2.3 ApoB and AI

ApoB and ApoA-I concentrations were measured by nephelometry according to standardized clinical procedures using a BN Prospect station (Dade Berhing).

4.5.2.4 CRP

Plasma CRP levels were measured using the Behring Latex-Enhanced (highly sensitive) CRP assay on the Behring Nephelometer BN-100 (Behring Diagnostic, Westwood, MA) and the calibrators (N Rheumatology Standards SL) provided by the manufacturer. The sensitivity of the assay ranged from 0.175 to 11 mg/L. The mean interassay coefficient of variation for plasma CRP levels calculated, using two separate measures of the same aliquot in 134 men, was < 1% at both low and high plasma CRP concentrations (Pirro et al, 2001).

4.5.2.5 Blood lipid measurements (cholesterol, HDL cholesterol, triglycerides)

Cholesterol and triglyceride levels were performed by enzymatic methods on the Vitros 950 Chemistry Station (Ortho-Clinical Diagnostics, Raritan, NJ) using the manufacturer's reagents and calibrators. For cholesterol and triglyceride lipids, 11 µL of sample were analyzed by multilayer film dry-slide chemistry with colorimetric detection. The coefficients of variability were 2.6 and 1.4% respectively. The functional domains varied from 1.29 to 8.40 mmol/L for the cholesterol and from 0.11 to 5.93 mmol/L for the triglycerides. The reference values were <6.0mmol/L and <1.7mmol/L respectively.

HDL cholesterol was measured using the Vitro direct high-density lipoprotein cholesterol slide assay (Ortho-Clinical Diagnostics, Raritan, NJ), based on the precipitation of apolipoprotein B-containing lipoproteins by sulfate dextran/magnesium chloride using magnetic beads. Cholesterol level was then performed by enzymatic methods on the Vitros 950 Chemistry Station. Calibration levels were performed with the VITROS Chemistry Prototype Calibrator Kit 2 (Ortho-Clinical Diagnostics) and verified using VITROS Performanc Verifier fluids. The coefficient of variability was 3.6. The reference values were 0.08 to 1.30 mmol/L. LDL-cholesterol was calculated based on the total cholesterol and HDL cholesterol measurements.

4.5.2.6 Fatty acid determinations

Blood concentrations of fatty acids (FA) were determined in red blood cell (RBC) membranes by gas-liquid chromatography. RBCs (300 µL) were thawed and lysed in 1 mL water. Membranes were isolated by centrifugation (21,000 g for 15 minutes) and washed twice with a 0.9% NaCl solution. The pellet was spiked with an internal standard of phosphatidylcholine C:15 (Avanti

Polar Lipids, Alabaster AL) and lipids were liquid-liquid extracted using chloroform and methanol (2:1 v/v) according to a modified Folch method (Shaikh and Downar, 1981). FAs from membrane phospholipids were methylated in methanol/benzene (4:1 v/v) mixed with acetyl chloride according to previously described methods (Lepage and Roy, 1986). FA profiles were obtained by capillary gas chromatography using a temperature gradient on a HP5890 gas chromatograph (Hewlett Packard, Toronto, Canada) equipped with a HP8823 capillary column coupled with a flame ionization detector (FID). Helium was used as an elution gas (split ratio 1:72). FAs were identified according to their retention time on the column, using a standard mixture of 37 FAs as a basis for comparison (FAME 37 mix, Supelco Inc., Bellefonte PA), which contained the FA standard C15:0, as well as the following FAs: C22:5w6, C22:5w3 cis-12, a mixture of 31 FAs GLC-411 (NuCheck Prep Inc. Elysian, MN) and a mixture PUFA-3 (Matreya Inc, Ontario, Canada). Finally, a mixture of trans FA were also used as standards, containing a mixture of C18:2w6 cis/trans and a mixture of C18:3w3 cis/trans (Supelco Inc., Bellefonte, PA), as well as FA C14:1 trans-9, C16:1 trans-9, C18:1 cis-7, cis-13, trans-6, trans-9, and trans-11. Results were expressed as percent total FAs.

4.5.2.7 OGTT, blood glucose, insulin

An oral glucose tolerance test was performed in the morning after an overnight fast to determine the glucose tolerance status of participants. Blood samples were collected through a venous catheter from an antecubital vein under fasting conditions, then 75 g glucose solution was administered orally and a second blood sample was collected 120 minutes after glucose ingestion for the determination of plasma glucose and insulin concentrations. Fasting plasma insulin was measured by immunoassay with chemiluminescent detection using the Bayer Health Care ImmunoAssay system (Advia Centaur, USA; analytic sensibility 3.6 pmol/L, reference values: 30 to 90 pmol/L). Fasting blood glucose was measured using a spectrophotometric assay (Vitros 950, Vitros Chemistry, Ortho-Clinical Diagnostics, Rochester, NY; fasting reference values: 3.6-6.1 mmol/L). Plasma analysis assessed fasting glucose levels [reference value (RV): 3.6–5.8 mmol/L] and insulin [RV: 0–150 pmol/L].

4.5.2.8 Thyroid hormones

TSH, free T4 and total T3 were measured by immunoassays with chemiluminescent detection using the Advia Centaur analyzer (ImmunoAssay system Bayer Health Care). The TSH, free T4 and total T3 had functional sensitivities of 0.01 mIU/L, 1.3 pmol/L and 0.15 nmol/L respectively, and functional domains from 0.01 to 155 mIU/L, 1.3 to 155 pmol/L and 0.15 to 12.3 nmol/L respectively. The coefficients of variability of inter- and intra-assays were 5.31%

and 2.48% for TSH, 4.60% and 4.67% for free T4, and 1.33% and 3.18% for total T3. The reference values were 0.25 to 5.00 mIU/L, 11 to 27 pmol/L and 1.3 to 3.1 nmol/L respectively. Subclinical or mild hypothyroidism was defined as a TSH > 4.5 mIU/L and T4 ≥ 8 pmol/L, whereas clinical hypothyroidism was considered when TSH > 4.5 mIU/L and T4 < 8 pmol/L. Subclinical hyperthyroidism was defined as a TSH < 0.1 mIU/L and T4 ≤ 22 pmol/L, whereas clinical hyperthyroidism was considered when TSH < 0.1 mIU/L and T4 > 22 pmol/L.

4.5.2.9 Oxidized LDL

OxLDL was measured in EDTA-plasma using a commercial ELISA kit (Mercodia AB) containing a specific antibody (mAb-4E6) that recognizes oxidized LDL and MDA-LDL (malondialdehyde-LDL) (Holvoet et al., 2001).

4.5.2.10 Inflammatory markers (TNF-a, IL-6, homocysteine)

TNF-α and IL-6 were measured in EDTA-plasma using a human TNF-α ELISA kit (Quantikine HS, R&D System) and a human IL-6 ELISA kit (Quantikine HS, R&D System), respectively.

Total plasma homocysteine was quantitatively measured by chemiluminescent immunoassay with reagents provided by the manufacturer and using the Advia Centaur analyzer (Bayer Health Care ImmunoAssay system, USA). The analytic sensitivity was 0.50 μmol/L. The functional domain varied from 0.5 to 65 μmol/L. The reference values were 4.0 to 14.0 μmol/L. The coefficients of variability of inter- and intra-assays were 2.9% and 3.7%.

4.5.2.11 Vitamins (Carotenoids, C, E)

Plasma vitamin C was determined using a Waters HPLC system equipped with an autosampler, a reverse-phase C18 analytical column and UV detection as previously published (Chung et al, 2001).

Alpha-tocopherol (vitamin E) was determined using a Waters HPLC system equipped with an autosampler, a reverse phase column (Nucleosil ODS1) and UV detection as previously published (Talwar et al., 1998). This system simultaneously measured vitamin A, α and β-carotenes.

4.6 Morphometric and Clinical Assessments

Height was measured in centimetres using a measuring tape with the patient standing barefoot on a hard surface. Weight was measured on a beam scale. Waist was measured at the end of exhalation with the tape placed horizontally between the last floating rib and the iliac crest. Hip circumference was also obtained with a tape placed on the hips at the pubic symphysis and the most prominent part of the buttocks. Waist and hip circumferences were recorded to the half nearest centimetre, and height to the nearest centimetre. We transformed anthropological measurements into body mass indices (BMI: kg/m^2) and we used international cut-offs to evaluate obesity in the population (BMI ≥ 30) (Bélanger et al 2004; Kuczmarski & Flegal, 2000; Santé Canada, 2003). Abdominal obesity was defined by the waist (waist ≥ 102 cm in men and ≥ 88 cm in women) (Santé Canada, 2003).

Blood pressure *(BP)* was taken according the WHO clinical guidelines for management of hypertension (Touyz, Feldman, Tremblay, & Milot, 2006) using mercury sphygmomanometers, 15-inch stethoscopes, and cuffs sized to the subjects' arms. Prior to having their blood pressure taken, subjects must have rested for 5 minutes and not eaten or smoked for at least 30 minutes. Each subject had three blood pressure readings. The mean BP was calculated using the two last measurements (Touyz et al., 2006) The target value for individuals at risk of hypertension is more than (140/90 mmHg) (systolic/diastolic hypertension) (Touyz et al., 2006).

Blood profile & inflammation. A selection of blood chemistry parameters relevant to cardiovascular health and diabetic status was analyzed in the 60 mL of blood taken from each participant. We analyzed plasma lipids, apolipoproteins and other associated CVD markers including LDL phenotype (particle size), oxidized LDL, inflammatory markers and dietary protective factors such as vitamins C, D, E and β-carotene (cf. section 4.5.2). Fatty acid profiles were determined in red blood cell (RBC) membranes. Plasma analysis assessed fasting glucose and insulin levels. Target values (Genest, Frohlich, Fodor, & McPherson, 2003) of lipids, glucose and insulin for individuals at high risk of cardiovascular disease and diabetes respectively are presented on Table 4.6.1.

TABLE 4.6.1 TARGET VALUES FOR DIFFERENT BIOCHEMICAL PARAMETERS

	Target values
LDL-C (mmol/L) level[a]	≥ 4.5
HDL-C (mmol/L) level[a]	< 1.00 in men < 1.3 in women
Triglycerides level (mmol/L)[a]	≥ 1.7
Cholesterol/HDL-C (mmol/L)[a]	≥ 6.0
Fasting glucose (mmol/L)[b]	≥ 5.6
Hyperinsulinemia (pmol/L)[b]	≥ 90

a Criteria for risk of cardiovascular disease

b Criteria for clinical identification of metabolic syndrome

Atherosclerosis was measured by carotid ultrasound examination. Carotid intima-media thickness (IMT) is the best assessment of sub-clinical atherosclerosis and is measured by a portable non-invasive ultrasound technique on twelve segments: 2 each of internal, external and common carotids, left and right sides (Bélanger et al., 2004; Lonn, 2001). Among parameters recorded, we used the mean maximum IMT, i.e., the average of the segment maximum IMT for each individual. Carotid IMT was performed only for individuals aged 40 to 74 years using a GE Logiq Book. Images were interpreted by Dr Eva Lonn (McMaster University, Hamilton ON).

Heart rate variability, which informed about the autonomic cardiac function was measured in participants aged 15 years and over. Parameters of heart rate variability were derived from a 2-hour Holter monitoring (Bélanger et al., 2004). These included the median of all RR intervals (NN), the standard deviation of the RR intervals (SDNN) and the standard deviation of the average RR intervals calculated over 5-min. periods (SDANN). We also obtained the square root of the mean squared differences of successive RR intervals (rMSDD) and the proportion of interval differences of successive NN intervals greater than 50 ms (pNN50), which are two indices of cardiac parasympathetic modulation. The analysis of the frequency domain included very low frequency (VLF = 0.0033-0.04 Hz), low frequency (LF = 0.04-0.15 Hz) and high frequency (HF = 0.15-0.40 Hz). The LF/HF ratio was finally calculated.

Bone density. Women aged 35 to 74 years were recruited among the randomly selected participants and a total of 49 women participated. They answered a few questions related to their menopausal status and anthropometric measurements were recorded. Blood samples were collected for the analysis of organochlorine compounds and cadmium concentrations. The risk of

osteoporotic fractures was assessed using the AchillesTM ultrasound bone densitometer, at the right calcaneum. This technique is fast (approximately 3 minutes), simple, non invasive, safe (radiation-free), inexpensive and portable (Lunar Corporation Wisconsin 1995). The ultrasonic pulse propagates through the heel bone. The three ultrasound parameters measured are, firstly broadband ultrasound attenuation (BUA, dB/MHz), which reflects bone density as well as architecture, secondly speed of sound (SOS, m/sec), which reflects bone density and elasticity, and thirdly bone stiffness index (SI, %), which reflects the rigidity of bone structure. SI was computed from BUA and SOS measurements using the manufacturer's equation and expressed as a percentage of young adults' average peak SI (SI = 0.67*BUA + 0.28*SOS –420) (Lunar Corporation Wisconsin 1995). The densitometer was calibrated daily.

The World Health Organization (WHO, 1994) criteria were used for Dual Energy X-ray Absorptiometry (DEXA) to classify Bone Mass Densitometry (BMD) values as normal (BMD less than 1 standard deviation (SD) below the mean for young adults, T-score), osteopenia (BMD between 1 and 2.5 SDs below the mean for young adults) or osteoporotic (BMD more than 2.5 SD below the mean for young adults). The Quantitative Ultrasound (QUS) values were categorized according to the same definition. In the present study, an age-adjusted Z-score of –1 was used as the threshold for risk of fracture.

4.7 Dietary Habits and Nutritional Status

This report covers the nutritional adequacy and dietary quality component of the study and the analysis and interpretation of some of the dietary data. For this report we examined and reported on intake of traditional foods, selected market foods, macronutrients and selected micronutrients and food group intake in relation to Canadian food group guidelines and recommended goals for dietary intake in relation to the number of individuals having an intake that is below estimated average recommendations (EAR) or adequate intakes (AI) as defined by the Dietary Reference Intakes (DRI) (IOM 2000a). In addition, the report includes the results of the serum 25(OH) D (a marker of vitamin D status), and explores the relationship between markers of dietary fat quality as they relate to traditional and market food intake. Finally, the results of preliminary analyses are provided regarding how dietary quality is related to adiposity.

4.7.1 Dietary assessment

Dietary intake was assessed using two food frequency questionnaires (FFQ) and a 24-hour recall (see section 4.3.3). The average daily nutrient composition of the diet of study participants was estimated using CANDAT software (Godin Inc, London, Ontario). This software uses the

Canadian Nutrient file (Health Canada 2001) plus additional food items as necessary (Johnson-Down et al., 2006) including CINE's published data on traditional food nutrient composition data (http://cine.mcgill.ca/nutrients/searchpage.php). Double verification (recall data entry verification by two people) was done.

4.7.2 Assessment of inadequate nutrient intake

To enable public health agencies to formulate nutrition messages for the community, it is important to know the proportion of individuals in a group whose usual daily intake of a nutrient is less than the requirement for that nutrient. To assess inadequate nutrient intake, the Estimated Average Requirement (EAR) cut-point method was used (IOM 2003). Observed daily intakes were adjusted to estimate the distribution of usual daily intakes using either the National Research Council Method or the Iowa State University method (IOM 2003). Then, the proportion of individuals in the group with intakes below the daily median requirement or EAR is determined. This method is not appropriate for energy or iron in menstruating women because the requirements are not normally distributed (IOM 2000b) however the frequency of inadequate iron intake in adult women was estimated using the probability method (IOM 2000b).

4.7.3 Anthropometric indices

Height, weight and waist circumference were measured (see Section 4.6), and body fat percentage were measured using a bioelectrical impedance scale (Tanita). Body mass index (BMI) was calculated (kg/m^2).

4.8 Physical Activity

Physical activity is a protective factor against overweight and obesity (Tremblay & Williams, 2003), and physical inactivity is associated with an increased risk of chronic diseases (Pols, et al 1998). Culturally acceptable and validated instruments for assessing physical activity among Indigenous Peoples' are lacking and sorely needed for health behaviour surveillance and for evaluation of the effectiveness of health promotion efforts. Also, in epidemiologic studies, a valid physical activity instrument can facilitate multidisciplinary research regarding the health determinants. Thus, a physical activity assessment was added to the Mistissini 2005 Study.

The primary objective of the current chapter was to evaluate whether the International Physical Activity Questionnaire (IPAQ) physical activity score correlates with anthropometric indices in the pilot study conducted in Mistissini in the summer of 2005. If the IPAQ is a valid tool for physical activity assessment among the Cree, then significant correlations between activity level

and anthropometric indices should be observed in the study population and thereby justify further adaptation of the questionnaire for the Cree, and further validation using accelerometers, heart rate monitors and/or pedometers, as well as exploration of the IPAQ ability to predict biomarkers known to be associated with physical activity in a larger sample.

4.8.1 Background on the international physical activity questionnaire (IPAQ)

The IPAQ questionnaire was developed in 1996 by an International Consensus Group in an attempt to address the lack of internationally comparable physical activity measures (IPAQ, 2005). Two versions of the IPAQ were developed, the short and the long versions. The short version was designed for use in surveillance studies. The long version was designed for a more comprehensive assessment of daily activity for use in research. However, given community concerns regarding the questionnaire burden of health research on participants, the short version was selected for the Cree study. The IPAQ assesses activity performed in leisure time, domestic activities, work and transportation-related activities and is designed to be culturally adaptable. The reliability and validity of the IPAQ tests show that its abilities to measure physical activity levels are comparable to other generally accepted self-reported assessment methods. Correlation ranges of 0.34 to 0.89 have been obtained from reliability studies and 0.14 to 0.53 in validation studies (Craig et al, 2003). Furthermore, the IPAQ has been selected for use in various high-profile studies such as the European Physical Activity Surveillance System (EUPASS), the European Health Interview Survey (EUROHIS), the Countrywide Integrated Non-communicable Disease Intervention (CINDI), and the WHO World Health Survey (WHS) (IPAQ, 2005). However, the statistical methods used to determine the reliability and validity of the IPAQ have been criticized (Hallal & Victoro, 2004), and a study involving the measurement of physical activity in urban Indigenous Australians abandoned the IPAQ when participants had considerable trouble understanding and completing the questionnaire (Marshall, 2004).

While doubly-labelled water testing, involving deuterium and oxygen-18 enriched water, is considered the best, or gold standard, for validating a physical activity questionnaire, it is time-consuming, expensive and problematic to execute in remote communities. Accelerometers and heart rate monitors (Tremblay et al, 2002; Bassett, 2000) can be used in field settings to validate questionnaires. Another approach is a self-reported log book and activity diaries. As a first phase pilot study evaluation, our objective was to determine whether the IPAQ correlated with anthropometric indices.

4.8.2 IPAQ questionnaire administration

The interview-administered short version of the IPAQ was used in the current study as part of the individual questionnaire (see Appendix 1). It is recommended that cultural adaptations are made to the physical activities used in the original IPAQ questionnaire in order to increase cultural relevance (IPAQ 2005). Bilingual Cree research interviewers reviewed the original IPAQ and suggested culturally appropriate examples of physical activities to replace the original examples provided in the IPAQ, and translated the questionnaire. The comprehensive compendium of physical activity (Ainsworth et al., 2000) was used to calculate physical activity as metabolic equivalents (METs), which represent multiples of resting metabolic rates, and a standard body weight of 60 kg to measure the volume of each type of activity and to sum the MET minutes per week. MET values and formulas for the computation of MET minutes/week were based upon the formulas provided by an IPAQ Reliability Study (Craig et al, 2003). Six adult participants were excluded from the analyses due to missing physical activity data. All activities were summed to provide a Total MET score, whereas, for Vigorous MET scores, only activities listed as vigorous in intensity in the compendium of physical activity were used to calculate the score. The questionnaire covered the past 7 days.

Total MET and Vigorous MET scores were evaluated as continuous data and as ordered categorical groupings approximating quartiles for Total METs and approximating tertiles for Vigorous METs. Due to the distribution of the scores, uneven sample sizes exist in the various groupings.

4.9 Statistical Analysis

Statistical analyses were run with a significance threshold of $\alpha = 5\%$ using SAS (SAS Version 8.2 and 9.1, SAS Institute, Cary, NC) except for principal component analysis (PCA) which was performed using SPSS (version 11, Lead Technologies).

4.9.1 Dietary habits and nutritional status

Software for Intake Distribution Estimation (SIDE) (Software for Intake Distribution Estimation, Iowa State University 1996) was used to obtain estimates of the usual nutrient intake distributions using observed intakes on repeated days adjusting for the interview sequence and the day of the week. When the SIDE software was unable to adjust a nutrient, the NRC method was attempted (National Research Council 1986).

4.9.2 Physical activity

Only adults 18 years of age and older were included in the current analyses. Bivariate Spearman correlations between the total metabolic equivalents (METs) and vigorous METs and BMI, % body fat and waist circumference (WC) were examined, which is appropriate for skewed data. Furthermore, mean and standard deviations (SD) for the anthropometric variables were evaluated by the approximate quartile groupings of total METs and the approximate tertile groupings of vigorous METs. Multivariable linear regression analyses were conducted to control for age and gender, and we explored the homogeneity of the results by testing physical activity level by sex interaction terms, and by separately conducting age-adjusted regressions for men and women. Furthermore, because of the high prevalence of obesity, we further stratified by obesity (BMI $<$ 30 vs. BMI $\geq$ 30) and re-evaluated physical activity associations with WC and % body fat.

4.9.3 Environmental contaminants exposure

Percent detection was computed for all contaminants according to age group. Non-detects were replaced with a value equal to half the limit of detection. Further statistical analyses were carried-out only when a minimum of 60% of individuals had detectable levels of a given contaminant. Descriptive statistics are presented for contaminant body burdens. Since most contaminants follow a log-normal distribution, geometric means and confidence intervals were computed and compared. The associations between hair and blood concentrations of mercury, and between blood and nail concentrations of selenium were assessed using Pearson's correlation coefficients. The association between the results of the DR-Calux assay with PCB-153, as a marker for exposure to the environmental mixture of organochlorine pesticides containing dioxin-like compounds, was assessed using Pearson's correlation coefficient.

Principal component analysis (PCA; Gauch 1982) and correspondence analysis (CA; Thioulouse et al. 1997) were employed to generate a smaller number of uncorrelated variables containing most of the variance of the raw data sets of plasma contaminants (Tsuji et al, 2006). Plasma contaminant concentrations, both PCB congeners and organic pesticides, were log $(x + 1)$ transformed before CA or PCA. Concentrations of contaminants below the detection limit (DL) were imputed as DL/2. In addition to the CA performed on all contaminants, a sub-analysis was conducted using only those PCBs and pesticides for which the detection frequency $\geq$ 70%. Both the measured contaminant concentrations, and the new CA and PCA summary variables, were analyzed by 2-way ANOVA to examine the effects of age group and gender.

Plasma contaminant summary variables (principal components, correspondence analysis axes, and sums of PCB congeners and pesticides) were investigated to determine if values of these variables were dependent on consumption of the various traditional food items. PCA analysis of the consumption frequencies of traditional food items derived from the diet questionnaire was carried out after screening of the diet data to eliminate those variables with zero variance. Partial correlation analyses adjusting for age were used to explore the interdependence of the various traditional food items and those between the organochlorine contaminants and the traditional dietary-consumption frequency data.

Analyses were performed using SPSS version 13 (SPSS 2006), with the exception of CA, which was carried out using the ADE-4 package (Thioulouse et al. 1997).

4.9.4 CVD and diabetes risk factors

The analyses reported here are descriptive according to the categories of the various variables such as socio-demographics, lifestyle habits and anthropometric variables. Variance analysis allowed us to compare means and the Khi^2 test was used to compare proportions. When the distribution of the variable was not normally distributed, the median and interquartile range (IQR = Q75-Q25) were presented, and comparisons were carried out with Mann-Whitney U test. All data were weighted in order to take into account sampling strategy. Linear regression and/or Pearson product moment correlations were used to evaluate the relationship between mercury and Holter parameters. Because of the small sample size, other multivariate analyses were not carried out. An increased sample size will allow an extensive exam of chronic diseases and their association with other factors in the framework.

4.9.5 Osteoporosis

For descriptive analysis, weighted frequencies and prevalence for categorical variables and weighted means for continuous variables were calculated to describe osteoporosis and its risk factors in the 49 liyiyiu women. The osteoporosis risk factor variables that were available were age (years), weight (kg), height (cm), waist circumference (cm), hip circumference (cm), physical activity (measured by sitting less than 3 hours per day), menopausal status (assessed by the question “Do you still have your period?”), current hormonal replacement therapy and current smoking status. Weighted means and confidence intervals of the ultrasound measurements were also calculated according to certain factors such as current smoking status, physical activity, menopausal status among peri- and post-menopausal women, and oral contraceptive use among the women who still have their periods. Age was the major risk factor

that explained roughly 46% of the ultrasound measurement variations. Multivariate analysis was not performed in the present analysis because of the small sample size and the low association between osteoporosis and other risk factors. It will be done when the data from the other communities is included and the sample size is larger.

4.10 Participation in Dietary, Environmental Exposure, Clinical Biochemistry and Medical Outcomes

There are a number of reasons why the participation rates varied between the various components of the study. Of these, non-compliance with answering questions on the appropriate questionnaire, exclusion/inclusion of children, and sub-studies that targeted specific participant groups constituted the primary reasons.

Total Population. There were a total of 282 participants, divided into age-specific subgroups as shown in Tables 4.2.1 and 4.2.2.

Socio-demographic characteristics. As illustrated in Table 5.1.1, exclusion of 0 to 7-year-olds reduced the participants to 228 in the individual questionnaire. It is also clear from Tables 5.1.1-5.1.3 that not all participants answered every question, or that some questions focused on sub-groups (e.g., hunters; Table 5.1.2).

Dietary habits, nutritional status and lifestyles. The number of individuals who participated in the three dietary questionnaires again was 228, as children aged 0-7 years were excluded. Details for the 24-hour recall questionnaire, including repeats, are provided in Table 5.2.1. For the physical component, activity scores could be calculated for 161 adults, with n = 111 for the walking activity (see Table 5.2.15).

Environmental contaminants. The participant number depended on the specific contaminant measured in plasma or whole blood, and primarily reflects whether children under 8 years old were included: cadmium (223), lead (276), mercury (223), selenium (223), and PCBs/organochlorine pesticides (234; see Table 5.3.14). Hair mercury was assessed for all children and adults (n = 275). The Dr-Calux assay involved plasma samples from 203 individuals 15 years old or over (119 women, 84 men). In addition, 23 pooled samples were analyzed for 86 compounds, with the number of individual mixed specimens varying between 4 and 22 (see Table 4.5.1).

Clinical biochemistry and clinical assessments. The core study group did not include the 0-7 year olds. Carotid intima-media thickness measurements were made for 63 individuals between

the ages of 40 and 74, and heart rate variability was measured in 167 persons. Bone density measurements were made in 49 women aged 35 to 75 years.

Seroprevalence of zoonoses. A total of 50 active hunters/trappers participated; they were not part of the core study.

5. RESULTS AND DISCUSSION

5.1 Demographics and lifestyle

5.1.1 Socio-demographic profile

Some aspects of the socio-demographic profile of the study participants are summarized in Table 5.1.1. Clearly, female participation was considerably greater than that of males. Cree was the primary language, followed by English. Most individuals completed secondary education or higher, and the proportion of students was 25.9%. While 35.1% declared working full-time, 13.2% declared having part-time employment or working occasionally. 25.9% of respondents declared being unemployed, but further information regarding reasons for unemployment is not provided.

5.1.2 Bush-related activities

From the information compiled in Table 5.1.2, it is evident that close to one-half of the participants spent time in the bush during the autumn and winter, but considerably less so in the summer. A comparable proportion was involved in hunting. Use of lead-containing ammunition appeared to be similar to that for non-lead shot.

TABLE 5.1.1 SOCIO-DEMOGRAPHIC CHARACTERISTICS OF MISTISSINI PARTICIPANTS

	Number of replies	Mistissini (%)
Gender	282	
Male		39.7
Female		60.3
Language spoken at home (excluding 0-7 yr. olds)	228	
Cree		97.8
English		48.7
French		4.4
Proportion of households with adults aged 15 to 49 years	228	
0		7.5
1-2		48.7
3-4		32.0
≥5		11.8
Proportion of households with adults aged 50 years or more	224	
0		62.5
1-2		36.6
3-4		0.9
≥5		0
Proportion of households with children aged 14 years or less	228	
0		28.5
1-2		42.1
3-4		26.8
≥5		2.6
Highest level of formal education completed	228	
No schooling		10.5
Elementary		26.8
Secondary		48.3
Collegial and over		14.5
Working status	228	
Student		25.9
Work full-time		35.1
Work part-time or occasionally		13.2
Jobless		25.9

TABLE 5.1.2 BUSH-RELATED ACTIVITIES AND USE OF FIREARMS BY MISTISSINI PARTICIPANTS

	Number of replies	Mistissini (%)
Number of days in bush during last fall	228	
Never		52.6
≤ 3/month		11.8
≥ 1/week		35.5
Number of days in bush during last winter	228	
Never		57.0
≤ 3/month		14.9
≥ 1/week		28.1
Number of days in bush during last spring	227	
Never		26.4
≤ 3/month		14.5
≥ 1/week		59.0
Number of days in bush during last summer	227	
Never		67.8
≤ 3/month		13.7
≥ 1/week		18.5
Hunting	228	
Yes		46.1
No		53.9
Hunting with a gun	114	
Yes		86.0
No		14.0
Used bullets	103	
Yes		78.6
No		21.4
Used lead shot	98	
Yes		58.2
No		41.8
Used non-lead shot	97	
Yes		55.7
No		44.3

5.1.3 Sources of drinking water

In the community, bottled water was the primary routine source of drinking water (close to 57.9%) and spring water was the second choice (32.5%), with tap water and lake/river water third (16.2% and 20.6%, respectively). Melted ice or snow was rarely used (see Table 5.1.3). By contrast, the primary source of drinking water in the bush was from a lake or river (70%) and water from a spring second (32.4%), with bottled water third (12.8%). Use of tap and melted ice or snow was rare.

TABLE 5.1.3 SOURCES OF DRINKING WATER USED BY MISTISSINI PARTICIPANTS

	In the community (n = 228)	In the bush (n = 219)
	%	%
Tap water		
All / most time	16.2	0.5
Sometimes	24.1	5.0
Rarely / never	59.7	94.5
Bottled water		
All / most time	57.9	12.8
Sometimes	34.2	18.3
Rarely / never	7.9	68.9
Water from a spring		
All / most time	32.5	32.4
Sometimes	25.0	12.8
Rarely / never	42.5	54.8
Water from a lake/river		
All / most time	20.6	70.0
Sometimes	22.4	13.2
Rarely / never	57.0	16.8
Melted ice or snow		
All / most time	0.4	1.8
Sometimes	5.3	8.2
Rarely / never	94.3	89.9

5.1.4 Smoking status

Iiyiyiuch, for the most part, are not smoking in their homes: only 3.5% of those surveyed indicated that there was a smoker in their home. Nearly a third of the participants (30.3%) reported current smoking, and an equal percentage reported being former smokers (30.7%). Heavy smoking of more than 10 cigarettes per day was reported by 26% of smokers. The results indicate that Iiyiyiuch are aware of the damaging effects of second-hand smoke and are actively limiting smoking in their homes, and that a sizable proportion of the population (30%) have quit smoking. More information on smoking habits is provided in section 5.3.1.1 (cadmium exposure).

5.2 Dietary Assessment and Physical Activity

5.2.1 Dietary habits and nutritional status

5.2.1.1 Anthropometry

For anthropometry, adult guidelines are usually based on cut-off values for individuals over 20 years of age, and all those 20 years of age and under are recommended to be assessed using BMI percentiles rather than absolute BMI. For adults (over 20 years of age), 6.4% of women and 10% of men had a healthy body mass index (BMI) of less than 25 kg/m^2, whereas 20.2% of women and 31.7% of men had a BMI indicative of being overweight (25.1-29.9), and 73.4% of women and 58.3% of men had a BMI of 30 or greater indicating a high risk of health-related complications due to excess body weight for height. Percent body fat indicated elevated risk for 98.9% of women and 71.4% of men using age and gender specific cut-off values from a three-country study (Gallagher et al. 1999). Similarly, waist circumference measures indicated that 92.6% of women and 61.9% of men are at risk for health-related complications due to central fat patterning based upon WHO cut-off values of 88 cm for women and 102 cm for men (WHO 2000).

For children and youth (20 years of age and under), average waist circumference was 87.5 cm (SD = 17.8) for girls and 87 cm (SD = 14.7) for boys, whereas percent body fat was 36.4% (SD = 9.5) for girls and 26.8% (SD = 11.7) for boys. At risk of overweight (i.e., having a BMI $\geq$ 85th percentile) was highly prevalent with 66.6% of girls and 53.6% of boys having a BMI percentile $\geq$ 85. For overweight (BMI $\geq$ 95th percentile), 55% of girls and 43.6% of boys were overweight.

As childhood overweight predicts overweight and obesity in adulthood (Guo and Chumlea 1999), the data indicate that Mistissini youth are at risk of future obesity and health-related

complications due to excess adiposity. For adults, the anthropometric parameters suggest that a large proportion of community members are at risk of health-related complications due to excess adiposity. Women in particular showed a greater prevalence of obesity than men.

5.2.1.2 Dietary assessment

The age and sex distribution of project participants as well as the number of repeat recalls are presented in Table 5.2.1. A total of 228 individuals participated in the dietary component of the study; repeat recalls were obtained for 41 individuals or 18% of respondents. Unfortunately, the repeat recalls were not obtained uniformly in the different age groups, which had an impact on our ability to adjust the nutrient data according to Institute of Medicine guidelines.

Energy intakes (EI) were validated by comparing them to 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 consumed is realistic given the energy requirements of one's height, weight, gender and age. In adults, EI: BMR_{est} <1.5 for a group indicates underreporting (Black et al. 1991). The ratio of the EI to the BMR was 1.04 ± 0.22 for men 19 years of age and older, 1.36 ± 0.45 for women 19 years of age and older, 1.12 ± 0.38 for boys 18 years of age and younger, and 1.46 ± 0.38 for girls 18 years of age and younger. Further investigation is required to determine the reason for the serious underreporting in men and boys: one possible reason is that men and boys may be impatient with dietary questions; another reason for the under-reporting may be that the female interviewers may have been reluctant to probe and get complete information from men. Because of the under-reporting, caution is needed in interpreting the absolute values of micronutrient intake in men and boys.

TABLE 5.2.1 TOTAL NUMBER OF 24-HOUR RECALLS COLLECTED IN THE CREE COMMUNITY OF MISTISSINI BY SEX AND AGE GROUPS (N = 228)

Age (years)	8-13		14-18		>19	
Recall	One	Repeat	One	Repeat	One	Repeat
Men/ Boys	26	8	9	0	103	18
Women/ Girls	11	1	15	4	64	10
Total	37	9	24	4	167	28

Total respondents = 228

5.2.1.3 Traditional food intake

Table 5.2.2 presents data on the percentage of the population consuming specific traditional foods corresponding to the questions on food frequency. This table gives average monthly frequency of consumption of these foods in days/month for consumers. Overall, caribou, moose, geese and ptarmigan (or other related birds) were common traditional food items with over 50% of the population reporting that they consumed these items in the past year with an average consumption of 2 or more times a month for each of these items (Table 5.2.2). When traditional food consumption was evaluated by gender and age, there were striking differences noted in the frequency of traditional food consumption by age group, with adults 40 years of age or over consuming 2-4 times more game, fish, fowl, and berries than children or adults under 40 (Figure 5.2.1). The reports of traditional foods on the 24-hour recalls showed a similar trend (Figure 5.2.2). While food frequencies may tend to overestimate consumption of foods especially those that are considered desirable, this is unlikely to account for the striking differences observed by age.

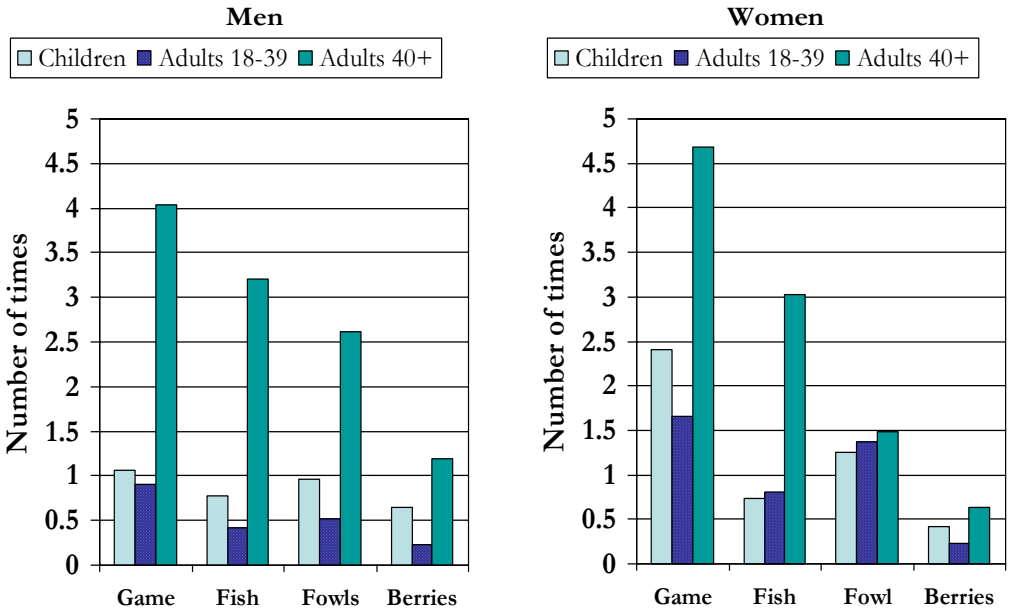
TABLE 5.2.2 FREQUENCY OF TRADITIONAL FOOD CONSUMPTION AS PERCENTAGE OF THE POPULATION CONSUMING EACH TRADITIONAL FOOD ITEM IN THE PAST YEAR AND AVERAGE MONTHLY FREQUENCY OF CONSUMPTION (NUMBER OF DAYS/MONTH) *FOR CONSUMERS ONLY* BY AGE AND SEX[A]

Food	Girls (<19) n = 26 % cons. (days/month)	Boys (<19) n = 35 % cons. (days/month)	Women (≥19) n = 64 % cons. (days/month)	Men (≥19) n = 103 % cons. (days/month)	Total population n = 228 % cons. (days/month)
1. Bear meat dried	4.76 (0.17)	5.71 (4.29)	26.1 (0.95)	27.2 (1.05)	21.5 (1.13)
2. Bear meat cooked	38.1 (0.83)	37.1 (0.83)	78.3 (0.91)	59.2 (0.74)	59.7 (0.82)
3. Bear liver or kidney	4.76 (0.08)	2.86 (0.08)	4.35 (0.08)	4.85 (0.20)	4.39 (0.14)
4. Moose meat dried	19.1 (1.00)	2.86 (0.5)	43.5 (1.19)	36.9 (1.22)	32.0 (1.19)
5. Moose meat cooked	**95.2 (4.81)**	**91.4 (2.50)**	**98.6 (5.05)**	**96.1 (3.66)**	**96.1 (4.03)**
6. Moose liver or kidney	28.6 (0.31)	14.3 (0.40)	59.4 (0.34)	46.6 (0.28)	43.9 (0.31)
7. Caribou meat dried	14.3 (2.59)	11.4 (1.00)	27.5 (3.15)	22.3 (1.62)	21.5 (2.22)
8. Caribou meat cooked	**66.7 (3.54)**	74.3 (1.00)	**89.9 (2.47)**	**79.6 (2.27)**	**80.7 (2.25)**
9. Caribou liver or kidney	9.52 (0.21)	5.71 (0.12)	10.1 (0.68)	6.8 (0.32)	7.89 (0.43)
10. Beaver meat	81.0 (1.54)	65.7 (0.81)	87.0 (1.52)	77.7 (1.18)	79.0 (1.28)
11. Rabbit Meat	61.9 (1.35)	54.3 (0.53)	72.5 (1.10)	62.1 (1.61)	64.0 (1.27)
12. Smoked game animal	33.3 (1.16)	31.4 (0.14)	46.4 (1.01)	28.2 (0.73)	34.7 (0.80)

Food	Girls (<19) n = 26 % cons. (days/month)	Boys (<19) n = 35 % cons. (days/month)	Women (≥19) n = 64 % cons. (days/month)	Men (≥19) n = 103 % cons. (days/month)	Total population n = 228 % cons. (days/month)
17. Speckled trout	52.4 (1.11)	40.0 (2.46)	71.0 (1.32)	58.3 (1.87)	58.8 (1.67)
18. Walleye	76.2 (1.47)	57.1 (1.11)	**85.5 (2.51)**	73.8 (1.55)	75.0 (1.82)
19. Whitefish	9.52 (0.08)	5.71 (0.50)	30.4 (1.54)	35.0 (2.02)	26.8 (1.73)
20. Pike	38.1 (1.05)	37.1 (0.75)	58.0 (1.58)	52.4 (1.57)	50.4 (1.44)
21. Lake trout	47.6 (0.93)	37.1 (2.23)	68.1 (1.31)	42.7 (2.32)	50.0 (1.77)
22. Sturgeon	9.52 (0.17)	11.4 (0.23)	34.8 (0.44)	28.2 (0.94)	25.9 (0.67)
23. Burbot	9.52 (0.08)	5.71 (1.34)	10.1 (1.75)	13.6 (2.37)	11.0 (1.93)
24. Red or white sucker	14.3 (2.09)	14.3 (1.55)	18.8 (2.27)	23.3 (1.97)	19.7 (2.02)
25. Fish from the ocean	4.76 (0.67)	2.86 (0.50)	11.60 (1.50)	10.70 (0.55)	9.21 (0.92)
26. Fish eggs	9.52 (0.54)	5.71 (0.08)	17.4 0.67)	20.4 (1.12)	16.2 (0.88)
27. Smoked wild fish	28.6 (0.89)	37.1 (0.76)	53.6 (1.67)	41.8 (1.01)	43.4 (1.21)
32. Loon or merganser	4.76 (0.08)	2.86 (0.08)	11.60 (0.62)	4.85 (0.58)	6.58 (0.53)
33. Geese	**100 (2.60)**	**100 (2.00)**	**100 (2.39)**	**98.1 (2.22)**	**99.1 (2.27)**
34. Dabblers	23.8 (0.80)	22.9 (1.15)	42.0 (1.17)	28.2 (1.43)	31.1 (1.25)
35. Sea ducks	19.1 (0.86)	22.9 (0.73)	33.3 (0.86)	28.2 (1.25)	28.1 (1.02)
36. Other ducks	0 (0)	5.71 (1.13)	5.80 (1.06)	1.94 (7.73)	3.51 (2.75)
37. Ptarmigan, partridge and other birds	**81.0 (2.46)**	65.7 (1.47)	**87.0 (2.10)**	**78.6 (2.49)**	**79.4 (2.23)**
38. Goose gizzard	28.6 (1.74)	34.3 (2.06)	60.9 (1.56)	49.5 (1.29)	48.7 (1.50)
46. Wild berries	66.7 (1.53)	77.1 (2.04)	63.8 (1.36)	66.0 (1.99)	67.1 (1.77)
47. Wild berry jam	57.1 (1.38)	71.4 (1.77)	62.3 (1.33)	66.0 (2.00)	64.9 (1.72)
48. Bear grease	23.8 (1.22)	11.4 (0.21)	71.0 (0.75)	48.5 (1.37)	47.4 (1.04)
49. Goose grease	66.7 (1.78)	48.6 (1.47)	60.9 (1.72)	51.5 (1.93)	55.3 (1.78)
50. Moose grease	0 (0)	0 (0)	13.0 (2.20)	7.77 (2.14)	7.46 (2.17)

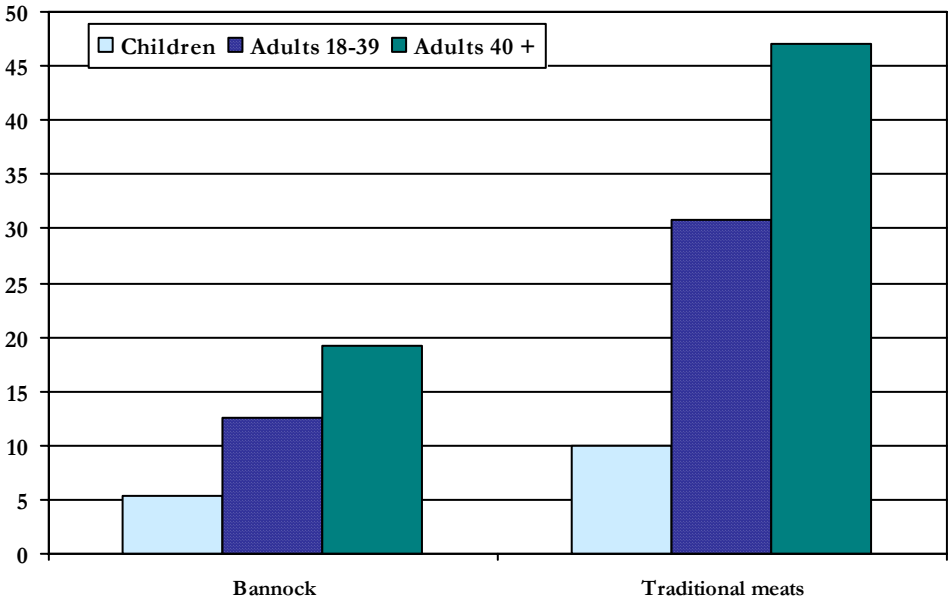
A. Characters in bold when percentage of the population greater than or equal to 50% and number of days per month greater than or equal to 2.

FIGURE 5.2.1 AVERAGE NUMBER OF TIMES PER WEEK RESPONDENTS REPORTED EATING TRADITIONAL FOODS ON THE TRADITIONAL FOOD FREQUENCY QUESTIONNAIRE



28 February 2006

FIGURE 5.2.2 FREQUENCY OF INDIVIDUALS CONSUMING TRADITIONAL FOODS IN THE PREVIOUS 24 HOURS (SUMMER 2005)



Partial correlation analysis between traditional dietary frequency variables and principal component analysis (PCA) scores, adjusted for age, indicated strong associations between the annual mean consumption frequencies of many of the traditional food items (Table 5.2.3). This is illustrated by the fact that the first principal component axis (PC-1) was correlated ($p = 0.000$) with all 14 major traditional food items except internal organ meat. PC-1 explained 20.5% of the variability in the original diet data, and featured the high positive loadings for cooked moose meats, a selection of fish (speckled trout, walleye, whitefish, pike, lake trout), fish eggs, a number of water fowl (geese, dabbler ducks, sea ducks), ptarmigan and other birds, wild berries and wild berry jams (Table 5.2.4). PC-2 to PC-5 axes respectively explained 6.7, 6.0, 5.5 and 4.4% of the variability in dietary frequency data. PC-2 reflects the consumption of small and large animals with an emphasis on dried meats, as well as smoked fish (Tables 5.2.3 and 5.2.4). Negative loadings occurred, indicating higher consumption at low PC-2 scores, for the following food items: burbot, red or white sucker, and ducks (with emphasis on ducks other than the dabblers and sea ducks). PC-3 accentuated positive weightings for bear grease, goose grease and other fats, small mammals, ptarmigan and other birds, but negative loadings for lake trout, some bird gizzards, large mammals, loon and merganser, dabbler ducks and berries (including their jams; Tables 5.2.3 and 5.2.4). PC-4 was positive for piscivorous fish and goose grease and PC-5 for organ meats with no other distinguishing features for either.

The groupings of the consumption frequencies observed (see Table 5.2.2 for compilation) are to some extent enlightening. It is helpful to examine the patterns of the relationships between the various food items (data not shown). It is clear from this that the consumption of mammals (small and large) are correlated with that of fish, loon and merganser, and geese, while for fish there are additional associations with the consumption of dabbler ducks, sea ducks and other birds ($p = 0.000$). Interestingly berries are related to 11 of the 14 major food items, with small mammals, bear grease and internal organ meats as the exceptions; and thus cannot be considered an independent food item. PC-2 loadings suggest that dried and smoked meats are preferred by a subgroup, while PC-3 and PC-4 identify others who consume bear and/or goose grease, and PC-5 those that eat internal organ meats.

TABLE 5.2.3 PARTIAL CORRELATIONS BETWEEN TRADITIONAL DIET FREQUENCY VARIABLES AND TRADITIONAL DIET PCA VARIABLES CALCULATED FROM THE FOOD FREQUENCY QUESTIONNAIRE, CONTROLLING FOR AGE (N = 244)

	Principal Component (PC) Variables				
Summary Diet Variables (mean daily frequencies over year)	PC-1 (20.5%)	PC-2 (6.7%)	PC-3 (6.0%)	PC-4 (5.5%)	PC-5 (4.4%)
Sum of organ meat (livers, kidneys, etc,)	0.1158	-0.0672	0.0558	0.0975	0.2698
	p = 0.070	p = 0.294	p = 0.384	p = 0.127	p = 0.000
Sum of large mammal meat (no organ meats)	0.6363	0.524	-0.2623	-0.0314	0.0786
	p = 0.000	p = 0.000	p = 0.000	p = 0.625	p = 0.220
Sum of small mammal (no organ meats)	0.4326	0.2854	0.2381	-0.1378	-0.0097
	p = 0.000	p = 0.000	p = 0.000	p = 0.031	p = 0.880
Sum of piscivorous fish (no livers)	0.8004	0.1086	-0.1731	0.256	-0.1212
	p = 0.000	p = 0.089	p = 0.006	p = 0.000	p = 0.058
Sum of non-piscivorous fish (no livers)	0.7722	-0.192	-0.0176	-0.1566	-0.0599
	p = 0.000	p = 0.002	p = 0.784	p = 0.014	p = 0.349
Loon or merganser	0.4255	-0.1983	-0.4073	0.129	-0.0073
	p = 0.000	p = 0.002	p = 0.000	p = 0.043	p = 0.909
Geese	0.5609	-0.1501	0.1925	0.0828	-0.0979
	p = 0.000	p = 0.018	p = 0.002	p = 0.196	p = 0.126
Dappler ducks	0.5706	-0.4325	-0.2357	-0.0756	-0.0479
	p = 0.000	p = 0.000	p = 0.000	p = 0.237	p = 0.454
Sea ducks	0.6597	-0.4448	-0.2662	-0.164	-0.0553
	p = 0.000	p = 0.000	p = 0.000	p = 0.010	p = 0.388
Ptarmigan, partridge and other birds	0.56	-0.1618	0.2341	0.0021	-0.0605
	p = 0.000	p = 0.011	p = 0.000	p = 0.974	p = 0.345
Wild berries	0.681	-0.0043	-0.2917	0.0657	-0.1675
	p = 0.000	p = 0.946	p = 0.000	p = 0.305	p = 0.008
Wild berry jam	0.7398	-0.098	-0.3103	0.0159	-0.1597
	p = 0.000	p = 0.125	p = 0.000	p = 0.804	p = 0.012
Bear grease	0.4048	-0.4336	0.3533	-0.0584	0.0097
	p = 0.000	p = 0.000	p = 0.000	p = 0.362	p = 0.880
Goose grease	0.4465	0.0214	0.2575	0.2666	-0.0961
	p = 0.000	p = 0.739	p = 0.000	p = 0.000	p = 0.133

significant at p = 0.05

significant at p = 0.0005

TABLE 5.2.4 PRINCIPAL COMPONENT LOADINGS FROM PCA OF TRADITIONAL DIET MEAN DAILY FREQUENCY OVER YEAR DATA

Mean daily frequency over year	Trad. Diet PC-1 (20.5%)	Trad. Diet PC-2 (6.7%)	Trad. Diet PC-3 (6.0%)
Bear meat, dried	0.515	0.074	-0.368
Bear meat, cooked	0.354	0.133	-0.090
Bear liver or kidney	0.110	0.061	0.183
Moose meat, dried	0.504	0.499	0.059
Moose meat, cooked	0.599	0.408	-0.126
Moose liver or kidney	0.283	0.028	-0.264
Caribou meat, dried	0.510	0.467	-0.020
Caribou meat, cooked	0.527	0.371	-0.207
Caribou liver or kidney	0.008	0.049	-0.077
Beaver meat	0.529	0.286	0.227
Rabbit meat	0.371	0.194	0.225
Smoked game animal meat	0.433	-0.078	-0.031
Other game animal 1	0.426	0.078	0.276
Other game animal 2	0.102	0.121	0.049
Other game animal 3	0.285	0.200	0.066
Speckled trout	0.589	0.130	-0.290
Walleye	0.648	0.131	0.290
Whitefish	0.598	0.394	0.225
Pike	0.737	0.140	0.101
Lake trout	0.674	0.078	-0.431
Sturgeon	0.275	-0.103	0.232
Burbot	0.418	-0.676	0.105
Red or white sucker	0.545	-0.468	0.275
Fish from the ocean	-0.017	0.013	0.019
Fish eggs	0.593	-0.324	0.255
Smoked wild fish	0.480	0.485	-0.065
Other wild fish 1	-0.042	-0.007	-0.027
Fish liver 1	0.184	-0.175	0.237
Loon or merganser	0.410	-0.190	-0.387
Geese	0.582	-0.127	0.220
Dappler (or dabbler) ducks	0.579	-0.407	-0.198
Sea ducks	0.692	-0.397	-0.202
Other ducks	0.544	-0.644	-0.342
Ptarmigan, partridge and other birds	0.594	-0.135	0.264
Bird and duck gizzards 1	0.516	0.013	0.023
Bird and duck gizzards 2	0.369	-0.061	-0.480
Bird and duck gizzards 3	0.004	-0.005	-0.090
Bird and duck livers or kidneys 1	-0.031	0.036	-0.032
Bird and duck livers or kidneys 2	-0.012	0.045	-0.047
Bird and duck livers or kidneys 3	-0.012	0.045	-0.047
Wild berries	0.684	0.014	-0.246
Wild berry jam	0.747	-0.073	-0.255
Bear grease	0.499	-0.375	0.384
Goose grease	0.472	0.038	0.280
Other animal fats 1	0.267	0.034	0.352
Other animal fats 2	0.258	-0.006	0.491
Other animal fats 3	0.062	-0.002	0.359
Other animal fats 4	0.062	-0.002	0.359

Shadowed cells identify strong loading on PC

5.2.1.4 Nutrient intake estimates

Macronutrients, saturated fat and cholesterol

The percent of energy as protein, total fat, and carbohydrates are provided in Figures 5.2.3-5.2.6. Acceptable Macronutrient Distribution Range (AMDR) for fat intake as a percent of total energy range from 20-35% for adults (IOM 2005). Both men and women exceeded this range. In men total fat contributed, on average, to 37% of energy whereas in women total fat contributed, on average, to 38.8% of energy. For children, the AMDR for fat intake as a percent of total energy ranges from 25-35%, and total fat intake as a percent of total energy for both boys and girls were within the recommended range.

For men and women, median daily protein intake was adequate, with only an estimated 5.9% of men and 4.9% of women below the estimated average requirement (IOM 2005). Protein intake was adequate in girls and boys as well as within guidelines recommending 10-30% of energy as protein (DRI, 2002). In the past, Canadian guidelines suggested that saturated fat intake be less than or equal to 10% of energy consumed to prevent type 2 diabetes and heart disease. For men, women and children, on average, 50% had a saturated fat intake greater than the previously recommended amounts (Figure 5.2.7). It is now recommended that the daily consumption of saturated fat and cholesterol be as low as possible while consuming a nutritionally adequate diet. Cholesterol intake in adults is considered high compared to other North American studies (IOM 2005, Gray-Donald et al., 2000). Also, previous guidelines have recommended that daily cholesterol intake be limited to 300 mg/day. The median intake of cholesterol was high for men (385 g/day) and was likely higher in reality given that men tended to under-report energy intake (Table 5.2.5). Also, median cholesterol levels were high for women (555 g/day), and girls (381 g/day) and the intake in boys (182 g/day) may have been under-estimated given the under-estimation in energy intake (see below).

FIGURE 5.2.3 PERCENTAGE OF ENERGY AS MACRONUTRIENTS IN MEN AGED 19 YEARS AND OLDER

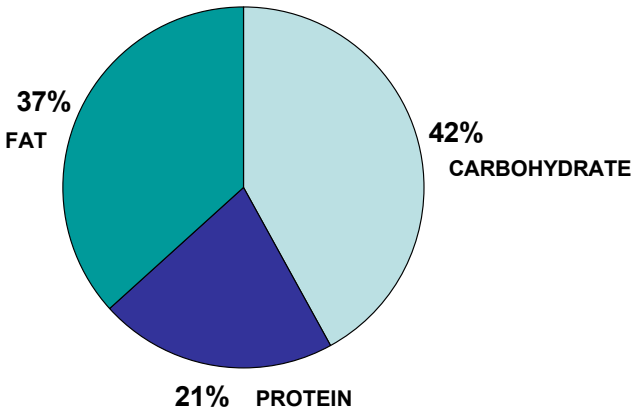


FIGURE 5.2.4 PERCENTAGE OF ENERGY AS MACRONUTRIENTS IN WOMEN AGED 19 YEARS AND OLDER

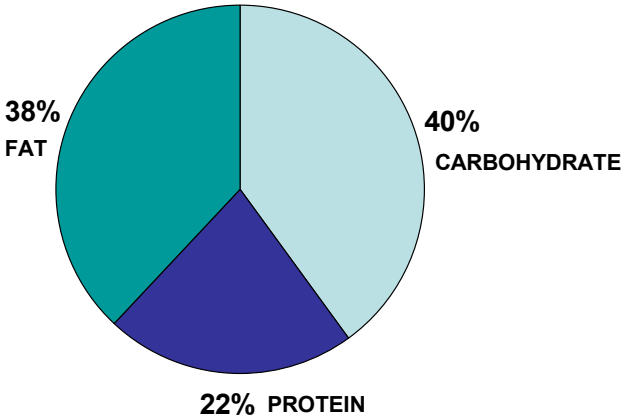


FIGURE 5.2.5 PERCENTAGE OF ENERGY AS MACRONUTRIENTS IN BOYS AGED 8-18 YEARS

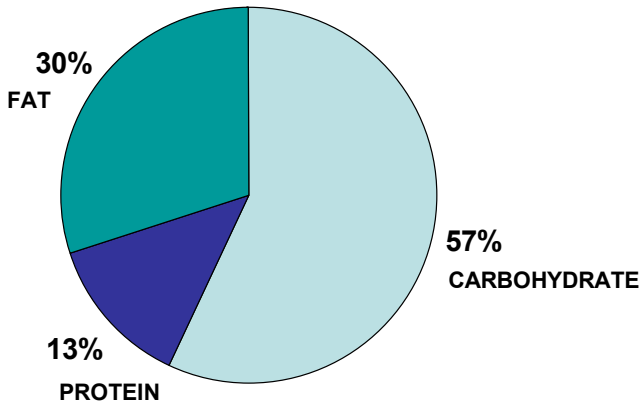


FIGURE 5.2.6 PERCENTAGE OF ENERGY AS MACRONUTRIENTS IN GIRLS AGED 8-18 YEARS

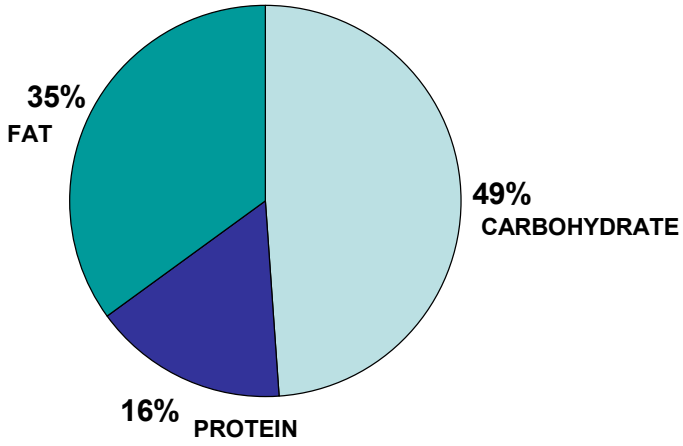


FIGURE 5.2.7 PERCENT OF POPULATION CONSUMING MORE THAN 10% SATURATED FAT

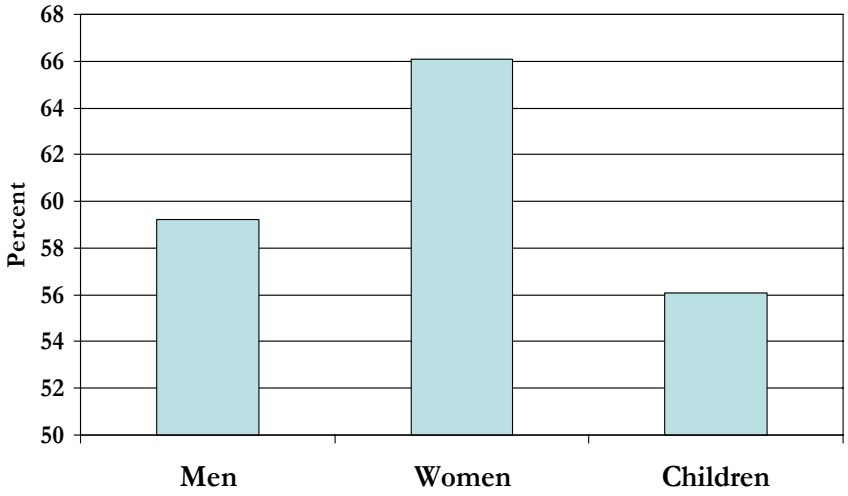


TABLE 5.2.5 ADJUSTED NUTRIENT INTAKE (INCLUDING SUPPLEMENTS) FOR NUTRIENTS WITH AN EAR FOR WOMEN 19 YEARS OF AGE AND OLDER (N = 64)[A]

Nutrient	Mean intake	± SD	Median intake	% Individuals below EAR	EAR	RDA or recommended levels
Energy[b] (kilocalories)	2 350	609	2 338	NA		
Cholesterol[b] (mg)	563	154	555	NA		As low as possible while consuming a nutritionally adequate diet
Folate[b] (DFE)	401	271	337	46.5	320	400
Vitamin C [b](mg)	154	64.5	145	3.36	60	75
Iron[c] (19-50 yrs) (mg)	20.2	23.4	19.6	2.31	8.1	18
Iron[c] (≥ 51 yrs) (mg)	17.2	2.55	17.4	0	5	8
Magnesium[b] (19-30 yrs) (mg)	278	80.6	301	29	255	310
Magnesium[b](≥ 31 yrs) (mg)	302	114	294	42	265	320
Zinc[b] (mg)	15.9	6.29	15.0	3.64	6.8	8

A. EAR = estimated average requirements; NA = not applicable; SD = standard deviation; RDA = recommended; daily allowance

b. Nutrient adjusted using SIDE software (Iowa State University 1996). Adjustments made for sequence and day of week. Where appropriate, this software also provides the number below the EAR.

c. Nutrient adjusted using NRC method

Micronutrient intake in adults

A small percentage of men (2.91%) were below EAR for daily folate intake but 46.5% of women had inadequate intake of folate (IOM 1998) (Tables 5.2.5-5.2.8). The reverse was true for vitamin C intake. Only 3.36% of women consumed inadequate amounts of vitamin C, while 41.3% of men had inadequate intakes of vitamin C although some of this may be a result of underreporting (IOM 2000c). Mean vitamin D intake for both men (3.03 μg) and women (2.43 μg) was below adequate intake levels (AI), which range from 5-15 μg/day, depending on age.

Mean daily calcium intake for men was 659 mg/d and for women 681 mg/d and was considerably below the adequate intake of 1 000 – 1 200 mg/day (IOM 1997). Also noteworthy is the low magnesium intake in men and women. Ninety three percent of men, aged 19-30, and 100% of men, aged 31 and older had inadequate magnesium intake (IOM 1997). Women fared a little better, with 29% of women aged 19-30 years, and 42% of women aged 31 and older having inadequate magnesium intake. For zinc, only a small percentage of men (2.77%) and women (3.64%) consumed inadequate amounts (IOM 2000b). Iron intake could not be adjusted in men but the median was high relative to the EAR (IOM 2000b). In women, the probability method was used and showed a very small probability of inadequate iron intake in women of pre-menopausal age (19-50 years old), with 2.3% falling into the inadequate intake range and no probability of inadequacy in older women (> 50 years of age).

Because of the under-reporting of daily energy intake in men, caution is warranted in interpreting the extent of dietary inadequacy for micronutrient intakes expressed in milligrams/day or micrograms/day (Tables 5.2.5 and 5.2.6). The ratio of the energy intake to the basal metabolic rate indicated under-reporting of about 30%. If we add an additional 30% to each of the micronutrient intake estimates for men that are presented in Tables 5.2.5 and 5.2.6, (assuming that under-reporting is consistent across all food items), then the average daily magnesium intake remains below the estimated average requirement for magnesium and the average daily fibre and calcium intakes remain below the adequate intake for fibre.

TABLE 5.2.6 ADJUSTED NUTRIENT INTAKE (INCLUDING SUPPLEMENTS) FOR NUTRIENTS WITH AN AI FOR WOMEN 19 YEARS OF AGE AND OLDER (N = 64)[A]

Nutrient	Mean intake	± SD	Mean intake	% Individuals below EAR	AI
Fiber[b] (g)	10.7	2.7	10.4	NA	21-25
Linoleic acid[b] (g)	13.6	1.65	13.5	NA	11-12
Linolenic acid[b] (g)	2.05	0.44	2.03	NA	1.1
Vitamin D[c] (µg)	2.43	1.40	2.12	NA	5-15
Calcium[b] (mg)	681	89.1	677	NA	1 000-1 200

A. NA = not applicable; SD = standard deviation; AI = adequate intake

b. Nutrient adjusted using SIDE software (Iowa State University 1996). Adjustments made for sequence and day of week. Where appropriate, this software also provides the number below the EAR.

c. Nutrient adjusted using NRC method.

TABLE 5.2.7 ADJUSTED NUTRIENT INTAKE (INCLUDING SUPPLEMENTS) FOR NUTRIENTS WITH AN EAR FOR MEN 19 YEARS OF AGE AND OLDER (N = 103)[A]

Nutrient	Mean intake	± SD	Median intake	% Individuals below EAR	EAR	RDA or recommended levels
Energy[b] (kilocalories)	1 824	215	1 819	NA		
Cholesterol[c] (mg)	438	322	385	NA		As low as possible while consuming a nutritionally adequate diet
Folate[b] (DFE)	417	55.7	413	2.91	320	400
Vitamin C[b] (mg)	111	85.9	89.1	41.3	75	90
Iron[c] (mg)	16.3	12.9	13.6	NA	6	8
Magnesium[b] (19-30 yrs) (mg)	229	63.8	218	92.9	330	400
Magnesium[b] (≥ 31 yrs) (mg)	253	26.6	253	100	350	420
Zinc[b] (mg)	12.7	1.98	12.6	2.77	9.4	11

a. EAR = estimated average requirements; NA = not applicable; SD = standard deviation; RDA = recommended daily allowance

b. Nutrient adjusted using SIDE software (Iowa State University 1996). Adjustments made for sequence and day of week. Where appropriate, this software also provides the number below the EAR.

c. Error difference of within person variance and between person variance resulted in a negative value therefore the nutrients could not be adjusted.

TABLE 5.2.8 ADJUSTED NUTRIENT INTAKE (INCLUDING SUPPLEMENTS) FOR NUTRIENTS WITH AN AI FOR MEN 19 YEARS OF AGE AND OLDER (N = 103)[A]

Nutrient	Mean intake	± SD	Median intake	AI
Fiber[b] (g)	9.56	3.48	9.16	30-38
Linoleic acid[b] (g)	9.77	1.68	9.69	14-17
Linolenic acid[b] (g)	1.51	0.60	1.42	1.6
Vitamin D[b] (μg)	3.03	1.58	2.72	5-15
Calcium[b] (mg)	659	245	619	1 000-1 200

A. SD = standard deviation; AI = adequate intake

b. Nutrient adjusted using SIDE software (Iowa State University 1996). Adjustments made for sequence and day of week. Where appropriate, this software also provides the number below the EAR.

Micronutrient intake in children

The adjusted daily mean nutrient intakes for children are listed in Tables 5.2.9-5.2.12 in relation to Dietary Reference Intakes (DRI) for individuals and, when applicable, in relation to the number of individuals having an intake that is below estimated average requirements (EAR) (IOM 1997, 1998, 2000b, 2000c, 2005). DRI age groups for requirements in younger children are 9 to 13 years of age: because our sample included 8-year-olds, these were added to this group although their requirements are sometimes different. Inadequate intake can only be quantified by the EAR cut-point method if the data can be adjusted to estimate usual intake (IOM 2003). In addition, it is necessary to adjust each nutrient by age and sex categories corresponding to the requirements. Using this method on unadjusted intake can overestimate inadequacy by more than 100% (Jahns et al. 2004). In the Mistissini sample, it was not always possible to adjust the data for two reasons: some age groups did not have enough repeats to allow adjustment of the data and in some instances, within subject variation was larger than between subject variation. The first can be corrected with more stringent sampling procedures whereas we are looking into possible methods for dealing with the second.

Thus, for children, there were a number of micronutrients for which the recommended guidelines could not be followed for calculating daily intakes in the population, due to a lack of repeat recalls (i.e., folate for all girls and for boys 14-18; vitamin C and iron in girls, and magnesium and zinc in both girls and boys could not be estimated).

Fifty-four percent of boys aged 9-13 were below the EAR for folate intake (IOM 1998). Mean vitamin D intakes for both boys and girls were below the AI of 5 µg/day with 2.56 µg/day and 3.98 µg/day respectively (IOM 1997). Mean calcium intake for boys was 702 mg/d and for girls 974 mg/d and was below the AI of 1300 mg/day (IOM 1997). Among boys aged 9-13 only 3.8% consumed inadequate amounts of iron whereas 11.1% of boys aged 14-18 had inadequate iron intake (IOM 200b). Unadjusted intakes of magnesium appeared low in this population with medians much less than the EAR (IOM 1997).

TABLE 5.2.9 ADJUSTED NUTRIENT INTAKE (INCLUDING SUPPLEMENTS) FOR NUTRIENTS WITH AN EAR FOR BOYS 8-18 YEARS OF AGE (N = 35)[A]

Nutrient	Age	Mean intake	± SD	Median intake	% Individuals below EAR	EAR	RDA or recommended levels
Energy[b] (kilocalories)	8-18	1 766	428	1 741	NA		
Cholesterol[b] (mg)	8-18	186	45.7	182	NA		As low as possible while consuming a nutritionally adequate diet
Folate[b] (DFE) (n = 26)	8-13	254	101	241	54	250	300
Folate[c] (DFE) (n = 9)	14-18	305	122	289	NA	330	400
Vitamin C[c] (mg)	8-13	151	118	112	NA	39	45
Vitamin C[c] (mg)	14-18	236	213	176	NA	63	75
Iron[d] (mg) (n = 26)	8-13	16.1	7.23	16.2	3.85	5.9	8
Iron[c] (mg) (n = 9)	14-18	13.8	5.68	12.3	NA	7.7	11
Magnesium[c](mg) (n = 26)	8-13	214	97.8	184	NA	200	240
Magnesium[c] (mg) (n = 9)	14-18	252	85.3	244	NA	340	410
Zinc[c] (mg) (n = 26)	8-13	8.24	4.73	6.91	NA	7	8
Zinc[c] (mg) (n = 9)	14-18	8.70	5.43	7.68	NA	8.5	11

A. EAR = estimated average requirement; NA = not applicable; SD = standard deviation; RDA = recommended daily allowance

b. Nutrient adjusted using SIDE software (Iowa State University 1996). Adjustments made for sequence and day of week. Where appropriate, this software also provides the number below the EAR.

c. Error difference of within person variance and between person variance resulted in a negative value therefore the nutrients could not be adjusted. Observed values were used for means and EAR cut-offs knowing that this method would overestimate the percentage below the cut-off.

d. Nutrient adjusted using NRC method.

TABLE 5.2.10 ADJUSTED NUTRIENT INTAKE (INCLUDING SUPPLEMENTS) FOR NUTRIENTS WITH AN AI FOR BOYS 8-18 YEARS OF AGE (N = 35) [A]

Nutrient	Age	Mean intake	± SD	Median intake	AI
Fiber[b] (g)	8-18	10.2	6.95	8.35	31-38
Linoleic acid[c] (g)	8-18	9.30	2.46	9.10	12-16
Linolenic acid[c] (g)	8-18	0.96	0.17	0.96	1.2-1.6
Folate[b] (DFE) (n = 9)	14-18	305	122	289	
Vitamin D[c] (µg)	8-18	2.56	0.96	2.44	5
Calcium[b] (mg)	8-18	702	474	565	1 300

a. NA = not applicable; SD = standard deviation

b. Error difference of within person variance and between person variance resulted in a negative value therefore the nutrients could not be adjusted. Observed values were used for means and EAR cut-offs knowing that this method would overestimate the % below the cut-off.

c. Nutrient adjusted using SIDE software (Iowa State University 1996). Adjustments made for sequence and day of week. Where appropriate, this software also provides the number below the EAR.

TABLE 5.2.11 ADJUSTED NUTRIENT INTAKE (INCLUDING SUPPLEMENTS) FOR NUTRIENTS WITH AN EAR FOR GIRLS 8-18 YEARS OF AGE (N = 26) [A]

Nutrient	Age (yrs)	Mean intake	± SD	Median intake	% Individuals below EAR	EAR	RDA or recommended levels
Energy[b] (kilocalories)	8-18	2,355	333	2,326	NA		
Cholesterol[b] (mg)	8-18	406	256	381	NA		As low as possible while consuming a nutritionally adequate diet
Folate[c] (DFE)	8-13	219	98.1	201	NA	250	300
Folate[c] (DFE)	14-18	395	183	345	NA	330	400
Vitamin C[c] (mg)	8-13	140	154	86.6	NA	39	45
Vitamin C[c] (mg)	14-18	246	184	192	NA	56	65
Iron[c] (mg) (n = 11)	8-13	18.4	9.59	15.7	NA	5.7	8
Iron[c] (mg) (n = 15)	14-18	16.0	6.76	16.5	NA	7.9	15
Magnesium[c] (mg) (n = 11)	8-13	297	123	294	NA	200	240
Magnesium[c] (mg) (n = 15)	14-18	278	96.1	255	NA	330	360
Zinc[c] (mg) (n = 11)	8-13	12.6	6.36	11.4	NA	7	8
Zinc[c] (mg) (n = 15)	14-18	11.6	4.94	12.1	NA	7.3	9

a. EAR = estimated average requirement for groups; NA = not applicable; SD = standard deviation

b. Nutrient adjusted using SIDE software (Iowa State University 1996). Adjustments made for sequence and day of week. Where appropriate, this software also provides the number below the EAR.

c. Error difference of within person variance and between person variance resulted in a negative value therefore the nutrients could not be adjusted. Observed values were used for means and EAR cut-offs knowing that this method would overestimate the percentage below the cut-off.

TABLE 5.2.12 ADJUSTED NUTRIENT INTAKE (INCLUDING SUPPLEMENTS) FOR NUTRIENTS WITH AN AI FOR GIRLS 8-18 YEARS OF AGE (N = 26)[A]

Nutrient	Age (yrs)	Mean intake	± SD	Median intake	AI
Fiber[b] (g)	8-18	11.2	3.7	11.0	26
Linoleic acid[c] (g)	8-18	13.2	6.87	13.1	10-11
Linolenic acid[b] (g)	8-18	1.52	0.81	1.35	1.0-1.1
Vitamin D[b] (µg)	8-18	3.98	2.96	3.35	5
Calcium[b] (mg)	8-18	974	248	963	1,300

a. NA = not applicable; SD = standard deviation

b. Nutrient adjusted using SIDE software (Iowa State University 1996). Adjustments made for sequence and day of week. Where appropriate, this software also provides the number below the EAR.

c. Error difference of within person variance and between person variance resulted in a negative value therefore the nutrients could not be adjusted. Observed values were used for means and EAR cut-offs knowing that this method would overestimate the percentage below the cut-off.

5.2.1.5 Food Intake Analyses

Dietary habits

We investigated dietary habits compared to those recommended by Canada's Food Guide to Healthy Eating (http://www.hc-sc.gc.ca/fn-an/food-guide-aliment/index_e.html) (Table 5.2.13). Daily servings of vegetables and fruits and milk products were below recommendations. This would further indicate possible inadequacies in vitamin D, calcium and magnesium.

TABLE 5.2.13 PORTIONS OF DAILY SERVINGS FROM CANADA'S FOOD GUIDE TO HEALTHY EATING IN THE CREE COMMUNITY OF MISTISSINI BY SEX AND AGE GROUP (N = 228).

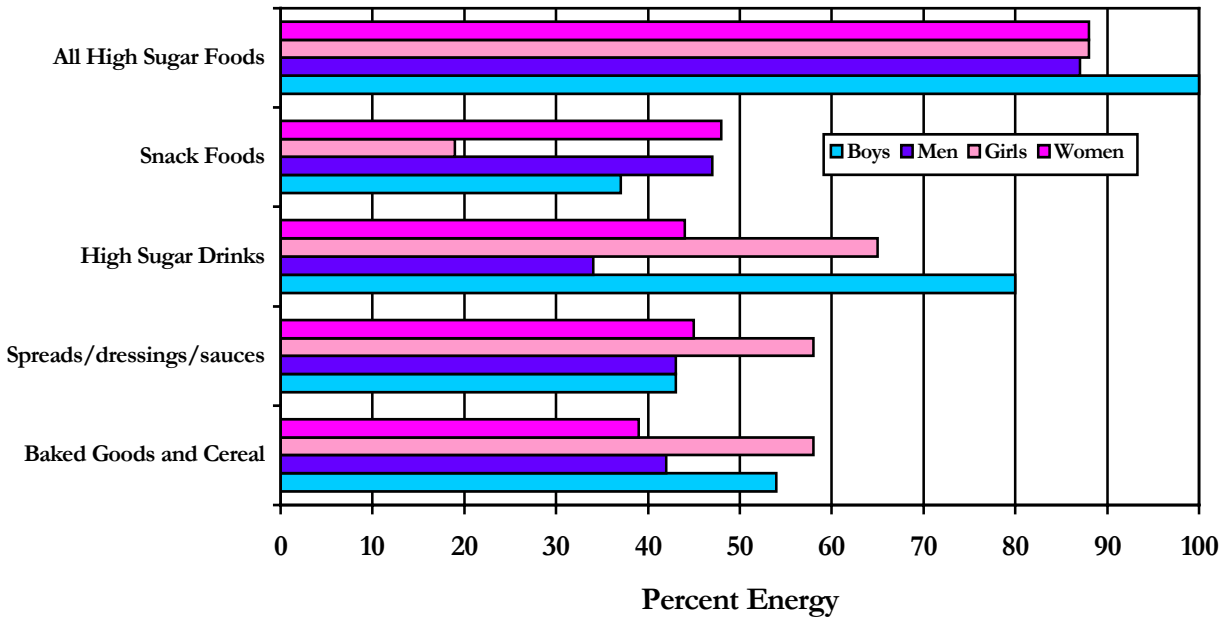
CFGHE Group	Girls (<19) n = 26	Boys (<19) n = 35	Women (≥19) n = 64	Men (≥19) n = 103	Total population n = 228	Recommended
Vegetables and fruit	4.55 ± 3.71	3.66 ± 3.10	4.38 ± 4.01	2.97 ± 2.76	3.65 ± 3.36	5-10
Grains	6.57 ± 3.87	5.58 ± 2.75	5.13 ± 3.34	4.83 ± 2.64	5.23 ± 3.05	5-12
Milk products	1.51 ± 1.31	0.94 ± 0.80	0.71 ± 0.82	0.74 ± 0.72	0.85 ± 0.88	2-4
Meat and alternates	3.55 ± 2.40	2.10 ± 2.50	5.29 ± 3.73	3.52 ± 2.64	3.80 ± 3.11	2-3

We looked at the frequency of individuals consuming high-sugar foods as defined by foods with greater than 25% energy as sugar (Figure 5.2.8) and the percent of total energy intake that these foods provided in the 24-hour recalls (Figure 5.2.9). (Nutrient-rich foods containing high levels of sugar were excluded from the list, such as fruits and vegetables). More than 85% of the total

population are consuming high-sugar foods. Greater than 30% of the adults and more than 65% of children were found to consume sweet drinks, such as soft drinks and fruit punches/powdered drinks in the 24-hour recall. These drinks represented 9-14% or more of the daily energy intake in men, women and children (Figure 5.2.9). Adults who consumed high-sugar drinks consumed on average 1.5 cans/day (SD = 0.9), whereas youth consumed on average 2.16 cans/day (SD = 1.96) with a maximum of 8.4 cans reported in one individual.

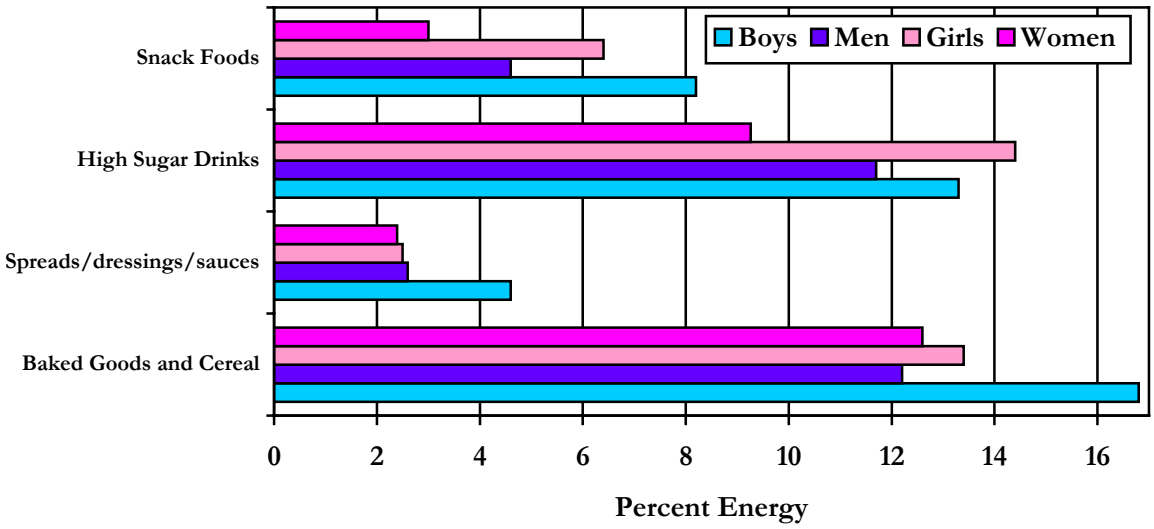
We also investigated the frequency of individuals consuming high-fat foods as defined by foods with greater than 40% energy as total fat (Figure 5.2.10) and the percent of total energy that these foods provided in the 24-hour recalls (Figure 5.2.11). Greater than 50% of the energy intake for girls was obtained from snack foods, fast foods and baked goods while that number is 40% for boys, and 30% for men and women.

FIGURE 5.2.8 FREQUENCY OF INDIVIDUALS CONSUMING HIGH-SUGAR FOODS[A] IN THE CREE COMMUNITY OF MISTISSINI IN THE PREVIOUS 24 HOURS



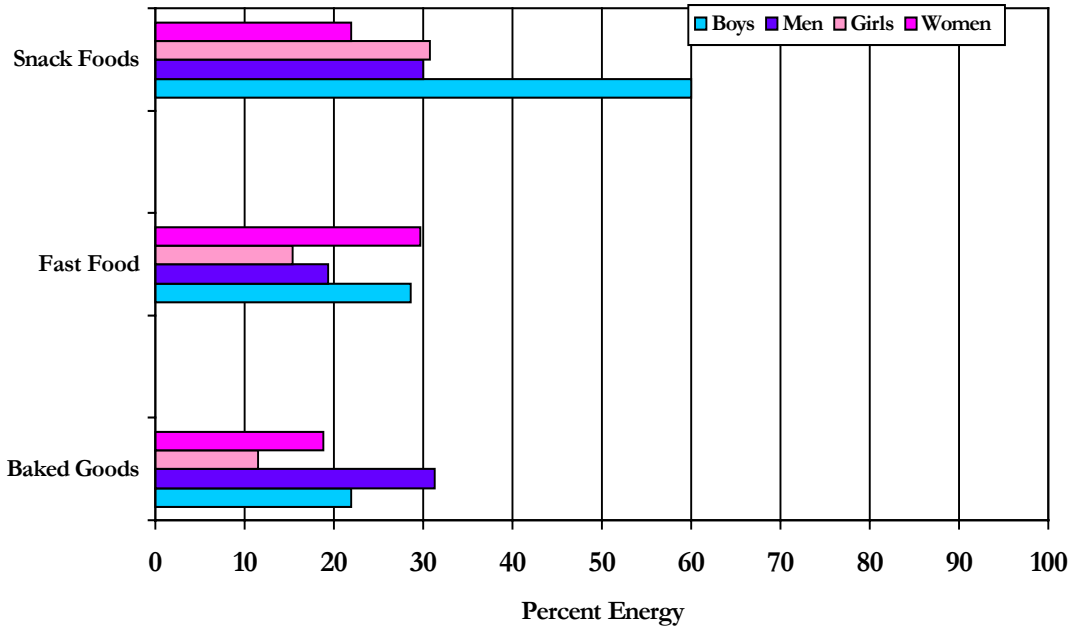
a. High- sugar foods defined as >25% energy as total sugar excluding fruits, vegetables and their juices, alcoholic beverages, chocolate milk, ice cream, cheese and yogurt. 89.5% of individuals in the sample ate at least one category of high-sugar food.

FIGURE 5.2.9 PERCENT OF ENERGY FROM HIGH-SUGAR FOODS[A] FOR INDIVIDUALS IN THE CREE COMMUNITY OF MISTISSINI CONSUMING THEM IN THE PAST 24 HOURS



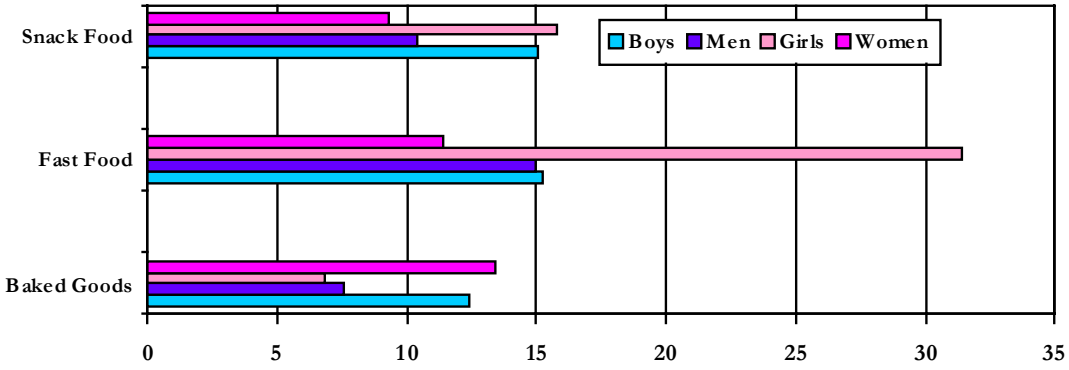
A. High-sugar foods defined as >25% energy as total sugar excluding fruits, vegetables and their juices, alcoholic beverages, chocolate milk, ice cream, cheese and yogurt. 89.5% of individuals in the sample ate at least one category of high-sugar food.

FIGURE 5.2.10 FREQUENCY OF INDIVIDUALS CONSUMING HIGH-FAT FOODS[A] IN THE CREE COMMUNITY OF MISTISSINI IN THE PREVIOUS 24 HOURS



A. High-sugar foods defined as >25% energy as total sugar excluding fruits, vegetables and their juices, alcoholic beverages, chocolate milk, ice cream, cheese and yogurt. 89.5% of individuals in the sample ate at least one category of high-sugar food.

FIGURE 5.2.11 PERCENT OF ENERGY FROM HIGH-FAT FOODS[A] FOR INDIVIDUALS IN THE CREE COMMUNITY OF MISTISSINI CONSUMING THEM IN THE PAST 24 HOURS



a. High-fat foods defined as >40% energy as total fat excluding bread, pasta, eggs, ice cream, meat, fish, milk products, main dishes, nuts, soups and traditional foods.

Vitamin D status assessment

Serum 25 (OH) D is considered the best indicator of vitamin D status, which reflects both cutaneous production and dietary exposure. Results of the laboratory analyses of serum 25 (OH) D indicate that Iiyiyiu summer-time vitamin D status is normal. The values observed were a mean of 49.1 nmol/L (SD = 13.8) for women and a mean of 54.7 nmol/L (SD = 11.7) for men. Values between 20 and 100 nmol/L are considered normal regardless of age or gender (IOM, 1997). As the population was tested in the summer, the low dietary intake of vitamin D identified in the dietary surveys would be compensated by cutaneous production of vitamin D with sunlight exposure. Recommendations for future work include the evaluation of PTH along with serum 25 (OH) D, which together with bone mineral density provide the best assessment of dietary adequacy of vitamin D (IOM, 1997). Testing a sub-sample of individuals in the winter to observe changes in PTH and serum 25 (OH) D would provide another assessment of the seasonal fluctuations in vitamin D status. During winter months, fat from traditional food, milk, cheese, and yoghurt can provide vitamin D in one's diet. Supplements are also available and may be needed, particularly in winter months, for pregnant and lactating women and children.

Markers of dietary fat quality as they relate to traditional and market food intake

In men, long-chain *n*-3 fatty acids (EPA and DHA), measured as a % of total fatty acids in erythrocyte membranes, was highly related to the frequency of traditional food and fish consumption averaged over the entire past year and over the past summer season (Table 5.2.14). For women, significant associations were observed between the frequency of traditional food and fish consumption averaged over the past year but somewhat weaker correlations were observed between the past summer season and n-3 fatty acids in women compared to men. For children, no significant correlations were observed between n-3 fatty acids and the frequency of traditional food and fish consumption, which is not surprising given the overall low consumption of all traditional food and fish consumption in children.

TABLE 5.2.14 PEARSON CORRELATION COEFFICIENTS BETWEEN TRADITIONAL FOOD CONSUMPTION AND OMEGA-3 (*N*-3 AS EPA AND DHA) FATTY ACIDS AS A % OF TOTAL FATTY ACIDS IN ERYTHROCYTE MEMBRANE PHOSPHOLIPIDS [A]

Average Daily Frequency	Past Year Traditional food consumption	Past Year Fish consumption	Summer Traditional food consumption	Summer Fish consumption
Adult Men	0.60 ****	0.49 ****	0.66 ****	0.51 ****
Adult Women	0.36 **	0.42 ***	0.26 *	0.20
Children	0.03	0.03	-0.07	0.00

a. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$.

As traditional food replaces market food, the relationship between *n*-3 and *trans* fatty acids was evaluated. As expected, there was a negative correlation between *n*-3 and *trans* fatty acids ($r = -0.35$, $p \leq 0.0001$). In other words, as the heart-healthy *n*-3 fat from fish increased in the blood, the heart-dangerous *trans* fat decreased, indicating the importance of traditional food in maintaining a healthy diet in Iiyiyiuch.

Trans fat in erythrocyte membranes correlated significantly with the market food frequency questionnaire items on baked and high-fat food items ($r = 0.27$, p-value ≤ 0.0001) which were summed and evaluated as a percentage of estimated energy intake based upon the basal metabolic rate times 1.55 (WHO reference find). However, past-day consumption of baked goods, fast foods, and snack foods in the 24-hour recall did not correlate as strongly or significantly with *trans* fat in erythrocyte membranes ($r = 0.12$, p-value = 0.07), indicating that assessment of these dietary habits for one day does not distinguish dietary habits as adequately as a food frequency questionnaire.

In both the 24-hour recall and the market food frequency questionnaire, high-sugar drinks were significantly related to *trans* fat in erythrocyte membranes in children ($r = 0.37$, $p \leq 0.01$) but not in adults ($r = 0.01$ for men, and $r = -0.09$ for women). These data indicate that high-risk trans fat and high-sugar beverage consumption behaviour tends to cluster in children and youth.

5.2.1.6 Discussion

The dietary data provide valuable background information on the dietary habits and nutritional status of communities and a context from which to evaluate and manage benefits and risks as they pertain to dietary habits and traditional food consumption. The intakes show sufficient intake of animal foods that are good sources of iron and zinc but low intake of fruits and vegetables leading to low magnesium, folate, calcium and fibre intake. We suspect that the vitamin C intake may result from fortified beverages. Low intake of milk products led to low calcium and vitamin D intakes because these are the main sources of these nutrients. Given the importance of magnesium in protecting against hypertension and its likely role in preventing type-2 diabetes mellitus, future community consultations need to emphasize the many aspects of nutrition and health to promote healthier dietary habits.

Analyses of food intake highlight that interventions in targeting the intake of soft drinks and other sugared drinks as well as snack foods, fast foods and baked goods would reduce caloric intake without reducing intake of important nutrients. All of these foods are an optional part of a total diet and represent as much as 40-50% of the energy intake of those participating in the health study. If intake of these food items are underestimated, as indicated by the nutrient analyses, there is even more cause for concern. The finding of high-sugar drink consumption is particularly worthy of discussion and communication with community members. Each can of high-sugar drink (carbonated beverage, or sweetened drink) provides approximately 155 kcals. Provided that all other dietary intake represents the intake needed to maintain one's weight, the addition of one can of pop per day to one's diet would result in a 16-pound weight gain over a one-year period. In the current study, the average intake of sweetened drinks was 1.5 cans/day for adults and 2.2 cans/day for children/youth. Simple changes like replacing a can of pop with water over a lifetime could result in remarkable improvements in achieving a healthy body weight and in promoting overall health and well-being.

5.2.1.7 Recommendations for future data collection

- Change the minimum age for collection of nutrition data to 9 years old in order to reflect the age groupings that correspond with the Dietary Reference Intakes.
- Implement a sampling protocol whereby we get representative numbers of 9 to 13-year-old and 14 to 18-year-old children. Ensure that adequate amounts of repeat recalls are obtained in order to correctly adjust the data.
- Increase training for community interviewers or use dieticians to conduct the interviews.
- Minimize the length of the market food frequency questionnaire and take out serving sizes from both the traditional and market food frequency questionnaire as analyses showed that frequency of consumption of items correlated better with markers of intake (i.e., trans fat and omega-3 fatty acids).
- Add the evaluation of PTH to the study protocol to improve the assessment of vitamin D status and consider re-testing a sub-sample of individuals in the winter to evaluate fluctuations in vitamin D status.

5.2.2 Physical activity

Significant inverse correlations were observed between the IPAQ Total MET score and % body fat (r = -0.19, $p \leq 0.01$) and the IPAQ Vigorous MET score and % body fat (r = -0.26, $p \leq 0.001$). The inverse association between the physical activity scores and % body fat was particularly strong among the 114 individuals with a BMI $\geq$ 30 kg/m^2 (r = -0.32, $p \leq 0.001$ for total MET score; r = -0.36, $p \leq 0.001$ for vigorous MET score). Total MET and vigorous MET scores were inversely correlated with BMI and WC, but the associations were weak and non-significant ($r \leq 0.10$ and p-value ≥ 0.10).

When total MET scores were evaluated as quartiles and vigorous MET scores as tertiles, men were more active and more vigorously active compared to women, but gender differences were only significant for vigorous activity tertile groups (chi-square for differences in proportion by tertiles of vigorous activity $p < 0.01$) (Table 5.2.13). 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 5.2.13). Also, in multivariable analyses adjusting for age, gender, and BMI grouping (under 30 vs. $\geq$ 30 kg/m^2), total MET quartiles were significantly and inversely related to % body fat (Table 5.2.14). There was no relationship between gender and physical activity. However, in analyses stratified by gender and adjusting for age and BMI group (non-obese vs.

obese), the inverse relationship was strongest for men (*Beta* -1.63, SE = -0.74) compared to women (*Beta* -0.84, SE = -0.44). The associations between vigorous MET tertiles and % body fat was similar to that of total MET quartiles when evaluated in separate analyses adjusting for age, gender, and BMI group, and in analyses conducted separately for men and women (Table 5.2.14). No significant associations between the physical activity scores and BMI or waist circumference were observed in either univariate or multivariable analyses.

Summary of implications

The results indicate that the dedicated walkers are enjoying the health benefits of their physical activity and that physical activity in general can improve health status in Iiyiyiuch. The results also indicate that the IPAQ has potential as a surveillance and research tool in Iiyiyiu Aschii 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). The IPAQ, however, sums all activities that occurred during the week without considering whether the activities occurred on different days of the week. Thus, 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 determine whether Canadian guidelines are followed would be worthwhile from a public health perspective.

Another limitation is that interviewer informants indicated that the questionnaire was difficult to administer and that community members had difficulty quantifying their activities, particularly the duration of activities and intensity levels over the past week. Further work is needed to develop the IPAQ into a culturally acceptable research tool for the Cree and to evaluate its validity against accelerometers, heart rate monitors, and/or pedometers. More work is also needed to ensure the cultural adaptation of the IPAQ for the Cree. Cultural adaptation requires conceptual equivalence, which ensures that people attach the same meaning to terms and concepts used; metric equivalence, which ensures that the substitute activities have the same intensity levels as the original activities; and linguistic equivalence to ensure that the questions' meanings are translated appropriately rather than literally.

In summary, the current pilot study indicates that the IPAQ holds promise as a surveillance and research tool for Cree and potentially for other Indigenous Peoples in Canada. The results may prove to be an inspiration to community members in that they demonstrate that physical activity can make a difference.

TABLE 5.2.15 MEANS AND STANDARD DEVIATIONS (SD) OF ANTHROPOMETRIC INDICES AND AGE, AND GENDER DISTRIBUTION BY TOTAL MET QUARTILES AND VIGOROUS MET TERTILES IN ADULT CREE, MISTISSINI, 2006[A]

Activity score	Age (yrs)	% Female	BMI	% Body fat	W.C.
Total MET quartiles (n = 161)					
1 (n = 35)	42.2 (18.7)	71.4	33.8 (6.8)	41.1 (10.3) *	108.8 (14.4)
2 (n = 42)	33.8 (14.2)	66.7	33.4 (6.9)	40.4 (10.0)	107.3 (14.6)
3 (n = 42)	34.9 (11.0)	61.9	32.2 (6.0)	38.2 (10.5)	106.5 (15.6)
4 (n = 42)	41.4 (16.6)	47.6	32.9 (6.0)	36.3 (9.7)	108.1 (12.9)
Vigorous MET tertiles (n = 161)					
1 (n = 72)	37.3 (15.8)	73.6 **	33.9 (6.8)	41.6 (10.0)***	108.6 (13.8)
2 (n = 48)	37.8 (15.0)	60.4	32.8 (5.6)	38.7 (8.4)	107.7 (13.1)
3 (n = 41)	38.9 (16.1)	41.5	31.8 (6.3)	35.0 (11.3)	105.9 (16.5)
Walking					
None – Moderate (n = 111)	40.6 (16.2)*	68.5**	34.1 (6.4)**	41.0 (9.1)**	110.3 (14.5)**
6-7 days and ≥60 min/day (n = 56)	33.9 (13.5)	46.4	31.4 (6.4)	35.4 (11.0)	104.0 (15.0)

A. * p-value ≤ 0 .05 ; * * p-value ≤ 0.01 ; * * * p-value ≤ 0.001

TABLE 5.2.16 PHYSICAL ACTIVITY MEASURES PREDICT BODY FAT % IN MULTIVARIABLE LINEAR REGRESSION ANALYSES IN CREE ADULTS, MISTISSINI, 2006

Models	Beta	(SE)[c]
All Adults		
Age (yrs)	0.04	(0.03)
Sex (Female vs. Male)	11.25	(0.91) ***
BMI group (<30 vs. ≥30)	11.37	(0.92) ***
Total MET Quartiles [a]	- 1.05	(0.39) **
Vigorous MET Tertiles [a]	-1.51	(0.54) **
Men		
Age (yrs)	0.04	(0.05)
BMI group (<30 vs. ≥30)	13.85	(1.65) ***
Total MET Quartiles [b]	- 1.63	(0.74) *
Vigorous MET Tertiles [b]	-2.74	(0.95) **
Women		
Age (yrs)	0.03	(0.03)
BMI group (<30 vs. ≥30)	9.57	(1.08) ***
Total MET Quartiles [b]	- 0.84	(0.44) #
Vigorous MET Tertiles [b]	- 0.84	(0.64)

a. Total and vigorous MET scores evaluated separately adjusting for age, sex, and BMI group.

b. Total and vigorous MET scores evaluated separately adjusting for age and BMI group.

c. # p-value = 0.06 ; *p-value < 0.05 ; * *p-value < 0.01 ; * * *p-value < 0.001

5.3 Environmental contaminants

5.3.1 Toxic metals in individual samples

5.3.1.1 Cadmium

Data in Table 5.3.1a shows the mean blood concentrations of cadmium in participants stratified by age group. Despite overlapping confidence intervals, concentrations of cadmium are slightly higher in women than in men ($p = 0.03$) in all age groups and increase significantly with age ($p < 0.0001$). When cadmium exposure data is stratified by smoking status (Table 5.3.1b), blood cadmium concentrations observed were 7 to 10 times higher in smokers than in non-smokers and ex-smokers ($p > 0.0001$), and no significant difference was observed between non-smokers and ex-smokers. A comparison with data obtained in the Inuit of Nunavik during the Inuit Health Survey of 2004 can be carried out when the analyses are restricted to the 18 to 74-year-old group (in order to obtain a comparable sample). Mean blood cadmium concentrations stratified by smoking category are slightly lower in smokers (arithmetic mean and CI 95%, 33.5 nmol/L in Mistissini [26.5-37.4]; 45.1 nmol/L in Nunavik [43.5-46.7]), and ex-smokers (4.0 nmol/L in Mistissini [2.8-5.3] and 7.6 nmol/L in Nunavik [6.8-8.4]) and similar in non-smokers (4.1 nmol/L in Mistissini [2.0-6.1] and 5.9 nmol/L in Nunavik [5.2-6.7]). Levels in non-smokers are also similar to the mean concentrations observed in Oujé-Bougoumou (6.83 nmol/L) and Nemaska (4.27 nmol/L) Cree populations (Dewailly and Nieboer, 2005), and in the general Quebec population (4.73 nmol/L) (Leblanc et *al*, 2003).

The relationship of blood cadmium concentrations with smoking is better shown in Figure 5.3.1. A strong association of blood cadmium with self-declared cigarette consumption (cigarettes per day) was observed in smokers (Pearson's $r = 0.726$, $p < 0.001$, $n = 97$) and this significant association was maintained in all age groups when the analysis was stratified by age category. Linear regression modeling confirmed that diet is a non-significant source of cadmium exposure, leaving active smoking as the only variable explaining the variance in blood cadmium levels ($R^2 = 0.57$, $p < 0.0001$). Other variables such as gender and age were not related to cadmium concentrations when smoking was included in the regression model, and no dietary variable showed a significant association with blood cadmium levels.

TABLE 5.3.1A WHOLE-BLOOD CONCENTRATIONS OF CADMIUM (NMOL/L) IN MISTISSINI PARTICIPANTS (≥8 YEARS OF AGE) STRATIFIED BY AGE GROUP AND GENDER

Group	n	% det.[a]	Mean (SD)	Geometric mean (95% CI)		Minimum	Percentiles 10th	50th	90th	Maximum
8-14 years	43	100	5.87 (11.39)	2.48	(1.77-3.47)	0.49	0.85	1.69	12.46	55.16
Women	28	100	6.21 (10.10)	2.88	(1.87-4.42)	0.49	0.85	1.73	15.12	47.15
Men	15	100	5.22 (13.84)	1.88	(1.10-3.20)	0.63	0.80	1.51	3.56	55.16
15-39 years	112	100	22.59 (19.72)	11.43	(8.77-14.90)	0.36	1.42	20.02	48.04	77.40
Women	66	100	22.98 (18.60)	13.25	(9.72-18.06)	0.73	1.42	20.46	46.26	77.40
Men	46	100	22.04 (21.41)	9.25	(5.81-14.74)	0.36	0.98	18.68	49.82	74.73
≥40 years	68	100	9.49 (14.38)	4.88	(3.81-6.25)	0.72	1.69	3.83	32.92	67.62
Women	40	100	11.11 (16.26)	5.99	(4.40-8.18)	1.33	2.14	5.16	35.59	67.62
Men	28	100	7.19 (11.05)	3.63	(2.47-5.35)	0.72	1.60	2.71	32.92	42.70
Total (≥ 8 years)	223	100	15.37 (18.32)	6.57	(5.46-7.89)	0.36	1.25	5.25	44.49	77.40
Women	134	100	15.93 (17.86)	7.60	(6.08-9.50)	0.49	1.33	6.58	44.49	77.40
Men	89	100	14.53 (19.07)	5.27	(3.87-7.19)	0.36	0.89	2.85	44.49	74.73

a. % of detection; detection limit (DL): 1 nmol/L

TABLE 5.3.1B WHOLE-BLOOD CONCENTRATIONS OF CADMIUM (NMOL/L) IN MISTISSINI PARTICIPANTS (≥8 YEARS OF AGE) STRATIFIED BY SMOKING CATEGORIES IN EACH AGE GROUP

Group	n	% det.[1]	Mean (SD)	Geometric mean (95% CI)		Minimum	Maximum
8-14 years							
Smoker	10	100	16.82 (19.90)	7.68	3.18-18.57	1.07	55.16
Ex-smoker	1	100	5.25 (NA)	5.25		5.25	5.25
Non-smoker	32	100	2.46 (3.15)	1.70	1.31-2.21	0.49	15.12
15-39 years							
Smoker	72	100	32.85 (16.86)	28.03	24.30-32.34	3.83	77.40
Ex-smoker	20	100	4.54 (6.96)	2.62	1.73-3.97	0.73	31.14
Non-smoker	20	100	3.71 (6.69)	1.87	1.14-3.07	0.20	31.14
≥ 40 years							
Smoker	15	100	29.54 (20.40)	21.28	13.20-34.31	3.47	67.62
Ex-smoker	36	100	3.56 (2.00)	3.05	2.52-3.69	0.72	8.90
Non-smoker	17	100	4.36 (3.00)	3.59	2.65-4.86	1.33	12.46

a. % of detection; detection limit (DL): 1 nmol/L

FIGURE 5.3.1 ASSOCIATION OF BLOOD CADMIUM CONCENTRATION WITH SELF-DECLARED CIGARETTE CONSUMPTION

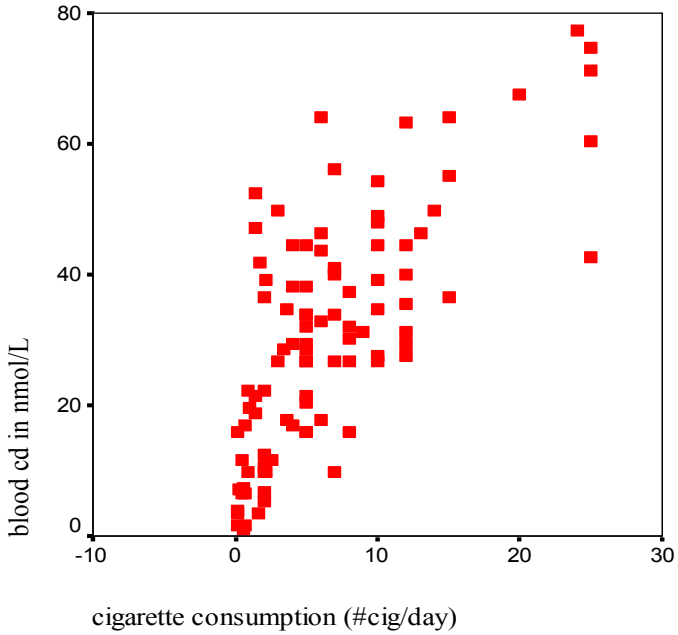


Table 5.3.2a shows the number of participants exceeding concern levels and action levels in all age groups according to thresholds determined in earlier studies and stratified according to smoking status. Smoking is an important determinant of the proportion of participants exceeding concern or action levels. None of the non-smokers exceeded the action level established to prevent kidney damage (44.5 nmol/L), while 20% of smokers exceeded this value. In smokers, several younger adults showed levels above the 25 nmol/L threshold determined in the Jarup et al (1988) and Elinder and Jarup (1996) studies. However, some non-smokers (4 children 8-14 yrs. old, 7 young adults and 14 older adults) showed blood cadmium concentrations above the upper limit reported for the southern Quebec population (5 nmol/L). Of these individuals, 12 out of 25 are ex-smokers, which could explain the slightly higher cadmium levels observed. Other sources of exposure for non-smokers could include second-hand smoke and dietary intake.

TABLE 5.3.2A EXCEEDANCES OF THE CONCERN AND ACTION LEVELS FOR WHOLE-BLOOD CADMIUM IN MISTISSINI PARTICIPANTS (≥8 YEARS OF AGE) BASED ON THRESHOLDS DETERMINED IN EARLIER STUDIES AND STRATIFIED BY SMOKING STATUS (NON-SMOKERS MERGED WITH EX-SMOKERS)

		> Concern level [a]		> Action level [a]	
		Concern level		Action level	
Group	Category	(nmol/L)	n (%)	(nmol/L)	n (%)
8-14 years	Non-smokers	5.0	4 (12.1)	44.5	0
	Smokers	25.0	3 (30.0)	44.5	2 (20.0)
15-39 years	Non-smokers	5.0	7 (17.5)	44.5	0
	Smokers	25.0	49 (68.1)	44.5	14 (19.4)
≥40 years	Non-smokers	5.0	14 (26.4)	44.5	0
	Smokers	25.0	9 (60.0)	44.5	3 (20.0)

a. Source: CTQ 1990-1995; or Järup et al., 1988; Elinder and Järup (1996). Level of concern from Oujé-Bougoumou / Nemaska report (Dewailly et al. 2005)

In the individual questionnaire, a question was asked in order to document smoking habits inside houses and help indicate possible exposure of non-smokers to second-hand smoke. Surprisingly, of the 100 people declaring smoking every day or occasionally who answered the question, only 3 declared smoking in their house on a regular basis. Regarding ex-smokers and non-smokers, of the 129 people who answered the question, only 5 declared that someone smokes in their house on a regular basis (c.f. section 5.1.4), and the latter showed cadmium levels above 5 nmol/L, suggesting that second-hand smoke is a source of exposure for non-smokers. However, the low percentage of people actually exposed to second-hand smoke shows Mistissini residents have already taken the habit of smoking outside, hence lowering the risks associated with second-hand smoke exposure.

Other sources of exposure to cadmium could be dietary, but remain minor sources of exposure. Indeed, 8 out of 14 non-smokers over 40 years old showing cadmium levels above 5 nmol/L reported consuming moose and caribou offal, but only 2 out of 11 non-smokers below 40 years old showing cadmium levels above 5 nmol/L reported consuming organ meat (the higher frequency of traditional food consumption is further discussed in section 5.2.1). Moreover, multivariate regression modeling confirmed that diet is a marginal source of cadmium exposure (see above), leaving smoking as the main source of cadmium exposure.

Therefore, exposure to cadmium is mainly related to smoking (active, past and passive smoking), while diet is not a likely source of exposure. The possibility of under-declaration of smoking status, especially among the 8 to 14-year-old group, is a non-negligible factor that could explain higher than expected cadmium concentrations in non-smokers.

The thresholds for the determination of the exceedances of concern and action levels used in the current study to orient a follow-up are based on a review of medical evidence for the effects of cadmium exposure. Based on these thresholds, 2 children/teens showed concentrations above the action level of 45 nmol/L, and the latter were smokers (Tables 5.3.2b). Five other teens showed concentrations above the concern level. In the younger adult group, 54 participants showed concentrations exceeding the concern level and 14 had blood concentrations above the action level (all smokers). In older adults, only nine participants had levels above the concern level and three were above the action level. Cadmium levels above 45 nmol/L were associated with renal dysfunction. Populations with kidney damage from causes unrelated to cadmium exposure, including diabetes, are expected to be more susceptible to cadmium-related kidney damage. Knowing that cadmium is only one of the many toxic components of tobacco smoke, the strong association of cadmium blood levels with smoking as well as the exceedances of concern and action levels observed in smokers of all ages reinforces the need to encourage people to quit smoking.

TABLE 5.3.2B EXCEEDANCES OF THE CONCERN AND ACTION LEVELS FOR WHOLE-BLOOD CADMIUM IN MISTISSINI PARTICIPANTS (≥8 YEARS OF AGE), BASED ON THRESHOLDS USED IN THE CURRENT FOLLOW-UP PROTOCOL

Group	Level (nmol/L)	n (%)
8-14 years	<10.0	36 (83.7)
	10.0-44.9	5 (11.6)
	≥45.0	2 (4.7)
15-39 years	<10.0	44 (39.3)
	10.0-44.9	54 (48.2)
	≥45.0	14 (12.5)
≥40 years	<10.0	56 (82.4)
	10.0-44.9	9 (13.2)
	≥45.0	3 (4.4)

5.3.1.2 Lead

Mean lead concentrations in blood increased with age ($p < 0.0001$), with individuals aged 40 years and older exhibiting a mean concentration about two to three-fold higher than mean values for younger participants (Table 5.3.3a). When comparing lead levels observed in Mistissini to those observed in other populations, concentrations are two-fold lower in Mistissini adults 18-74 years old (geometric means and CI 95%, 0.13 µmol/L in men [0.11-0.16] and 0.09 µmol/L in women [0.07-0.10]) than in adult Inuit of Nunavik (0.22 µmol/L in men [0.21-0.24] and 0.17 µmol/L in women [0.16-0.17]). However, levels observed in Mistissini are similar to the levels observed in Oujé-Bougoumou and Nemaska communities (Dewailly and Nieboer, 2005). These mean lead concentrations in blood are all within the reference levels proposed by the INSPQ (0.04 to 0.32 µmol/L) and concentrations observed in Mistissini are similar to the mean lead levels observed in the general population of Quebec (0.10 µmol/L) (Leblanc et *al*, 2003).

Blood lead concentrations were higher in men then women ($p = 0.004$) but there was no difference between smokers and non-smokers ($p = 0.44$) (Table 5.3.3b) suggesting other sources of exposure, such as the use of lead shot during hunting activities (exposure when firing lead shot) or dietary sources (ingestion of contaminated meat or ingestion of residual pellets).

TABLE 5.3.3A WHOLE-BLOOD CONCENTRATIONS OF LEAD (µMOL/L) IN MISTISSINI PARTICIPANTS STRATIFIED BY AGE GROUP AND GENDER

Group	n	% det	Mean (SD)	Geometric mean (95% CI)		Minimum	Percentiles 10th	50th	90th	Maximum
0-7 years	53	100	0.09 (0.08)	0.08	(0.07-0.09)	0.02	0.04	0.08	0.14	0.63
Women	32	100	0.10 (0.10)	0.08	(0.07-0.10)	0.03	0.05	0.08	0.14	0.63
Men	21	100	0.08 (0.03)	0.07	(0.06-0.09)	0.02	0.04	0.08	0.11	0.14
8-14 years	43	100	0.06 (0.03)	0.06	(0.05-0.07)	0.03	0.03	0.06	0.12	0.15
Women	28	100	0.06 (0.03)	0.05	(0.05-0.06)	0.03	0.03	0.06	0.09	0.14
Men	15	100	0.07 (0.03)	0.07	(0.05-0.08)	0.04	0.04	0.07	0.12	0.15
15-39 years	112	100	0.10 (0.10)	0.07	(0.06-0.08)	0.02	0.03	0.06	0.16	0.68
Women	66	100	0.07 (0.05)	0.06	(0.05-0.07)	0.02	0.03	0.05	0.14	0.25
Men	46	100	0.14 (0.14)	0.10	(0.08-0.13)	0.03	0.04	0.09	0.29	0.68
≥ 40 years	68	100	0.22 (0.14)	0.18	(0.15-0.21)	0.04	0.08	0.20	0.44	0.63
Women	40	100	0.21 (0.14)	0.17	(0.14-0.21)	0.05	0.07	0.18	0.42	0.63
Men	28	100	0.22 (0.13)	0.19	(0.15-0.23)	0.04	0.09	0.21	0.47	0.53
Total	276	100	0.12 (0.12)	0.09	(0.08-0.10)	0.02	0.04	0.08	0.26	0.68
Women	166	100	0.11 (0.11)	0.08	(0.07-0.09)	0.02	0.03	0.07	0.25	0.63
Men	110	100	0.14 (0.13)	0.11	(0.09-0.12)	0.02	0.04	0.10	0.29	0.68

TABLE 5.3.3B WHOLE-BLOOD CONCENTRATIONS OF LEAD (µMOL/L) IN MISTISSINI PARTICIPANTS (≥8 YEARS OF AGE) STRATIFIED BY SMOKING CATEGORIES IN EACH AGE GROUP

Group		n	Mean (SD)		Min	Max	Geometric mean (95% CI)	
8-14 yrs	Smokers	10	0.06	(0.03)	0.03	0.14	0.05	(0.04-0.07)
	Ex-smokers	1	0.04	(NA)	0.04	0.04	0.04	
	Non-smokers	32	0.07	(0.03)	0.03	0.15	0.06	(0.05-0.07)
15-39 yrs	Smokers	72	0.10	(0.11)	0.02	0.68	0.07	(0.06-0.09)
	Ex-smokers	20	0.09	(0.05)	0.03	0.19	0.08	(0.06-0.09)
	Non-smokers	20	0.10	(0.11)	0.03	0.53	0.08	(0.06-0.10)
40+ yrs	Smokers	15	0.22	(0.12)	0.06	0.47	0.18	(0.14-0.25)
	Ex-smokers	36	0.20	(0.14)	0.04	0.63	0.16	(0.13-0.20)
	Non-smokers	17	0.24	(0.14)	0.05	0.53	0.20	(0.15-0.28)

In the individual questionnaire, a question was asked to document the use of lead shot during hunting activities. Of the 98 people who answered the question, three refused to answer or did not know, 57 declared using lead shot and 41 declared not using any lead shot. Mean blood lead concentrations in these categories are shown in Table 5.3.3c and despite slightly higher blood lead concentrations in lead shot users, no significant difference was found between lead shot users and non-users (log transformed values, adjusted for age $p = 0.13$). This result suggests that the use of lead shot during hunting is not a significant source of exposure in the Mistissini population.

TABLE 5.3.3C WHOLE-BLOOD CONCENTRATIONS OF LEAD (µMOL/L) IN MISTISSINI PARTICIPANTS DECLARING USING (OR NOT USING) LEAD SHOT FOR HUNTING

Lead shot use	n	Mean (SD)		Min	Max	Geometric mean (95% CI)	
Yes	56	0.165	(0.131)	0.040	0.676	0.130	0.108-0.155
No	40	0.144	(0.138)	0.028	0.531	0.099	0.076-0.129
Don't know	3	0.069	(0.038)	0.038	0.111	0.063	0.034-0.115

Another source of lead exposure could be dietary intake. Indeed, even if lead shot firing is not a significant source of exposure, lead pellets remain in the environment after hunting and animals may ingest them and become contaminated. Also, lead pellets may be ingested by humans directly when consuming animals killed using lead shot, or when consuming bird gizzards.

When multivariate regression modeling is used to assess the relation of blood lead concentrations with selected dietary sources (mainly terrestrial game and bird consumption), the main variable explaining lead levels in blood is the age of participants (partial $r^2 = 0.29$, $p < 0.0001$), but the consumption of ducks (partial $r^2 = 0.02$, $p = 0.04$) and bird gizzards (partial $r^2 = 0.04$, $p = 0.002$) explains a small percentage of the variance of blood lead concentrations (R^2 model = 0.44, $p < 0.0001$). The stronger influence of age on lead concentration could be related to the fact that older people have a more traditional diet (see section 5.2.1 and 5.3.2.2) and therefore may be more exposed through higher consumption of wild foods. Indeed, mean consumption frequencies for total birds (excluding ducks), bird gizzards, and terrestrial game increase significantly in the older age group (ANOVA on mean daily frequencies for all food items between age categories, $p < 0.05$).

Lead concentration in whole blood primarily represents recent exposure, but for low levels also reflects the body burden. The half-life of lead in blood is about 2 months, while it is 12-16 years in bone where 95% of the body burden is stored. Therefore, since sampling for the current study was carried out in early summer, lead concentrations in whole blood could reflect recent dietary exposure from the spring hunting season.

Table 5.3.4 shows the percent of the population exceeding the concern and action levels determined for blood lead concentration. One child aged less than 7 years old showed levels above the action level of 0.48 µmol/L, suggesting the need for an appropriate follow-up. Other children did not show levels above concern or action levels. Six adults (3 in each age group) showed concentrations above the concern level, suggesting the need for a review of sources of exposure (Table 5.3.4).

TABLE 5.3.4 EXCEEDANCES OF THE CONCERN AND ACTION LEVELS OF WHOLE-BLOOD LEAD AMONG THE MISTISSINI PARTICIPANTS ACCORDING TO THRESHOLDS USED IN THE CURRENT STUDY

Group	Level (µmol/L)	n (%)
0-7 years	≤0.48	52 (98.1)
	>0.48	1 (1.9)
8-14 years	≤0.48	43 (100.0)
	>0.48	0 (0.0)
15-39 years	<0.5	109 (97.3)
	0.5- 0.9	3 (2.7)
	≥1.0	0 (0.0)
≥ 40 years	<0.5	65 (95.6)
	0.5- 0.9	3 (4.4)
	≥1.0	0 (0.0)

5.3.1.3 Mercury

Concentrations of total mercury in blood samples are presented in Table 5.3.5. A strong effect of age on mercury levels was observed ($p < 0.0001$), but no significant gender-related differences were noted ($p = 0.72$). The differences in mercury concentrations were stronger with the 40-years-old-and-over group. When restricted to the 18 to 74-year-old group, mean blood mercury concentration is two-fold lower in Mistissini (geometric mean and CI 95% 27.5 nmol/L [22.6-33.5]) than in Nunavik Inuit, based on the 2004 health survey (51.2 nmol/L [47.9-54.6]). As for cadmium and lead, mercury concentrations are similar to the levels observed in Oujé-Bougoumou and Nemaska Cree populations (Dewailly and Nieboer, 2005). However, the mean concentration observed is higher in Mistissini than in the general population of Quebec (3.7 nmol/L) (Leblanc et *al*, 2003).

TABLE 5.3.5 WHOLE-BLOOD CONCENTRATIONS OF TOTAL MERCURY (NMOL/L) IN MISTISSINI PARTICIPANTS (≥8 YEARS OF AGE)

Group	n	% det.	Mean (SD)	Geometric mean (95% CI)	Minimum	Percentiles 10th	50th	90th	Maximum
8-14 years	43	100	12.9 (13.0)	7.9 (5.7-10.9)	0.4	2.4	9.5	27.9	59.8
Women	28	100	12.5 (13.4)	7.9 (5.5-11.3)	2.1	2.4	8.2	28.9	59.8
Men	15	100	13.6 (12.5)	7.8 (4.0-15.2)	0.4	0.9	10.0	27.9	47.4
15-39 years	112	100	22.8 (25.0)	14.5 (12.1-17.3)	0.8	3.7	14.0	54.8	159.5
Women	66	100	20.1 (24.7)	13.3 (10.7-16.5)	2.0	3.7	14.0	35.9	159.5
Men	46	100	26.7 (25.2)	16.3 (11.8-22.4)	0.8	3.6	16.2	64.8	104.7
≥ 40 years	68	100	116.1 (100.0)	77.3 (59.9-99.7)	0.9	24.4	104.7	284.2	498.5
Women	40	100	120.9 (93.7)	87.6 (65.9-116.4)	3.5	27.7	104.7	256.7	393.8
Men	28	100	109.2 (109.8)	64.6 (40.6-102.8)	0.9	12.5	74.8	284.2	498.5
Total (≥ 8 years)	223	100	49.3 (73.1)	21.4 (18.0-25.6)	0.4	3.5	21.4	124.6	498.5
Women	134	100	48.6 (71.8)	21.0 (16.8-26.2)	2.0	3.5	19.7	139.6	393.8
Men	89	100	50.5 (75.3)	22.2 (16.6-29.7)	0.4	3.6	23.9	114.7	498.5

Table 5.3.6 presents the percentage of participants exceeding concern or action levels for mercury. None of the children showed concentrations above 60 nmol/L and only three young adults displayed concentrations above the concern level of 100 nmol/L. However, more than half of the participants in the 40-years-old-and-over age group had a mercury concentration exceeding the concern level, hence suggesting that a review of possible sources of exposure in this particular age group could be useful. However, it is important to note that none of the participants showed levels of exposure above the action thresholds.

TABLE 5.3.6 EXCEEDANCES OF THE CONCERN AND ACTION LEVELS FOR WHOLE-BLOOD TOTAL MERCURY IN MISTISSINI PARTICIPANTS (≥8 YEARS OF AGE) ACCORDING TO THRESHOLDS USED IN THE CURRENT STUDY

Group	Level (nmol/L)	n (%)
8-14 years	<60.0	43 (100.0)
	60.0-99.9	0 (0.0)
	≥100.0	0 (0.0)
15-39 years	<100.0	109 (97.3)
	100.0-499.9	3 (2.7)
	≥500.0	0 (0.0)
≥ 40 years	<100.0	33 (48.5)
	100.0-499.9	35 (51.5)
	≥500.0	0 (0.0)

The concentration of mercury in hair samples (0-2 cm segments) was also determined. Hair mercury concentrations increased with age and no difference was noted between men and women (Tables 5.3.7a, b). The strongest differences were noted in the 40-years-old-and-over age group. As shown in Figure 5.3.2, the concentrations of hair and blood mercury were strongly associated in young adults (Pearson's $r = 0.699$, $p < 0.001$) and elders (Pearson's $r = 0.804$, $p < 0.001$), but the association showed only borderline significance in children (low levels of mercury) (Pearson's $r = 0.267$, $p = 0.083$), mainly because of the lower levels observed (and lower variability). Only one child/teen showed a high level of hair mercury not corresponding to a high level of blood mercury, suggesting previous exposure to a high concentration, since mercury concentrations in hair reflect past exposure while blood concentrations reflect current exposure.

FIGURE 5.3.2 ASSOCIATION OF BLOOD MERCURY CONCENTRATIONS WITH HAIR MERCURY CONCENTRATIONS, LABELLED BY AGE GROUPS

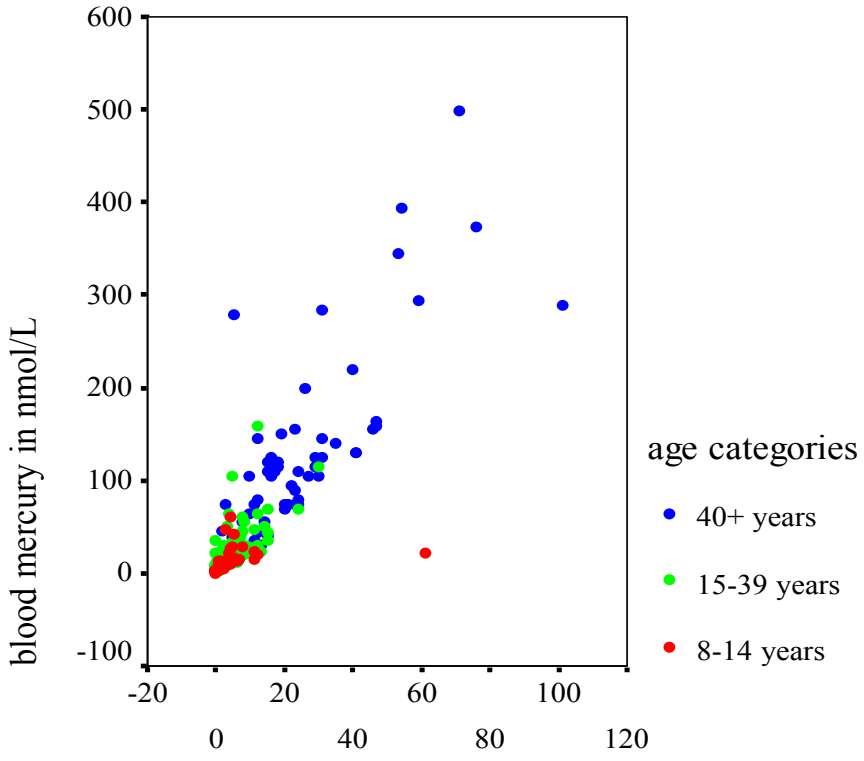


TABLE 5.3.7A HAIR (0-2 CM) CONCENTRATIONS OF TOTAL MERCURY IN MISTISSINI PARTICIPANTS IN (A) NMOL/G

Group	n	% det.[a]	Mean (SD)	Geometric mean (95% CI)	Minimum	Percentiles 10th	50th	90th	Maximum
0-7 years	53	66.0	1.67 (2.12)	0.93 (0.71-1.22)	<DL	<DL	0.72	5.1	8.0
Women	31	67.7	1.66 (2.16)	0.92 (0.65-1.32)	<DL	<DL	0.74	5.1	7.7
Men	22	63.6	1.69 (2.11)	0.94 (0.61-1.46)	<DL	<DL	0.69	4.1	8.0
8-14 years	45	73.3	4.22 (9.17)	1.73 (1.18-2.53)	<DL	<DL	2.20	7.8	61.0
Women	29	72.4	4.41 (11.21)	1.48 (0.91-2.41)	<DL	<DL	0.95	6.8	61.0
Men	16	75.0	3.88 (3.48)	2.28 (1.25-4.16)	<DL	<DL	3.20	11.0	11.0
15-39 years	109	84.4	4.34 (4.84)	2.43 (1.95-3.03)	<DL	<DL	3.10	11.0	30.0
Women	69	84.1	3.90 (4.75)	2.18 (1.67-2.85)	<DL	<DL	2.30	8.4	30.0
Men	40	85.0	5.10 (4.96)	2.94 (2.02-4.28)	<DL	<DL	4.20	12.0	24.0
≥ 40 years	68	97.1	22.54 (19.31)	14.89 (11.53-19.24)	<DL	3.70	17.50	47.0	101.0
Women	41	97.6	22.49 (17.03)	15.89 (11.67-21.63)	<DL	5.20	18.00	47.0	76.0
Men	27	96.3	22.61 (22.68)	13.50 (8.62-21.15)	<DL	3.20	15.00	46.0	101.0
Total	275	82.2	8.31 (13.51)	2.99 (2.50-3.57)	<DL	<DL	3.4	23.0	101.0
Women	170	82.4	8.06 (12.91)	2.82 (2.24-3.54)	<DL	<DL	2.9	23.0	76.0
Men	105	81.9	8.70 (14.48)	3.30 (2.48-4.38)	<DL	<DL	3.8	24.0	101.0

a. Detection limit (DL): 0.1 μg/g. Means calculated when the percentage of detection was at least 60%.

TABLE 5.3.7B HAIR (0-2 CM) CONCENTRATIONS OF TOTAL MERCURY IN MISTISSINI PARTICIPANTS IN μG/G

Group	n	% det.[a]	Mean (SD)	Geometric mean (95% CI)	Minimum	Percentiles 10th	50th	90th	Maximum
0-7 years	53	66.0	0.33 (0.43)	0.19 (0.14-0.25)	<DL	<DL	0.14	1.02	1.60
Women	31	67.7	0.33 (0.43)	0.19 (0.13-0.26)	<DL	<DL	0.15	1.02	1.54
Men	22	63.6	0.34 (0.42)	0.19 (0.12-0.29)	<DL	<DL	0.14	0.82	1.60
8-14 years	45	73.3	0.85 (1.84)	0.35 (0.24-0.51)	<DL	<DL	0.44	1.56	12.23
Women	29	72.4	0.88 (2.25)	0.30 (0.18-0.48)	<DL	<DL	0.19	1.36	12.23
Men	16	75.0	0.78 (0.70)	0.46 (0.25-0.83)	<DL	<DL	0.64	2.21	2.21
15-39 years	109	84.4	0.87 (0.97)	0.49 (0.39-0.61)	<DL	<DL	0.62	2.21	6.02
Women	69	84.1	0.78 (0.95)	0.44 (0.33-0.57)	<DL	<DL	0.46	1.69	6.02
Men	40	85.0	1.02 (0.99)	0.59 (0.40-0.86)	<DL	<DL	0.84	2.41	4.81
≥ 40 years	68	97.1	4.52 (3.87)	2.99 (2.31-3.86)	<DL	0.74	3.51	9.43	20.26
Women	41	97.6	4.51 (3.42)	3.19 (2.34-4.34)	<DL	1.04	3.61	9.43	15.25
Men	27	96. 3	4.53 (4.55)	2.71 (1.73-4.24)	<DL	0.64	3.01	9.23	20.26
Total	275	82.2	1.67 (2.71)	0.60 (0.50-0.72)	<DL	<DL	0.68	4.61	20.26
Women	170	82.4	1.62 (2.59)	0.56 (0.45-0.71)	<DL	<DL	0.58	4.61	15.25
Men	105	81.9	1.74 (2.90)	0.66 (0.50-0.88)	<DL	<DL	0.76	4.81	20.26

a. Detection limit (DL): 0.1 μg/g. Means calculated when the percentage of detection was at least 60%.

Table 5.3.8 shows the proportion of the population in each age stratum that exceeded concern and action levels for hair mercury concentrations. Only 1 participant younger than 40 years old exhibited hair levels above the concern level and one child exhibited levels above the action level. For the latter participant, the blood level was not high enough to exceed either the concern or action level, hence suggesting a punctual exposure to high levels of mercury. In older participants (40 years old and over), 25% exceeded the concern level and none were above the action level (Table 5.3.8).

TABLE 5.3.8 EXCEEDANCES OF THE CONCERN AND ACTION LEVELS OF HAIR MERCURY (0-2 CM) IN MISTISSINI PARTICIPANTS ACCORDING TO THRESHOLDS USED IN THE CURRENT STUDY

Group	Level (μg/g)	n (%)
0-7 years	<4.0	53 (100.0)
	4-5.9	0 (0.0)
	≥6.0	0 (0.0)
8-14 years	<4.0	44 (97.8)
	4-5.9	0 (0.0)
	≥6.0	1 (2.2)
15-39 years	<6.0	108 (99.1)
	6.0-29.9	1 (0.9)
	≥30.0	0 (0.0)
≥40 years	<6.0	51 (75.0)
	6.0-29.9	17 (25.0)
	≥30.0	0 (0.0)

When sources of exposure to mercury were investigated by multivariate regression analysis, the contribution of fish (piscivorous vs. non-piscivorous species) and duck consumption was tested, with adjustment for age and gender. The final regression model ($R^2 = 0.60$, $p < 0.0001$) showed that the most significant dietary source of exposure was the consumption of piscivorous fish (partial $r^2 = 0.14$, $p = 0.0008$) followed by consumption of herbivorous fish (partial $r^2 = 0.04$, $p = 0.01$), while age was the main variable explaining mercury variation (partial $r^2 = 0.32$, $p < 0.0001$).

5.3.1.4 Selenium

Similarly to mercury levels, blood selenium concentrations increased with age (Table 5.3.9). In the 8 to 14-year-old group, the median concentration was 1.9 µmol/L, compared to 2.3 µmol/L in the 40-years-old-and-older group. Concentrations were similar in men and women. Table 5.3.10 shows the percentage of the population sample above the upper limit of the selenium concentration observed in the southern Quebec population (2 µmol/L), and two concern levels determined in the framework of other studies (3 and 4 µmol/L). In general, selenium levels were higher than those observed in the southern Quebec population, but only 3 older adults showed levels above the 4 µmol/L level of concern determined by the US EPA (the 3 µmol/L level of concern is based on the follow-up of a child who suffered acute poisoning, and should not be applied as a concern level for adults). However, it is important to note that selenium is an essential element that is necessary for the normal functioning of several physiological and biochemical functions and the latter thresholds are very conservative. Selenium poisonings are not frequent 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 seleniferous areas (Longnecker et al, 1991). In the current study, all participants had blood selenium levels below 8.5 µmol/L, hence suggesting that selenium exposure is not an issue of concern in Mistissini.

Selenium was also analysed in the nails of participants. In contrast to whole-blood selenium, concentrations in nails do not vary between age groups (Table 5.3.11). As illustrated in Figure 5.3.3, the association between nail selenium levels and concentrations measured in blood is not very strong (Pearson's $r = 0.267$, $p < 0.001$ $n = 204$), although significant. When the analysis is conducted on data stratified by age group, the association is similar in children/teens ($r = 0.228$, $p = 0.072$, $n = 40$) and young adults ($r = 0.228$, $p = 0.021$, $n = 103$) but slightly stronger in the older age group ($r = 0.343$, $p = 0.007$, $n = 61$). In the Longnecker et al (1991) study, nail selenium concentrations as high as 48 nmol/g were not associated with adverse health effects.

TABLE 5.3.9 WHOLE-BLOOD CONCENTRATIONS OF SELENIUM (µMOL/L) IN MISTISSINI PARTICIPANTS (≥8 YEARS OF AGE)

Group	n	% det.	Mean (SD)	Geometric mean (95% CI)	Minimum	Percentiles 10th	50th	90th	Maximum
8-14 years	43	100	1.95 (0.26)	1.94 (1.86-2.01)	1.39	1.77	1.90	2.15	2.79
Women	28	100	1.95 (0.23)	1.94 (1.86-2.02)	1.65	1.77	1.90	2.15	2.79
Men	15	100	1.95 (0.32)	1.93 (1.78-2.09)	1.39	1.65	2.03	2.25	2.79
15-39 years	112	100	2.10 (0.28)	2.09 (2.04-2.14)	1.52	1.90	2.03	2.41	3.29
Women	66	100	2.07 (0.29)	2.05 (1.99-2.12)	1.52	1.77	2.03	2.53	3.17
Men	46	100	2.15 (0.27)	2.14 (2.07-2.21)	1.77	1.90	2.15	2.41	3.29
≥40 years	68	100	2.47 (0.67)	2.40 (2.27-2.54)	1.65	2.03	2.28	3.42	4.94
Women	40	100	2.58 (0.77)	2.49 (2.30-2.69)	1.90	1.96	2.28	3.48	4.94
Men	28	100	2.32 (0.47)	2.28 (2.13-2.44)	1.65	2.03	2.15	3.04	3.67
Total (≥8 years)	223	100	2.19 (0.48)	2.15 (2.09-2.20)	1.39	1.77	2.03	2.66	4.94
Women	134	100	2.20 (0.54)	2.15 (2.08-2.22)	1.52	1.77	2.03	2.78	4.94
Men	89	100	2.17 (0.37)	2.14 (2.08-2.21)	1.39	1.77	2.15	2.53	3.67

TABLE 5.3.10 EXCEEDANCES OF THE CONCERN AND ACTION LEVELS OF WHOLE-BLOOD SELENIUM IN MISTISSINI PARTICIPANTS (≥8 YEARS OF AGE)

	> Concern level (2 μmol/L)[a]	> Concern level (3.0 μmol/L)[b]	> Concern level (4.0 μmol/L)[c]
Group	**n (%)**	**n (%)**	**n (%)**
8-14 years	18 (41.9)	0 (0)	0 (0)
15-39 years	78 (69.6)	2 (1.8)	0 (0)
≥ 40 years	62 (91.2)	13 (19.1)	3 (4.4)

a. Source: CTQ, 2003; upper end of the laboratory reference range. PLevel of concern from Oujé-Bougoumou/Nemaska report

b. Source: Nantel et al., Vet Hum Toxicol 1985; 27:513-5; based on the follow-up of acute poisoning in a child

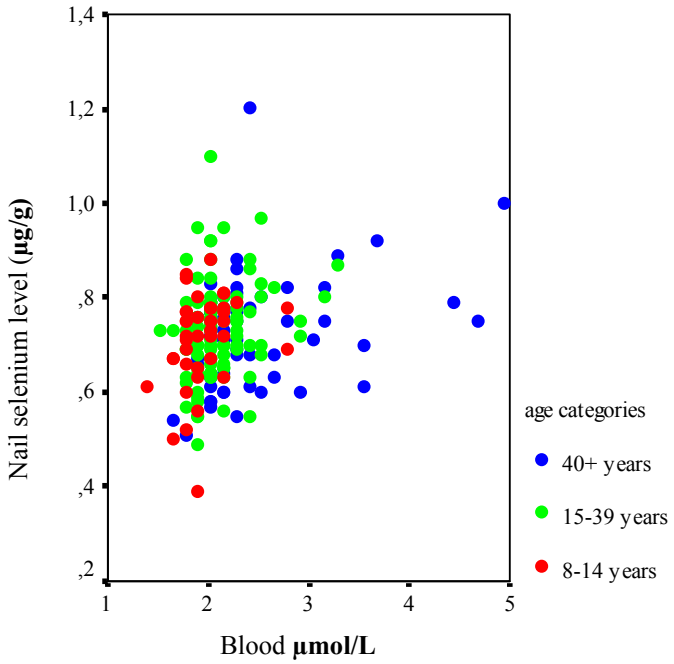
c. Source: US EPA; http://www.epa.gov/iris/subst/0472.htm

TABLE 5.3.11 CONCENTRATIONS OF SELENIUM IN NAILS (NMOL/G) OF MISTISSINI PARTICIPANTS (≥8 YEARS OF AGE)

		%	Mean	Geometric mean		Percentiles			
Group	n	det.[1]	(SD)	(95% CI)	Minimum	10th	50th	90th	Maximum
8-14 years	42	100	9.00 (1.26)	8.91 (8.48-9.35)	4.94	7.60	9.18	10.26	11.14
Women	26	100	9.02 (1.24)	8.92 (8.37-9.51)	4.94	7.98	9.50	10.13	10.76
Men	16	100	8.98 (1.34)	8.89 (8.16-9.67)	6.33	6.59	9.12	10.26	11.14
15-39 years	108	100	9.27 (1.28)	9.18 (8.94-9.42)	6.21	7.85	9.25	11.02	13.93
Women	65	100	9.64 (1.26)	9.56 (9.26-9.87)	6.97	8.11	9.50	11.65	13.93
Men	43	100	8.71 (1.12)	8.64 (8.30-8.99)	6.21	7.22	8.61	10.13	11.14
≥ 40 years	59	100	9.21 (1.49)	9.10 (8.74-9.48)	6.46	7.35	9.25	10.89	15.20
Women	35	100	9.56 (1.44)	9.46 (9.02-9.92)	7.35	7.98	9.50	10.51	15.20
Men	24	100	8.71 (1.45)	8.60 (8.02-9.22)	6.46	6.97	8.68	10.89	11.65
Total	209	100	9.20 (1.34)	9.10 (8.92-9.29)	4.94	7.60	9.25	10.64	15.20
Women	126	100	9.49 (1.32)	9.40 (9.17-9.63)	4.94	7.98	9.50	10.89	15.20
Men	83	100	8.76 (1.25)	8.67 (8.40-8.95)	6.21	7.09	8.74	10.39	11.65

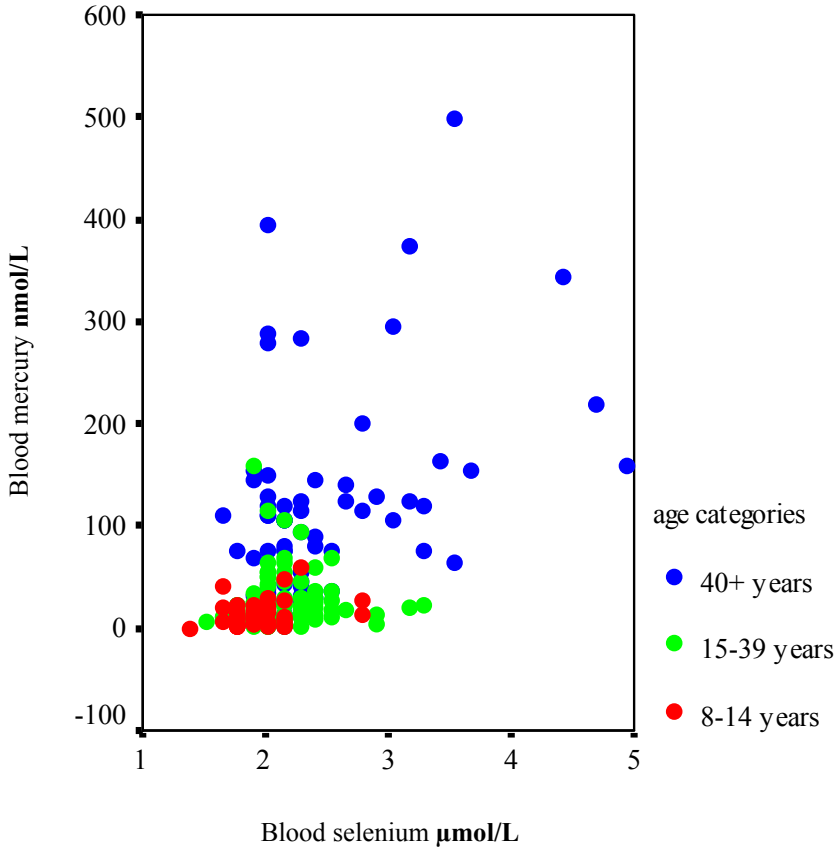
a. Detection limit (DL): 0.09 μg/g

FIGURE 5.3.3 ASSOCIATION OF BLOOD SELENIUM CONCENTRATIONS WITH NAIL SELENIUM CONCENTRATIONS, LABELLED BY AGE GROUP



Selenium concentrations in blood were associated with mercury concentrations in blood (Pearson's r = 0.509, p < 0.001, n = 215), but when the analysis was conducted on data stratified by age group, the association remained significant only for the older age group (r = 0.411, p < 0.001, n = 69) suggesting that this correlation was driven mainly by the concentrations measured in this age group, which showed the highest levels for both metals. This is well illustrated in figure 5.3.4. This suggests that the source of exposure for mercury and selenium is the same (at least partially) and most probably related to fish consumption.

FIGURE 5.3.4 ASSOCIATION OF BLOOD SELENIUM CONCENTRATIONS WITH BLOOD MERCURY CONCENTRATIONS, LABELLED BY AGE GROUP



5.3.2 Persistent organic pollutants

5.3.2.1 Observed concentrations in plasma

Plasma concentrations of total PCBs (expressed as Aroclor 1260) are presented in Table 5.3.12 (A for plasma concentrations expressed on a volume basis, B for concentrations expressed on a lipid basis) according to gender and age. As expected from studies in other populations, young participants displayed much lower concentrations than those in the 40-years-old-and-older group. The mean concentration in the older age group was more than 10-fold greater than that in the 15 to 39-year-old group.

Exceedances of the concern and action levels for total PCBs are presented in Table 5.3.13. In the younger age group, only 1 child out of 44 displayed total PCB plasma concentration above the 20 µg/L threshold and appropriate follow-up was offered. For the young adult group (15-39 years old), 3 people out of 115 showed levels between 20 and 99 µg/L, but no one exceeded the action level of 99 µg/L. However, in the older age group, 33 people out of 68 showed levels between 20 and 99 µg/L and 12 out of 68 exceeded the level of 99 µg/L. There is little chance for acute PCB toxicity at these levels of exposure, and the risk for developmental toxicity is mainly a concern for children and pregnant women and their foetuses, which do not compose the majority of the older age group. However, little is known about the toxicity related to chronic exposure to these levels of PCBs and further investigations are warranted regarding this issue, in the framework of this and other studies.

The age dependency in body burdens of organochlorines is mainly due to the fact that they bioaccumulate in fatty tissues and that older individuals had more time to accumulate significant concentrations of the latter. Also, the consumption of wild fish and game, which are known sources of exposure to these compounds, differs between age groups, thus influencing exposure levels. Another factor influencing this age dependency (although to a lesser extent) may be related to the fact that most organochlorines measured have been banned around the late 70s through mid-80s. The environmental concentrations of these compounds are decreasing slowly since their ban of use, which could be associated to lower exposure levels for people of younger age groups to these compounds. The dependence on age and gender is explored further in section 5.3.2.2.

TABLE 5.3.12 PLASMA CONCENTRATIONS OF TOTAL PCBS IN MISTISSINI PARTICIPANTS (≥8 YEARS OF AGE) EXPRESSED AS AROCLOR 1260 IN A) µG/L AND B) µG/KG PLASMA LIPIDS

Group		n	% det.	Mean µg/L (SD)		Min	Max	Geomean (IC 95%)	
A	**Aroclor 1260 (µg/L)**								
8-14 yrs	Female	29	90	3.57	(14.55)	<DL	78.89	0.52	(0.31-0.88)
	Male	16	94	0.58	(0.59)	<DL	2.15	0.39	(0.25-0.61)
	Total	45	91	2.51	(11.71)	<DL	78.89	0.47	(0.32-0.68)
15-39 yrs	Female	71	97	3.87	(4.55)	<DL	20.15	1.98	(1.48-2.66)
	Male	49	98	4.57	(5.97)	<DL	30.2	2.39	(1.70-3.37)
	Total	120	98	4.15	(5.17)	<DL	30.2	2.14	(1.71-2.67)
40+ yrs	Female	40	100	55.31	(57.71)	0.88	248.46	30.92	(21.03-45.45)
	Male	29	100	51.45	(70.14)	0.35	334.88	26.57	(16.66-42.39)
	Total	69	100	53.69	(62.77)	0.35	334.88	29.01	(21.59-38.99)
B	**Aroclor 1260 (µg/kg lipids)**								
8-14 yrs	Female	29	90	635	(2 351)	<DL	12 724	113	(68-190)
	Male	16	94	129	(136)	<DL	489	85	(54-134)
	Total	45	91	455	(1 893)	<DL	12 724	102	(71-148)
15-39 yrs	Female	71	97	680	(758)	<DL	3 782	366	(274-489)
	Male	49	98	764	(935)	<DL	4 751	445	(325-608)
	Total	120	98	714	(831)	<DL	4 751	396	(320-490)
40+ yrs	Female	40	100	8 517	(8 124)	167	33 137	4 856	(3 303-7 140)
	Male	29	100	6 891	(6 794)	51	24 503	3 950	(2 493-6 258)
	Total	69	100	7 833	(7 584)	51	33 137	4 452	(3 317-5 976)

TABLE 5.3.13 EXCEEDANCES OF THE CONCERN AND ACTION LEVELS FOR TOTAL PCBS (MEASURED AS AROCLOR 1260 IN μG/L) IN MISTISSINI PARTICIPANTS

Group	Level	n (%)
8-14 years (n = 44)	<20 μg/L	43 (97.7)
	≥20 μg/L	1 (2.3)
15-39 years (n = 115)	<20 μg/L	112 (97.4)
	20-99 μg/L	3 (2.6)
	≥100 μg/L	0 (0.0)
≥40 years (n = 68)	<20 μg/L	23 (33.8)
	20-99 μg/L	33 (48.5)
	≥100 μg/L	12 (17.7)

Table 5.3.14 shows the percent detection for all individual organochlorine compounds measured in plasma samples from Mistissini participants. In the younger age group, only three PCB congeners (138, 153 and 180) and two pesticides (*p,p'*-DDE and HCB) are detected. These organochlorines are among the most dominant compounds found in the environmental mixture of persistent organic pollutants, which explains why they are the only ones detected in the younger age group. In both adult age groups, most PCB congeners are detected, except for PCB-28, 101 and 128. PCB-105 is detected only in the older age group. For pesticides, trans-nonachlor, Mirex, *p,p'*-DDE and HCB are detected in both age groups. In the older age group, two additional compounds are detected: cis-nonachlor (a component of technical chlordane) and oxy-chlordane (a metabolite of chlordane). For all compounds, no statistically significant differences in % detection is observed according to gender (assessed by χ^2 test), despite apparent differences for PCB-170, PCB-183, oxy-chlordane and trans-nonachlor in the young adults age group, and PCB-105 in the older adults age group.

TABLE 5.3.14 PERCENT DETECTION OF PCB CONGENERS AND CHLORINATED PESTICIDES IN MISTISSINI PARTICIPANTS, STRATIFIED BY AGE GROUP AND GENDER

	Percent detected								
	8-14 yrs			15-39 yrs			40+ yrs		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
Polychlorinated biphenyls	**n = 29**	**n = 16**	**n = 45**	**n = 71**	**n = 49**	**n = 120**	**n = 40**	**n = 29**	**n = 69**
PCB-28	0.00	0.00	0.00	0.00	0.00	0.00	5.00	3.45	4.35
PCB-99	20.69	12.50	17.78	69.01	71.43	70.00	97.50	96.55	97.10
PCB-101	0.00	0.00	0.00	4.23	2.04	3.33	30.00	13.79	23.19
PCB-105	6.90	0.00	4.44	26.76	24.49	25.83	95.00	86.21	91.30
PCB-118	44.83	37.50	42.22	85.92	85.71	85.83	100.00	100.00	100.00
PCB-128	3.45	0.00	2.22	1.41	6.12	3.33	57.50	37.93	49.28
PCB-138	72.41	68.75	71.11	95.77	95.92	95.83	100.00	100.00	100.00
PCB-153	96.55	93.75	95.56	98.59	100.00	99.17	100.00	100.00	100.00
PCB-156	13.79	18.75	15.56	67.61	71.43	69.17	97.50	96.55	97.10
PCB-170	34.48	31.25	33.33	76.06	85.71	80.00	100.00	96.55	98.55
PCB-180	65.52	68.75	66.67	94.37	95.92	95.00	100.00	100.00	100.00
PCB-183	13.79	6.25	11.11	59.15	73.47	65.00	97.50	96.55	97.10
PCB-187	44.83	31.25	40.00	83.10	87.76	85.00	100.00	96.55	98.55
Chlorinated pesticides									
Aldrin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
α-chlordane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.45	1.45
γ-chlordane	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.45	1.45
Oxy-chlordane	13.79	12.50	13.33	52.11	61.22	55.83	100.00	96.43	98.41
Cis-nonachlor	3.45	0.00	2.22	19.72	30.61	24.17	92.50	93.10	92.75
Trans-nonachlor	17.24	18.75	17.78	64.79	77.55	70.00	100.00	96.55	98.55
Hexachlorobenzene	96.55	100.00	97.78	100.00	97.96	99.17	100.00	100.00	100.00
β-hexachlorocyclohexane	0.00	0.00	0.00	0.00	2.00	0.83	40.00	13.79	28.99
Mirex	13.79	0.00	8.89	63.38	69.39	65.83	97.50	96.55	97,10
p,p′-DDT	0.00	0.00	0.00	4.23	4.08	4.17	27.50	27.59	27.54
p,p′-DDE	100.00	100.00	100.00	100.00	97.96	99.17	100.00	100.00	100.00

Shadowed cells indicate groups where less than 60% detection was observed (no descriptive statistics computed).

Tables 5.3.15 and 5.3.16 show the mean concentrations of individual organochlorines measured in plasma and detected in more than 60% of individual samples. Concentrations are expressed on a volume basis (μg/L) and a lipid basis (μg/kg plasma lipids) and stratified according to age group and gender. For PCB congeners (Table 5.15), the most dominant ones are, in decreasing order, PCB-153, PCB-180, PCB-138 and PCB-187, which mainly correspond to highly chlorinated poly-ortho substituted congeners found in commercial mixtures of PCBs (such as Aroclor 1260 and 1254) which were introduced into the environment until their ban in the late 1970s. In general, PCB concentrations observed were lower in men than in women, but when confidence intervals for geometric means are compared, the only significant gender difference observed is for PCB-105 in the older age group, a mono-ortho substituted congener (often referred to as dioxin-like congeners). Closer observation of the data obtained suggests that there might be few women showing very high values, which would explain the higher mean levels observed for this gender, but the absence of significant difference (outlier effect). All PCBs showed increasing concentrations with age, explained by their propensity to bioaccumulate, compounded by the fact that elders tend to have more traditional dietary habits (see section 5.2.1). Similarly to PCBs, organochlorine pesticides (Table 5.3.16) show no significant gender differences in concentrations, and increasing concentrations are observed within older age groups. The most dominant compound in this category is by far *p,p'*-DDE, with concentrations more than 10 to 20-fold those observed for other OCs in this category.

Table 5.3.17 is a correlation matrix for all POPs measured in more than 60% of samples, stratified by age group. All compounds are highly correlated with each other (Pearson's coefficients ranging from 0.564 to 1.000, all significant $p < 0.0001$). The strongest associations were noted among PCB congeners, while pesticides showed slightly lower associations.

TABLE 5.3.15 PLASMA CONCENTRATIONS OF INDIVIDUAL PCB CONGENERS (µG/L AND MG/KG PLASMA LIPIDS) IN MISTISSINI PARTICIPANTS (≥8 YEARS OF AGE) FOR COMPOUNDS DETECTED IN MORE THAN 60% OF PARTICIPANTS

Group			Arithmetic mean (SD)		Min.	Max.	Geometric mean (IC 95%)		Arithmetic mean (SD)		Min.	Max.	Geometric mean (IC 95%)	
IUPAC#	Age	Gender	µg/L plasma				µg/L plasma		µg/kg plasma lipids				µg/kg plasma lipids	
PCB-99	15-39	Female	0.052	(0.063)	0.010	0.300	0.031	(0.024-0.039)	9.231	(10.263)	1.258	49.677	5.635	(4.460-7.120)
	yrs	Male	0.049	(0.062)	0.010	0.346	0.030	(0.023-0.039)	8.255	(10.027)	1.263	54.428	5.205	(3.994-6.782)
		Total	0.051	(0.063)	0.010	0.346	0.030	(0.025-0.036)	8.837	(10.135)	1.258	54.428	5.457	(4.581-6.502)
	40+ yrs	Female	0.540	(0.520)	0.010	1.998	0.313	(0.214-0.458)	85.088	(82.504)	1.476	332.889	49.222	(33.574-72.161)
		Male	0.342	(0.524)	0.010	2.622	0.178	(0.117-0.271)	42.743	(42.142)	1.465	163.810	26.480	(17.711-39.591)
		Total	0.457	(0.527)	0.010	2.622	0.247	(0.185-0.329)	67.290	(71.264)	1.465	332.889	37.931	(28.489-50.503)
PCB-105	40+ yrs	Female	0.269	(0.289)	0.010	1.279	0.145	(0.099-0.212)	41.798	(42.802)	1.476	160.860	22.743	(15.475-33.424)
		Male	0.103	(0.124)	0.010	0.532	0.060	(0.041-0.089)	14.303	(14.020)	1.159	58.384	8.936	(6.088-13.117)
		Total	0.199	(0.247)	0.010	1.279	0.100	(0.075-0.134)	30.242	(36.312)	1.159	160.860	15.358	(11.439-20.620)
PCB-118	15-39	Female	0.077	(0.090)	0.010	0.457	0.046	(0.036-0.058)	13.505	(14.071)	1.258	67.303	8.427	(6.646-10.685)
	yrs	Male	0.085	(0.138)	0.010	0.786	0.044	(0.032-0.059)	14.327	(22.423)	1.530	123.643	7.764	(5.811-10.374)
		Total	0.081	(0.112)	0.010	0.786	0.045	(0.037-0.054)	13.837	(17.826)	1.258	123.643	8.153	(6.790-9.790)
	40+ yrs	Female	1.650	(1.837)	0.033	8.349	0.833	(0.551-1.259)	255.258	(265.323)	6.051	1 050.057	130.873	(86.483-198.048)
		Male	0.732	(0.888)	0.018	3.682	0.393	(0.253-0.612)	105.149	(109.301)	2.637	400.567	58.492	(37.526-91.172)
		Total	1.264	(1.571)	0.018	8.349	0.608	(0.444-0.832)	192.169	(225.531)	2.637	1 050.057	93.294	(67.992-128.011)

CONG-138	8-14	Female	0.179	(0.690)	0.010	3.744	0.032	(0.020-0.053)	32.155	(111.554)	1.923	603.871	6.994	(4.303-11.369)
	yrs	Male	0.035	(0.034)	0.010	0.126	0.024	(0.016-0.036)	7.645	(7.872)	1.539	28.636	5.206	(3.400-7.969)
		Total	0.127	(0.555)	0.010	3.744	0.029	(0.020-0.041)	23.441	(89.894)	1.539	603.871	6.297	(4.450-8.910)
	15-39	Female	0.219	(0.257)	0.010	1.085	0.117	(0.089-0.154)	38.455	(42.428)	2.104	194.257	21.589	(16.432-28.365)
	yrs	Male	0.248	(0.329)	0.010	1.810	0.135	(0.098-0.186)	41.624	(52.411)	1.972	284.726	24.914	(18.585-33.398)
		Total	0.231	(0.288)	0.010	1.810	0.124	(0.100-0.153)	39.734	(46.515)	1.972	284.726	22.874	(18.713-27.960)
	40+ yrs	Female	2.990	(2.953)	0.066	12.091	1.716	(1.177-2.501)	462.935	(427.110)	12.560	1 532.809	269.480	(184.659-393.262)
		Male	2.481	(3.329)	0.022	15.251	1.295	(0.820-2.047)	334.084	(338.212)	3.223	1 287.795	192.566	(122.579-302.512)
		Total	2.776	(3.103)	0.022	15.251	1.525	(1.140-2.039)	408.780	(394.754)	3.223	1 532.809	233.984	(175.003-312.845)
CONG-153	8-14	Female	0.509	(2.109)	0.010	11.426	0.069	(0.041-0.117)	89.959	(340.463)	2.128	1 842.903	14.997	(8.910-25.241)
	yrs	Male	0.078	(0.080)	0.010	0.287	0.050	(0.032-0.080)	17.202	(18.386)	2.041	65.227	10.929	(6.762-17.663)
		Total	0.356	(1.696)	0.010	11.426	0.062	(0.042-0.090)	64.090	(274.080)	2.041	1 842.903	13.401	(9.205-19.510)
	15-39	Female	0.525	(0.620)	0.010	2.841	0.265	(0.196-0.357)	92.286	(103.631)	2.425	533.221	48.969	(36.457-65.776)
	yrs	Male	0.631	(0.824)	0.018	3.998	0.330	(0.235-0.463)	105.254	(128.274)	3.550	628.913	61.063	(44.633-83.541)
		Total	0.568	(0.709)	0.010	3.998	0.290	(0.231-0.363)	97.518	(113.846)	2.425	628.913	53.530	(43.099-66.486)
	40+ yrs	Female	7.645	(8.192)	0.104	36.288	4.215	(2.854-6.224)	1174.872	(1143.744)	19.791	4 839.691	661.990	(448.291-977.560)
		Male	7.414	(10.179)	0.045	49.149	3.799	(2.368-6.093)	991.087	(971.870)	6.592	3 424.410	564.646	(354.549-899.241)
		Total	7.548	(9.009)	0.045	49.149	4.034	(2.992-5.440)	1097.629	(1071.232)	6.592	4 839.691	619.184	(459.975-833.499)
PCB-156	15-39	Female	0.053	(0.064)	0.010	0.325	0.031	(0.024-0.039)	9.329	(10.903)	1.258	60.999	5.544	(4.364-7.042)
	yrs	Male	0.064	(0.089)	0.010	0.471	0.035	(0.026-0.047)	10.605	(13.764)	1.379	67.421	6.204	(4.652-8.273)
		Total	0.058	(0.075)	0.010	0.471	0.032	(0.027-0.039)	9.844	(12.097)	1.258	67.421	5.801	(4.828-6.969)
	40+ yrs	Female	0.825	(0.972)	0.010	4.881	0.446	(0.303-0.657)	125.757	(133.600)	1.903	650.974	70.051	(47.694-102.889)
		Male	0.978	(1.414)	0.010	6.975	0.484	(0.305-0.767)	129.646	(131.820)	1.465	411.264	71.880	(45.808-112.793)
		Total	0.890	(1.171)	0.010	6.975	0.461	(0.344-0.619)	127.391	(131.893)	1.465	650.974	70.814	(52.972-94.666)

TABLE 5.3.15 CONTINUED

Group			Arithmetic mean (SD)		Min.	Max.	Geometric mean (IC 95%)		Arithmetic mean (SD)		Min.	Max.	Geometric mean (IC 95%)	
IUPAC#	Age	Gender	µg/L plasma				µg/L plasma		µg/kg plasma lipids				µg/kg plasma lipids	
PCB-170	15-39	Female	0.101	(0.125)	0.010	0.622	0.051	(0.039-0.068)	17.748	(21.101)	1.258	116.742	9.456	(7.139-12.526)
	yrs	Male	0.129	(0.172)	0.010	0.845	0.068	(0.049-0.094)	21.417	(26.475)	1.921	120.969	12.460	(9.168-16.936)
		Total	0.113	(0.146)	0.010	0.845	0.058	(0.046-0.072)	19.228	(23.375)	1.258	120.969	10.570	(8.576-13.027)
	40+ yrs	Female	1.528	(1.736)	0.022	7.954	0.834	(0.568-1.225)	232.178	(235.961)	4.187	1060.816	131.048	(89.431-192.031)
		Male	1.877	(2.644)	0.010	12.871	0.927	(0.571-1.507)	249.105	(247.454)	1.465	823.217	137.833	(85.735-221.589)
		Total	1.674	(2.153)	0.010	12.871	0.872	(0.646-1.177)	239.292	(239.201)	1.465	1060.816	133.858	(99.567-179.959)
PCB-180	8-14	Female	0.450	(2.062)	0.010	11.154	0.035	(0.020-0.062)	77.163	(332.595)	1.923	1798.968	7.608	(4.285-13.508)
	yrs	Male	0.042	(0.043)	0.010	0.149	0.028	(0.017-0.044)	9.390	(9.954)	1.539	33.932	5.988	(3.734-9.602)
		Total	0.305	(1.657)	0.010	11.154	0.032	(0.021-0.048)	53.066	(267.403)	1.539	1798.968	6.987	(4.665-10.467)
	15-39	Female	0.371	(0.455)	0.010	2.250	0.172	(0.125-0.237)	65.294	(77.173)	2.104	422.279	32.270	(23.603-44.119)
	yrs	Male	0.498	(0.696)	0.010	3.771	0.237	(0.163-0.345)	82.596	(106.399)	1.972	539.737	45.255	(32.351-63.306)
		Total	0.423	(0.567)	0.010	3.771	0.196	(0.154-0.251)	72.276	(90.068)	1.972	539.737	36.988	(29.341-46.627)
	40+ yrs	Female	5.872	(6.785)	0.073	32.368	3.168	(2.147-4.673)	895.758	(932.839)	13.854	4316.871	497.576	(337.994-732.502)
		Male	7.070	(9.188)	0.022	44.446	3.601	(2.177-5.957)	969.103	(935.261)	3.281	2797.497	535.260	(325.434-880.374)
		Total	6.375	(7.844)	0.022	44.446	3.343	(2.459-4.545)	926.584	(927.677)	3.281	4316.871	513.080	(378.438-695.624)

PCB-183	15-39	Female	0.041	(0.047)	0.010	0.216	0.026	(0.020-0.032)	7.271	(7.588)	1.184	31.907	4.655	(3.727-5.815)
	yrs	Male	0.049	(0.061)	0.010	0.329	0.030	(0.023-0.039)	8.088	(9.668)	1.379	51.754	5.209	(4.033-6.729)
		Total	0.044	(0.053)	0.010	0.329	0.027	(0.023-0.032)	7.601	(8.457)	1.184	51.754	4.871	(4.119-5.761)
	40+ yrs	Female	0.507	(0.491)	0.010	2.298	0.297	(0.205-0.432)	78.637	(70.783)	1.903	289.020	46.690	(32.104-67.904)
		Male	0.449	(0.613)	0.010	2.964	0.249	(0.165-0.376)	58.849	(55.428)	1.465	221.678	37.057	(24.890-55.172)
		Total	0.483	(0.542)	0.010	2.964	0.276	(0.210-0.364)	70.320	(65.080)	1.465	289.020	42.369	(32.231-55.695)
PCB-187	15-39	Female	0.138	(0.166)	0.010	0.726	0.069	(0.051-0.092)	24.231	(27.449)	1.336	136.261	12.743	(9.522-17.054)
	yrs	Male	0.179	(0.237)	0.010	1.089	0.091	(0.064-0.129)	29.597	(36.659)	1.921	171.307	16.858	(12.242-23.214)
		Total	0.155	(0.198)	0.010	1.089	0.077	(0.061-0.097)	26.396	(31.447)	1.336	171.307	14.267	(11.483-17.725)
	40+ yrs	Female	2.084	(2.321)	0.023	10.456	1.144	(0.775-1.689)	319.075	(320.199)	4.377	1394.505	179.733	(121.951-264.892)
		Male	2.272	(3.103)	0.010	15.153	1.158	(0.711-1.884)	303.360	(295.233)	1.465	995.360	172.082	(106.823-277.207)
		Total	2.163	2.658	0.010	15.153	1.150	(0.850-1.556)	312.470	(307.821)	1.465	1394.505	176.477	(130.872-237.973)

TABLE 5.3.16 PLASMA CONCENTRATIONS OF CHLORINATED PESTICIDES (µG/L AND MG/KG PLASMA LIPIDS) IN MISTISSINI PARTICIPANTS (≥8 YEARS OF AGE) FOR COMPOUNDS DETECTED IN MORE THAN 60% OF PARTICIPANTS

Group			Arithmetic mean (SD)		Min.	Max.	Geometric mean (IC 95%)		Arithmetic mean (SD)		Min.	Max.	Geometric mean (IC 95%)	
Pesticide	Age	Gender	µg/L plasma						µg/kg plasma lipids					
Cis-nonachlor	40+ yrs	Female	0.193	0.202	0.010	0.865	0.108	(0.075-0.157)	29.975	29.003	1.476	108.817	17.019	(11.759-24.633)
		Male	0.204	0.289	0.010	1.400	0.104	(0.067-0.160)	26.753	27.385	1.465	97.448	15.397	(10.184-23.278)
		Total	0.198	0.240	0.010	1.400	0.106	(0.080-0.140)	28.621	28.174	1.465	108.817	16.317	(12.405-21.464)
Oxy-chlordane	15-39 yrs	Male	0.028	0.028	0.010	0.139	0.020	(0.017-0.025)	4.520	4.339	1.379	21.866	3.470	(2.862-4.208)
		Total	0.025	0.024	0.010	0.139	0.019	(0.017-0.022)	4.276	3.713	1.258	21.866	3.344	(2.965-3.772)
	40+ yrs	Female	0.329	0.393	0.026	1.558	0.178	(0.122-0.259)	49.724	53.458	3.837	213.104	28.132	(19.369-40.861)
		Male	0.304	0.504	0.010	2.555	0.144	(0.093-0.224)	38.705	44.214	1.465	182.131	21.616	(14.214-32.873)
		Total	0.318	0.442	0.010	2.555	0.162	(0.122-0.216)	44.827	49.487	1.465	213.104	25.024	(18.942-33.057)
Trans-nonachlor	15-39 yrs	Female	0.041	0.048	0.010	0.274	0.026	(0.021-0.033)	7.111	7.367	1.258	38.071	4.819	(3.926-5.915)
		Male	0.055	0.068	0.010	0.294	0.034	(0.026-0.044)	9.098	10.687	1.437	45.954	5.937	(4.610-7.646)
		Total	0.047	0.057	0.010	0.294	0.029	(0.025-0.034)	7.913	8.867	1.258	45.954	5.242	(4.468-6.150)
	40+ yrs	Female	0.554	0.577	0.021	2.497	0.330	(0.234-0.464)	85.505	81.674	3.996	320.752	51.760	(36.778-72.843)
		Male	0.640	0.968	0.010	4.911	0.322	(0.206-0.502)	82.241	82.377	1.465	279.933	47.858	(31.254-73.283)
		Total	0.590	0.761	0.010	4.911	0.326	(0.249-0.428)	84.133	81.380	1.465	320.752	50.082	(38.416-65.291)

HCB	8-14 yrs	Female	0.039	0.063	0.010	0.364	0.028	(0.023-0.035)	7.845	9.983	1.923	58.710	6.165	(5.030-7.556)
		Male	0.027	0.009	0.015	0.048	0.026	(0.022-0.030)	5.953	2.006	2.885	10.227	5.626	(4.727-6.697)
		Total	0.035	0.051	0.010	0.364	0.027	(0.024-0.032)	7.172	8.101	1.923	58.710	5.968	(5.166-6.894)
	15-39 yrs	Female	0.044	0.024	0.016	0.123	0.039	(0.035-0.043)	7.706	3.478	2.893	17.643	7.030	(6.350-7.782)
		Male	0.050	0.031	0.010	0.186	0.043	(0.037-0.050)	8.290	5.002	1.437	30.969	7.246	(6.245-8.408)
		Total	0.046	0.027	0.010	0.186	0.041	(0.037-0.044)	7.942	4.150	1.437	30.969	7.116	(6.537-7.747)
	40+ yrs	Female	0.275	0.210	0.041	0.909	0.208	(0.163-0.265)	43.330	31.948	6.936	128.462	32.654	(25.561-41.715)
		Male	0.194	0.218	0.029	1.135	0.136	(0.101-0.182)	26.360	20.381	4.248	76.338	20.145	(15.360-26.420)
		Total	0.241	0.215	0.029	1.135	0.174	(0.143-0.210)	36.198	28.768	4.248	128.462	26.655	(22.055-32.213)
Mirex	15-39 yrs	Female	0.047	0.053	0.010	0.236	0.027	(0.022-0.035)	8.220	8.976	1.258	44.294	4.982	(3.941-6.297)
		Male	0.063	0.083	0.010	0.389	0.033	(0.024-0.045)	10.209	12.639	1.065	55.683	5.867	(4.352-7.909)
		Total	0.053	0.067	0.010	0.389	0.030	(0.025-0.036)	9.023	10.599	1.065	55.683	5.322	(4.426-6.398)
	40+ yrs	Female	0.741	0.809	0.010	3.505	0.388	(0.256-0.588)	113.950	112.607	1.782	440.825	60.926	(40.050-92.684)
		Male	1.021	1.284	0.010	5.907	0.561	(0.361-0.871)	138.558	130.570	1.465	451.974	83.341	(54.210-128.125)
		Total	0.859	1.036	0.010	5.907	0.453	(0.334-0.615)	124.293	120.176	1.465	451.974	69.500	(51.327-94.108)
p.p'-DDE	8-14 yrs	Female	0.592	1.956	0.069	10.713	0.209	(0.146-0.300)	109.510	314.563	14.681	1 727.903	45.490	(32.036-64.595)
		Male	0.268	0.249	0.084	1.063	0.202	(0.141-0.289)	58.649	55.461	16.769	241.591	43.901	(30.423-63.351)
		Total	0.476	1.575	0.069	10.713	0.207	(0.159-0.269)	91.426	254.210	14.681	1 727.903	44.919	(34.691-58.161)
	15-39 yrs	Female	0.854	0.820	0.108	3.131	0.574	(0.466-0.707)	151.115	140.264	23.273	587.650	105.428	(86.237-128.890)
		Male	0.991	1.285	0.025	7.863	0.634	(0.487-0.826)	166.619	211.506	3.594	1 309.191	111.618	(86.083-144.728)
		Total	0.910	1.032	0.025	7.863	0.598	(0.508-0.704)	157.371	171.867	3.594	1 309.191	107.884	(92.063-126.423)
	40+ yrs	Female	10.549	8.798	0.189	31.296	6.899	(4.945-9.623)	1 658.131	1 401.011	27.893	5 187.800	1 083.586	(777.219-1510.718)
		Male	7.191	8.316	0.163	35.023	4.158	(2.736-6.318)	1 062.464	1 188.648	23.876	4 513.855	618.009	(406.302-940.027)
		Total	9.138	8.698	0.163	35.023	5.576	(4.274-7.274)	1 407.778	1 339.866	23.876	5 187.800	855.791	(655.001-1118.134)

TABLE 5.3.17 PEARSON'S CORRELATION COEFFICIENTS BETWEEN ORGANOCHLORINE COMPOUNDS DETECTED IN MORE THAN 60% OF SAMPLES IN PARTICIPANTS AGED A) 8-14 YEARS B) 15-39 YEARS C) 40 YRS. AND OLDER

A	PCB-138	PCB-153	PCB-180	HCB
PCB-153	1.000			
PCB-180	0.998	0.999		
HCB	0.989	0.989	0.989	
p,p'-DDE	0.996	0.996	0.995	0.993

- All coefficients statistically significant $p < 0.0001$- n = 45

B	PCB-118	PCB-138	PCB-153	PCB-156	PCB-170	PCB-180	PCB-183	PCB-187	PCB-99	HCB	Mirex	Oxy-chl
PCB-138	0.934											
PCB-153	0.894	0.982										
PCB-156	0.821	0.927	0.976									
PCB-170	0.845	0.948	0.987	0.990								
PCB-180	0.814	0.919	0.973	0.992	0.992							
PCB-183	0.934	0.990	0.972	0.915	0.944	0.916						
PCB-187	0.882	0.964	0.992	0.981	0.992	0.985	0.963					
PCB-99	0.852	0.879	0.827	0.742	0.763	0.724	0.873	0.798				
HCB	0.791	0.779	0.776	0.756	0.749	0.746	0.763	0.784	0.680			
Mirex	0.789	0.887	0.931	0.945	0.953	0.957	0.893	0.950	0.713	0.733		
Oxy-chl	0.815	0.832	0.836	0.841	0.817	0.819	0.809	0.849	0.711	0.852	0.789	
p,p'-DDE	0.831	0.883	0.895	0.891	0.889	0.889	0.874	0.908	0.745	0.882	0.878	0.856

- All coefficients statistically significant $p < 0.0001$- n = 120

C	Cis-nona	PCB-105	PCB-118	PCB-138	PCB-153	PCB-156	PCB-170	PCB-180	PCB-183	PCB-187	PCB-99	HCB	Mirex	Oxy-chl	p,p'-DDE
PCB-105	0.709														
PCB-118	0.788	0.970													
PCB-138	0.956	0.811	0.871												
PCB-153	0.973	0.728	0.818	0.982											
PCB-156	0.955	0.601	0.712	0.930	0.980										
PCB-170	0.959	0.607	0.708	0.932	0.979	0.992									
PCB-180	0.956	0.620	0.731	0.933	0.982	0.995	0.995								
PCB-183	0.961	0.792	0.840	0.989	0.974	0.922	0.937	0.928							
PCB-187	0.976	0.681	0.781	0.962	0.995	0.990	0.990	0.992	0.960						
PCB-99	0.835	0.852	0.826	0.915	0.845	0.755	0.772	0.756	0.929	0.807					
HCB	0.915	0.810	0.865	0.935	0.925	0.885	0.876	0.882	0.917	0.905	0.861				
Mirex	0.926	0.564	0.663	0.877	0.933	0.951	0.968	0.965	0.891	0.951	0.712	0.816			
Oxy-chl	0.905	0.580	0.671	0.848	0.887	0.895	0.897	0.885	0.849	0.890	0.715	0.879	0.845		
p.p'-DDE	0.821	0.838	0.877	0.858	0.809	0.738	0.714	0.736	0.814	0.782	0.783	0.862	0.669	0.703	
Trans-no	0.990	0.656	0.738	0.943	0.973	0.971	0.972	0.965	0.954	0.981	0.822	0.897	0.933	0.906	0.772

- All coefficients statistically significant $p < 0.0001$ $n = 69$

When multivariate regression analysis is performed to identify possible dietary sources of PCBs and organochlorines, the plasma concentration of Aroclor 1260 is used as a dependant variable and main independent variables include the mean daily consumption over a year for total piscivorous fish species, non-piscivorous fish species and ducks. Models are adjusted for age and gender. The final model ($R^2 = 0.71$, $p < 0.0001$) includes age (partial $r^2 = 0.68$, $p < 0.0001$) and piscivorous fishes (partial $r^2 = 0.02$, $p = 0.04$) as only significant independent variables explaining the variability of total PCB concentrations in plasma. The strong effect of age is explained by the fact that older individuals have a longer cumulative exposure to PCBs, which bioaccumulate, compounded by the fact that elders have more traditional dietary habits and hence eat more fish than younger people.

5.3.2.2 Age and gender dependence

The plot depicted in Figure 5.3.5 clearly illustrates the dependence on age of the accumulation of PCBs and OCPs. This is further supported by the results of analysis of variance (ANOVA) summarized in Table 5.3.18, in which the dependence on age or gender of a number of variables is tested. Correspondence analysis axes for the total suite of PCBs and OCPs and for the reduced suite of 6 PCBs and 2 OCPs for which the detection frequency was ≥70%, as well as for the principal component analysis axes PC-1 and PC-2, and for the sum of PCBs and OCPs, showed a strong dependence on age with p-values of <0.0005. Only two summary variables had some dependence on gender, namely CA-3 of PCBs & OCPs and CA-2 of the reduced suite of 6 PCBs & 2 OCPs. This also is identified when considering both gender and age (i.e., gender*age category interactions), indicating that the effect of age category is dependent upon gender for these variables.

Post-hoc pair-wise comparisons between the three age categories, following significant ANOVA results for that variable, showed that all three age categories were generally distinguishable on the basis of the various measures of plasma contaminants (Table 5.3.19). Figure 5.3.6 illustrates the clear separation of age categories (but not of genders) in plasma contaminant loadings as summarized by CA-1 scores of the complete suite of organic contaminants. Simple summaries of contaminants (PCBs, or OCPs) were less likely to distinguish between age categories than were multivariate summary variables (i.e., CA and PC scores). Age category differences in traditional diet frequency, using the dietary PC scores, were less well defined. The two younger age groups (8-14 and 15-39 yrs.) could not be distinguished using these measures of traditional diet, but both younger age categories had significantly lower diet PC-1 scores, indicating lower consumption of certain traditional foods (piscivorous fish and fish eggs, cooked moose meat, geese, dabbling and sea ducks, and wild berries and their jam (see diet PCA loadings in Table 5.2.4).

FIGURE 5.3.5 ORGANIC CONTAMINANT SUMMARY IN THREE AGE CATEGORIES

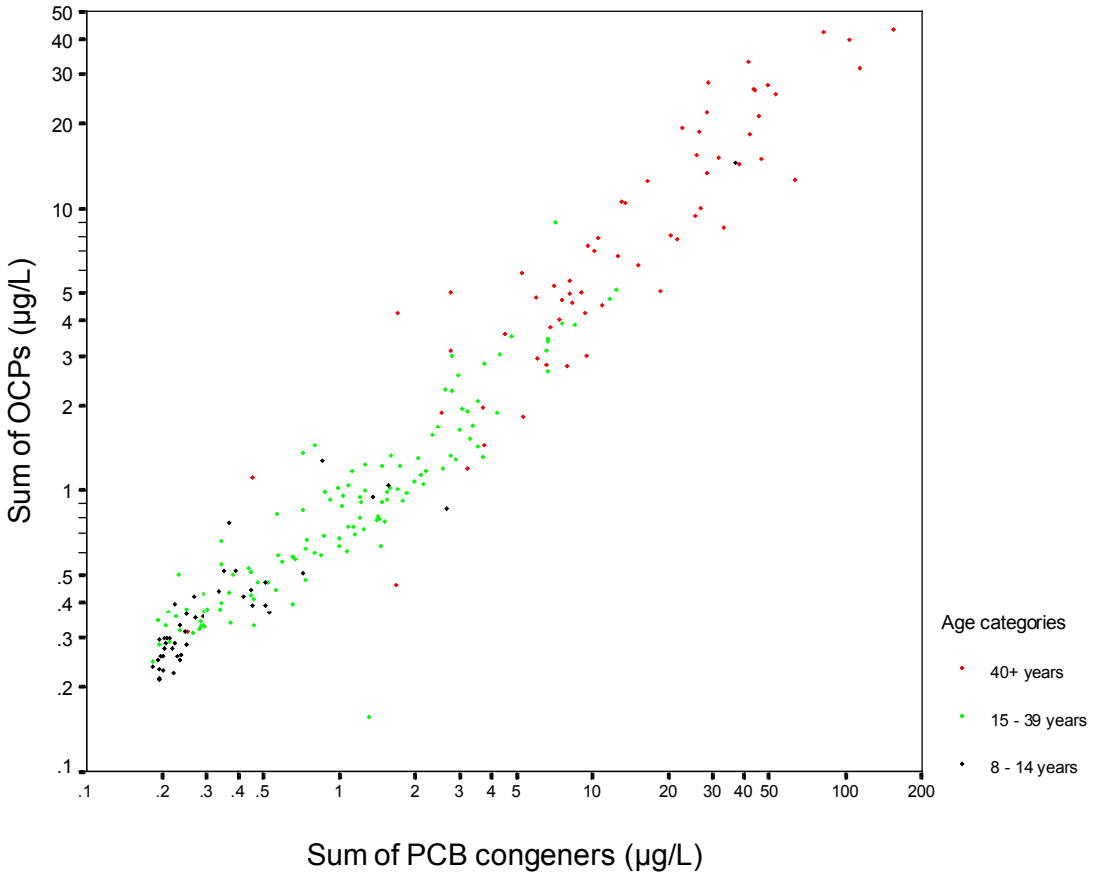


TABLE 5.3.18 ANOVA OF THE EFFECTS OF GENDER AND AGE CATEGORY ON CONTAMINANT AND DIET VARIABLES

Independent variable	Dependent variable	Mean square	F-ratio	p-value	Power
Gender (female, male)	**Plasma contaminants (PCBs and organic pesticide summary variables)**				
	CA-1 of PCBs & OCPs (59.6%)	0.00842	0.05222	0.81946	0.05595
	CA-2 of PCBs & OCPs (18.3%)	0.01151	0.18876	0.66439	0.07169
	CA-3 of PCBs & OCPs (10.1%)	0.18978	15.68475	0.00010	0.97629
	PC-1 of PCBs and OCPs (81.8%)	0.25689	0.44611	0.50491	0.10199
	PC-2 of PCBs and OCPs (7.1%)	0.89659	0.97851	0.32369	0.16635
	Sum of PCB congeners (µg/L)	1.45793	0.00600	0.93831	0.05068
	Sum of OCPs (µg/L)	39.68980	1.14724	0.28534	0.18699
	CA-1 of 6 PCBs & 2 OCPs (66.1%)	0.00363	0.05492	0.81494	0.05626
	CA-2 of 6 PCBs & 2 OCPs (20.9%)	0.12695	7.31076	0.00741	0.76783
	CA-3 of 6 PCBs & 2 OCPs (7.2%)	0.03965	2.89639	0.09023	0.39536
	Traditional Diet Frequency data (summary variables; see Diet PCA loadings; see Tables 5.2.3 and 5.2.4)				
	Trad. Diet Frequency PC-1 (20.5%)	0.23612	0.30569	0.58092	0.08537
	Trad. Diet Frequency PC-2 (6.7%)	2.60676	2.77364	0.09729	0.38147
	Trad. Diet Frequency PC-3 (6.0%)	0.39058	0.47674	0.49065	0.10564
	Trad. Diet Frequency PC-4 (5.5%)	0.03892	0.08612	0.76946	0.05983
	Trad. Diet Frequency PC-5 (4.4%)	0.05124	0.04788	0.82701	0.05545
Age category	**Plasma Contaminants (PCBs and organic pesticide summary variables)**				
	CA-1 of PCBs & OCPs (59.6%)	18.60595	115.45281	0.00000	1.00000
	CA-2 of PCBs & OCPs (18.3%)	3.30109	54.12537	0.00000	1.00000
	CA-3 of PCBs & OCPs (10.1%)	0.09848	8.13941	0.00039	0.95726
	PC-1 of PCBs and OCPs (81.8%)	46.05343	79.97708	0.00000	1.00000
	PC-2 of PCBs and OCPs (7.1%)	13.22130	14.42928	0.00000	0.99875
	Sum of PCB congeners (µg/L)	10 739.84694	44.23106	0.00000	1.00000
	Sum of OCPs (µg/L)	2 245.25053	64.89921	0.00000	1.00000
	CA-1 of 6 PCBs & 2 OCPs (66.1%)	5.05687	76.54122	0.00000	1.00000
	CA-2 of 6 PCBs & 2 OCPs (20.9%)	0.66105	38.06970	0.00000	1.00000
	CA-3 of 6 PCBs & 2 OCPs (7.2%)	0.61738	45.09456	0.00000	1.00000

TABLE 5.3.18 CONTINUED

Independent variable	Dependent variable	Mean square	F-ratio	p-value	Power
	Traditional Diet Frequency data (summary variables; see Diet PCA loadings; see Tables 5.2.3 & 5.2.4)				
	Trad. Diet Frequency PC-1 (20.5%)	15.87162	20.54757	0.00000	0.99997
	Trad. Diet Frequency PC-2 (6.7%)	0.44558	0.47410	0.62310	0.12695
	Trad. Diet Frequency PC-3 (6.0%)	0.72799	0.88858	0.41275	0.20203
	Trad. Diet Frequency PC-4 (5.5%)	0.88236	1.95255	0.14443	0.40171
	Trad. Diet Frequency PC-5 (4.4%)	2.76578	2.58439	0.07780	0.51182
Gender*Age interaction	**Plasma Contaminants (PCBs and organic pesticide summary variables)**				
	CA-1 of PCBs & OCPs (59.6%)	0.08596	0.53339	0.58739	0.13735
	CA-2 of PCBs & OCPs (18.3%)	0.01386	0.22723	0.79693	0.08530
	CA-3 of PCBs & OCPs (10.1%)	0.20079	16.59495	0.00000	0.99967
	PC-1 of PCBs and OCPs (81.8%)	0.20411	0.35446	0.70197	0.10639
	PC-2 of PCBs and OCPs (7.1%)	1.35682	1.48078	0.22978	0.31390
	Sum of PCB congeners (µg/L)	26.35230	0.10853	0.89720	0.06644
	Sum of OCPs (µg/L)	36.13596	1.04451	0.35365	0.23128
	CA-1 of 6 PCBs & 2 OCPs (66.1%)	0.13776	2.08507	0.12682	0.42566
	CA-2 of 6 PCBs & 2 OCPs (20.9%)	0.07558	4.35267	0.01403	0.74965
	CA-3 of 6 PCBs & 2 Ps (7.2%)	0.00837	0.61140	0.54353	0.15125
	Traditional Diet Frequency data (summary variables; see Diet PCA loadings; see Tables 5.2.3 & 5.2.4)				
	Trad. Diet Frequency PC-1 (20.5%)	0.98232	1.27172	0.28246	0.27429
	Trad. Diet Frequency PC-2 (6.7%)	1.36551	1.45293	0.23618	0.30864
	Trad. Diet Frequency PC-3 (6.0%)	0.10238	0.12496	0.88259	0.06900
	Trad. Diet Frequency PC-4 (5.5%)	0.07037	0.15572	0.85590	0.07384
	Trad. Diet Frequency PC-5 (4.4%)	0.89619	0.83741	0.43424	0.19252

Significant ANOVA result; $p < 0.05$

TABLE 5.3.19 PAIR-WISE POST-HOC COMPARISONS OF AGE CATEGORIES FROM ANOVA

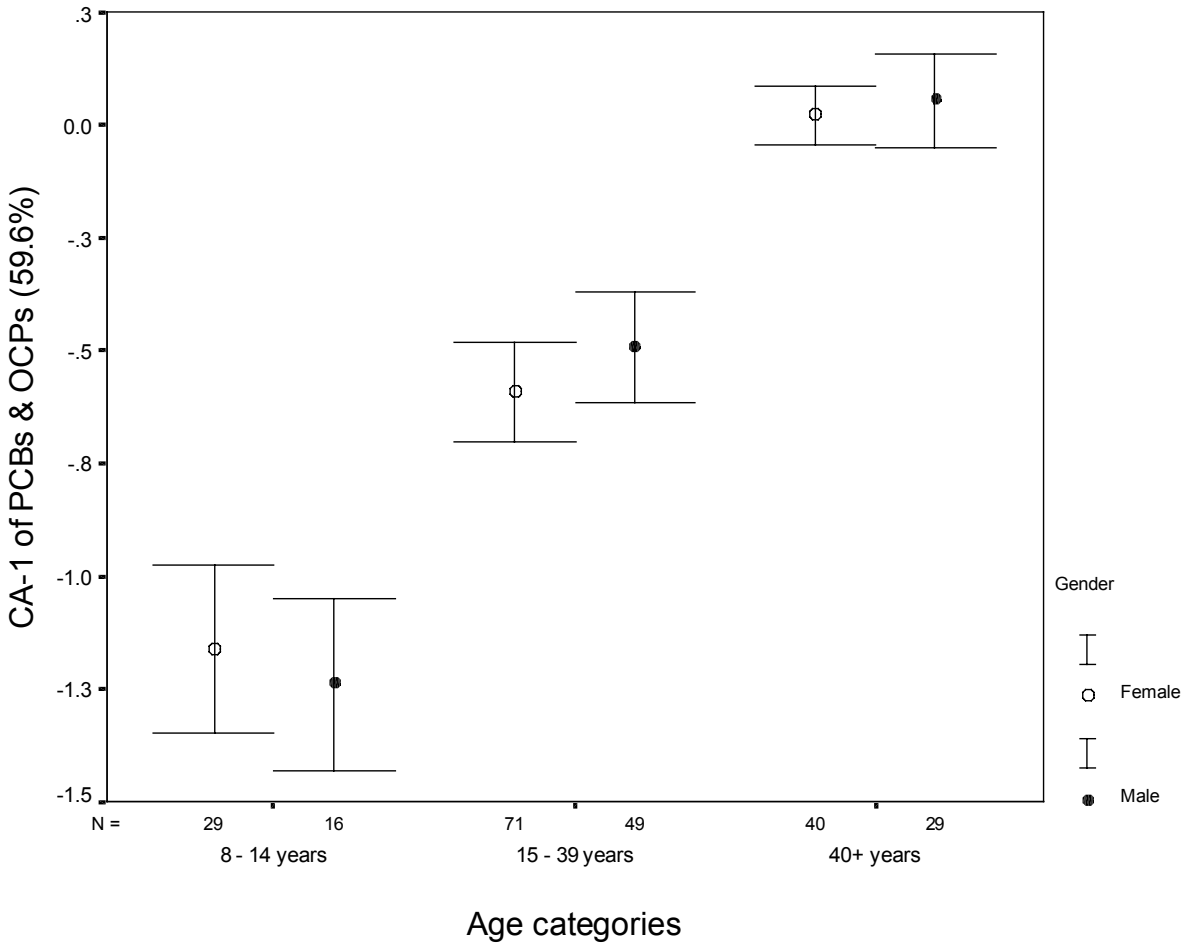
Dependent variable	Age category (I)	Age category (J)	Mean difference (I-J)	p-value	95% Confidence interval	
					Lower bound	Upper bound
CA-1 of PCBs & OCPs (59.6%)	8-14 y	15-39 y	-0.6382	0.0000	-0.8296	-0.4468
	8-14 y	≥40 y	-1.2142	0.0000	-1.3954	-1.0331
	15-39 y	≥40 y	-0.5760	0.0000	-0.7023	-0.4497
CA-2 of PCBs & OCPs (18.3%)	8-14 y	15-39 y	-0.4457	0.0000	-0.5896	-0.3017
	8-14 y	≥40 y	-0.4501	0.0000	-0.5935	-0.3067
	15-39 y	≥40 y	-0.0044	0.9980	-0.0749	0.0660
CA-3 of PCBs & OCPs (10.1%)	8-14 y	15-39 y	-0.0833	0.0000	-0.1298	-0.0369
	8-14 y	≥40 y	-0.0927	0.0020	-0.1564	-0.0290
	15-39 y	≥40 y	-0.0094	0.9660	-0.0641	0.0453
PC-1 of PCBs and OCPs (81.8%)	8-14 y	15-39 y	-0.1164	0.1120	-0.2517	0.0189
	8-14 y	≥40 y	-1.5519	0.0000	-1.9993	-1.1044
	15-39 y	≥40 y	-1.4355	0.0000	-1.8697	-1.0012
PC-2 of PCBs and OCPs (7.1%)	8-14 y	15-39 y	0.2088	0.0110	0.0389	0.3786
	8-14 y	≥40 y	0.8828	0.0010	0.3207	1.4450
	15-39 y	≥40 y	0.6741	0.0110	0.1256	1.2226
Sum of PCB congeners (µg/L)	8-14 y	15-39 y	-0.6328	0.8360	-2.6962	1.4307
	8-14 y	≥40 y	-22.6675	0.0000	-31.9526	-13.3824
	15-39 y	≥40 y	-22.0347	0.0000	-31.1410	-12.9284
Sum of OCPs (µg/L)	8-14 y	15-39 y	-0.4912	0.3820	-1.3154	0.3330
	8-14 y	≥40 y	-10.7001	0.0000	-14.2073	-7.1930
	15-39 y	≥40 y	-10.2090	0.0000	-13.6494	-6.7685

TABLE 5.3.19 CONTINUED

Dependent variable	Age category (I)	Age category (J)	Mean difference (I-J)	p-value	95% Confidence interval	
					Lower bound	Upper bound
CA-1 of 6 PCBs & 2 OCPs (66.1%)	8-14 y	15-39 y	0.2508	0.0000	0.1454	0.3562
	8-14 y	≥40 y	0.6038	0.0000	0.4943	0.7133
	15-39 y	≥40 y	0.3530	0.0000	0.2581	0.4480
CA-2 of 6 PCBs & 2 OCPs (20.9%)	8-14 y	15-39 y	0.1948	0.0000	0.1312	0.2585
	8-14 y	≥40 y	0.1880	0.0000	0.1191	0.2569
	15-39 y	≥40 y	-0.0069	0.9830	-0.0570	0.0433
CA-3 of 6 PCBs & 2 OCPs (7.2%)	8-14 y	15-39 y	-0.1825	0.0000	-0.2530	-0.1121
	8-14 y	≥40 y	-0.2076	0.0000	-0.2772	-0.1380
	15-39 y	≥40 y	-0.0251	0.1710	-0.0571	0.0069
Trad. Diet Frequency PC-1 (20.5%)	8-14 y	15-39 y	0.1341	0.2990	-0.0697	0.3379
	8-14 y	≥40 y	-0.7875	0.0010	-1.2972	-0.2778
	15-39 y	≥40 y	-0.9216	0.0000	-1.4081	-0.4351
Trad. Diet Frequency PC-2 (6.7%)	8-14 y	15-39 y	0.0278	0.9690	-0.1398	0.1954
	8-14 y	≥40 y	-0.0924	0.9710	-0.6612	0.4763
	15-39 y	≥40 y	-0.1202	0.9350	-0.6768	0.4364
Trad. Diet Frequency PC-3 (6.0%)	8-14 y	15-39 y	0.0219	0.9630	-0.1012	0.1450
	8-14 y	≥40 y	-0.1796	0.7920	-0.7075	0.3483
	15-39 y	≥40 y	-0.2015	0.7220	-0.7237	0.3206
Trad. Diet Frequency PC-4 (5.5%)	8-14 y	15-39 y	0.0061	0.9980	-0.0940	0.1063
	8-14 y	≥40 y	0.1992	0.5150	-0.1900	0.5884
	15-39 y	≥40 y	0.1931	0.5300	-0.1915	0.5776
Trad. Diet Frequency PC-5 (4.4%)	8-14 y	15-39 y	-0.0733	0.2630	-0.1795	0.0328
	8-14 y	≥40 y	-0.4369	0.2260	-1.0430	0.1691
	15-39 y	≥40 y	-0.3636	0.3740	-0.9677	0.2405

Significant Tamhane's T2 test result: $p < 0.05$; Tamhane's T2 test for unequal variances, following Levene's test for homogeneity of variances.

FIGURE 5.3.6 MEAN VALUES OF PLASMA CONTAMINANT SUMMARY VARIABLE CA-1 (± 95% CONFIDENCE INTERVAL) BY GENDER AND AGE CATEGORY



A brief discussion of contaminant loadings for the various CA and PC axes is helpful along the manner done for the diet PC axes in Section 5.2.1.3 (also see Section 5.3.2.3). The PC and CA summary variables are based on contaminant concentrations transformed according to log10 (x + 1).

The CA incorporating all contaminants explained 88 percent of the variation in the raw contaminant data in the first 3 axes (Table 5.3.20). CA axis-1, explaining 60 percent of the variation, showed strong negative scores for PCB-28, PCB-101, β-HCH, and DDT, and moderately positive scores for PCB-156, PCB-170, and Mirex. An examination of the detection frequency data in Table 5.3.14 suggests that negative loadings appear to coincide with rather abrupt changes in the percent detection across the three age groups especially when traversing

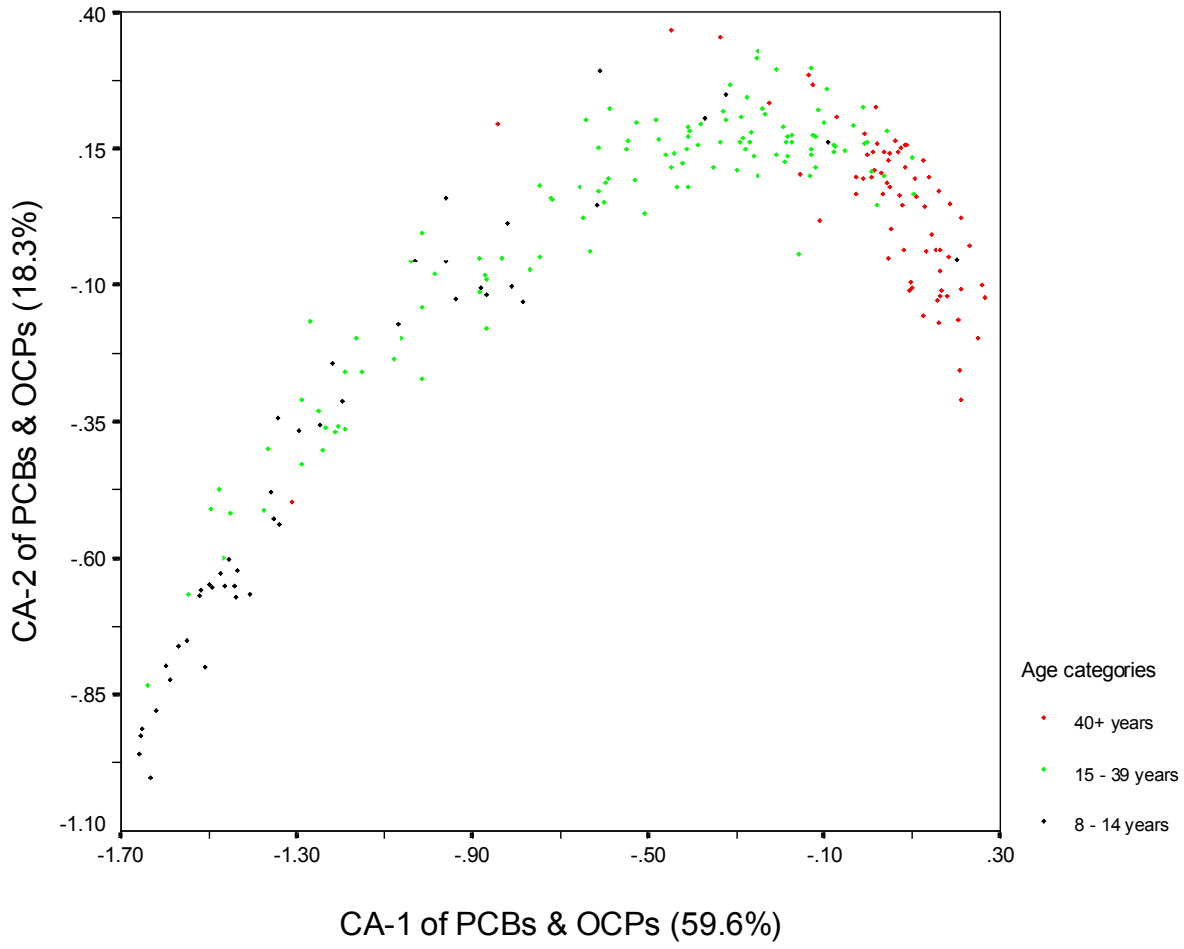
from the 15 to 39-year-old group to those over 40. By contrast positive entries reflect a more ubiquitous presence in all three groups. The positive loadings from PCB-153 and p,p-DDE suggest that the CA-2 axis in Table 5.3.20 is driven primarily by contaminant concentration, as these compounds were present in plasma at relatively high levels (see Tables 5.3.1.5 and 5.3.1.6). The scatterplot of CA-1 score versus CA-2 score supports the suggested interpretations, as it illustrates that organochlorine concentrations in plasma are strongly associated with the age of the subjects (Figure 5.3.7). The youngest (8-14 yrs.) group has rather low scores on both CA axes, though the range of scores overlaps broadly with that of the 15 to 39-year-old group. By contrast, the oldest individuals, ≥40 yrs., are not as clearly distinguished from the 15 to 39-year-olds on the CA-2 score. It is perhaps fortuitous, but for positive entries in the CA-3 column of Table 5.3.20, the plasma contaminant concentrations observed for females were higher than in males; the reverse concentration ratio is apparent for negative loadings. This suggests that CA-3 constitutes a gender axis, a conclusion supported by the significant gender and gender*age interaction in the ANOVA.

TABLE 5.3.20 CORRESPONDENCE ANALYSIS (CA) OF ALL PCBS AND ORGANIC PESTICIDES IN PLASMA SAMPLES

Organic Contaminant	CA-1 of PCBs & OCPs (59.6%)	CA-2 of PCBs & OCPs (18.3%)	CA-3 of PCBs & OCPs (10.1%)
PCBs: log10 (1+ congener 28 (µg/L))	-1.613300	-0.355600	-0.248920
PCBs: log10 (1+ congener 99 (µg/L))	0.113850	-0.148380	0.270620
PCBs: log10 (1+ congener 101 (µg/L))	-1.333600	-0.437870	-0.154200
PCBs: log10 (1+ congener 105 (µg/L))	0.055331	-0.376320	0.400730
PCBs: log10 (1+ congener 118 (µg/L))	0.184150	-0.164070	0.269780
PCBs: log10 (1+ congener 128 (µg/L))	-0.965730	-0.457630	-0.015127
PCBs: log10 (1+ congener 138 (µg/L))	0.103170	0.033212	0.061520
PCBs: log10 (1+ congener 153 (µg/L))	0.018748	0.138780	-0.030087
PCBs: log10 (1+ congener 156 (µg/L))	0.251690	-0.171610	-0.104410
PCBs: log10 (1+ congener 170 (µg/L))	0.223860	-0.069524	-0.118390
PCBs: log10 (1+ congener 180 (µg/L))	0.103530	0.115470	-0.116750
PCBs: log10 (1+ congener 183 (µg/L))	0.186160	-0.189790	0.072885
PCBs: log10 (1+ congener 187 (µg/L))	0.187880	-0.020294	-0.057001
OCPs: log10 (1+ β-HCH (µg/L))	-1.405100	-0.413020	-0.181430
OCPs: log10 (1+ cis-nonachlor (µg/L))	0.109070	-0.405130	-0.006700
OCPs: log10 (1+ pp'-DDE (µg/L))	-0.277220	0.175960	0.086751
OCPs: log10 (1+ pp'-DDT (µg/L))	-1.127900	-0.387570	-0.111460
OCPs: log10 (1+ hexachlorobenzene (µg/L))	-0.277750	-0.179760	0.065854
OCPs: log10 (1+ mirex (µg/L))	0.268280	-0.168530	-0.216700
OCPs: log10 (1+ oxy-chlordane (µg/L))	0.132840	-0.365470	-0.043210
OCPs: log10 (1+ trans-nonachlor (µg/L))	0.193220	-0.212330	-0.004558

Indicates high CA scores for contaminant

FIGURE 5.3.7 CORRESPONDENCE AXES SCORES IN PLASMA (ALL CONTAMINANTS; TABLE 5.3.20) OF INDIVIDUALS IN THREE AGE CATEGORIES



The reduced suite CA analysis reported in Table 5.3.21 was performed on those contaminants with ≥70% detected concentrations, to minimize distortion of the analysis by variables with few detectable concentrations, since CA is sensitive to "rare" data, as illustrated. This subsidiary analysis included 6 PCB congeners and 2 OCPs, and explained 94 percent of the variation in the raw data in the first 3 CA axes. The first of these axes was a measure contrasting the relative concentrations of all 6 PCBs versus the 2 OCPs, with all PCBs scoring negatively on CA-1, and both pesticides scoring positively. Of all the organochlorine compounds determined, the detection frequency (Table 5.3.14) and concentrations for the latter (i.e., p,p-DDE and hexachlorobenzene; Table 5.3.16) showed the least age dependence, and this is consistent with the interpretation assigned to the CA-1 axis of the whole suite of organochlorines (Table 5.3.20). The second axis contrasted the concentrations of PCB-118 and hexachlorobenzene, both scoring

positively, against PCB-180, which increases in concentration with negative CA-2 score. As seen for CA-3 in Table 5.3.20, CA-2 appears to exhibit gender dependence, since PCB-118 and hexachlorobenzene concentrations in plasma in the over-40-years-old group were considerably higher in females than in males, although not significantly (see Table 5.3.15 and 5.3.16). In adults over 15 to 39 years of age, the reverse gender concentration pattern was evident. The third retained axis is mostly a measure of the concentration of hexachlorobenzene, which increases in concentration with negative CA-3 score.

TABLE 5.3.21 CORRESPONDENCE ANALYSIS (CA) OF 8 ORGANOCHLORINE CONTAMINANTS FOUND WITH ≥70 PERCENT DETECTABILITY IN PLASMA OF MISTISSINI SUBJECTS

Organic Contaminant	CA-1 of 6 PCBs & 2 OCPs (66.1%)	CA-2 of 6 PCBs & 2 OCPs (20.9%)	CA-3 of 6 PCBs & 2 OCPs (7.2%)
PCBs: log10 (1+ congener 118 (µg/L))	-0.189730	0.359970	0.086688
PCBs: log10 (1+ congener 138 (µg/L))	-0.103770	0.046967	0.063288
PCBs: log10 (1+ congener 153 (µg/L))	-0.017949	-0.082227	0.057382
PCBs: log10 (1+ congener 170 (µg/L))	-0.264390	-0.000894	-0.124270
PCBs: log10 (1+ congener 180 (µg/L))	-0.113690	-0.124180	-0.011733
PCBs: log10 (1+ congener 187 (µg/L))	-0.209720	0.010461	-0.051248
OCPs: log10 (1+ pp'-DDE (µg/L))	0.334960	0.011636	-0.004249
OCPs: log10 (1+ hexachlorobenzene (µg/L))	0.230690	0.246940	-0.268040

Indicates high CA scores for contaminant

The PC analysis of these same data, performed on the correlation matrix, explained 89 percent of the variation in raw contaminant concentration in the first 2 axes (Table 5.3.22). Subsequent axes had eigen values <1 and were not considered. PC-1 axis loaded positively on all contaminants, with highest loadings for PCB-183 and trans-nonachlor. This axis can be considered a measure of overall contaminant loadings in plasma. The second PC axis was largely a measure of the relative concentration of PCB-28 and PCB-101, echoing the structure of the first axis from the CA analysis above (Table 5.3.20).

And finally, it is pertinent to point out that PC summary variables are more closely associated with actual amounts than CA summary variables, and this is consistent with PC-1 having high loadings for 10 of the 13 congeners, and 5 of the 8 OCPs (Table 5.3.22). CA contaminant scores tend to reflect relatively more than absolute change in concentrations, which appears to include differences in biological variances related to age and gender, as illustrated.

TABLE 5.3.22 AXIS LOADINGS FROM PRINCIPAL COMPONENT ANALYSIS OF PLASMA CONTAMINANTS

	PC-1 (81.8%)	PC-2 (7.1%)
PCBs: log10 (1+ congener 28 (µg/L))	0.476	0.730
PCBs: log10 (1+ congener 99 (µg/L))	0.941	0.050
PCBs: log10 (1+ congener 101 (µg/L))	0.769	0.553
PCBs: log10 (1+ congener 105 (µg/L))	0.901	0.152
PCBs: log10 (1+ congener 118 (µg/L))	0.957	-0.043
PCBs: log10 (1+ congener 128 (µg/L))	0.871	0.361
PCBs: log10 (1+ congener 138 (µg/L))	0.973	-0.183
PCBs: log10 (1+ congener 153 (µg/L))	0.947	-0.271
PCBs: log10 (1+ congener 156 (µg/L))	0.970	-0.126
PCBs: log10 (1+ congener 170 (µg/L))	0.968	-0.174
PCBs: log10 (1+ congener 180 (µg/L))	0.939	-0.289
PCBs: log10 (1+ congener 183 (µg/L))	0.989	-0.001
PCBs: log10 (1+ congener 187 (µg/L))	0.976	-0.183
OCPs: log10 (1+ β-HCH (µg/L))	0.754	0.335
OCPs: log10 (1+ cis-nonachlor (µg/L))	0.973	0.070
OCPs: log10 (1+ pp'-DDE (µg/L))	0.900	-0.277
OCPs: log10 (1+ pp'-DDT (µg/L))	0.649	0.050
OCPs: log10 (1+ hexachlorobenzene (µg/L))	0.981	-0.009
OCPs: log10 (1+ mirex (µg/L))	0.944	-0.149
OCPs: log10 (1+ oxy-chlordane (µg/L))	0.934	0.017
OCPs: log10 (1+ trans-nonachlor (µg/L))	0.986	-0.025

Identifies strong loadings on component

Of the 13 PCB congeners measured in the AMAP suite, PCB-105, 118, and 156 have some dioxin-like activity (see Section 5.3.2.4). It is therefore of interest that CA-3 of the PCBs & OCPs showed that males had a significantly lower loading than females of the over-40-years-old group, suggesting metabolic differences in handling PCB-105. Furthermore, the same phenomenon is evident for CA-2 of the 6 PCBs & 2 OCPs, for which PCB-118 provides the primary positive loading. Interestingly, the detection frequency of congener 105 was lower in males (86.2% vs. 95%), while for both genders it was 100% for PCB-118 (Table 5.3.14). However, in both cases the geometric mean concentrations are more than two-fold higher in

females (Table 5.3.15), although the only significant difference in concentration was observed for PCB-105, based on confidence intervals (See Table 5.3.15).

5.3.2.3 Potential sources

The results of a partial correlation analysis between the sum of the concentrations of the PCB congeners measured in plasma and traditional diet consumption frequencies are summarized in Table 5.3.23. Partial correlations are also provided for the sum of the OCPs, as well as the PC-1 and CA-1 scores of the suite of PCBs and OCPs, and for the CA-1 scores from the reduced suite of the 8 contaminants present at detection frequencies ≥70%.

In terms of the sum of PCB congeners, large mammals and all fish are identified as sources with the greatest confidence (highlighted in yellow with $p = 0.000$), while sea ducks, dabbler ducks and loon or merganser are identified with somewhat less confidence (i.e., higher p-values). Much of the same pattern was observed for the sum of pesticides, with minor differences in p-values, and small mammals being identified rather than large mammals. The PC-1 axis of the sum of PCBs and pesticides reinforce these findings. As discussed in Section 5.2.1.3, and as illustrated by the strong association with age category exhibited in Table 5.3.18 for the primary principal component axis of the traditional diet frequency data (i.e., PC-1), the various food items mentioned are not independent. This is especially the case for the consumption of wild berries and berry jam, as they correlated with 11 of 14 major food items considered in the PC analysis (see Section 5.2.1.3). Nevertheless, the identification of fish-eating and dabbler ducks, rather than other ducks, is encouraging, as the former are known to feed on aquatic/benthic invertebrates and are known to accumulate both PCBs and OCPs (Hydro-Quebec 1994). Furthermore, the dietary variable PC-3 in Table 5.3.23 exhibits negative associations, and based on its loadings (Tables 5.2.3 and 5.2.4) suggests that goose and bear grease, other fats, geese, other birds (non-water fowl), and small mammals are not likely significant sources of organochlorine contaminants. The present findings broaden the concern of potential food-chain sources, as fish until now have been considered their primary origin. Clearly, tissue analyses are required to confirm this suggestion.

TABLE 5.3.23 PARTIAL CORRELATIONS BETWEEN ORGANIC CONTAMINANTS IN HUMAN PLASMA AND TRADITIONAL DIET FREQUENCY DATA, CONTROLLING FOR EFFECT OF SUBJECT AGE

	Plasma contaminant variables				
Diet variables	Sum of PCB congeners (µg/L)	Sum of OCPs (µg/L)	CA-1 of PCBs & OCPs (59.6%)	PC-1 of PCBs and OCPs (81.8%)	CA-1 of 6 PCBs & 2 OCPs (66.1%)
Traditional Diet, sum of organ meat daily consumption frequencies (means over year data)	-0.043 225 p = 0.519	-0.0298 219 p = 0.660	0.0401 225 p = 0.548	-0.0563 219 p = 0.405	-0.0223 224 p = 0.739
Traditional Diet, sum of large mammal meat daily consumption frequencies (means over year data, no organ meats)	0.2456 225 p = 0.000	0.1268 219 p = 0.060	-0.2139 225 p = 0.001	0.2001 219 p = 0.003	0.0884 224 p = 0.185
Traditional Diet, sum of small mammal meat daily consumption frequencies (means over year data, no organ meats)	0.1228 225 p = 0.065	0.1702 219 p = 0.011	-0.0695 225 p = 0.297	0.2272 219 p = 0.001	-0.0199 224 p = 0.766

Diet variables	Plasma contaminant variables				
	Sum of PCB congeners (µg/L)	Sum of OCPs (µg/L)	CA-1 of PCBs & OCPs (59.6%)	PC-1 of PCBs and OCPs (81.8%)	CA-1 of 6 PCBs & 2 OCPs (66.1%)
Traditional Diet, sum of piscivorous fish daily consumption frequencies (means over year data, no livers)	0.2043 224 p = 0.002	0.1738 218 p = 0.010	-0.0535 224 p = 0.423	0.2488 218 p = 0.000	-0.0501 223 p = 0.454
Traditional Diet, sum of non-piscivorous fish daily consumption frequencies (means over year data, no livers)	0.2855 224 p = 0.000	0.3254 218 p = 0.000	-0.097 224 p = 0.146	0.3587 218 p = 0.000	0 223 p =1.000
Mean daily frequency over year for Q32: loon or merganser	0.1727 225 p = 0.009	0.1795 219 p = 0.007	0.0719 225 p = 0.280	0.2243 219 p = 0.001	-0.0845 224 p = 0.206
Mean daily frequency over year for Q33: geese	0.1043 225 p = 0.117	0.0975 219 p = 0.149	-0.1025 225 p = 0.123	0.1407 219 p = 0.037	0.0864 224 p = 0.196
Mean daily frequency over year for Q34: dappler ducks	0.1368 225 p = 0.040	0.267 219 p = 0.000	0.0162 225 p = 0.808	0.2465 219 p = 0.000	-0.0795 224 p = 0.234

Diet variables	Plasma contaminant variables				
	Sum of PCB congeners (µg/L)	Sum of OCPs (µg/L)	CA-1 of PCBs & OCPs (59.6%)	PC-1 of PCBs and OCPs (81.8%)	CA-1 of 6 PCBs & 2 OCPs (66.1%)
Mean daily frequency	0.164	0.2818	-0.0596	0.2638	0.0036
over year for Q35:	225	219	225	219	224
sea ducks	p = 0.013	p = 0.000	p = 0.371	p = 0.000	p = 0.957
Mean daily frequency	0.1215	0.1459	-0.068	0.1842	0.0241
over year for Q37: ptarmigan,	225	219	225	219	224
partridge and other birds	p = 0.068	p = 0.030	p = 0.307	p = 0.006	p = 0.718
Mean daily frequency	0.265	0.3121	-0.05	0.3283	0.011
over year for Q46:	225	219	225	219	224
wild berries	p = 0.000	p = 0.000	p = 0.454	p = 0.000	p = 0.869
Mean daily frequency	0.2682	0.3192	-0.1156	0.3382	0.0377
over year for Q47:	225	219	225	219	224
wild berry jam	p = 0.000	p = 0.000	p = 0.082	p = 0.000	p = 0.573
Mean daily frequency	-0.0147	0.0853	-0.0421	0.0916	0.0076
over year for Q48:	225	219	225	219	224
bear grease	p = 0.826	p = 0.207	p = 0.528	p = 0.175	p = 0.910
Mean daily frequency	0.0956	0.1081	-0.1273	0.115	0.1237
over year for Q49:	225	219	225	219	224
goose grease	p = 0.151	p = 0.109	p = 0.055	p = 0.088	p = 0.063

Diet variables	Plasma contaminant variables				
	Sum of PCB congeners (µg/L)	Sum of OCPs (µg/L)	CA-1 of PCBs & OCPs (59.6%)	PC-1 of PCBs and OCPs (81.8%)	CA-1 of 6 PCBs & 2 OCPs (66.1%)
Trad. Diet Frequency PC-1 (20.5%)	0.2882	0.3119	-0.1353	0.366	0.0247
	224	218	224	218	223
	p = 0.000	p = 0.000	p = 0.042	p = 0.000	p = 0.713
Trad. Diet Frequency PC-2 (6.7%)	-0.0511	-0.198	-0.0802	-0.1396	0.0446
	224	218	224	218	223
	p = 0.445	p = 0.003	p = 0.230	p = 0.039	p = 0.505
Trad. Diet Frequency PC-3 (6.0%)	-0.2049	-0.1544	-0.0372	-0.1852	0.0396
	224	218	224	218	223
	p = 0.002	p = 0.022	p = 0.578	p = 0.006	p = 0.554
Trad. Diet Frequency PC-4 (5.5%)	-0.0692	-0.1522	-0.1262	-0.1609	0.1333
	224	218	224	218	223
	p = 0.301	p = 0.024	p = 0.058	p = 0.017	p = 0.046
Trad. Diet Frequency PC-5 (4.4%)	0.0181	0.0082	0.0401	0.0465	-0.0576
	224	218	224	218	223
	p = 0.787	p = 0.904	p = 0.549	p = 0.493	p = 0.390

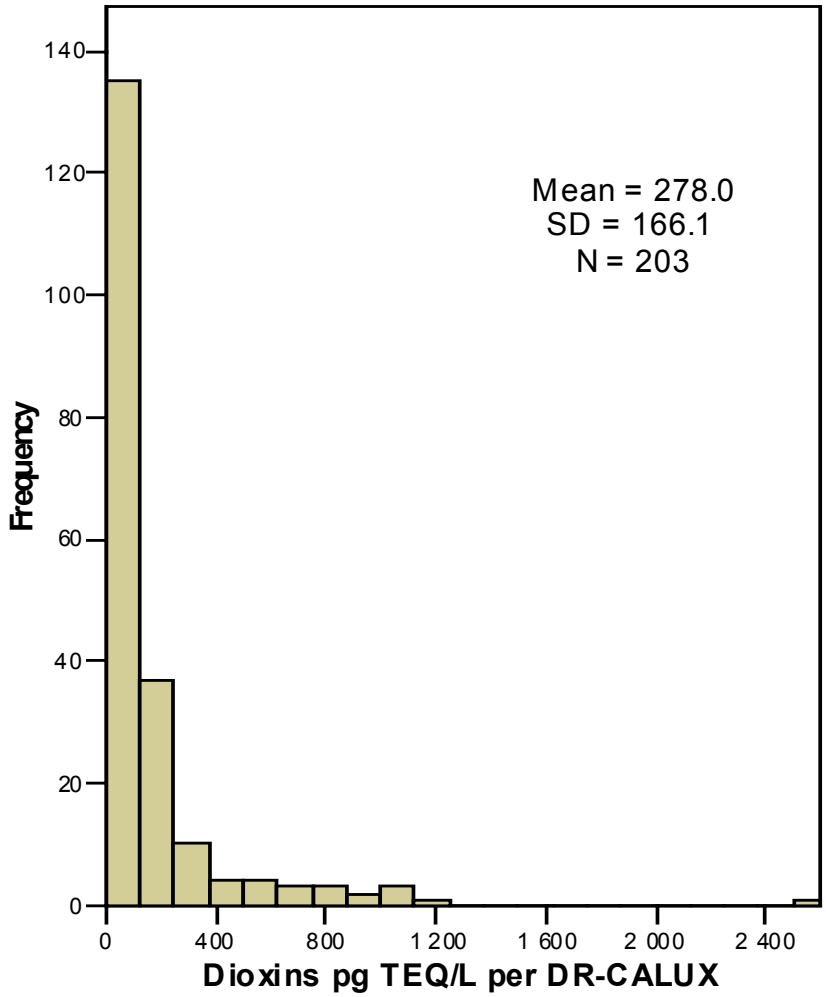
Significant at p = 0.05 level

Significant at p = 0.005 level

5.3.2.4 Analysis of plasma samples for DLCs using the DR-CALUX assay

We analysed 203 plasma samples from Iiyiyiuch (119 women, 84 men; mean age = 32 years) using the DR-CALUX reporter gene cell assay. Plasma samples were first submitted to a solid phase extraction and then purified on an acid silica column (see the method in section 4.5.1.4). The mean dioxin-like compounds (DLC) concentration is 166 pg TEQ/L [standard deviation (SD) = 278]. The median concentration is 81 pg TEQ/L, with values ranging from below the detection limit (<30 pg TEQ/L) to 2624 pg TEQ/L. When expressed on a lipid basis the mean concentration is 31 pg TEQ/g lipids (SD = 46) and the median concentration is 15 pg TEQ/g lipids (range = 1.6-350 pg TEQ/g lipids). Forty-seven samples (23%) were below the detection limit of 30 pg TEQ/L. The frequency distribution of DLC plasma concentrations is shown in Figure 5.3.8. The strong relation between TEQ concentrations determined using the DR-CALUX assay and PCB-153 plasma concentrations is shown in Figure 5.3.9. As shown earlier (Table 5.3.17), PCB-153 is correlated to many other organochlorine compounds, including the mono-ortho PCBs, which show dioxin-like activities. Therefore, PCB-153 can be used as an indicator of exposure to the environmental mixture of POPs comprising DLCs.

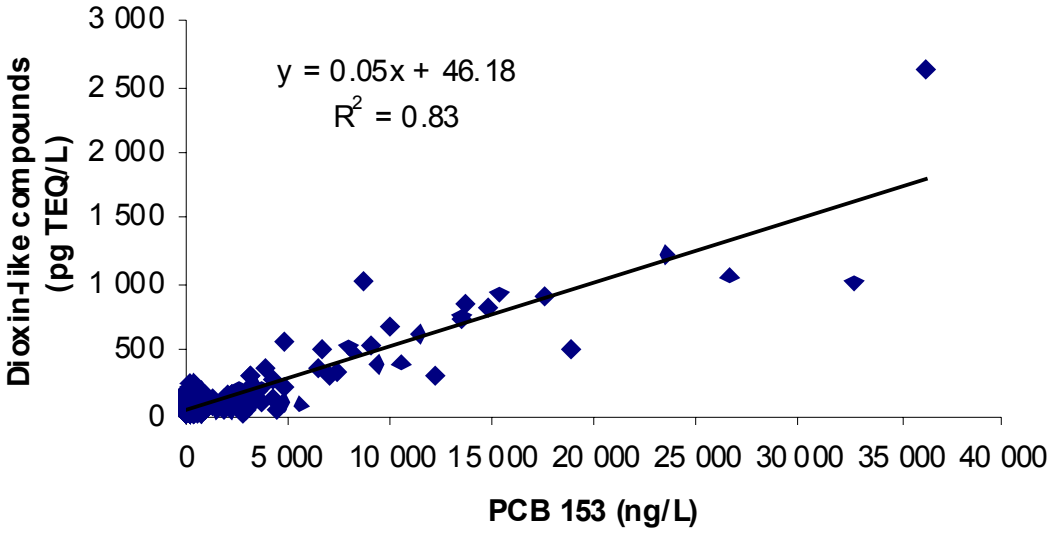
FIGURE 5.3.8 FREQUENCY DISTRIBUTION OF DLC CONCENTRATIONS IN PLASMA SAMPLES FROM 203 IIYIYIUCH (MISTISSINI, 2005)



DLC concentration values obtained in the Mistissini population can be compared to those obtained in other populations using a similar reporter-gene assay procedure. A mean concentration of 35 pg TEQ/g fat was reported for 47 pooled serum samples originating from samples collected in 1999 from 200 women aged between 50 and 65 years, and living in two areas of Flanders, Belgium (Koppen et al., 2002). This value is quite similar to that obtained in the Mistissini population and reported in the present study (i.e., 31 pg TEQ/g fat). Pauwels et al. (2000) reported a mean concentration of 46.8 pg TEQ/g fat in 106 Belgian women visiting a fertility clinic between 1996 and 1998 (mean age = 32 years). A much higher concentration (103 pg TEQ/g fat) was reported in 12 samples collected between 1990 and 1992 from nursing mothers (mean age = 30 years) participating in an infant cohort study in the Netherlands

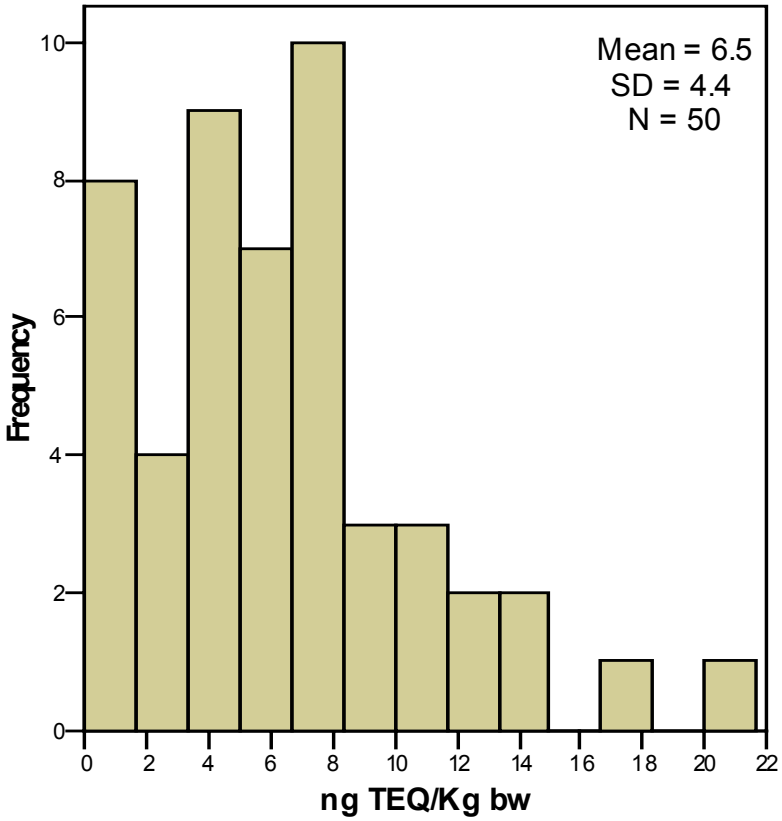
(Pauwels et al., 2000). Finally, Ayotte et al. (2005) reported a mean concentration of 102 pg TEQ/g fat in plasma samples collected in 1992 from 40 residents (23 women, 17 men; mean age = 47 years) from fish-eating communities located along the Lower North Shore of the St. Lawrence River (Québec, Canada). In general, the concentrations obtained in different populations during the 1990s were higher than those observed in the current decade. The samples obtained from the Mistissini population show concentrations of DLCs that are similar to those obtained more recently (early 2000s) in other populations.

FIGURE 5.3.9 RELATIONSHIP BETWEEN CONCENTRATIONS OF DIOXIN-LIKE COMPOUNDS MEASURED BY THE DR-CALUX ASSAY AND CONCENTRATIONS OF PCB-153 IN PLASMA SAMPLES FROM 203 IIYIYIUCH (MISTISSINI, 2005)



In laboratory animals exposed to TCDD, adverse effects (hormonal, reproductive and developmental) have been observed at body burdens in the range of 28-73 ng TCDD/kg body weight (BW) (van Leeuwen et al. 2000). The fat mass had been estimated by impedance measurements for 146 of the 203 Iiyiyiuch participants for whom we measured the plasma DLC concentration. We calculated the DLC body burden in those 146 Iiyiyiuch. The mean body burden is 13.2 ng TEQ/Kg bw (SD = 20.7). The median is 5.9 ng TEQ/Kg BW with values ranging from <1 to 146.2 ng TEQ/Kg BW. Since the most sensitive adverse health effects listed above concern women of reproductive age, we focused our attention on this subgroup. The distribution of DLC body burdens in women of reproductive age is shown in Figure 5.3.10. None of these women had a DLC body burden exceeding the body burden associated with the most sensitive adverse health effect in laboratory animals i.e. decreased sperm count in offspring at a body burden of 28 ng TEQ/kg BW.

FIGURE 5.3.10 FREQUENCY DISTRIBUTION OF DIOXIN-LIKE COMPOUND BODY BURDENS IN 50 WOMEN OF REPRODUCTIVE AGE (MISTISSINI, 2005)



Analyses of DLCs in plasma samples from Mistissini participants using the DR-CALUX assay were completed in September 2006. We are currently reanalysing some samples for which values for the DR-CALUX assay were either much lower or much greater than expected on the basis of their PCB concentration. We are also assembling 10 pooled plasma samples that will be analysed by HRGC-HRMS at AXYS Analytical Inc. The pooled samples will also be analysed for DLCs using the DR-CALUX assay, which will allow for a comparison of both methods. We recommend conducting the DR-CALUX assay for participants in the next two communities to be visited in 2006-2007.

5.3.4 Analysis of emergent environmental contaminants in pooled plasma samples

We analysed 23 pooled plasma samples for 86 compounds using the automated solid-phase extraction method (see section 4.5.1.4 for method description). Only 60 compounds were detected in more than 70% of the samples.

Table 5.3.24 lists the concentration of total PCBs (Aroclor 1260) in pooled plasma samples obtained from women and men residing in the Mistissini community, according to age and fish consumption. One can see a tendency towards higher values with increasing consumption of fish. Concentrations clearly increase with age. There is a 76-fold difference between PCB concentrations in 15 to 19-year-old women with low fish consumption compared to women aged 50 years and older with high fish consumption. Concentrations were not markedly different between men and women.

TABLE 5.3.24 TOTAL PCB CONCENTRATION (AROCLOR 1260; NG/L) IN POOLED PLASMA SAMPLES FROM IIYIYIUCH (MISTISSINI, 2005)

	Fish consumption		
Women - Age group	**Low**	**Moderate**	**High**
15-19 years	1 300 (11)[a]	NA[b]	NA
20-29 years	1 700 (22)	2 200 (4)	NA
30-39 years	5 100 (12)	7 200 (12)	8 800 (5)
40-49 years	NA	19 000 (11)	15 000 (7)
50 years and over	38 000 (4)	84 000 (9)	99 000 (22)
Men - Age group			
15-19 years	1 100 (5)	680 (4)	NA
20-29 years	2 200 (6)	2 100 (7)	2 700 (7)
30-39 years	9 300 (5)	5 200 (7)	9 500 (4)
40-49 years	NA	22 000 (6)	16 000 (6)
50 years and over	NA	54 000 (7)	79 000 (15)

a. The number of individual samples in the pooled sample is indicated in brackets.

b. NA: not available because of insufficient number of samples in the strata (<4).

Table 5.3.25 shows the concentrations of toxaphene (Parlar 50) in pooled plasma samples. In all fish consumption groups, age-dependency may be observed as older individuals show higher plasma concentrations, with differences of up to 33-fold between younger and older age groups. As well, people who consume moderate to high amounts of fish show higher exposure levels

than in the low fish-consumption group (with differences up to 3-4 fold between the low consumption groups and high consumption groups). This shows that toxaphene behaves in a similar manner to PCBs in the environment and that the main sources of exposure to this compound are dietary.

TABLE 5.3.25 TOXAPHENE (PARLAR #50) CONCENTRATION (NG/L) IN POOLED PLASMA SAMPLES FROM IIYIYIUCH (MISTISSINI, 2005)

	Fish consumption		
Women - Age group	**Low**	**Moderate**	**High**
15-19 years	ND[c] (11)[a]	NA[b]	NA
20-29 years	ND (22)	6.0 (4)	NA
30-39 years	12 (12)	16 (12)	39 (5)
40-49 years	NA	49 (11)	40 (7)
50 years and over	120 (4)	200 (9)	270 (22)
Men - Age group			
15-19 years	ND (5)	ND (4)	NA
20-29 years	5.1 (6)	8.5 (7)	ND (7)
30-39 years	17 (5)	25 (7)	25 (4)
40-49 years	NA	50 (6)	63 (6)
50 years and over	NA	120 (7)	160 (15)

a. The number of individual samples in the pooled sample is indicated in brackets.

b. NA: not available because of insufficient number of samples in the strata (<4).

c. ND below detection limit of 5 ng/L

Table 5.3.26 presents the concentrations of perfluorooctane sulfonate (PFOS) in pooled plasma samples. High values are observed in older individuals, but no clear age-dependency can be observed. Higher values are observed in women who consume moderate to high amounts of fish, but again, there is no clear association with fish consumption. This suggests that PFOS may bioaccumulate and that some exposure may be attributable to dietary sources, but other sources could also contribute to total exposure of this emerging environmental contaminant. The relationship between PCB-153 and PFOS is shown in Figure 5.3.11.

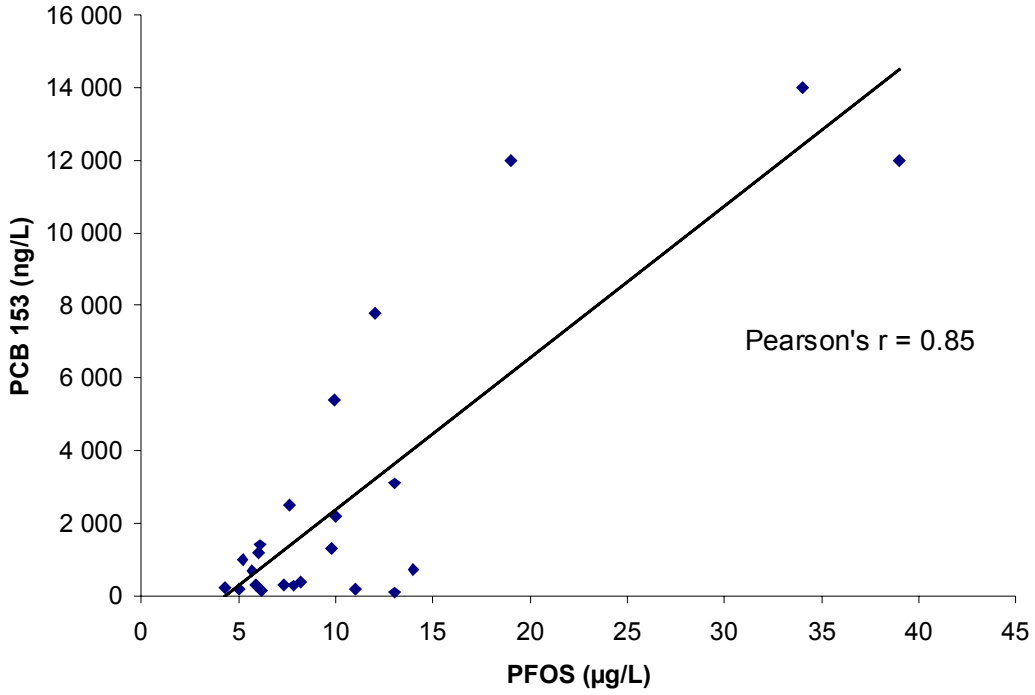
TABLE 5.3.26 PERFLUOROOCTANE SULFONATE CONCENTRATION (µG/L) IN POOLED PLASMA SAMPLES FROM IIYIYIUCH (MISTISSINI, 2005)

	Fish consumption		
Women - Age group	**Low**	**Moderate**	**High**
15-19 years	5.0 (11)[a]	NA[b]	NA
20-29 years	4.3 (22)	5.9 (4)	NA
30-39 years	5.7 (12)	5.2 (12)	6.0 (5)
40-49 years	NA	7.6 (11)	11 (7)
50 years and over	9.9 (4)	39 (9)	34 (22)
Men - Age group			
15-19 years	6.2 (5)	13 (4)	NA
20-29 years	7.3 (6)	7.8 (7)	8.2 (7)
30-39 years	9.8 (5)	14 (7)	6.1 (4)
40-49 years	NA	13 (6)	10 (6)
50 years and over	NA	12 (7)	19 (15)

a. The number of individual samples in the pooled sample is indicated in brackets.

b. NA: not available because of insufficient number of samples in the strata (<4).

FIGURE 5.3.11 CORRELATION BETWEEN PFOS AND PCB-153 CONCENTRATIONS IN POOLED PLASMA SAMPLES FROM IIYIYIUCH (MISTISSINI, 2005)



A totally different picture emerges when examining data for PBDE-47, which is the major PBDE congener measured in the pooled samples (Table 5.3.27). There is no tendency towards higher concentrations of this brominated flame retardant with increasing age or consumption of fish. The highest concentration of PBDE-47 was observed in women in the youngest age group (160 ng/L). When compared to the mean concentration of PCB-153, the most abundant PCB congener (2 930 ng/L), the mean concentration of PBDE-47 in all pooled samples was almost 50-fold lower (63 ng/L).

TABLE 5.3.27 POLYBROMINATED DIPHENYL ETHER CONCENTRATION (PBDE CONGENER NO. 47; NG/L) IN POOLED PLASMA SAMPLES FROM IIYIYIUCH (MISTISSINI, 2005)

	Fish consumption		
Women - Age group	**Low**	**Moderate**	**High**
15-19 years	160 (11)[a]	NA[b]	NA
20-29 years	53 (22)	43 (4)	NA
30-39 years	47 (12)	43 (12)	65 (5)
40-49 years	NA	70 (11)	15 (7)
50 years and over	42 (4)	83 (9)	42 (22)
Men - Age group			
15-19 years	78 (5)	54 (4)	NA
20-29 years	53 (6)	42 (7)	43 (7)
30-39 years	70 (5)	60 (7)	48 (4)
40-49 years	NA	70 (6)	66 (6)
50 years and over	NA	54 (7)	41 (15)

a. The number of individual samples in the pooled sample is indicated in brackets.

b. NA: not available because of insufficient number of samples in the strata (<4).

Table 5.3.28 shows the concentrations of pentachlorophenol in pooled plasma samples. For this compound, no clear association with age or fish consumption can be observed with the data from the pooled samples, suggesting that exposure comes from other sources than food chain contamination, and that this compound may not bioaccumulate the same way other organochlorines do (absence of age dependency).

TABLE 5.3.28 PENTACHLOROPHENOL CONCENTRATION (NG/L) IN POOLED PLASMA SAMPLES FROM IIYIYIUCH (MISTISSINI, 2005)

	Fish consumption		
Women - Age group	**Low**	**Moderate**	**High**
15-19 years	610 (11)[a]	NA[b]	NA
20-29 years	520 (22)	590 (4)	NA
30-39 years	410 (12)	740 (12)	330 (5)
40-49 years	NA	570 (11)	3 900 (7)
50 years and over	490 (4)	620 (9)	620 (22)
Men - Age group			
15-19 years	1 000 (5)	1 000 (4)	NA
20-29 years	680 (6)	870 (7)	1 100 (7)
30-39 years	1 200 (5)	630 (7)	1 100 (4)
40-49 years	NA	520 (6)	570 (6)
50 years and over	NA	1 200 (7)	570 (15)

a. The number of individual samples in the pooled sample is indicated in brackets.

b. NA: not available because of insufficient number of samples in the strata (<4).

We performed correlation analyses to examine the relationship between major compounds frequently detected in pooled samples: PCB-153, PCB-118, PCB-99, PFOS, hexachlorobenzene, *p,p*'-DDE, 3-methyl sulfonyl-DDE, toxaphene (Parlar 50), chlordecone, mirex, PBDE-47, pentachlorophenol, 4-hydroxy PCB-107, 4-hydroxy PCB-146, 4-hydroxy PCB-187, and 4-hydroxy heptachlorostyrene. We observed that all compounds were highly inter-correlated (Pearson's r = 0.78-0.99), with the exception of PBDE-47 and pentachlorophenol, which were not correlated to any other compound. This indicates that the latter compounds are not behaving the same way in the environment as the other POPs.

5.4 Prevalence of Selected Clinical Chemistry (Biochemistry), Morphometric and Medical Outcomes

5.4.1 Prevalence of cardiovascular disease and risk factors

5.4.1.1 Prevalence of self-reported CVD

Prevalence of CVD and its risk factors were evaluated using two methods 1) a clinical questionnaire on self-reported CVD and a few risk factors (reported to be diagnosed by a physician or a nurse); 2) during the clinical session for carotid ultrasonography to measure subclinical atherosclerosis, and Holter to measure heart rate variability, blood pressure, blood lipids and diabetes markers. According to information gathered in the clinical questionnaire, we learned that 17% and 2% of participants declared suffering from high blood pressure (HBP) and heart disease respectively, 16% of them declared to be diabetic and only 6% declared to have hypercholesterolemia. There is no difference in these frequencies according to gender.

Information on self-reported heart diseases was unfortunately too vague to be compared with similar questions in the 1991 health survey. This imprecision also impedes a correct estimation of the true prevalence of specific heart disease. For HBP, we crossed data gathered in the questionnaire and those measured during the clinical session. According to our clinical measurements, 30% of participants diagnosed with HBP were new cases. For the rest of the sample known to have HBP (70%), it would be useful to have more information on medication or medical history in order to better understand why the hypertensive status of these people is not stabilized and then, suggest strategies to improve the situation. This highlights the need for precise information through a medical file review.

5.4.1.2 Atherosclerosis

During the clinical session, we also evaluated atherosclerosis in a sub-sample of the population aged 40 and over by measuring, by ultrasound, the mean maximum carotid artery intima media thickness (mmIMT). Among 68 individuals selected for this test, 5 persons did not undergo the carotid evaluation. These individuals were not significantly older than other people who had the test ($p = 0.09$). Among men, the mmIMT was 0.71 mm (CI at 95%: [0.6-0.8]) and 0.67 mm (CI at 95%: [0.6-0.7]) among women. After adjustment for age, the mmIMT was not significantly different between genders ($p = 0.39$). However, this measurement increased significantly with age in the entire group ($p < 0.0001$) as well as in both genders ($p < 0.0001$). Major determinants of IMT are presented in Table 5.4.1. Except for age, IMT was not associated with these determinants, nor with total cholesterol ($p = 0.47$), LDL-chol ($p = 0.92$) or HDL-chol ($p = 0.11$).

TABLE 5.4.1 MEAN MAXIMUM CAROTID ARTERY INTIMAL MEDIAL THICKNESS (MM) IN THE ENTIRE POPULATION AND BY GENDER ACCORDING TO VARIOUS DETERMINANTS

		Overall		Women		Men	
		Mean	SD	Mean	SD	Mean	SD
BMI (kg/m^2)	<25	0.58	0.10	0.65	-	0.50	-
	25-29.9	0.73	0.15	0.71	0.14	0.74	0.19
	30+	0.68	0.20	0.66	0.20	0.73	0.20
Age (years)	40-44	0.54	0.11	0.54	0.14	0.54	0.07
	45-54	0.60	0.10	0.59	0.12	0.62	0.06
	55-74	0.82	0.16	0.79	0.18	0.88	0.13
Hypertension mmHg:	>140/90	0.74	0.25	0.42	-	0.80	0.22
	<140/90	0.68	0.18	0.67	0.18	0.69	0.18
Smoking status:	Smoker	0.71	0.20	0.69	0.20	0.73	0.18
	Non-smoker	0.63	0.16	0.61	0.13	0.67	0.23
Fasting glucose: Normal	(<6.1 mmol/L)	0.68	0.18	0.68	0.20	0.68	0.19
	Impaired (6.1-6.9 mmol/L)	0.68	0.21	0.64	0.22	0.76	0.18
	Diabetes mellitus (≥6.9 mmol/L)	0.70	0.19	0.68	0.17	0.75	0.22

5.4.1.3 Heart rate variability (HRV)

Descriptive statistics of the HRV parameters are presented in Table 5.4.2. Parameters such as VLF, LF, LF/HF ratio, RR interval and SDNN are lower in women than in men. Stratified by age, the VLF, LF, HF, rMSSD and pNN50 result in lower values for individuals 40 years and older, while the RR interval is higher in this group (data not shown).

The effect of mercury on HRV was studied in this population (Table 5.4.3). Mercury is moderately correlated with VLF, LF, HF, NN, rMSSD and pNN50 in simple regression but these associations are non-significant after adjusting for gender and age.

TABLE 5.4.2 TIME AND FREQUENCY DOMAINS PARAMETERS (N = 167)

Variable	mean ± SD	IC 95%	Range
VLF (ms^2)[a]	982.00	878.40–1 097.04	201.58–7 038.75
LF (ms^2)[a]	535.00	464.38- 617.33	47.12–5 877.92
HF (ms^2)[a]	194.00	164.40-228.07	8.43-2 761.89
LF/HF[a]	2.77	2.55-3.00	0.45-12.99
NN (ms)	833 ± 130	812.90-852.77	577.00-1 299.00
SDNN (ms)	83.00 ± 28.00	79.02-87.49	27.00-202.00
SDANN (ms)	50.00 ± 21.00	46.88-53.19	13.00-145.00
rMSSD (ms)[a]	32.53	30.30–34.90	11.00-108.00
pNN50 (%)[a]	8.35	6.83-10.22	0.00-71.30

a. The geometric mean is presented for log-transformed variables

TABLE 5.4.3 SIMPLE REGRESSION AND MULTIPLE REGRESSIONS BETWEEN MERCURY AND HOLTER PARAMETERS (ADJUSTED FOR AGE AND GENDER)

	Mercury		
	Simple correlation[a]	Multiple regression[a]	
	r Pearson	β-adjusted	Model R^2
VLF (ms^2)	-0.20	0.04*	0.15
LF (ms^2)	-0.29	0.09*	0.30
HF (ms^2)	-0.27	0.03*	0.18
LF/HF	0.03*	0.06*	0.09
NN (ms)	0.29	10.96*	0.18
SDNN (ms)	-0.11*	0.86*	0.08
SDANN (ms)	0.002*	-1.59*	0.04*
rMSSD (ms)	-0.18	0.03*	0.11
pNN50 (%)	-0.20	0.06*	0.11

a. * Not significant at $p < 0.05$

5.4.1.4 Risk factors: blood pressure

HBP was evaluated during the clinical session and is defined as a tension greater than 140/90 mmHg (systolic/diastolic). Blood pressure was measured in 227 participants. The study revealed that HBP occurred in less than 4% of the sample (n = 8). We observed that most of the

participants with HBP (89%) were obese, with abdominal obesity (100%), and were significantly older than other participants ($p < 0.05$). Comparisons with the 1991 survey are unfeasable as definitions of HBP were different between the two surveys.

The effect of mercury on blood pressure was assessed in 223 individuals aged 8 years and older (Table 5.4.4). Systolic blood pressure (SBP) increased linearly with increasing blood mercury concentrations ($r = 0.54$; $p < 0.0001$) and this association remained significant after adjusting for age and triglycerides ($\beta = 3.03$; $p < 0.01$). Diastolic blood pressure (DBP) also increased with blood mercury concentration ($r = 0.25$; $p < 0.0001$) and the association persisted after controlling for gender, docosahexanoic acid (DHA) and waist circumference (WC).

TABLE 5.4.4 SIMPLE REGRESSION AND MULTIPLE REGRESSIONS BETWEEN MERCURY AND BLOOD PRESSURE PARAMETERS

Blood pressure parameters	Mercury[a]		
	Simple correlation	Multiple regression	
	r Pearson	β adjusted	Model R^2
SBP (mm Hg) [b]	0.54 (<0.0001)	3.03 (0.0048)	0.32 (<0.0001)
DBP (mm Hg) [c]	0.25 (0.0001)	2.1 (0.0049)	0.28 (<0.0001)

Variable log-transformed

Adjusted for age and triglycerides

Adjusted for gender, DHA and WC

5.4.1.5 Blood lipids

Lipid profile

The blood lipid evaluation revealed a prevalence of high blood cholesterol (≥0.2 mmol/L) in 3.7% of the population, 85% of them were men and none were obese. However, as presented in Table 5.4.5, the total cholesterol level was positively associated with age ($p < 0.001$). Similar positive association was observed for LDL-chol ($p < 0.01$) concentrations, but not for other blood lipids such as total cholesterol/HDL ratio ($p = 0.09$), HDL-chol ($p = 0.27$), and triglycerides ($p = 0.10$).

The prevalence of high total cholesterol/HDL (≥6.0) was less than 1%. Prevalence of low HDL-chol was 37% and varied between genders (7% in men and 30% in women) and by weight (35% in obese vs. 2% in non-obese people; $p < 0.01$). The prevalence of high LDL-chol (>4.5 mmol/L) was less than 2%, but was not different between genders, or with obesity status. The prevalence of a high level of triglycerides (>1.7 mmol/L) was approximately 38% but the proportion was not different between genders. Most of the participants with high levels of triglycerides were obese ($p < 0.0001$).

TABLE 5.4.5 BLOOD LIPID CONCENTRATIONS ACCORDING TO AGE AND GENDER

	Overall				Male				Female			
	15-39 years		40 years and over		15-39 years		40 years and over		15-39 years		40 years and over	
Total Cholesterol	4.22[a]	(0.80)	4.79	(1.15)	4.47	(0.88)	4.84	(1.42)	4.05	(0.70)	4.76	(0.91)
(mmol/L)	4.14[b]	[2.86-6.02]	4.66	[2.94-7.38]	4.39	[2.98-6.46]	4.64	[2.61-8.26]	3.99	[2.82-5.64]	4.67	[3.25-6.73]
Cholesterol/HDL	3.44	(0.76)	3.71	(1.00)	3.63	(0.86)	4.17	(1.19)	3.30	(0.66)	3.40	(0.71)
(mmol/L)	3.35	[2.15-5.23]	3.60	[2.21-5.86]	3.53	[2.15-5.79]	4.02	[2.36-6.85]	3.24	[2.17-4.82]	3.33	[2.25-4.93]
HDL-chol	1.27	(0.30)	1.32	(0.26)	1.27	(0.28)	1.17	(0.21)	1.27	(0.32)	1.42	(0.24)
(mmol/L)	1.24	[0.80-1.90]	1.30	[0.87-1.92]	1.24	[0.83-1.87]	1.16	[0.80-1.66]	1.23	[0.79-1.93]	1.40	[1.00-1.96]
LDL-chol	2.21	(0.65)	2.61	(0.89)	2.46	(0.70)	2.67	(1.03)	2.05	(0.56)	2.57	(0.79)
(mmol/L)	2.12	[1.18-3.81]	2.46	[1.25-4.87]	2.36	[1.32-4.23]	2.47	[1.10-5.54]	1.97	[1.14-3.41]	2.46	[1.35-4.47]
Triglycerides	1.61	(0.76)	2.06	(2.60)	1.61	(0.83)	2.66	(3.95)	1.60	(0.71)	1.65	(0.66)
(mmol/L)	1.46	[0.63-3.40]	1.63	[0.52-5.07]	1.44	[0.57-3.63]	1.79	[0.40-8.04]	1.47	[0.67-3.27]	1.53	[0.70-3.34]

a. Arithmetic mean (SD)

b Geometric mean [95% CI]

Fatty acid profile in red blood cells

Fatty acid concentrations are similar to those measured in 1992 in the same population (concentrations around 6%) and about 2-3 times those of the general population of Québec. Omega-3 concentrations reflect the intake of fish and game and increase with age (Table 5.4.6). An opposite trend is observed with trans fatty acids, with very high concentrations found among teenagers probably reflecting the consumption of junk food rich in trans fats (chips, fries, cookies, etc). Trans fats are a serious risk factor for CVD and prevention regarding this issue should be further addressed in this population, especially in younger age groups.

TABLE 5.4.6 RELATIVE CONCENTRATIONS OF FATTY ACIDS IN ERYTHROCYTE MEMBRANES EXPRESSED BY AGE IN MISTISSINI PARTICIPANTS

Fatty acids	8-14 years (n = 44)	15-39 years (n = 115)	≥ 40 years (n = 68)
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
EPA[b]	0.35 (0.30-0.40)	0.39 (0.38-0.41)	0.62 (0.56-0.68)
DHA[b]	2.80 (2.61-2.99)	3.12 (3.01-3.23)	4.38 (4.14-4.62)
EPA +DHA	3.15 (2.93-3.37)	3.51 (3.39-3.63)	5.00 (4.71-5.29)
PUFA, n-3 series[b,c]	5.48 (5.23-5.73)	5.87 (5.73-6.01)	7.40 (7.09-7.71)
PUFA, n-6 series[b,c]	32.34 (32.01-32.62)	31.83 (31.67-32.00)	30.16 (29.78-30.55)
Total PUFA	37.79 (37.56-38.03)	37.70 (37.55-37.85)	37.57 (37.36-37.77)
n-3/n-6 ratio	0.17 (0.16-0.18)	0.19 (0.19-0.20)	0.25 (0.24-0.27)
MUFA[b,e]	20.11 (19.82-20.40)	20.22 (20.06-20.38)	19.96 (19.71-20.20)
SFA[b,f]	41.96 (41.90-42.22)	41.85 (41.71-42.00)	42.31 (42.12-42.50)
Total trans	1.71 (1.61-1.80)	1.49 (1.44-1.54)	1.38 (1.29-1.47)

a. Arithmetic mean (95% CI) of the percentage by weight of total fatty acids

b. EPA, eicosapentanoic acid; DHA, docosahexanoic acid; PUFA, polyunsaturated fatty acids; MUFA, monounsaturated fatty acids; SFA, saturated fatty acids

c. PUFA, n-3 series: (C18:3 + C18:4 + C20:3 + C20:4 + C20:5 + C22:5 + C22:6)

d. PUFA, n-6 series: (C18:2 +C18:3 + C20:2 + C20:3 + C20:4 + C22:2 +C22:4 + C22:5)

e. MUFA: (C14:1 + C16:1 + C18:1 + C20:1 + C22:1 + C24:1)

f. SFA: (C14:0 +C16:0 + C17:0 + C18:0 + C20:0 + C22:0 +C24:0)

5.4.1.6 New cardiovascular risk factors

Considering that Hg and PCBs can be sources of oxidative stress, and that selenium present in fish is an essential element for several antioxidant enzymes, we measured two biomarkers of oxidative stress (plasmatic homocysteine and oxidized LDL (oxLDL)). In addition to these analyses, selected blood biochemistry parameters relevant to cardiovascular health are being measured in order to test their validity as biomarkers for CVD. For this purpose, our research team is analyzing apolipoproteins A and B, LDL phenotype and oxidized LDL. Associated CVD markers such as CRP, IL-6, and TNF-α have also been analyzed. Only preliminary statistical analyses are presented here. In-depth analyses will be done when a sufficient sample size has been reached after other Cree communities have been surveyed.

Apo B was relatively low and averaged 0.82 g/L in participants and was only influenced by age (Table 5.4.7), as expected. In the Canadian general population, apolipoprotein B mean values increase with age. In men, levels range from 0.80 g/L at age 18-24 years, to a maximum of 1.16 g/L at age 45-54 years old. For women, the values increase more gradually, from 0.81 g/L for age 18-24 years to 1.19 g/L at age 65-74 years (Connelly et al, 1999).

The distribution of apolipoprotein A-I is unrelated to age. Means for men varied from 1.35 g/L to 1.42 g/L, and for women from 1.50 g/L to 1.61 g/L. Apolipoprotein B concentrations are related to coronary artery disease risk. Concentrations lower than 1.04 g/L indicate low risk, concentrations 1.04 g/L to 1.22 g/L indicate moderate risk, concentrations 1.22 g/L to 1.40 g/L indicate high risk, and concentrations greater or equal to 1.40 g/L indicate very high risk. The prevalence of high-risk plasma apolipoprotein B levels is higher in men and women with triglycerides greater than 2.3 mmol/L. Apolipoprotein A-I concentrations of less than 1.20 g/L indicate an increased risk, and 1.65 g/L or greater indicate a lower risk for coronary artery disease. The prevalence of apolipoprotein A-I at less than 1.20 g/L was 19% in men and 6% in women, whereas the prevalence of apolipoprotein AI at 1.65 g/L or greater was 9% in men and 28% in women. In Cree participants, Apo A-1 averaged 1.44 g/L and was comparable to the Canadian population (Connelly et al. 1999). As presented in Table 5.4.8, Apo-A1 tended mostly to be associated with diabetes status.

TABLE 5.4.7 APO-B (G/L) AND OTHER CVD PARAMETERS

APO B levels stratified by BMI (kg/m^2)			
BMI	n	Mean	CI 95%
≤ 24.9	19	0.75	(0.69-0.82)
25-29.9	45	0.84	(0.78-0.90)
30-39.9	87	0.85	(0.80-0.89)
≥ 40	28	0.82	(0.76-0.88)

APO B levels stratified by fasting glucose (mmol/L)			
Glucose	n	Mean	CI 95%
<5.6	83	0.80	(0.76-0.84)
5.6-6.9	74	0.84	(0.79-0.88)
≥7	32	0.84	(0.79-0.90)

APO B levels stratified by IMT max (mm)			
IMT	n	Mean	CI 95%
≤0.595	19	0.91	(0.81-1.01)
0.595 - 0.738	19	0.99	(0.89-1.09)
>0.738	19	0.87	(0.80-0.94)

APO B levels stratified by age (yrs)			
Age	n	Mean	CI 95%
15-39	120	0.78	(0.75-0.82)
40 +	69	0.89	(0.84- 0.94)

TABLE 5.4.8 APO-AI (G/L) AND OTHER CVD PARAMETERS

APO AI levels stratified by BMI (kg/m^2)			
BMI	n	Mean	CI 95%
≤ 24.9	19	1.53	(1.44-1.62)
25-29.9	45	1.45	(1.40-1.51)
30-39.9	87	1.42	(1.38-1.47)
≥ 40	28	1.46	(1.34-1.58)

APO AI levels stratified by fasting glucose (mmol/L)			
Glucose	n	Mean	CI 95%
<5.6	83	1.45	(1.40-1.50)
5.6-6.9	74	1.39	(1.34-1.44)
≥ 7	32	1.54	(1.45-1.62)

APO-AI levels stratified by IMT max (mm)			
IMT	n	Mean	CI 95%
≤ 0.595	19	1.54	(1.47-1.60)
0.595-0.738	19	1.59	(1.49-1.69)
>0.738	19	1.49	(1.38-1.60)

APO-AI levels stratified by age (yrs)			
Glucose	n	Mean	CI 95%
15-39	120	1.40	(1.36-1.44)
40-74	69	1.52	(1.47-1.57)

In general, and compared to reference populations, blood concentrations for inflammatory markers were elevated in study participants. CRP was very high and averaged 4.74 mg/L. In the Women's Health Study, respective concentrations of less than 1, 1-3 and more than 3 mg/L were considered to be low, moderate and high-risk groups (Ridker *et al.* 2003). Almost all subgroups of participants were considered at risk except for participants with a BMI less than 25 kg/m^2. CRP was not associated with age, but increased with BMI, diabetes status and IMT (Table 5.4.9(1)). Interleukine-6 (IL-6) averaged 3.16 pg/mL in study participants and 1.53 pg/mL in women from Quebec City (Piché *et al.,* 2005). IL-6 tended to increase with BMI, diabetes and age (Table 5.4.9(2)). TNF-α concentrations were in the expected range and averaged 1.55g/mL in Mistissini participants compared to 1.76 pg/mL among 112 post-menopausal women from Quebec City (Piché et al., 2005). As shown in Table 5.4.9(3), TNF-α tended to increase with BMI and IMT.

TABLE 5.4.9 INFLAMMATORY MARKERS AND CVD RISK FACTORS

1) CRP (mg/L)

CRP level stratified by BMI (kg/m^2)

BMI	n	Mean	CI 95%
≤24.9	19	1.63	(0.95-2.31)
25-29.9	47	3.22	(2.31-4.13)
30-39.9	87	5.11	(4.15-6.07)
≥40	28	8.48	(6.25-10.72)

CRP level stratified by fasting glucose (mmol/L)

Glucose	n	Mean	CI 95%
<5.6	83	3.82	(2.82-4.82)
5.6-6.9	74	5.16	(4.12-6.21)
≥7	32	6.22	(4.77-7.67)

CRP level stratified by IMT max (mm)

IMT	n	Mean	CI 95%
≤0.595	19	4.86	(3.14-6.58)
0.595-0.738	19	4.07	(3.00-5.13)
>0.738	19	5.81	(3.75- 8.25)

CRP level stratified by age (yrs)

Age	n	Mean	CI 95%
15-39	120	4.76	(3.88-5.64)
40 +	69	4.71	(3.74-5.68)

2) IL – 6 (pg/mL)

IL-6 level stratified by BMI (kg/m^2)			
BMI	n	Mean	CI 95%
≤24.9	19	1.78	(1.32-2.24)
25-29.9	47	2.73	(2.27-3.19)
30-39.9	87	3.11	(2.77-3.44)
≥40	28	4.48	(3.77-5.20)

IL-6 level stratified by fasting glucose (mmol/L)			
Glucose	n	Mean	CI 95%
<5.6	83	2.99	(2.59-3.38)
5.6-6.9	74	3.10	(2.70-3.51)
≥7	32	3.77	(3.19-4.35)

IL-6 level stratified by IMT max (mm)			
IMT	n	Mean	CI 95%
≤ 0.595	19	2.90	(2.07-3.73)
0.595-0.738	19	3.87	(3.03-4.70)
>0.738	19	3.11	(2.54-3.68)

IL-6 level stratified by age (yrs)			
Age	n	Mean	CI 95%
15-39	120	3.03	(2.70-3.35)
40 +	69	3.41	(2.98-3.83)

3) TNF-α (pg/ml)

TNF-α level stratified by BMI (kg/m^2)			
BMI	n	Mean	CI 95%
≤24.9	19	1.37	(1.09-1.66)
25-29.9	47	1.64	(1.30-1.98)
30-39.9	87	1.44	(1.28-1.60)
≥40	28	1.81	(1.27-2.35)

TNF-α level stratified by fasting glucose mmol/L)			
Glucose	n	Mean	CI 95%
<5.6	83	1.77	(1.50-2.05)
5.6-6.9	74	1.28	(1.17-1.40)
≥7	32	1.59	(1.29-1.88)

TNF-α level stratified by IMT max (mm)			
IMT	n	Mean	CI 95%
≤0.595	19	1.34	(0.93-1.75)
0.595-0.738	19	1.50	(1.23-1.77)
>0.738	19	1.87	(1.44-2.29)

TNF-α level stratified by age (yrs)			
Age	n	Mean	CI 95%
15-39	120	1.56	(1.37-1.75)
40+	69	1.54	(1.34-1.75)

Homocysteine averaged 7.68 µmol/L, a little less than in the general US population (9.4 µmol/L) (Meigs et al., 2001) or in Sweden (11 µmol/L in men and 9.7 in women) (Bjork, et al. 2006) and comparable to Greece (7.4 µmol/L) (Papandreou et al., 2006). A homocysteine average concentration of 7.4 µmol/L was also found in Salluit (Nunavik) (Belanger et al. 2006). Table

5.4.10 shows that homocysteine is clearly associated with age and tends to be associated with IMT.

Oxidized LDL (ox-LDL) is thought to play a key role in the inflammatory response in the arterial vessel wall. Baseline mean plasma concentrations of ox-LDL were significantly higher in subjects who subsequently experienced a cardiovascular event compared with controls (mean ± SD, 110 ± 32 versus 93 ± 28 U/L (Meisinger et al. 2005). In Mistissini, ox-LDL levels were relatively low (54.6 U/L) and were only associated with age (Table 5.4.11).

TABLE 5.4.10 HOMOCYSTEINE (μMO/L) AND CVD PARAMETERS

Homocysteine level stratified by BMI (kg/m^2)				Homocysteine level stratified by fasting glucose (mmol/L)			
BMI	n	Mean	CI 95%	Glucose	n	Mean	CI 95%
≤24.9	19	7.74	(7.07-8.41)	<5.6	83	7.63	(7.21-8.06)
25-29.9	47	7.96	(7.34-8.57)	5.6-6.9	74	7.40	(6.57-7.84)
30-39.9	87	7.28	(6.91-7.64)	≥7	32	8.47	(7.57-9.37)
≥40	28	7.71	(6.89-8.53)				

Homocysteine level stratified by IMT max (mm)				Homocysteine level stratified by age (yrs)			
IMT	n	Mean	CI 95%	Age	n	Mean	CI 95%
≤0.595	19	7.24	(6.28-8.19)	15-39	120	7.02	(6.75-7.29)
0.595-0.738	19	9.22	(0.30-10.14)	40 +	69	8.88	(8.26-9.51)
>0.738	19	9.42	(8.44-10.39)				

TABLE 5.4.11 OXIDIZED LDL (U/L) AND CVD PARAMETERS

Ox-LDL level stratified by BMI (kg/m^2)

BMI	n	Mean	CI 95%
≤24.9	19	52.3	(45.7-58.8)
25-29.9	47	54.9	(51.1-58.8)
30-39.9	87	56.7	(53.5-59.8)
≥40	28	52.3	(48.0-56.6)

Ox-LDL level stratified by fasting glucose (mmol/L)

Glucose	n	Mean	CI 95%
<5.6	83	52.9	(48.8-56.0)
5.6-6.9	74	56.6	(5.32-60.0)
≥7	32	54.2	(50.5-57.9)

Ox-LDL level stratified by IMT max (mm)

IMT	n	Mean	CI 95%
≤0.595	19	59.7	(52.5-66.9)
0.595-0.738	19	64.7	(58.2-71.3)
>0.738	19	60.5	(54.8-66.2)

Ox-LDL level stratified by age (yrs)

Age	n	Mean	CI 95%
15-39	120	49.4	(49.4-54.2)
40 +	69	56.1	(56.1-63.0)

An interesting new marker is LDL particle size. Small dense LDL particles are considered to be more atherogenous. It is considered that LDL diameters of less than 255 Å (angströms) are a risk. In Québec City, an average of 257 Å was found in healthy men and 255 Å in patients with heart diseases (Lamarche et al. 2001). In Mistissini participants, LDL average size (peak size) was 255.1 Å, was significantly associated with age and diabetes (increasing risk) and tended to be associated with BMI (see Table 5.4.12).

TABLE 5.4.12 LDL SIZE (Å, PEAK) AND CVD PARAMETERS

LDL size stratified by BMI (kg/m^2)			
BMI	n	Mean	CI 95%
≤24.9	19	256.9	(256.3-257.5)
25-29.9	47	254.9	(254.3-255.4)
30-39.9	87	255.0	(254.5-255.4)
≥40	28	254.9	(254.0-255.7)

LDL size stratified by fasting glucose (mmol/L)			
Glucose	n	Mean	CI 95%
<5.6	83	255.7	(255.3-256.1)
5.6-6.9	74	255.0	(254.4-255.5)
≥7	32	253.8	(253.2-254.4)

LDL size stratified by IMT max (mm)			
IMT	n	Mean	CI 95%
≤0.595	19	254.6	(253.7-255.5)
0.595-0.738	19	254.2	(253.4-255.0)
>0.738	19	254.3	(253.1-255.6)

LDL size stratified by age (yrs)			
Age	n	Mean	CI 95%
15-39	120	255.5	(255.1-255.9)
40 +	69	254.4	(254.4-254.9)

5.4.1.7 Discussion

Cardiovascular disease (CVD) is a leading cause of death and disability in Canadians. Despite the fact that the Cree population is in some ways protected from this plague (Courteau, 1989) by their traditional lifestyle, the evaluation of cardiovascular status and risk factors of CVD including hypertension, type II diabetes mellitus, and obesity and blood lipid troubles are significant. This is even more important, as conclusions from the last health survey in 1991 show that some of these factors are more prevalent than elsewhere in Quebec (Santé Québec, 1994) and also because many of these risk factors are modifiable and amenable to treatment (Grover et al., 2000).

For atherosclerosis, given the relatively low ischemic heart disease (IHD) mortality rate (Ministère de la Santé et des Services Sociaux du Québec, 1998), we expected to find lower mmIMT in Cree compared to other Canadian Aboriginal populations who participated in a similar study (same equipment). This was clearly observed for both men and women aged 46-55 years (mmIMT mean (SD) in women: 0.60 (0.1) mm for Cree vs. 0.71 (0.1) mm in other Aboriginal women and in Cree men: 0.70(0.2) mm vs. 0.78 (0.2) mm) (Anand et al., 2001) in other Aboriginal men. However, Cree have similar results to Inuit assessed in 2004 (Dewailly, Château-Degat, Ékoé, & Ladouceur, in press). Moreover, less than 5% of the population studied showed a mmIMT equal to or higher than 1 mm. Available epidemiological studies indicate that

an increased IMT above or equal to 1 mm represents a high risk of myocardial infarction and/or cerebrovascular disease (Simon, Gariepy, Chironi, Megnien, & Levenson, 2002). In the Inuit population this proportion was 10% (Dewailly et al., in press). One of the purposes of this study was to examine the relationship between mercury and the progression of atherosclerosis as previously proposed by others (Salonen, Seppanen, Lakka, Salonen, & Kaplan, 2000). Due to the size of the study sample, it is premature to examine this particular relationship. However in light of the above results, we are reassured that Cree from Mistissini are relatively well protected against atherosclerosis.

The HRV measures are used mainly in research and the information concerning standard values in the general population is sparse. The Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology has published some of these values which have been extracted from a 24-hour Holter monitoring (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). These values must be analysed carefully because of the small size of the study and also, because they can vary with respect to values obtained from a 2-hour Holter monitoring. However, the SDANN must be comparable since it is the standard deviation calculated for a 5-minute period. In the Mistissini population, the SDANN, an index of parasympathetic activity, is markedly lower than published values (127 ± 35). Also, it is of note that the LF/HF ratio, which represents the sympatho-vagal balance is slightly higher than the recommended value (between 1.5 and 2). Taking into account the decrease in the SDANN observed, the increase in the LF/HF ratio observed could be attributed to a decrease in parasympathetic activity. From the clinical point of view, this implies an increase in cardiac rhythm, which possibly leads to cardiac rhythm troubles such as ventricular fibrillation, which in turn can lead to sudden death.

Reduced HRV has been previously observed in children exposed in utero (Grandjean, Murata, Budtz-Jorgensen, & Weihe, 2004; Sorensen, Murata, Budtz-Jorgensen, Weihe, & Grandjean, 1999) to high mercury concentrations. In this population, the significant association observed between mercury and low frequency was attenuated after adjusting for gender and age. No significant associations were observed between mercury and other Holter parameters and thus, no impact of mercury on HRV was detected in this population.

For the risks factors of CVD, we observed a relatively low prevalence of hypertension (9% measured), as well as a low prevalence of elevated LDL-C or elevated total cholesterol on HDL-cholesterol ratio. Similar positive conclusions could not be drawn for other modifiable factors such as low HDL-C and high triglycerides, which were detected in more than 1/3 of the sample.

However, compared to the results obtained in the 1991 survey, the blood lipid profile is similar (Dewailly, Blanchet, Gingras, Lemieux, & Holub, 2002). Based on intervention studies, the observed lipid pattern (low HDL-C and high TG) associated with diabetes could increase the risk of cardiovascular complications (Leiter et al., 2006). However, lifestyle interventions were also associated with an improvement of lipid profiles (Leiter et al., 2006). Therefore, similar interventions could be an avenue to manage this problem in the community.

For less classical CV risk factors, when compared to reference populations, blood concentrations for inflammatory markers were elevated in study participants, particularly CRP and interleukine-6. However, other new cardiovascular risk markers such as TNF-a, homocysteine and LDL size were in the expected range. Most of these CVD risk markers tended to be associated with obesity, diabetes status and atherosclerosis measured by ultrasound. Lipid peroxidation was only associated with age. These preliminary data suggest that obesity and diabetes are associated with inflammatory markers, which are known to play a role in the development and progression of atherosclerosis.

5.4.2 Diabetes

5.4.2.1 Prevalence and indicators

Diabetes was evaluated in the following ways: 1) self-reported diabetes was measured during the clinical questionnaire by asking the participants if a physician or a nurse ever told them that they were diabetic; 2) during the clinical session, by blood analysis. Participants were advised to fast for at least eight hours prior to blood sampling. Glycaemia and insulinemia were evaluated. An Oral Glucose Tolerance Test (OGTT) was also performed on a sub-sample of solely non-diabetic, non-pregnant participants under fasting conditions (n = 68). Diabetes diagnosis was defined according to the Canadian Diabetes Association's cut-off levels presented in Table 5.4.13.

In the population as a whole, 15.7% of participants reported being told they have diabetes. Through blood sampling, we found that 14.4% of the population had a blood glucose level in the diabetes range (Table 5.4.13) of which 4% were undiagnosed cases or were aware of their condition but did not self-report diabetes. Additionally, 2% of people who self-declared having diabetes (15.7% of participants) had excellent diabetes control and normal fasting blood glucose levels. Among people with glucose levels within the impaired fasting glucose range (pre-diabetes) (11% of participants), 3% were already diagnosed with diabetes, hence suggesting that their condition was not completely under control at the time of testing.

Adjusted for age, glycaemia levels are not significantly different between genders (female (median): 5.6; IQR = 1.2 and male (median): 5.5; IQR: 0.6 p = 0.61). Similar results were obtained for the prevalence of diabetes (p = 0.08). According to BMI, a significant positive linear relationship was observed between BMI and fasting blood glucose level (p < 0.001). OGTT was performed on 68 participants. Among them, 5.8% were diagnosed with diabetes (likely newly-diagnosed cases or people who failed to report that they have diabetes) and 17.6% show pre-diabetes (7.8-11 mmol/L). These results are presented in Table 5.4.14. By crossing data obtained from OGTT and glucose in fasting condition, we observed that 6 individuals classified as Impaired or DM with fasting glucose investigation were declared normal by OGTT test. This observation suggests that these people were probably not in fasting condition. The OGTT detected 8 and 2 individuals with Impaired Glucose Tolerance (IGT) and DM respectively. These 10 individuals were classified as normal by glycaemia screening in fasting condition.

The great majority of diabetics are obese (79%) and nearly 21% of diabetics are overweight. In the Cree population, the prevalence of obesity defined by the BMI is 54.3% and abdominal obesity (waist circumference) is 68.5%. This risk factor mostly affects women as 79% of them suffer from abdominal obesity while only 52% of men do. Whilst fat mass was higher in women (37.2 kg vs. 28.5 kg), we observed that fat-free mass (kg) was higher in men (p < 0.0001). Moreover, we observed that BMI increased with age (p < 0.001) in both genders.

The prevalence of hyperinsulinemia is different between genders (p< 0.05) (Table 5.4.13). The median of insulin in the whole population is 132 pmol/L with an inter-quartile range of 25-75% (IQR) equal to 123 pmol/L. Insulinemia is higher in women (p < 0.001). We observed an increase of this parameter according to BMI (p < 0.001). In the entire group, insulin concentration is not associated with age as shown in Table 5.4.14. Moreover, a normal mean insulin level (<90 pmol/L) was observed in people with BMI less than 18.5 kg/m^2 (69.5 ± 22.02) but not so for other categories of BMI. Table 5.4.14 shows the distribution of insulin levels according to BMI tertiles, gender and age. As observed in this table, higher insulin levels were observed mainly in women, even in low BMI tertiles, and alarmingly in girls. According to abdominal obesity, people with elevated abdominal obesity have higher insulin levels compared to people with normal waist circumference [197.81 ± 135.5 *vs*. Normal: 93.56 ± 48.5; p < 0.0001]. According to the fasting glucose level, we observed that normal individuals had insulin levels significantly different from those with IFG or diabetes [Normal: 147.63 ± 98.4 *vs* IFG: 178.82 ± 94.8; diabetics: 256.63 ± 214.34]. Table 5.4.14 also shows the distribution of insulin according to glycaemia status, age and gender. Generally, a positive gradient was observed between glycaemia and insulinemia. However, people classified as “normal”, according to diabetic status, still have high levels of insulin (Table 5.4.14).

TABLE 5.4.13 PREVALENCE (%) OF DIABETES[A]

[a]Variables		Total	Male	Female
Diabetes (questionnaire) %	Yes	15.7	10.9	18.8
Fasting glucose (n = 183)				
Normal (<6.1 mmol/L)		74.6	82.2	69.7
IFG (6.1-6.9 mmol/L)		11.0	7.8	13.0
DM (≥7.0 mmol/L **)		14.4	10.0	17.3
OGTT (n = 66)				
Normal <7.75 mmol/L		76.6	85.6	66.9
IGT 7.8-11 mmol/L		17.6	8.6	27.2
DM ≥11.1 mmol/L		5.8	5.8	5.9.
Hyperinsulinemia: %	>90pmol/L	72.4	63.3	78.6

A. DM: diabetes mellitus; Impaired fasting glucose (IFG); Impaired glucose tolerance (IGT); OGTT, oral glucose tolerance test.

TABLE 5.4.14 INSULIN CONCENTRATIONS (PMOL/L) BY GENDER AND AGE ACCORDING TO BMI AND FASTING GLUCOSE

	Female			Male		
	8-15 years	15-39 years	40 years and over	8-15 years	15-39 years	40 years and over
	n = 29	n = 69	n = 39	n = 29	n = 69	n = 39
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
BMI (tertiles kg/m^2)						
≤27.4	108.59 ± 57.97	101.75 ± 31.88	140.00 ± 54.60	97.44 ± 25.40	87.6 ± 49.68	48.66 ± 17.60
27.4-33.9	351.80 ± 250.98	160.00 ± 84.04	154.33 ± 112.60	204.40 ± 39.90	119.3 ± 74.57	133.25 ± 82.90
>33.9	917.00 -	242.86 ± 162.64	208.94 ± 92.02	-	243.8 ± 76.77	174.20 ± 67.10
Fasting glucose % (mmol/L)						
Normal <6.1	150.50 ± 148.0	169.57 ± 85.00	147.29 ± 110.0	135.64 ± 60.15	128.8 ± 88.11	123.42 ± 72.30
IFBG 6.1-6.9	- -	194.86 ± 107.64	180.18 ± 81.24		146.6 ± 126.01	171.00 ± 119.00
DM ≥7.0	576.00 ± 473.8	376.86 ± 305.03	208.21 ± 106.5	- -	154.0 ± -	153.60 ± 71.33

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5.4.2.2 Discussion

The prevalence of self-reported diabetes in Mistissini is 14%, which is 3 times higher than in the rest of Canada (Centre de prévention et de contrôle des maladies chroniques (Agence de santé publique du Canada), 2002). This high prevalence is quite similar to that observed in adult Oji-Cree from Ontario (17%) (Harris et al., 1997). Other results that are also of concern are 1) 4% of screened participants are new cases of diabetes 2) 11% of participants are classified as impaired fasting glucose. These two points highlight the fact that diabetes is increasing and that diabetes screening needs to be intensified. An encouraging result is that only a few people with diabetes seemed unaware of their condition, therefore suggesting that this problem is already a concern for the individuals of the community. It would be useful to obtain more information on medication and medical history, which is difficult during an interview or by self-report questionnaire, but could be easily done by medical file review.

As already observed in other studies (Brassard, Robinson, & Lavallée, 1993; Harris et al., 1997), women are identified as a high-risk group in the Mistissini community. Indeed, even if we did not detect a clear difference between genders according to diabetic status, Cree women have the highest prevalence of diabetes risk factors such as obesity and hyperinsulinemia. Tentative explanations include a potential oestrogenic impact as well as a genetic susceptibility (Pollex et al., 2006). Nevertheless, these results imply that a particular effort should be made to adapt prevention programs to young women and girls.

The prevalence of obesity and overweight in the Cree needs urgent action. Indeed, 54% of participants are obese. This proportion is 2 times higher than in the Inuit (Dewailly et al., in press) and 2 times higher than that of the general Canadian population (14%) (Mongeau, Audet, Aubin, & Baraldi, 2005). In this study, we also observed elevated plasma insulin concentrations, particularly in women and young girls. Similar levels of fasting insulin were measured in girls from an Oji-Cree community in north-western Ontario (Oji-Cree girls (median): 101.0 pmol/l; IQR: [88] vs. Mistissini girl (median): 103.1; IQR: [118] (Retnakaran, Zinman, Connelly, Harris, & Hanley, 2006). This observation in children from Mistissini is of particular concern since hyperinsulinemia, obesity and hyperglycemia in children can predict CVD in adulthood (Retnakaran et al., 2006). In light of these results, we propose future analysis to expand the evaluation of the prevalence of these metabolic syndromes as well as non-traditional CVD risk factors such as inflammatory factors (C-reactive protein, interleukine-6, TNF-a or adipocyte-derived cytokines) in the Cree paediatric population in order to confirm or negate our observations in the Mistissini community, evaluate the magnitude of the phenomenon and

suggest public health action in order to reverse the inevitable process that leads to the development of diabetes and cardiovascular disease.

The small sample size of this study limits our ability to do extensive statistical analyses that would allow a better understanding of observations obtained here. Moreover, it is important to keep in mind that conclusions drawn here are only applicable to the Mistissini community. Nevertheless, these findings are consistent with studies realized in other aboriginal populations. Another limitation to consider is that we have missed some information on the medical history of participants that could hamper the true estimation of CVD risk factors. For example, information on medication taken by diabetic participants would help to estimate the true prevalence of diabetes.

In conclusion, a prompt reaction is needed, as diabetes is well known for its microvascular and macrovascular complications, and we can reasonably assume that CVD is likely to increase in the near future.

5.4.3 Endocrine parameters and bone ultrasound measurements

5.4.3.1 Prevalence of thyroid disorders

Presence of thyroid diseases and goiter were reported by 4.8% of Mistissini participants. The percentage of men reporting thyroid problems was 3.3% whereas it was of 6.9% among women (Table 5.4.15). Medical record assessment was not done within the framework of this survey. Therefore, declaration of presence or absence of thyroid diseases and goiter by participants couldn't be corroborated by medical file information.

Table 5.4.16 shows a prevalence of subclinical and overt hypothyroidism and hyperthyroidism according to sex in Mistissini participants who have not reported thyroid diseases or goiter. Subclinical and clinical hypothyroidism and hyperthyroidism are risk factors for hyperlipidemia, hypercholesterolemia, hyperhomocysteinemia, atrial fibrillation, cardiac dysfunction, osteoporosis and neuropsychiatric diseases (Braverman & Utiger, 2005; Surks et al., 2004).

The prevalence of subclinical hypothyroidism in men was 12.4% compared to 2.9% in women. These results differ from previous studies where subclinical (Hoogendoorn et al., 2006) and overt hypothyroidism (Canaris, Manowitz, Mayor, & Ridgway, 2000; Hollowell et al., 2002; Vanderpump et al., 1995) were more common in women. This discrepancy may be explained by a more intensive screening of thyroid failure in women considering their well-established higher

probability to develop thyroid abnormalities with increasing age. Consequently, in this survey, we found a higher proportion of women reporting a history of thyroid diseases or goiter compared to men, but a smaller proportion of women with abnormal biochemical tests.

Overt hypothyroidism was not detected in participants with no history of thyroid disease or goiter (Table 5.4.16). This result is surprising since hypothyroidism is the most common form of thyroid failure worldwide. In this survey, criteria used in defining subclinical and clinical forms of thyroid disorders were based on population-based reference intervals and not on clinical criteria. From a clinical point of view, other information such as presence of symptoms and quantified anti-peroxidase antibodies (TPOAb), a thyroid antibody known as a risk factor for hypothyroidism, would have been used to classify subclinical and clinical hypothyroidism cases. Unfortunately, these data were not collected during the survey.

Mild and overt hyperthyroidism was found in 3% of the Mistissini participants and only in women. The reported prevalence of these two forms of hyperthyroidism in previous studies was variable, ranging from 0.5% to 6.3% in men and women, respectively (Canaris et al., 2000; Hollowell et al., 2002; Hoogendoorn et al., 2006; Vanderpump et al., 1995). Nevertheless, as observed in this survey, the prevalence in women was always higher than in men.

The prevalence of subclinical and clinical hypothyroidism and hyperthyroidism obtained in the framework of this survey should be analysed with caution since information on several factors influencing thyroid hormone concentrations was not available. These factors include use of thyroid medication, pregnancy, level of thyroid antibodies (TPOAb and thyroglobulin autoantibodies), presence of other thyroid disorders, estrogen, androgen and lithium use. Access to participants' medical files and measurements of thyroid antibodies would be necessary in order to adequately estimate the prevalence of thyroid disorders in the Mistissini population.

TABLE 5.4.15 PREVALENCE OF SELF-REPORTED THYROID DISEASES OR GOITER IN MISTISSINI PARTICIPANTS (≥15 YEARS OF AGE)

	n	Percentage (%)
Men	90	3.3
Women	118	6.9

TABLE 5.4.16 PREVALENCE OF THYROID DISORDERS AMONG MISTISSINI PARTICIPANTS (≥15 YEARS OF AGE) WITH NO HISTORY OF THYROID DISEASES OR GOITER

	n	Hypothyroidism (%)		Hyperthyroidism (%)	
		Subclinical	Clinical	Subclinical	Clinical
Men	73	12.4	0	0	0
Women	102	2.9	0	1.0	2.0

5.4.3.2 Osteoporosis: risk factors for osteoporotic fractures among peri- and post-menopausal Iiyiyiu women

Osteoporotic fractures are the major cause of disabilities among menopausal women (Lindsay and Meunier, 2000; Orcel, 1995). The risk of osteoporotic fractures and the associations between ultrasound bone parameters, lifestyle and environmental factors, among peri- and post-menopausal Iiyiyiu women were evaluated.

The target study group within the Mistissini study participants consisted of 49 Iiyiyiu women whose mean age was 49 years (Table 5.4.17). In this table, selected well-known risk factors for osteoporosis (Lane, 2006; NAMS 2006) are presented and in this population we observe high BMI values (obese is defined as >27 kg/m^2). Moreover, approximately half of the women spend more than 3 hours per day sitting, none are currently using hormonal replacement therapy (HRT), and 30% of the women are currently smoking. The frequency distributions for QUS parameters measured at the right calcaneum are shown in Table 5.4.18. Mean values for BUA, SOS, and SI were respectively 115 dB/MHz (Standard deviation; SD = 17), 1 546 m/sec, (SD = 39) and 89% (SD = 21).

The T-score of the Iiyiyiu women showed that 55.1% have no risk of osteoporotic fracture, 34.7% have a low risk of fracture and 10.2% a high risk of fracture. While the Z-score, which is the age-matched comparison, showed that 83.7% of the Iiyiyiu women have no risk of osteoporotic fracture, while 16.3% showed a risk of fracture (data not shown).

We also tested relations between quantitative ultrasound parameters (QUS) and selected dichotomous risk factors for osteoporosis and noted that the women who had reached menopause, and were consequently older, had lower values of all three QUS parameters compared to their respective counterparts (Table 5.4.18). The numbers of hours sitting per day was marginally linked to BUA, SOS and SI values. Former smoking only influenced Stiffness value.

Other known risk factors such as calcium and vitamin D intake, anthropometric measurements, body weight, and the use of certain drugs, will be investigated. Exposure to environmental chemicals that are able to disrupt the hormonal equilibrium might represent another risk factor for this disease and will also be investigated.

TABLE 5.4.17 CHARACTERISTICS OF 49 PERI- AND POST-MENOPAUSAL IIYIYIU WOMEN

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Variables	Mean ± SD
Age (years)	49.0 ± 11.9
Weight (kg)	91.1 ± 17.9
Height (cm)	161.5 ± 5.8
Body mass index (kg/m^2)	35.0 ± 6.9
Waist circumference (cm)	110.8 ± 14.7
Hip circumference (cm)	119.1 ± 13.6
BUA (dB/MHz)	114.6 ± 17.1
SOS (m/sec)	1 545.5 ± 38.9
Stiffness (%)	89.1 ± 20.8
Variables	**%**
Smoking habits	
Smoker	28.8
Former smoker	44.7
Never smoker	26.6
Sitting (per day)	
≤ 3 hours	60.4
> 3 hours	39.6
Oral contraceptive use	
Yes	13.6
No	86.4
Current HRT use	
Yes	0
No	100
Menopausal	
Yes	48.4
No	51.6

TABLE 5.4.18 UNIVARIATE ANALYSES OF RELATIONSHIPS BETWEEN QUANTITATIVE ULTRASOUND MEASUREMENTS AND SELECTED RISK FACTORS FOR OSTEOPOROSIS IN 49 PERI- AND POST-MENOPAUSAL IIYIYIU WOMEN[A]

	BUA (dB/MHz)	SOS (m/sec)	Stiffness index (%)
	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
Smoking habits			
Smoker (n = 14)	121.8 (114.6-129.1)	1 565.45 (1 547.3-1 583.5)	99.3 (89.8-108.8)
Former smoker (n = 22)	106.9 (100.7-113.1)	1 528.0 (1 514.1-1 542.0)	79.2 (72.0-86.5)
Never smoker (n = 13)	120.2 (110.4-130.0)	1 554.4 (1 534.3-1 574.4)	95.2 (84.3-106.2)
Sitting (n = 48)			
≤ 3 hours (n = 29)	111.2 (105.1-117.3)	1 544.9 (1 531.1-1 558.7)	86.6 (79.2-94.0)
> 3 hours (n = 19)	119.1 (112.3-125.8)	1 546.6 (1 529.1-1 564.2)	92.4 (83.7-101.1)
Menopause			
Yes (n = 24)	102.9 (97.7-108.0)	1 520.0 (1 507.6-1 532.5)	74.2 (68.2-80.2)
No (n = 25)	125.9 (121.0-130.8)	1 570.0 (1 559.0-1 581.0)	103.4 (97.7-109.1)
Oral contraceptive use (n = 25)			
Yes (n = 5)	125.5 (113.8-137.1)	1 581.9 (1 553.1-1 610.6)	106.5 (91.1-121.9)
No (n = 20)	126.0 (120.4-131.5)	1 567.0 (1 555.5-1 578.6)	102.6 (96.6-108.6)

A. CI = confidence interval

6. SEROPREVALENCE OF ZOONOSES IN MISTISSINI: A PILOT STUDY

6.1 Introduction

As a result of their lifestyle and food habits, Cree trappers and hunters are at higher risk for contracting infectious diseases from wildlife. Tularemia, trichinosis, Q fever, leptospirosis, and more recently hantavirus infection, are all included in the passive epidemiological surveillance system for Mandatory Reportable Diseases, Quebec (Maladies à déclaration obligatoire – MADO). Surprisingly, from 1985 to 2005, none of these diseases were reported to the public health authorities in the Cree territories (Cree Board of Health). However, these infections are under-reported in the general population and often go unnoticed due to their non-specific presentation.

With the agreement of the Cree Board of Health, a seroprevalence pilot study was designed in Mistissini to help determine the scope of the problem in order to assess the relevance of implementing appropriate preventive measures. Data were collected from active hunters/trappers and their spouses. The aim of this study was to determine the seroprevalence of eight zoonoses in Iiyiyiu hunters and trappers for evidence of exposure to different microorganisms.

6.2 Methods

A total of 50 participants were included in this pilot study. All were active hunters/trappers and their spouses and selected for their extensive exposure to fauna. Participants were required to answer questionnaires regarding their hunting, fishing and trapping habits as well as to provide a blood sample for antibody analysis.

Francisella tularensis and four pathogenic parasites, already documented in the early 1980's by Tanner *et al*. (1987), namely *Trichinella* sp., *Toxoplasma gondii, Toxocara canis* and *Echinococcus granulosus* were included in the study. Two other infections not documented in the Cree territories, but very likely under-reported, were also investigated: infections with *Leptospira* sp. and *Coxiella burnetii*. This latter bacterium, which causes Q fever, was recently identified in wild cervids in the province of Quebec (Higgins 1999) while *Leptospira* sp. is a fauna-related infection previously documented in Quebec trappers (Lévesque *et al.* 1995). Finally, following the first reported case of hantavirus infection in Quebec, in the Mauricie region, it was decided to include the *Sin nombre* virus among the pathogens to be investigated.

Immunoenzymatic methods (ELISA) were used for the detection of IgG antibodies against *Trichinella* sp., *T. canis*, *E. granulosus* (IVD inc.), *T. gondii* (AxSYM, Abbott Diagnostics, Abbott Park, Illinois), *Leptospira* sp. and *C. burnetii* (Virion\Serion, Serion Immundiagnostica GmbH, Würzburg). ELISA assays were also used for the detection of IgG and IgM antibodies for the *Sin Nombre* virus (Feldmann et al., 1993; Ksiazek et al., 1995)). The detection of antibodies against *Francisella tularensis* was performed by means of a tube agglutination test (Snyder, 1980; Stewart, 1981). Table 6.1 lists the criteria used to interpret the results and the estimated persistence of antibodies for each serology, except for the detection of IgM and IgG-specific antibodies against the *Sin nombre* virus, for which all sera were negative. Generally, the persistence of an antibody is variable according to the microbial agent and methods used.

ELISA assays are highly sensitive methods, which allow the detection of very small quantities of antibodies. However, with the antigens used, it is generally impossible to ascertain whether equivocal titres are caused by old infections or cross-reactions with other pathogens. The strong reactivity of samples for bacterial zoonoses and the strong exposure of the Cree population to these microorganisms suggest that the weak positives or equivocal results could be the consequence of a residual immunity caused by old infections. In the present instance, we believe that to consider the high number of equivocal results as positive results is probably an alternative for describing past exposure of the Cree population to these bacteria. These facts were taken into account in the statistical analysis.

TABLE 6.1 CRITERIA FOR THE INTERPRETATION OF SEROLOGIC ANALYSES

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

a. Faine (1998)

b. Virion\Serion, Serion Immundiagnostica GmbH, Würzburg

c. Young et al. (1969)

The proportion of participants with one or more positive results was compared by univariate analysis with seronegative subjects in relation to different variables (age, sex, working status, education, number of days and main activity on the land, animals handled, game animals eaten, wearing of gloves when handling animals, pet animal at home) using the Fisher exact test. Moreover, a second set of analyses was performed taking into account equivocal results for bacteria as positive results (see preceding paragraph). The statistical threshold was set at 0.1. Thereafter, multivariate logistic regressions were conducted to assess confounding variables between the data for statistically significant variables. For this purpose, after excluding data for the summer season because of a high number of unavailable data, results were aggregated in relation to the primary activity on land into one variable representing all three remaining seasons, i.e., fall, winter and spring. Finally, univariate analyses, taking into account the inclusion of equivocal results for bacteria as positive results, were also performed for each bacterium (*Coxiella burnetii, Francisella tularensis, Leptospira* sp) in which the prevalence of antibodies was higher.

6.3 Results

Table 6.2 summarizes the results of analyses performed on blood samples obtained from the 50 participants. This group comprised 28 women, mean age 60.8 years (median = 62.0), and 22 men, mean age 57.1 years (median = 59.5). A total of 22 participants, 7 women and 15 men, were seropositive for at least one zoonotic infection. We reviewed the medical files of all of these participants, and one man with antibodies against *Coxiella burnetii* was investigated for symptoms compatible with this infection during the last five years, namely two different pneumonias of unknown etiology. There was also a man with a positive serology for *Francisella tularensis,* who was treated for an infected inguinal lymph node.

TABLE 6.2 RESULTS OF SEROLOGICAL ANALYSES FOR EIGHT ZOONOTIC INFECTIONS PERFORMED ON BLOOD SAMPLES FROM MISTISSINI HUNTERS/TRAPPERS AND THEIR WIVES (N = 50), 2005

Infections	Positive (%)	Negative (%)	Equivocal (%)	NI/IQ[a](%)
T. gondii	5 (10)	43 (86)	2 (4)	0
Leptospira sp.	7 (14)	36 (72)	7 (14)	0
C. burnetii	9 (18)	34 (68)	7 (14)	0
Sin Nombre virus	0	49 (98)	1 (2)	0
E. granulosus	0	50 (100)	0	0
T. canis	2 (4)	46 (92)	0	0
Trichinella sp.	0	50 (100)	0	0
F. tularensis	2 (4)	33 (66)	11 (22)	4 (8)

a Non-interpretable (NI) result or insufficient quantity (IQ). Non-interpretable results were removed from the statistical analysis for F. tularensis (n = 3). One sample with an insufficient quantity of blood was not analyzed for this infection.

There was no positive result for the infection by *Sin Nombre* virus. For parasitic infections, the seroprevalence was comparable between both sexes (*Toxoplasma gondii*: women, 10.7%; men, 9.1%; *Toxocara canis*: women, 3.6%; men, 4.5%; *Trichinella* sp.: women and men 0%). On the other hand, antibodies against agents of bacterial infections such as Q fever, leptospirosis and tularemia were more prevalent in men (*Coxiella burnetii*: women, 7.1%; men, 31.8%; *Leptospira* sp.: women, 7.1%; men: 22.7%; *Francisella tularensis*: women, 0%; men, 9.1%), although the relationship was only statistically significant for *Coxiella burnetii* ($p = 0.03$).

Table 6.3 lists the variables that were significantly related to a positive result for at least one pathogen, while Table 6.4 lists the variables related to a positive result when assigning equivocal results for bacteria as positive. As a whole, the variables identified were relatively similar, namely: being male, fishing/hunting/trapping as the main activity, handling of predators and eating smoked game, are all factors associated with seropositivity in the two analyses. Age was related to a seropositive result while the handling of ducks was linked to seropositivity when assigning equivocal results as positive.

TABLE 6.3 VARIABLES IN RELATION TO SEROPOSITIVITY[A]

Variables	- n (%)	+[a] n (%)	p
Sex			
Men	6 (28.6)	15 (71.4)	0.003
Women	20 (74.1)	7 (25.9)	
Age			
15-49	7 (63.6)	4 (36.4)	0.04
50-64	11 (57.9)	8 (42.1)	
≥65	8 (44.4)	10 (55.6)	
Main activity			
Fall			
F/H/T[b]	8 (34.8)	15 (65.2)	0.006
Stayed at camp	17 (77.3)	5 (22.7)	
Winter			
F/H/T	9 (37.5)	15 (62.5)	0.01
Stayed at camp	15 (79.0)	4 (27.0)	
Spring			
F/H/T	8 (32.0)	17 (68.0)	0.001
Stayed at camp	18 (81.8)	4 (18.2)	
Summer			
F/H/T	3 (27.3)	8 (72.7)	0.03
Stayed at camp	18 (72.0)	7 (28.0)	
Animals handled			
Predators (fox/wolf/bear/lynx)			
None	9 (81.8)	2 (18.2)	0.04
≥1	17 (45.9)	20 (54.1)	
Game animals eaten			
Smoked game animal			
No	15 (68.2)	7 (31.8)	0.09
Yes	11 (42.3)	15 (57.7)	

a. Positive serologies; equivocal results considered as negative

b. Fishing/Hunting/Trapping

TABLE 6.4 VARIABLES IN RELATION TO SEROPOSITIVITY WHEN INCLUDING EQUIVOCAL RESULTS FOR BACTERIA AS POSITIVE RESULTS

Variables	- n (%)	+[a] n (%)	p
Sex			
Men	2 (9.5)	19 (90.5)	0.01
Women	12 (44.4)	15 (55.6)	
Main activity			
Fall			
F/H/T[b]	3 (13.0)	20 (87.0)	0.02
Stayed at camp	10 (45.4)	12 (54.6)	
Winter			
F/H/T	3 (12.25)	27 (87.5)	0.007
Stayed at camp	10 (52.6)	9 (47.3)	
Spring			
F/H/T	2 (8.0)	23 (92.0)	0.0009
Stayed at camp	12 (54.5)	10 (45.5)	
Summer			
F/H/T	1 (9.1)	10 (90.9)	0.06
Stayed at camp	11 (44.0)	14 (56.0)	
Animals handled			
Bear			
None	10 (50.0)	10 (50.0)	0.01
≥1	4 (15.0)	23 (85.0)	
Lynx			
None	14 (35.0)	26 (65.0)	0.09
≥1	0 (0)	7 (100.0)	
Ducks			
≤9	12 (41.4)	17 (58.6)	0.03
≥10	2 (10.5)	17 (89.5)	
Game animals eaten			
Smoked game animal			
No	10 (45.4)	12 (54.6)	
Yes	4 (15.4)	22 (84.6)	0.03

a. Positive serologies for parasites and bacteria or equivocal serologies for bacteria

b. Fishing/Hunting/Trapping

When examined in multivariate models, the data for fishing, hunting or trapping were related with seropositivity whether equivocal results were assigned as positive ($p = 0.003$) or not ($p = 0.002$). Handling of ducks was also related to seropositivity in the present model when taking into account equivocal results as positive ($p = 0.02$). All other variables were non significant including age and sex.

Tables 6.5 and 6.6 list variables related to the presence of antibodies against *Coxiella burnetii* and *Francisella tularensis* respectively. Being male and handling lynxes emerged as risk factors for infections by *Coxiella burnetii.* Fishing, hunting or trapping in fall, winter or spring was also

significantly related to exposure to *Coxiella burnetii* including a tendency for infection in summer. Fishing, hunting and trapping were also significantly related to an infection by *Francisella tularensis* in spring with a tendency for infection in winter and fall (Table 6.6). There was no statistically significant variable for *Leptospira sp.*

TABLE 6.5 VARIABLES IN RELATION TO SEROPOSITIVITY FOR *COXIELLA*

Variables	- n (%)	+[a] n (%)	p
Sex			
Men	11 (50.0)	11 (50.0)	0.03
Women	23 (82.1)	5 (17.9)	
Main activity			
Fall			
F/H/T[b]	12 (50.0)	12 (50.0)	0.01
Stayed at camp	20 (87.0)	3 (13.0)	
Winter			
F/H/T	12 (48.0)	13 (52.0)	0.0008
Stayed at camp	19 (95.0)	1 (5.0)	
Spring			
F/H/T	13 (50.0)	13 (50.0)	0.007
Stayed at camp	20 (87.0)	3 (13.0)	
Summer			
F/H/T	6 (50.0)	6 (50.0)	0.15
Stayed at camp	19 (76.0)	6 (24.0)	
Animals Handled			
Lynx			
None	31 (75.6)	10 (24.4)	0.05
≥1	3 (37.5)	5 (62.5)	

a. Positive or equivocal serologies for Coxiella

b. Fishing/Hunting/Trapping

TABLE 6.6 VARIABLES IN RELATION TO SEROPOSITIVITY FOR *FRANCISELLA*

Variables	- n (%)	+[a] n (%)	p
Main activity			
Fall			
F/H/T[b]	13 (61.9)	8 (38.1)	0.18
Stayed at camp	18 (81.8)	4 (18.2)	
Winter			
F/H/T	13 (59.1)	9 (40.9)	0.10
Stayed at camp	16 (84.2)	3 (15.8)	
Spring			
F/H/T	13 (58.5)	10 (43.5)	0.05
Stayed at camp	19 (86.4)	3 (13.6)	
Summer			
F/H/T	6 (60.0)	4 (40.0)	0.40
Stayed at camp	19 (79.2)	5 (20.8)	

a. Positive or equivocal serologies for Francisella

b. Fishing/Hunting/Trapping

6.4 Discussion

The seroprevalence rates for parasitic infections observed in this project were comparable to the rates reported for First Nation people from northern Québec in the 1980s (Tanner, 1987). In the earlier survey, 3% of the sera of Native Indian people were positive for echinococcosis (hydatid disease), 2% for trichinellosis, 10% for toxocariasis and 12% for toxoplasmosis. In the same study, the seroprevalence rates in Northern Quebec Inuit people living further north were respectively 1%, 9%, 11% and 48% for the infection by *E. granulosus*, *Trichinella* sp., *T. canis* and *T. gondii* (Tanner et al., 1987). The higher rate of exposure to *T. gondii* in Inuit probably reflects different hunting practices and dietary habits. The 10% seroprevalence rate we observed in this study for *T. gondii* is comparable to or lower than reported rates in industrialized countries such as the United Kingdom (Nash et al., 2005), the United States (Lopez et al., 2000) and Scandinavian countries (Tenter et al., 2000). Moreover, we were unable to detect evidence of infection by the *Sin Nombre* virus.

As stated above, equivocal results generally indicate past infections or cross reactivity with another pathogen. For the bacterial infections investigated in this study, the probability of low positives due to past infections is higher when considering populations repeatedly exposed to wildlife such as hunters and trappers. The results for *Coxiella burnetii*, *Leptospira* sp. and *Francisella tularensis* noticeably differ when equivocal serologies are included in the analyses. Under a less conservative scenario, if we regard equivocal serologies as being positive, the results show that 32.0% (women, 17.9%; men 50.0%), 28.0% (women, 17.9%, men, 40.9%) and 28.3% of the subjects would have been exposed to C*oxiella burnetii*, *Leptospira* sp. and *Francisella tularensis* respectively, after removal of NI/IQ results (women, 25.9%; men, 31.6%).

A proportion of 28.3% of the participants with a titre higher than 1:20 for *Francisella tularensis* may appear high at first glance. However, many studies conducted among trappers or North American natives have shown seroprevalence rates of this magnitude depending on the area under investigation (Martin et al., 1982). Philip et al. (1962) recorded a percentage of 17.5% of 793 subjects in Alaska with serologies ranging in titre from 1:20 to 1:640. In Canada, Wood (1951) reported titres from 1:25 to 1:1600 in 11.7% of 2 940 samples from Native Indians in Ontario and Manitoba. The prevalence north of the 53rd parallel was 23%. Greenberg et al (1957) documented detectable levels of agglutinin (1:8) in 9% of Native Indians in southern Saskatchewan and in 29% of those in the James Bay area. Greenberg also conducted another study among the Inuit population with detection of agglutinin varying from 20 to 43% in 4 communities of Northern Québec. However, in Southern Québec, a study conducted among active trappers (157 men, 8 women) and in an equivalent number of controls matched for age, sex and the area of residence in the Québec City area (Lévesque et al., 1995), revealed a prevalence of antibodies with a titre of 1:20 and higher in only 2.4% and 0.6% for trappers and controls respectively. In previous studies, when seeking information regarding symptoms of *Francisella tularensis* infection, investigators generally found that most subjects were asymptomatic. As there are two types of *Francisella tularensis,* this apparent absence of clinical signs could be related to infections primarily due to type B (*holarctica*) (Ellis et al. 2002), which is the less virulent of the two (Hornick, 1998). There were no declared cases of tularemia between 1985 and 2005 in the Cree territories. Therefore, this population may in fact be exposed to the *holarctica* subspecies. Nevertheless, this study demonstrates that these individuals are indeed exposed to *Francisella tularensis* and that fishing, hunting and trapping on land is the only variable related to the infection (Table 6). Therefore, physicians should be aware of the disease, particularly in patients who are the most exposed to wildlife.

Twenty-eight percent (considering equivocal results as positive) of participants in this study had a positive test for antibodies against the different serovars of *Leptospira* sp. However, it is difficult to compare seroprevalence studies for *Leptospira* sp because of the divergent methods used in the literature. Nevertheless, seropositive percentages ranging from 12% up to 50% have been demonstrated in several studies in various population categories in Africa (Cacciapuoti et al. 1982; Onyemelukwe, 1993), Asia (Ratnam et al. 1993), South and Central America (Ciceroni et al., 1995; Everard et al., 1995), Europe (Cacciapuoti et al. 1994; Dastis-Bendala et al., 1996) and North-America (Demers et al., 1983; Childs et al. 1992). In the Quebec City study (Lévesque et al., 1995), the prevalence of antibodies against five serovars (bratislava, icterohaemorrhagiae, grippo typhosa, hardjo, pomona), based on the more frequent serovars identified in farm and domestic animals in Canada, was 9.1% for trappers comparatively to 4.8% in controls. In the present study, there was no variable statistically related to *Leptospira* sp. exposure, even for activities involving fishing, hunting and trapping. Therefore, the exposure to this bacterium appears to be more related to the surrounding environment in the community than to activities in the forest. *Leptospira* sp. infections are found in a number of mammals, particularly rats, livestock (pigs and cattle), dogs, and some wild mammals (foxes, skunks, raccoons, among others). It has also been reported in humans practicing aquatic activities such as rafting (Mumford, 1989). In spite of the high percentage of seropositivity documented, no cases of leptospirosis have been declared in the Mistissini population. In agreement with the observations of Mumford (Mumford, 1989), we believe that leptospirosis is underestimated partly due to a misperception of the disease. The classical clinical presentation with liver and renal failure is an outdated concept. Flu-like illness, pyrexia of unknown origin and aseptic meningitis are more frequent clinical manifestations (Mumford, 1989).

In the present study, we documented a 32% (considering equivocal results as positive) seropositivity rate for *Coxiella burnetii.* This infection has been reported in all continents (Fiset and Woodward, 1998). In Zambia, Okabayashi et al. (1999) showed a seroprevalence of 8.2% on a sample of 377 humans and in Mauritania, Niang et al. (1998) documented a 33% infection rate in 118 tested sera. In Turkey, Cetinkaya et al. (2000) recorded eight seropositive cases (7.8%) out of 102 sera. In a study conducted in Eastern Cantabria in Spain, Pascual-Velasco et al. (1998) documented a proportion of 48.6% seropositivity on 595 subjects and in Cyprus, Loukaides et al. (2006) reported 44.4% of 81 seronegative humans infected over the span of one year. Finally, in the Quebec City study conducted among trappers, Lévesque et al. (1995) documented a 15% prevalence of antibodies against *Coxiella burnettii* in trappers, with the same percentage observed in controls. The 32% positivity rate documented in this study is relatively high. Being male, fishing, hunting or trapping and handling lynxes appear to be positively related to the

infection (Table 5). However, only 5 individuals, seropositive for *Coxiella burnetii,* had actually handled one or more lynxes. Therefore, this association is probably caused by the fact that trappers who handle lynxes are more exposed to wildlife. In the long run, the intensity of exposure to wildlife is probably the main determinant for this infection. *Coxiella burnetii* infection is often subclinical (Fiset and Woodward, 1998; Loukaides et al., 2006). Nevertheless, in Nova Scotia, *Coxiella burnetii* was incriminated as the causative agent in 21.8% of 110 cases of acute pneumonia in patients admitted to hospitals during a 1-year period (Marrie et al., 1985). This pathogen can also result in hepatitis, endocarditis and neurological manifestations (Marrie and Raoult, 2004). Moreover, it was recently shown that *Coxiella burnetii* infection during pregnancy may result in abortion when the infection occurs during the first trimester (Marrie and Raoult, 2004; Raoult et al., 2002). While there were no cases of Q fever reported in the Cree territories between 1985 and 2005, clinicians should nevertheless maintain a high index of suspicion for Q fever, considering the high prevalence of *Coxiella burnetii* infection in this study.

When all of the documented pathogens are grouped together, fishing, hunting and trapping on land remain the variables most related to seropositivity, whether equivocal results for bacteria are assigned as positive (Table 4) or not (Table 3). Other variables are also related to seropositivity in univariate analysis. However, in multivariate analysis, only handling ducks, when assigning equivocal results for bacteria as positive, and fishing, hunting and trapping, which are good indicators of the intensity of exposure to wildlife, is statistically related to the infections. Considering the small sample size, we believe that handling ducks could also be a "proxy variable" of the exposure to wildlife and, therefore, we cannot conclude that ducks are, by themselves, a vector for all of these infections.

In conclusion, this study documents the prevalence of antibodies against eight pathogens in a sample population highly exposed to wildlife. The lack of serologic evidence for the *Sin Nombre* virus and the few positive results for three of the four parasites investigated (*E. granulosus, Trichinella* species*, T. canis*) indicate no or infrequent exposure to these pathogens. On the other hand, exposure to *T. gondii* and zoonotic bacteria appears to be more common. For *T. gondii*, seroprevalence is comparable to reported rates in different industrialized countries. When considering all pathogens together, seropositivity is related to fishing, hunting and trapping activities. This is particularly true for *C. burnetii* and *F. tularensis.* Hunters and trappers should therefore be made aware of the clinical features of these infections as well as safe procedures for handling dead animals. Finally, physicians should also be aware of zoonoses in this particular population, particularly Q fever, tularemia and leptospirosis.

7. MICROBIAL CONTAMINATION OF FRESHWATER ECOSYSTEMS

7.1. Introduction

7.1.1 Rationale

Water of good microbiological quality is essential for maintaining human health. Nevertheless, climate change, anthropic modifications of the landscape (i.e., dams and road construction) and animal migrations could have indirect impacts on infectious disease epidemiology in northern regions of the world.

Water is an important route of transmission for many of the most widespread and debilitating diseases that afflict humans (Reiff *et al.*, 1996). In order to benefit from water of healthy microbiological quality, most North-American citizens use public or private treated water. Indigenous community members, such as people of the Canadian Cree community of Mistissini, prefer to use water from lakes, rivers and creeks for drinking purposes but also for tea and juice preparation. Most often, this water is kept at home, in plastic containers. Water from natural environments is generally not free of infectious microorganisms such as viruses, bacteria and protozoa.

Current water testing microbiology methods are generally culture-based, except for microscopy-based methods for parasite enkysted forms. Furthermore, it has often been demonstrated that there is an equivocal correlation between the presence or absence of fecal contamination indicators and that of human pathogens of viral (e.g., *Norovirus*), bacterial (e.g., *Vibrio cholerae*), or parasitic origin (e.g., *C. parvum/hominis*, *G. intestinalis*, etc.) (Chauret *et al.*, 1995; Lemarchand and Lebaron 2003). By itself, this situation would warrant the development and implementation of adaptable, sensitive, specific, cost- and time-effective methods for the detection of emerging pathogens in water sources, especially those for which fecal contamination indicators are inadequate in predicting their presence (Atlas, 1998; Gostin *et al.*, 2000; Loge *et al.*, 2002). Molecular analysis done on these waters involves specific nucleic acid amplification, in this case DNA, of target microorganisms.

In the field of water microbiology, there is a need for more rapid, sensitive, specific, and affordable tests to improve water safety. It is vital to test the microbiological quality of drinking and environmental water used by members of Iiyiyiu communities for consumption.

The current approved procedure for the detection of waterborne parasites such as *C. parvum*, *C. hominis* or *G. intestinalis* (USEPA Method 1623, USEPA, 2001) is lengthy (3-4 days for analysis), cumbersome (sample volume of 10 litres), expensive (more than 300 US$ per sample of 10 litres), and complicated. We believe that the specific detection of these pathogens by molecular amplification is desirable and we are currently developing a novel approach enabling the molecular amplification of *C. parvum/hominis* (oo)cysts and *G. intestinalis* cysts with a sensitivity (approx. 2 (oo)cysts/L) and cost that will be more acceptable for outbreak analysis by public health agencies and routine surface water analysis by drinking water production plants prior to treatment and distribution.

7.1.2 Microbiology component objective

The main objective of the study is to evaluate water consumption habits that could be at risk for Cree communities. Microbial targets, including fecal contamination indicators and selected human pathogen microorganisms (Table 1), will be primarily tested by classical culture-based methods (whenever possible), but also by more rapid, specific, and adaptable molecular amplification methods.

7.2. Methods

7.2.1 Classical and molecular water microbiology

TABLE 7.1 MICROBIAL TARGETS OF THE CMM MODULE RESEARCH PROGRAM

Primary targets (assays being validated or under development)		Future targets	
Fecal contamination indicators	Total coliforms:	Bacteria	*Clostridium perfringens*
	Escherichia coli		*Campylobacter coli / C. jejuni*
	Enterococci		*Francisella tularensis*
			Legionella pneumophila
Waterborne pathogens/parasites	*Cryptosporidium parvum/ hominis*		*Pseudomonas aeruginosa*
	Giardia duodenalis		*Vibrio cholerae*
			V. vulnificus and *V. parahaemolyticus*
		Parasites	*Toxoplasma gondii*
			Entamoeba histolytica / E. dispar
		Viruses	*Norovirus* and *Sapovirus* (Caliciviruses)
			Human adenovirus

7.2.2 Detection of fecal contamination indicators by classical and molecular microbiology

As shown in Fig. 7.1, fieldwork essentially consists in collecting water samples from plastic jugs used to store raw water from and natural streams and lakes used as drinking water sources. According to recommendations, water samples are transported on ice (4^{o} C) to the CMM module, where they are split into several aliquots, 700 mL being reserved for testing fecal contamination indicators and up to 1 litre being used for the detection of protozoan parasites pathogens *C. parvum/hominis* and *G. intestinalis*. Classical and molecular microbiology tests for fecal contamination indicators were performed on site, while nucleic acid preparations were conserved for future analyses with molecular assays under development or validation. The details of the procedures are outlined in Figure 1. Two distinct classical microbiology techniques were used in this study to assess the detection of TC, EC and EI in water samples: membrane filtration (MF) and Most Probable Number (MPN). The former technique is recommended to detect TEC or EI (USEPA 1603; USEPA 1600; Dufour et al., 1981). The second technique, Most Probable Number (MPN) methods was used to detect TC, EC and EI.

7.2.3 Detection of protozoan parasite and bacterial pathogens by molecular microbiology

In addition to monitoring for the presence/absence of fecal contamination indicators (coliforms, *E. coli* and enterococci), 21 environmental water samples, taken from the 8 most important sites studied, were tested for the presence of parasite pathogens *Cryptosporidium parvum* and *Giardia duodenalis*. These tests were performed using a new molecular detection method. Briefly, one-litre samples were filtered and the total cellular genetic material was submitted to a molecular enrichment procedure adapted to be performed onboard the Atlantis CMM. This amplified total genetic material (40 µL) was frozen and stored until further testing by PCR for DNA from specific microorganisms. The overall approach is illustrated in Figure 2.

7.2.4 Quality control: classical and molecular microbiology diagnosis

Bacterial cultures of reference strains were grown onboard the CMM module as quality controls for media used in the determination of fecal contamination indicators. An internal control was also designed to assess the amplification performance of the molecular detection strategies. Positive and negative controls were also present to monitor the integrity of reagents and check for possible DNA carryover contamination that might arise from laboratory manipulations.

7.2.5 Water sampling

Twelve local water sources (6 lakes and 6 rivers) were analyzed as well as 24 plastic containers over a period of 30 days, from 20 July to 18 August, 2005.

The selected raw water sampling sites were chosen around Mistissini, with the help of community members. Eight sites were determined to be of major importance. The nearest site was located just a few kilometres from Mistissini (Perch River) and the farthest about 60 km along the road to Lac Albanel (Km 357). Sampling sites have been visited from 3 to 10 times during the 30-day period. Field data included water temperature, pH, turbidity and mean daily rain precipitation.

For water stored in plastic containers, respondents reported that water collection occurred once a week or a few times per year. On-site treatment of collected water consisted of a single filtration through a canvas or cotton cloth (pillow case, drying cloth) to remove solid particles. Water was stored in 5-gallon (18.93-litre) plastic containers.

Microbiological and field data analyses were accomplished onboard the Atlantis mobile environmental laboratory complex.

7.3 Results

Environmental water used for drinking was collected from lakes, rivers and storage containers, and tested onsite for fecal contamination indicators by classical and molecular microbiology methods, while the final testing for waterborne parasites was performed at the Centre de recherche en infectiologie in Québec City. The quality and robustness of the classical microbiology procedures performed by the CMM module's student scientist were confirmed by concomitant analyses done by local water production plant operators.

The presence of total coliforms, *E. coli* and enterococci was analyzed in 100 mL fractions of environmental water samples, using specific MPN and MF methods. Total coliforms were found in all 74 samples and MPN counts ranged from 3.1 to >200.5 colony-forming units (CFU)/100 mL (Table 2). In all samples, total coliform count averaged 161.78 CFU/100 mL. Samples from lakes and rivers contained, respectively, a mean of 132.6 and 191.0 total coliforms CFU/100 mL.

During this study, *E. coli* was found in 68% of samples and at least once at each site. *E. coli* counts ranged from <1.0 to 78.2 CFU/100 mL. Twenty-one percent (21%) of contaminated samples came from lake sites and contained an average of 3.1 *E. coli* CFU/100 mL, while the other 79%, which were from river sites, contained an average of 17.5 *E. coli* CFU/100 mL.

Using Enterolert™, enterococci counts in all samples ranged from <1.0 to 200.5 CFU/100 mL. Fifty-three percent (53%) of the samples turned out positive for enterococci. Sixty percent (60%) of positive samples were collected from lake sites, and contained an average of 8.5 enterococci CFU/100 mL. The remaining samples (40%), collected from river sites, contained an average of 2.9 enterococci CFU/100 mL. Also, the MF method was used on the last 35 environmental samples. Using this method, enterococci counts ranged from 0.0 to 100.0 CFU/100 mL. Eighty-three percent (83%) of these tested sub-fractions were positive for enterococci. Samples from lake sites comprised 45% of these contaminated samples and contained 16.0 enterococci CFU/100 mL. The remaining contaminated samples (55%) were from river sites and contained an average of 14.1 enterococci CFU/100 mL. The MF method indicated presence of enterococci while MPN suggested its absence in 20% of the 35 environmental water samples tested using both methods.

7.3.1 Drinking water-related habits

Every *Nituuchischaayihtitaau aschii* study participant surveyed for drinking water-related habits use environmental water, which they collect and store in portable containers. The majority of tested water samples had been collected from three environmental sites, which had been previously selected and were part of CMM's environmental sampling program. Sixty-six percent (66.6%) of portable water containers were filled with water from Wapachee Camp, 16.6% from Km 357, and 4.2% from Perche River. The remaining 12.5% contained water collected from unknown sites, other than the 12 environmental sites sampled during the study. On-site treatment of collected water by participants consisted of a single-step filtration through a canvas or cotton cloth (pillow case, drying cloth) to remove large particles such as insects or algae. Containers were filled with environmental water at irregular frequency, from once a week down to twice a year. Answers concerning the cleaning frequency also varied from once a week to twice a year. Cleaning methods ranged from rinsing with tap water, to washing with a bleach solution and then rinsing with tap water. All containers had a 18.93-litre (5-gallon) capacity, were made of plastic, and kept closed with a screw cap lid. However, some containers were transparent and others opaque. They were either kept inside or outside the house.

7.3.2 Portable water container samples

Sixteen (16) out of the 21 sampled water containers contained total coliforms and were thus considered unfit for consumption according to USEPA standards. Total coliform counts ranged from 1 to >200.5 CFU/100 mL. Six (6) samples contained ≥200.5 total coliform UFC/100 mL, while the remaining 10 averaged 9.64 total coliform CFU/100 mL. Samples 12 and 18 contained

E. coli, whereas samples 8, 10, 18 and 20 were contaminated with enterococci. When present, levels of contamination for *E. coli* and *Enterococcus* were low: between 1 and 6.4 CFU/100 mL. One sample out of 21 showed the presence of all three indicator microorganisms. Its water had been collected at Wapachee Camp.

7.3.3 Correlation analysis

Variation of fecal indicator counts over time was observed within all sites. However, correlation between microbial count fluctuation and time was not significant in itself. Nonparametric rank statistic analysis, using the Spearman correlation coefficient, showed that water turbidity and pH both significantly co-vary with total coliform counts ($r_s = 0.5$ and 0.4) as well as with *E. coli* counts ($r_s = 0.6$ and 0.4) using Colilert®. Daily rainfall and enterococci counts using Enterolert™ also correlated significantly ($r_s = 0.2$). Water temperature did not correlate with any microbiological result ($p > 0.05$). Analysis of enterococci-count data sets did not reveal an association between the two detection methods, Enterolert™ and MF. Significant correlation was also not observed between *E. coli* and enterococci counts using respective Colilert® and Enterolert™ methods.

TABLE 7.2 MICROBIOLOGICAL QUALITY OF ENVIRONMENTAL SURFACE WATER OF THE SELECTED MISTISSINI AREA SITES

Natural drinking water sites	Sample type	*E. coli* # positive mTEC	*E. coli* # positive Colilert ≥1 CFU/100 mL	Coliforms # positive Colilert ≥1 CFU/100 mL	Enterococci # positive mEI ≥1 CFU/100 mL	Enterococci # positive Enterolert ≥1 CFU/100 mL
Perch River	Lake water	1/5	1/9	9/9	3/5	7/9
Wapachee Camp	Lake water	1/6	1/10	10/10	5/6	6/10
Km 357	Lake water	0/3	2/6	6/6	2/3	5/6
Km 357 Camp	Lake water	0/3	1/6	6/6	3/3	4/6
Perch River bridge	River water	6/6	10/10	10/10	6/6	4/10
Icon	River water	4/4	9/9	9/9	4/4	2/9
Chalifour Camping	River water	2/3	2/6	6/6	2/3	5/6
Chalifour River bridge	River water	3/3	5/5	6/6	3/3	2/5
South Revelation River	River water	1/1	4/4	4/4	0/1	1/4
South Revelation River camp	Lake water	Not tested	3/3	3/3	Not tested	2/3
South Revelation River docking	Lake water	Not tested	1/3	3/3	Not tested	2/3
North Revelation River	River water	1/1	3/3	3/3	1/1	1/1
Plastic water containers		Not tested	2/21	16/21	Not tested	4/21

7.3.4 Molecular analysis

Unfortunately, the negative controls used for the molecular detection of *E. coli* and enterococci indicators revealed that carryover contamination occurred in a few instances while performing these PCR experiments onboard the CMM module. Therefore, new experimental designs will be required to warrant significant results for rapid molecular analysis directly on Atlantis.

Analysis of 2.5% of the total genetic material amplified from the one-litre samples revealed that DNA from *Giardia duodenalis* was strongly detected in a single sample (Km 357 Camp). Another sample (Icon River), presented a weak signal, suggesting the potential contamination of this sample by the parasite.

Analysis of another 2.5% fraction of the total genetic material obtained from the one-litre samples revealed that *Cryptosporidium parvum* DNA was strongly detected in five samples obtained from four different sites (Wapachee Camp, Km 357, Km 357 Camp and Chalifour River bridge). Three other samples from three distinct sites (Perche River, Km 357 Camp and Perch River Bridge) presented a weak signal, suggesting potential contamination of these samples by *C. parvum*.

7.4 Discussion

Traditional drinking habits and the absence of microbiological surveillance in drinking water sources facilitate contact to point source fecal contamination susceptible of containing viral, bacterial and protozoan waterborne human pathogens. All environmental sites tested yielded a positive microbiology result referring to fecal contamination at least once. The presence of parasite pathogens always correlated with the presence of at least one fecal contamination indicator, either total coliforms, *E.* coli and/or enterococci. However, the molecular methods for the detection of *Cryptosporidium* spp. and *Giardia* spp. are still being refined to improve their specificity and sensitivity.

We took field data like water temperature, pH, turbidity and mean daily rain precipitation into consideration in this study, but our sample number is rather low and more samples would be needed to conclude on the correlation of these parameters with microbiological methods. Several authors (Olyphant GA, Whitman RL., 2004; Olyphant GA, 2005) found a strong correlation between hydrometeorological factors and *E. coli* concentrations in beach waters, so we suggest keeping data collected for further reference and possible future use of these factors as simple indicators of drinking water quality, on a larger scale.

Microbiological culture results suggest that lake or river water in the Mistissini area should not be directly used for drinking, since positive results for fecal contamination indicators are obtained at a high frequency. It was also found that traditional community habits favoured water collection from Perche River and Wapachee Camp. The community sees these drinking water sources as containing the purest water. Interestingly, this study demonstrated that these two sites are those presenting the lowest total coliform concentrations, the lowest number of contaminated samples with *E. coli*, as well as having lower than mean *E. coli* and enterococci concentrations. Moreover, in these two sites, DNA from pathogen parasites was only detected once at a high level for the Wapachee camp site and only once at a very low level for Perch River. The results of this study suggest that water collected from these two sites can be regarded as the most acceptable of all environmental drinking water used by Cree people of Mistissini.

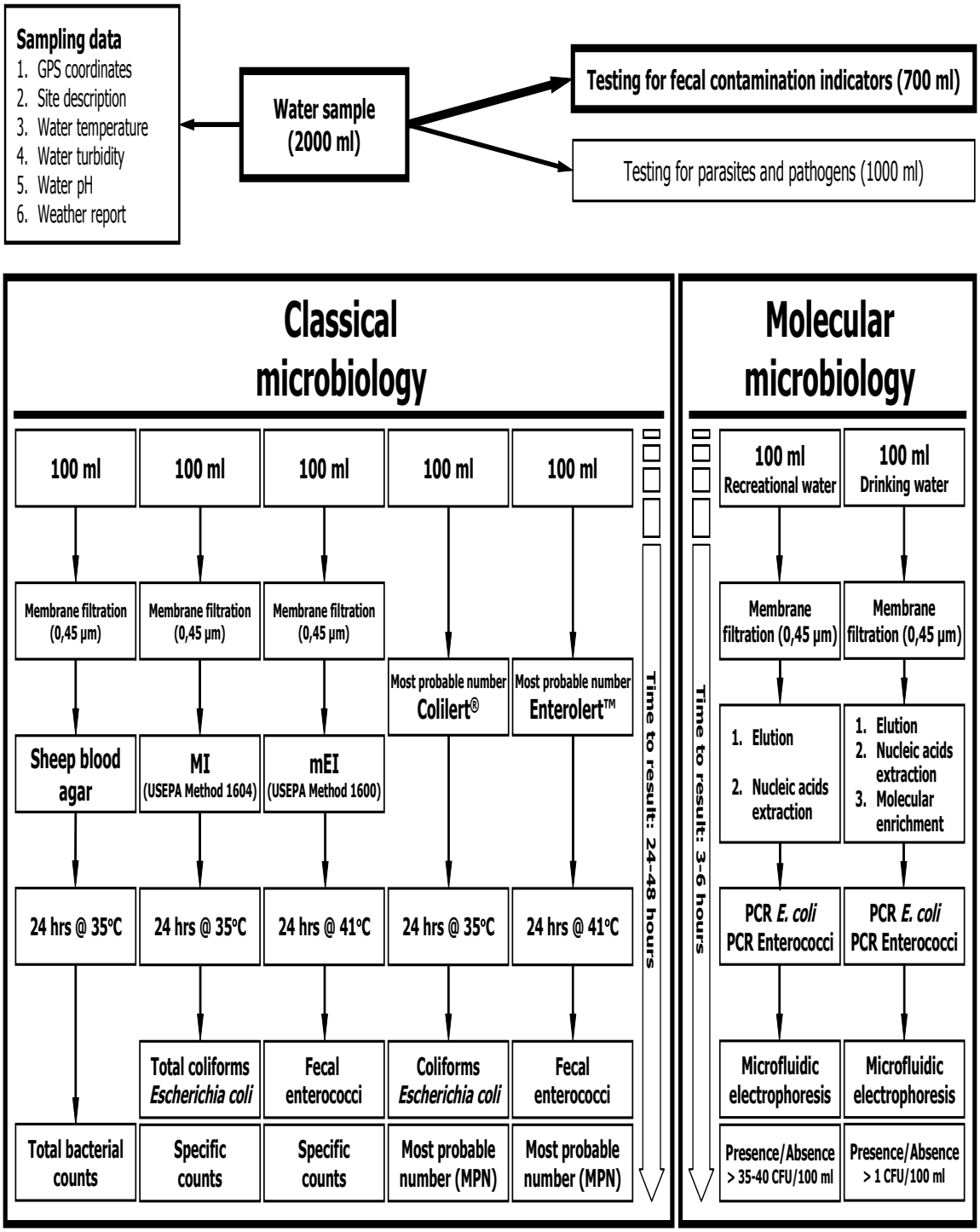
Samples from portable water containers contained less total coliform, *E. coli* and enterococci, counts than the environmental sites where these containers were filled. While 71% of sampled water containers had total coliform counts above acceptable drinking water guidelines, both *E. coli* and enterococci were not detected in respectively 90.9% and 86.6% of the samples. Apart from filtering with a cotton or canvas cloth when collecting water, community members did not directly treat their water. The low frequency of contaminated containers is probably due in part to the fact that they were most often filled from the least contaminated environmental sites. It can also reflect the fact that storage conditions cause post-collection death of target microorganisms, or their induction into a viable but non-culturable state.

Nevertheless, water from natural sources and water stored in plastic containers should be boiled, at least 1 minute, before drinking.

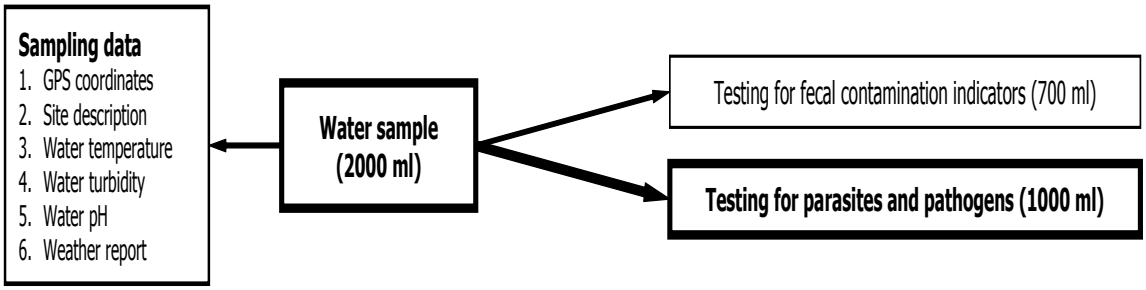
Although molecular methods offer more rapid testing of microbes, their exquisite sensitivity exposed them to carryover contamination problems. New procedures and technologies will be explored to circumvent these drawbacks. In a field laboratory such as Atlantis, equipment permitting closed-tube assays would be desirable.

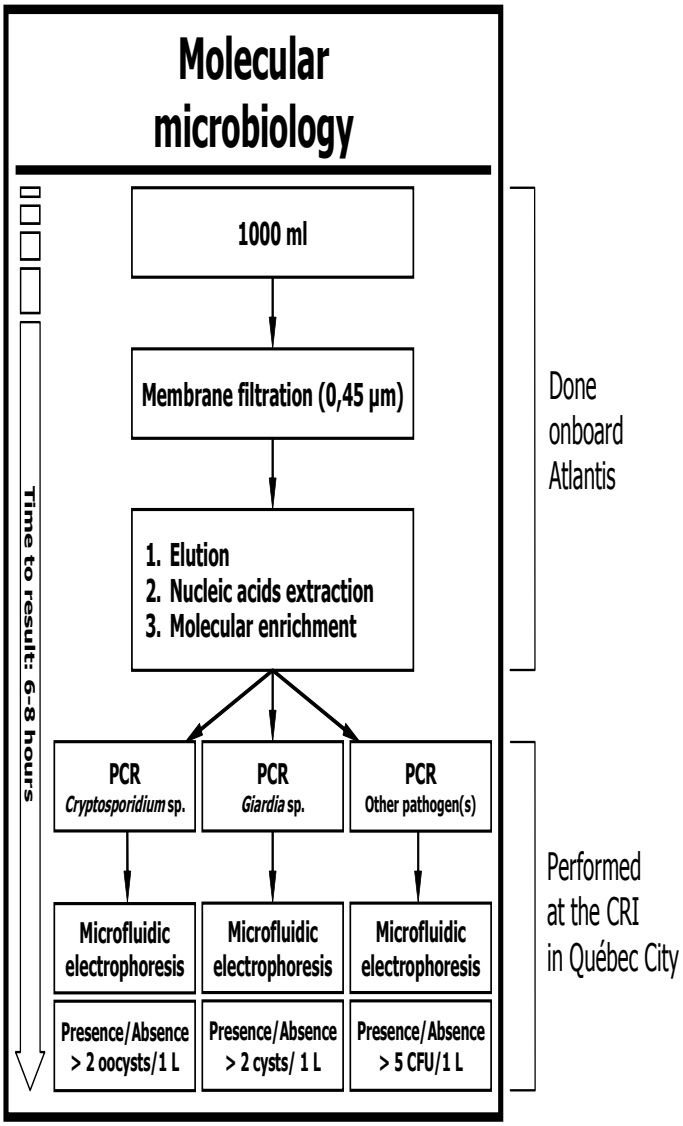
A significant advantage of the molecular approach we are developing is that stored enriched total genetic material is kept as an archival sample for future analysis. This material is very useful for method improvement and fundamental research on genetic diversity. But more importantly, archival samples are essential for retrospective studies on new health issues that were unforeseen or not exhaustively monitored at the time Atlantis visited the concerned populations. Provided validated primers and probes are available, nucleic acids from virtually all microbial species could be detected from this archived material.

Detection of fecal contamination indicators: *Escherichia coli* and enterococci



Detection of parasites and bacterial pathogens: *Cryptosporidium*, *Giardia*, etc.





8. EDUCATIONAL ACTIVITIES

8.1 Summary

The main purpose of the Educational Activities component of the program was to use the curiosity and interest raised by the arrival of Atlantis as an opportunity to build bridges between the community members of Mistissini, visiting scientists, CBHSSJB representatives and local administrators. The aim was to improve communication channels between these entities in order to share information about human health and environmental issues. The Educational Activities team planned to accomplish this by:

a) Setting up environmental workshops for teens and young adults;

b) Organizing information gathering sessions for community members;

c) Hiring two local young Cree persons to work with the educational activities team and to get training using the Atlantis Laboratories;

d) Creating a link between the Atlantis microbiology technician and local water treatment plant personnel for water quality testing in order to share information and develop local know-how;

e) Investigating the possibility of a partnership with the Nasivvik exchange program.

The overall approach of the study was to avoid a situation in which research was being carried out "by scientists, for scientists", and favour moving from "research about Iiyiyiu people" to "research with Iiyiyiu people", to ensure better feedback to the public. Therefore, communications focused on introducing science as a tool to complement Cree traditional knowledge.

Younger people were targeted through Environmental Workshops to stimulate scientific curiosity and raise awareness about certain environmental issues through hands-on experiments. Priority was placed on creating partnerships with local organizations by taking into consideration the many activities occurring in the community throughout the summer. Educational activities were therefore incorporated into some of those activities by setting up environmental workshops at the Sunrise Children's Camp, organizing nutrition workshops with a Cooking Class for Youth with local nutritionists, or planning around them, so as not to compete with the many sports camps and special events taking place in the community.

Adults were reached through information gathering sessions, as well as through the environmental workshops. The environmental workshops provided an opportunity for direct community contact with individuals through activities conducted with local youth, and generated curiosity about the science workshops. Communications were also established between local water treatment plant personnel and Atlantis staff, particularly the microbiology technician in charge of water quality testing. Training about the project and laboratory techniques related to analysis was available to teenagers. The interest for a partnership with the Nasivvik exchange program was also investigated.

Recommendations for educational activities were established according to the preliminary study findings. This year, the focus of educational activities was on introducing science activities to youth, by making it available, fun, interactive, and non-intimidating, as well as increasing contact with community members.

8.2 Introduction of Atlantis Laboratory and its Scientific Team to Community Members

8.2.1 Open Door

An open-door event was organized one week after the arrival of the Atlantis Mobile Laboratory in Mistissini, on Tuesday, June 21 from 1:00 to 8:30 pm. As the Atlantis tent had just been set up, this event provided an opportunity for community members to view the new installation, as well as additional means to promote the study. Laboratory visits were offered to the general public, and advertising was done through radio announcements and flyers distributed around the community, four days prior to the event. About 50 visitors came to the Atlantis Laboratory.

As a sign of respect, eight elders were invited to the event and given a tour of the facilities before the arrival of the general public. The project manager introduced the project and its purpose to the elders. This information was translated into Cree. Afterwards, a luncheon was served to the elders and team members.

Laboratory visits were conducted for the public. Posters explaining some of the laboratory procedures were put up to explain some of the tests being carried out during the time spent in Mistissini, and to assist staff in explaining their tasks to visitors. Leaflets about the project and the environmental workshops were distributed on site.

A stand to promote educational activities was set up at the Open Door and was also available during the opening ceremony. The two main attractions were the volcano demonstration and the dissection and observation (using a microscope) of insects, plants and zooplankton collected from the lake. The educational activity staff provided additional information about the ecology of plants and other organisms.

8.2.2 Logo contest

A logo was needed for the educational activities and a contest was organized between May 15 and June 15. Contacts were made with the school to present the project and the contest. A simple description of the project was given to the art teacher at Voyageur Memorial School, together with basic rules to follow (i.e., number of colors to be used, size). Additional advertising for the contest was broadcast on the radio. The winner was awarded a prize (a portable Sony MP3 player) during the Open Door event. Ariel Coon, a 13-year-old high school student, and her family, won this prize.

8.2.3 Official opening ceremony

An official opening ceremony took place on July 4, at noon, after the arrival of clinical staff, principal investigators and project collaborators. The Chief and Council and the Public Health Services Department from the Band Office were sent invitation letters. The general public was solicited through radio and poster advertisements. All the project staff was present. A regional radio station representative was also present to promote the event "live''. Lunch was offered to everyone. In total, about 60 persons attended.

The principal investigators presented introductions to the various aspects of the project. In the absence of the Chief, the Deputy Chief made a speech in support of the project and invited community members to participate. Laboratory visits were made available to the general public and leaflets were distributed to them. The stand to promote educational activities was set up.

8.2.4 Project-related information sessions

Information gatherings were set up in order to share information related to some of the themes mentioned in the feasibility study with community members.

"Issues related to the health consequences of modernization (westernization)" July 6, by Éric Dewailly (at the Shaaptuwaan tent)

Comments: This was scheduled to take place in the afternoon at 3:00 p.m. based on the availability of the project coordinator. However, an important religious event in the community, planned at the same time, affected the turnout for the event, and it had to be cancelled.

"Traditional medicinal plants and diabetes" July 28, by Sonia Grandi

Comments: This presentation took place during a local Traditional Gathering. Participation was good and interactive.

"A look at how other First Nations living in northern regions are affected by environmental issues." August 3, by Evert Nieboer

Comments: This presentation took place during the Local Annual General Assembly (LAGA). It had two objectives, namely: explain the Mistissini Environment-and-Health Study and put it into the perspective of similar studies among indigenous peoples in circumpolar countries. The presentation was well received.

8.3 Environmental Workshops for Youth

8.3.1 Workshops

The environmental workshops took place from July 4 to August 12. These workshops included a lot of hands-on activities, together with background information on the science behind the chosen topics. Their aim was to foster a deeper appreciation and interest for the field of science. At the same time, it gave young people an opportunity to see science as something fun, non-intimidating and accessible, outside of the school framework. Links to scientific careers and study pathways related to the subjects covered during the workshops were made through informal conversations. The workshops were presented in collaboration with the Youth Center, and other local summer camps. For the Youth Center, anywhere from two to four different activities a week were organized on Monday and Wednesday evenings, at 6:00 p.m. In addition, workshops were also carried out at the Sunrise Children's Camp, on Tuesday and Thursday afternoons. Different age groups attended the camp each week. The average time needed for a given workshop was one and a half hours. Activities were open to all children and teens, attracting mainly boys and girls between the ages of 7-14 years.

With the support of the Voyageur Memorial School, free access to scientific material and laboratory supplies was provided to the environmental workshop team. Many of the science activities conducted this summer were made possible because of the materials/supplies available from the school. This contributed to the workshop's success.

Joining local organizations/camps to conduct environmental workshops has been an effective way of reaching Youth without them having to sign up. Considering the fact that many activities are scheduled during the months of July and August, and that attendance at most camps was lower this year (i.e., the Traditional Camp set up through the Band Office for youth aged 10-16 years was cancelled due to the low subscription rate), the environmental workshops were a success, having reached between 20 and 30 youth on average. Also, collaboration with a well-known organization such as the Sunrise Children's Camp, led mainly by local volunteers, provided an excellent opportunity for introducing the project to key community members. At the same time, it demonstrated the project's potential to involve individuals of all ages in this unique Health-and-Environment Study.

The educational team was informed by several community members that many youths repeated the activities completed during the workshops, at home, for their parents or grandparents. Comments about the workshops such as, "I had a lot of fun", "I really enjoyed it", "I've never done anything like it", "I'll never forget it", have been heard many times over the course of the summer. The vice-principal of Voyageur Memorial School (Elma Moses) mentioned that although environmental workshops did not attract many older youth, she felt it important to reach the younger youth and was very happy that something like this happened in her community this summer. She hopes that this will continue in other communities.

8.3.2 Science fair

On August 11, a "Final Wrap-up" activity for the environmental workshops took place. Stands were set up, and several youth that attended the workshops regularly, presented seven of the main hands-on activities completed during the summer. Parents were invited to attend the final workshop through letters of invitation. Additional advertising was provided through posters inviting all community members to come and see their "Youth in Action". There was no doubt that those who attended appreciated the wrap-up session.

A science fair used to take place at the secondary school in Mistissini but was dropped in the last couple of years due to lack interest from the youth and low turnout. Teachers seemed really interested in bringing the event back to the school system but report lack of supervision resources.

8.3.3 Educational promotional visits to the school

The presentation of quick and interesting experiments was planned at both elementary and high school levels. This type of promotional activity is an excellent way to reach youth and get them interested in the activities. However, even though some appointments had been set up and confirmed from June 6-10, unforeseen events at the school led to circumstances that did not allow the visits to occur.

8.4 Jobs and Training Opportunities for Teenagers

8.4.1 Laboratory training

Half-day training took place for two youths from the community interested in pursuing their studies in a health-related field. They received training on some technical laboratory manipulations, such as those related to water quality testing, mercury and PCB analysis and blood sample handling and analysis. The training began with background information related to each laboratory test, followed by an introduction to daily laboratory procedures carried out by Atlantis staff. Trainees were given the opportunity to get familiar with manipulations. Academic support was provided through posters showing the different test procedures conducted in the Atlantis laboratories.

It should be pointed out that the two students involved in the Atlantis training were actually hired and sponsored by two different organizations, namely the Human Resource Centre and the Mistissini Youth Council Summer Student Program. Both groups participated in the recruitment process. This reinforced the partnership between the project and the community. The involvement of the two youths in these activities should improve their future possibilities of employment in any scientific or educational fields. They put their creativity, as well as their leadership and communication skills into practice. They increased their scientific knowledge and their understanding of the environment-and-health issues in their community. Both have expressed that they had never done anything like it before, and that they truly enjoyed their experience.

8.4.2 Link with Chibougamau College – Offer for course credits

Contacts have been made with Chibougamau College, to investigate the possibility of offering credits to trainees for their participation in the project. Élizabeth Harvey was the contact person

at the College and may be reached at (418) 748-7637 ext. 238. The training offered by Atlantis could be an incentive for many young adults to pursue their studies in the field of science.

This is a great opportunity for potential trainees to get official attestation for their experience. Interest has been expressed by the institution to develop a theoretical course to complete the training with Atlantis, although this would not be required for the training to be recognized by the college. The college proposed actively promoting the training among its students if a partnership is created.

8.5 Link to Public Health and Environmental Programs

8.5.1 Local programs or operations

The educational activities team assisted in two ongoing group activities. Firstly, in support of the Mistissini Public Health Diabetes Program, they led a special cooking class for youth conducted by a Cree Health Board nutritionist. Secondly, an environmental workshop took place at Elders' Point in the ongoing efforts to promote traditional fishing and lifestyle by the Board office and Public Health Services Department. And finally, two of the environmental workshops took place at the drinking water treatment plant and pumping station. Explanations about water analysis operation as well as demonstrations of various techniques used for water quality testing were presented by local staff. Approximately eight young people attended both visits. These visits were really appreciated. They also provided opportunities for establishing contact, concerning water quality testing, between the water management officer and the Atlantis microbiology technician.

8.5.2 Information on zoonoses

To develop and put together information related to zoonoses, contacts were established between the Cree Trappers' Association (CTA), the Band office and the Société de la faune et des parcs du Québec (FAPAQ) in Chibougamau. This was done by Valérie Messier. The goal was to create a permanent channel for analyzing samples of animals showing signs of potential diseases. Iiyiyiuch have expressed an interest in an information-gathering project on zoonoses. The best time to present information on this topic was thought to be general CTA assemblies, which are well attended.

8.6 Communication for the Clinical and Laboratory Activities

Some pedagogical material for laboratory procedures has been produced this year with the collaboration of the Atlantis staff. Visual material illustrating the laboratory's facilities have been shown to be very useful and helpful for direct communication between clinical and laboratory staff and participants in the study.

8.7 Nasivvik Exchange Program

The possibility of adopting the Nasivvik program on Inuit Health and Changing Environment was investigated. A full week of training for 8 to 10 participants was initially discussed and suggested by Nasivvik. Taking into consideration the context and the logistics of setting up such a program, the possibility for a shorter training with a smaller number of participants had been suggested as an alternative by the educational activities team. In the end, the partnership with Nasivvik fell through and the program described in this document was created instead.

Looking back at the project, the decision made concerning the Nasivvik program was the right one.

9. REPORTING OF THE RESULTS

A results-reporting protocol was devised for the Mistissini pilot study to ensure appropriate interpretation and follow-up of test results in a way that balances the risks of chronic exposure to contaminants with the benefits of a traditional Cree diet and way of life, such as reduction in cardiovascular risk factors. Its objectives were to help study participants better understand their laboratory results and to empower individuals to minimize exposure to environmental contaminants, while avoiding undue anxiety or overburdening the clinical system. The protocol development consisted of four phases: an initial exploratory step, protocol development, protocol testing and evaluation. During the process, there was ongoing consultation with stakeholders and collaboration with experts in toxicology and environmental health. The outcome measures were divided into four categories, namely A, B, C, and D. First there are "category A" test results that are known at the time of testing (e.g. blood pressure), and if these results are dangerously high, patients are advised in person to present immediately to the clinic. Next, there are "category B" test results that require minimal delay for referral if abnormal (e.g. Holter, carotid dopplers, heel ultrasound, and zoonoses). In these cases, the head nurse and/or MD at the local clinic are notified by telephone to discuss management on a case-by-case basis, the patient is phoned, and the appropriate referral and follow-up will already have been arranged for the patient by the time they receive the notification of an abnormal result. "Category C" test results are generally non-urgent (e.g. low levels of toxic metals and PCBs, or mildly abnormal glucose, lipids, thyroid function tests) and can be followed up by the local clinic over a period of a few weeks. Nonetheless, the batch of results are first reviewed to ensure there are no cases which should be managed as in "category B" by phone. For the remaining non-urgent cases, the results are sent to the clinic physician, and the participants are notified in a letter. The process of notifying participants about non-urgent results is discussed in greater detail below. Finally, "category D" results (for research purposes only; for example, inflammatory markers) will not be given to individuals unless the result is so abnormal that the expert responsible thinks there may be clinical relevance.

Another aspect of the reporting protocol involved the preparation of guidance for physicians and clinical staff. This was a particularly difficult area and primarily concerned Category C results. The focus is on chronic exposure to environmental contaminants. General guidance in case of acute exposure to environmental contaminants has been included, although that is likely to be very rare. For each of the major contaminants tested in the study (i.e., cadmium, lead, mercury and PCBs), there is a 2-page "Clinical Algorithm" intended for health professionals with a brief description of key signs and symptoms associated with chronic exposure, suggested laboratory tests, as well as treatment and prevention strategies. Copies are provided in Appendix 4.

10. PROJECT EVALUATION

Multi-Community Environment-and-Health Longitudinal Study in Eeyou Istchee:

Evaluation Report, Year 1: Summary

10.1 Objectives

The objectives of the participatory, formative evaluation of the multi-community study are to:

1) Document and assess the quality and effectiveness of the implementation of the multi-community study in the participating communities, including community engagement in the research process and appropriation of research tools and opportunities;

2) Determine the success of the study in achieving its formal objectives (from the points of view of the research team stakeholders) and the anticipated benefits for the communities (from the perspectives of community members and Cree entities);

3) Inform the planning of each successive implementation of the study in the Cree communities.

The evaluation is being directed by an 11-member stakeholder committee composed of representatives of the following: Mistissini Band (since January 2006), Cree Board of Health (Environmental Health, Evaluation), Cree Regional Authority (Environment Department), principal investigators, project staff (research and education components), and student researchers

This report summarizes the recommendations emerging from the two waves of evaluation data collection for the first year of the project, concentrating on the **experiences of the Mistissini community** with the study in 2005.

10.2 Methodology

The evaluation methodology was developed by the Evaluation Committee, which also reviewed and approved the data collection tools and participated in the interpretation of the findings.

Semi-structured interviews were conducted in person, individually or in small groups, in January-February 2006, involving a total of 26 individuals (21 adults and 5 children). The types of interviewees are shown in the table below. Potential key informants were identified with the help of CBHSSJB staff, Evaluation Committee members, and key informants, on the basis of their capacity to report on community-level experiences. Participant recruitment was conducted in such a way as to communicate that the evaluation is neutral with respect to the study. Additional interviews were conducted with representatives of Cree regional authorities, by telephone, in April-May 2006. Finally, in-person interviews were conducted with community members who had attended presentations of the study results in Mistissini, in August 2006.

TABLE 10.1 INTERVIEWS CONDUCTED, WAVE 1

Type of respondent	Number
Community representatives in areas linked to the research issues	
Mistissini Band	
Public Health Unit	1
Public works: Water management unit	1
Local Environment Administrators	2
Tourism Coordinators	2
Traditional Pursuits, fishing project	1
Geology coordinator	1
Local branch, Cree Trappers Association	1
School personnel	
Vice-principals (elementary and high school)	2
Science teachers	2
Cree School Board	1
Cree Health Board	2
Community members having supported or worked on the study	
Interviewers	1
Recruiters	2
Community members involved in study publicity	1
High school student – summer worker	1
Workers involved in delivering individual results communications	2
Community members selected as participants for the study *(some of these are also included above)*	
Participants	3
Non-participants	2
Children participating in educational activities (group interview)	5
Regional authorities	
Cree Regional Authority: environment unit	1
Cree Outfitting and Tourism Association	1
Cree Trappers' Association	1
Community members having attended results dissemination presentation and kiosk	12
Total no. of individuals interviewed	46

10.3 Main findings and recommendations[3]

In general, the results of the interviews within the Mistissini community suggested that while there was support for the study and interest in receiving and using the results, improvements could be made in the preparation of the community for its arrival and communications about the study components. After review of the detailed findings, the Evaluation Committee proposed a set of recommendations for subsequent years of the study. *It is important to note that most of these support and validate conclusions and recommendations already reached by the study team members in their various reports.*

Recommendation 1: Involve Cree representatives earlier and more fully

- Ensure that one or more representatives of the next community are directly involved in the planning process as early as possible
- Engage a local study coordinator, facilitating his/her participation through remuneration/compensation to the Band
- With the help of the coordinator, identify and engage key community members and organizations in the particular community during the planning process (including the Band communications officer if relevant)
- In the months before the study, engage the community in a two-way dialogue, exchanging information about the study while creating opportunities to learn about the community context, in particular about local activities during the summer that may hinder or facilitate the study implementation and local groups who could champion the project.

Recommendation 2: Develop and implement a communication strategy

- Ensure that the strategy is implemented, and especially that the staff required are hired as soon as possible
- Develop a strategy that begins promotion of the study in the community several months before it arrives, using varied methods known to be effective in the community

3 Note that as of the date of this report, these recommendations had been developed but not yet validated by the Evaluation Committee.

– Ensure that the communication strategy involves regional Cree authorities as well as the local community
– Prepare visual and accessible background documents on the study, especially on the research questions and hypotheses, to use in developing interest and support for the project in the community
– Ensure that the sampling strategy is well-communicated and understood
– Have some study team members arrive earlier in the community to intensify promotion of the study before the main team arrives
– Involve the study's principal investigators in communications with the community.

Recommendation 3: Expand the educational component of the program

– Involve key interested people in the school system as fully as possible, during the school year
– Develop and engage students (high school and elementary) in study-related science activities during the school year
– Expand opportunities for youth to be involved as workers in the project
– Ensure that the education program provides opportunities for community members to address their needs and concerns.

Recommendation 4: Open and promote the Atlantis laboratory as a learning opportunity

– In line with the above objective, ensure links between the laboratory and the school system with the general goal of bringing science closer to the community
– Build links between the laboratory and the educational program's summer activities for youth
– Develop and promote public awareness and access to the laboratory, through scheduled tours or other public events.

Recommendation 5: Ensure project staff and partners are fully prepared for their work

– Continue to ensure training, supervision and support of project staff
– Ensure that key community members who may be asked questions about the study are fully informed and engaged.

Recommendation 6: Re-assess the communication issues around mercury

– Given the presence of mixed messages in people's minds, carefully assess how best to communicate information about mercury

– Ensure that the community is aware of the study's funding in the context of the Mercury Agreements.

Once the data analyses and results communication for Mistissini had been completed, the Evaluation Committee prepared a revised evaluation plan for the 2006 study in Wemindji and Eastmain.

11. STUDY FINDINGS AND KEY MESSAGES

11.1 Traditional Food Harvesting and Consumption

Based on questionnaire responses, close to one-half of the participants spent time in the bush during the autumn and winter and a comparable proportion are involved in hunting. Moose, caribou, rabbit, beaver, certain fish species (trout, walleye, pike), smoked fish, geese, ptarmigan/partridge/other birds, goose grease and wild berries are consumed by 50-100% of the participants over 19 years old, with somewhat lower percentages for those under 19 for some of these food items. Dabbler and sea ducks are consumed by 20-40% of individuals independent of age. Clearly, traditional food continues to be an important dietary component. These foods are good sources of essential metals such as iron, zinc, copper and the element selenium, as well as healthy fats (i.e., omega-3 fatty acids) and vitamin B12. Consumption of traditional foods also reduces the risk of eating store-bought foods high in trans fats.

Overall, there are some concerns about the relatively low consumption of fruits and vegetables leading to low intakes of the essential macronutrients magnesium and calcium, as well as fibre and some vitamins (e.g., folate). Low consumption of milk is believed to contribute to the low calcium and vitamin D intakes. The presence of these essential substances in our diet promotes good health.

Optional parts of the diet, such as soft drinks and other sugared drinks, as well as snack foods, fast foods, and baked goods, account for as much as 40-50% of the energy intake. This is not only a concern for weight gain, but also the intake of trans fats, especially by children and teenagers. Trans fats constitute a risk factor for heart disease, as being overweight is a risk factor for diabetes.

11.2 Physical activity

Analysis of the physical activity questionnaire responses in relation to body fat assessment indicated that dedicated walkers are enjoying the health benefits of their physical activity. It is generally accepted that regular exercise can improve one’s health status.

11.3 Environmental contaminants

Compared to earlier assessments of lead and mercury in First Nation communities, the Mistissini results are encouraging, and very few individuals needed a follow-up. Although mercury levels

in the food chain appear to be getting lower, rather low blood concentrations of this toxic metal have recently been associated with cardiovascular disease. Indeed, there is a suggestion in the present study of a small increase in blood pressure associated with mercury levels in blood. For this reason, its release into the environment and accumulation in the food chain need to be reduced and controlled. Lead exposure is related to the consumption of birds and birds' gizzards. The levels of exposure noted in Mistissini are not of concern, but the reduction in blood lead levels may be linked to a switch to non-lead containing ammunition and its use must continue to be encouraged in order to reduce the introduction of lead into the environment, and therefore into bird tissue.

Cadmium is primarily an environmental issue because of cigarette smoking (including secondary smoke). Because this metal damages the kidneys and smoking causes respiratory cancer, it is prudent and wise to quit smoking and avoid exposure to second-hand smoke. Certainly the smokers in the present study are at risk of reduced kidney function based on their blood cadmium levels. Although consumption of animal livers and kidneys are a recognized source of cadmium, this is mostly of concern to those with, or susceptibility to, kidney dysfunction. In the current study, cadmium exposure was not significantly related to the consumption of caribou and moose offal and smoking remains the main significant, avoidable source of exposure.

The selenium blood levels observed reflect the consumption of fish and other traditional meats and are adequate for good health. Selenium is essential to our bodies and is believed to protect us from processes linked to the development of cancer and perhaps heart disease. Although too much selenium can be detrimental, the concentrations observed in Mistissini indicate safe levels.

Organochlorines such as PCBs and pesticides accumulate in the traditional food chain, are persistent and stay in the environment and in our bodies for a long time. It is for this reason that the plasma levels found increased strongly with age. Although there are health concerns associated with these compounds, the exact concentrations that affect health are not well established. Although the observed levels in the individuals under 40 years old were relatively low, a careful scrutiny of children and women of reproductive age was called for. They are understood to be the most sensitive subgroups due to the effects of some persistent organic pollutant on development. Although not necessary in the current study, clinical follow-up tests are recommended for them. In terms of the over 40-year group, the establishment of a follow-up protocol requires additional research. Although we have no evidence for ill-health effects in this older group of individuals, they are invited to contact the research team for consultation if they have concerns and, if warranted, there may be a follow-up.

Of the emerging persistent toxic chemicals, perfluorooctane sulfonate (PFOS) was found to be associated with fish consumption, and polybrominated diphenyl ethers and pentachlorophenol were not.

11.4 Health outcomes

The measurements of carotid artery intima media thickness (a measure of blood flow to the brain) provides reassurance that the Cree of Mistissini are relatively well protected against atherosclerosis. A relatively low prevelance of hypertension was also observed, as well as appropriate LDL/HDL and cholesterol/HDL (i.e., bad fat/good fat) ratios. However, the heart rate variability measurements were of some concern. Inflammatory markers of cardiovascular risk factors were also found to be elevated and were associated with obesity, diabetes status and artherosclerosis as measured by ultrasound.

The prevalence of diabetes in the community of Mistissini was 14%, which is high. Women were identified as the 'at risk group'. Impaired fasting glucose in 11% of the participants, and high fasting insulin concentrations were seen in women and young girls. The great majority (79%) of diabetics were obese (i.e., body mass index, BMI $\geq$ 30) while the remaining 21% were overweight (BMI of 25.0-29.9). Diabetes appears to be on the increase and it seems reasonable to assume that cardiovascular disease may follow. More intensive screening and preventive strategies are recommended.

Bone density measurements indicated that the percentage of women with a high risk of bone fracture was low.

11.5 Food and Water Safety

Positive results for a well-known virus and four parasites indicated no or only infrequent exposure to these pathogens. On the other hand, exposure to zoonotic bacteria appears to be more common, but not at unusual levels. Since seroposivity is likely related to fishing, hunting and trapping activities, hunters and trappers need to be aware of the clinical features of these infections, and physicians should also recognize the possibility of zoonotic outcomes.

Some of the drinking water collected during July and August of 2005 tested positive for microbial contamination. However, there is no evidence of effects on health in the community. Concerned residents are advised to boil their water before use when drinking water is obtained from a river or lake.

11.6 Educational activities

Around 200 children participated in at least one workshop. The environmental workshops for youth were organized to stimulate scientific curiosity and to raise awareness about environment-and-health issues and related activities in the community. For example this involved hands-on science projects facilitated by the high school, a cooking/nutrition class, and visits to the local water-treatment plant. Two youths received some laboratory training by Atlantis staff. Although limited in scale, this program was well received.

12. REFERENCES

Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, et al. Compendium of physical activities: an update of activity codes and met intensities. *Medicine and Science in Sports and Exercise.* 2000;**32**(9):S498-S516.

Anand SS, Yusuf S, Jacobs R, Davis AD, Yi Q, Gerstein H, Montague PA, Lonn E. Risk factors, atherosclerosis, and cardiovascular disease among Aboriginal people in Canada: the Study of Health Assessment and Risk Evaluation in Aboriginal Peoples (SHARE-AP). *Lancet.* 2001;**358**(9288):1147-1153.

Arctic Monitoring Assessment Programme (AMAP). *Assessment report: arctic pollution issues*. Oslo, Norway: The Programme; 1998; p. 183-371, 373-524, 775-844.

Arctic Monitoring Assessment Programme (AMAP). *AMAP assessment 2002: Human health in the arctic*. Oslo, Norway: The Programme; 2003; p. 31-56, 57-74, 95-105.

Atlas RM. R&D priorities and technical issues for molecular technologies for safe drinking water. OECD Workshop *Molecular Methods for Safe Drinking Water*, Interlaken (Switzerland); 1998.

(http://www.eawag.ch/publications_e/proceedings/oecd/Proceedings.html)

Atmar RL and MK Estes. Diagnosis of noncultivatable gastroenteritis viruses, the human caliciviruses. *Clin Microbiol Rev.* 2001;**14**:15-37.

Ayotte P, Dewailly E, Lambert GH, Perkins SL, Poon R, Feeley M, et al. Biomarker measurements in a coastal fish-eating population environmentally exposed to organochlorines. *Environ Health Perspect*. 2005;**113**(10):1318-24.

Bassett DR Jr. Validity and reliability issues in objective monitoring of physical activity. *Research Quarterly for Exercise and Sport*.2000;**71**(2):30-36.

Bélanger MC, Dewailly E, Berthiaume L, Mirault ME, Julien P. Could a diet rich in omega-3 fatty acids promote insulin-resistance when combined with refined carbohydrates: A study in Inuit of Nunavik. *Canadian Journal of Cardiology.* 2004;**20**(76D).

Belanger MC, Dewailly E, Berthiaume L, Noel M, Bergeron J, Mirault ME, Julien P.Dietary contaminants and oxidative stress in Inuit of Nunavik. *Metabolism.* 2006 Aug;**55**(8): 989-95.

Birnbaum LS, Staskal DF. Brominated flame retardants: cause for concern? *Environ Health Perspect*. 2004;**112**(1):9-17.

Bjorck J, Hellgren M, Rastam L, Lindblad U. Associations between serum insulin and homocysteine in a Swedish population-a potential link between the metabolic syndrome and hyperhomocysteinemia: the Skaraborg project. *Metabolism.* 2006 Aug;**55**(8):1007-13.

Black AE, Goldberg GR, Jebb SA, et al. Critical evaluation of energy intake data using fundamental principles of energy physiology: 2. Evaluating the results of published surveys. *Eur. J. Clin. Nutr.* 1991;**45**:583-599.

Bosch A. Human enteric viruses in the water environment: a minireview. *Int Microbiol*. 1998;**1**:191-196.

Brassard P, Robinson E, Lavallée C. (1993). Prevalence of diabetes mellitus among the James Bay Cree of northern Quebec. *Cmaj.* 1993;**149**(3):303-307.

Braverman LE and Utiger RD. *Werner & Ingbar's. The thyroid: a fundamental and clinical text.Ninth Edition.* (Ninth Edition ed.): Lippincott Williams & Wilkins;2005.

Brouwer A, Morse DC, Lans MC, Schuur AG, Murk AJ, Klasson-Wehler E, et al. Interactions of persistent environmental organohalogens with the thyroid hormone system: mechanisms and possible consequences for animal and human health. *Toxicology and Industrial Health.* 1998;**14**(1-2):59-84.

Bussières D, Ayotte P, Levallois P, Dewailly E, Nieboer E, Gingras S, et al. Exposure of a Cree population living near mine tailings in northern Quebec (Canada) to metals and metalloids. *Arch Environ Health*. 2004;**59**(12):732-41.

Cacciapuoti B, Nuti M, Pinto A, Sabrie AM. Human leptospirosis in Somalia: a serologic survey. *Trans Roy Soc trop Med Hyg.* 1982;**76**:178-182.

Cacciapuoti B, Ciceroni L, Pinto A, Apollini M, Rondinella V, Bonomi U, Benedetti E, Cinco M, Dessai S, Dettori G, et al. Survey on the prevalence of *Leptospira* infections in the Italian population. *Eur J Epidemiol.* 1994;**10**:173-180.

Calvert GM, Sweeney MH, et al. Evaluation of diabetes mellitus, serum glucose, and thyroid function among United States workers exposed to 2,3,7,8-tetrachlorodibenzo-p-dioxin. *Occup Environ Med*. 1999;**56**(4):270-6.

Canaris GJ, Manowitz NR, Mayor G, Ridgway EC. The Colorado thyroid disease prevalence study. *Arch Intern Med.* 2000;**160**(4):526-534.

Centre de prévention et de contrôle des maladies chroniques (Agence de santé publique du Canada). *Le diabète au Canada* (Deuxième édition). Ottawa: Santé Canada; 2002.

Cetinkaya B, Kalender H, Ertas HB, Muz A, Arslan N, Ongor H, Gurcay M. Seroprevalence of coxiellosis in cattle, sheep, and people in the east of Turkey. *Vet Rec.* 2000;**146**:131-136.

Chang GW, J Brill, and R Lum. Proportion of β-D-glucuronidase-negative *Escherichia coli* in human fecal samples. *Appl Environ Microbiol.* 1989;**55**:335-339.

Chauret C, Armstrong N, Fisher J, Sharma R, Springthorpe S, Sattar S. Correlating *Cryptosporidium* and *Giardia* with microbial indicators. *J Am Water Works Assoc.* 1995;**87**:76-84.

Cheek AO, Kow K, Chen J, McLachlan JA. Potential mechanisms of thyroid disruption in humans: interaction of organochlorine compounds with thyroid receptor, transthyretin, and thyroid-binding globulin. *Environ Health Perspect*. 1999;**107**(4):273-8.

Childs JE, Schwartz BS, Ksiazek TG, Graham RR, Leduc JW, Glass GE. Risk factors associated with antibodies to leptospires in inner-city residents of Baltimore: a protective role for cats. *Am J Public Health.* 1992;**82**:597-599.

Chung WY, Chung JKO, Szeto Y, Tomlinson B, Benzie IFF. Plasma ascorbic acid: measurement, stability and clinical utility revisited. *Clinical biochemistry.* 2001;**34**:623-627.

Ciceroni L, Bartoloni A, Pinto A, Guglielmetti P, Barahona HG, Roselli M, Paradisi F. Prevalence of leptospiral infections in humans in Cordillera Province, Bolivia. *Trans Roy Soc Trop Med Hyg.* 1995;**89**:385-386.

Clark JA. The detection of various bacteria indicators of water pollution by a presence-absence test. *Can J Microbiol.* 1969;**15**:771-883.

Connelly PW, Poapst M, Davignon J, Lussier-Cacan S, Reeder B, Lessard R, Hegele RA, Csima A. Reference values of plasma apolipoproteins A-I and B, and association with nonlipid risk factors in the populations of two Canadian provinces: Quebec and Saskatchewan. Canadian Heart Health Surveys Research Group. *Can J Cardiol*. 1999;Apr;**15**(4):409-18.

Côté S, Ayotte P, Dodin S, Blanchet C, Mulvad G, Petersen HS, et al. Plasma organochlorine concentrations and bone ultrasound measurements: a cross-sectional study in peri- and postmenopausal Inuit women from Greenland. *Environ Health.* 2006;**5**:33.

Courteau J. Mortality among the James Bay Cree in Northern Québec 1982-1986. Montréal: McGill University; 1989.

Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, et al. International Physical Activity Questionnaire: 12-country reliability and validity. *Medicine and Science in Sports and Exercise.* 2003;**35**(8):1381-1395.

Cranmer M, Louie S, et al. Exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) is associated with hyperinsulinemia and insulin resistance. *Toxicol Sci*. 2000;**56**(2):431-6.

De Rosa CT, Pohl HR, Williams M, Ademoyero AA, Chou CH, Jones DE. Public health implications of environmental exposures. *Environ Health Perspect.* 1998;**106** Suppl 1: 369-78.

Dastis-Bendala C, De Villar Conde E, Marin-Leon I, Manzanares-Torne L, Perez-Lozano MJ, Cano-Fuentes G, Vargas-Romero J, Pumarola-Suane T. Prospective serological study of leptospirosis in southern Spain. *Eur J Epidemiol*. 1996;**12**:257-262.

Demers RY, Thiermann A, Demers P, Frank R. Exposure to *Leptospira icterohaemorrhagiae* in inner-city and suburban children: a serologic comparison. *J Fam Pract.* 1983;**17**:1007-1011.

Dewailly E, Blanchet C, Gingras S, Lemieux S, Holub BJ. Cardiovascular disease risk factors and n-3 fatty acid status in the adult population of James Bay Cree. *Am J Clin Nutr.* 2002;**76**(1):85-92.

Dewailly E, Château-Degat M, Ékoé J, Ladouceur R. *The State of Cardiovascular Disease and Diabetes in Nunavik*. Québec: Nunavik Regional Board Health and Social Services and Institut national de santé publique du Québec, (in press).

Dewailly E, Nieboer E. Exposure and preliminary health assessments of the Oujé-Bougoumou Cree population to mine tailings residues. Québec: Institut National de Santé Publique du Québec; January 2005.

Dufour AP, Strickland ER, Cabelli VJ. Membrane filter method for enumerating Escherichia coli. *Apply Env Microbiol*. 1981;**41**(5): 1152-1158.

Dumas P, Sandanger TM, Sandau CD, Sjodin A, Ayotte P. Semi-automated method for the determination of 150 persistent organic pollutants in human serum using gas chromatography mass spectrometry (GC-MS) with simultaneous DR-Calux assay. *Organohalogen Compounds*. 2006;**68**:1593-1596.

Edberg SC, Rice EW, Karlin RJ, Allen MJ. *Escherichia coli*: the best biological drinking water indicator for public health protection. *Symp Ser Soc Appl Microbiol*. 2000;**29**:106S-116S.

Ellis J, Oyston PC, Green M, Titball RW. Tularemia. *Clin Microbiol Rev.* 2002;**15**:631-646.

Everard CO, Edwards CN, Everard JD, Carrington DG. A twelve-year study of leptospirosis on Barbados. *Eur J Epidemiol*. 1995;**11**:311-320.

Faine S. Leptospirosis. In M. Sussman (Ed.), *Topley and Wilson's microbiology and microbial infections* (9th edition ed., Vol. Volume 3: Bacterial infections, pp. 849-869). London: Arnold; 1998.

FAO/WHO/UNU Expert Committee. Energy and protein requirements. *World Health Organization, Technical Report Series.* Geneva (Switzerland): World Health Organization; 1985;724.

Feldmann H, Sanchez A, Morzunov S, Spiropoulou CF, Rollin PE, Ksiazek TG, Peters CJ, Nichol ST. Utilization of autopsy RNA for the synthesis of the nucleocapsid antigen of a newly recognized virus associated with hantavirus pulmonary syndrome. *Virus Research.* 1993;**30**:351-367.

Fierens S, Mairesse H, et al. Dioxin/polychlorinated biphenyl body burden, diabetes and endometriosis: findings in a population-based study in Belgium. *Biomarkers.* 2003;**8**(6):529-34.

Fiset P, Woodward E. Q fever. In AS Evans and PS Brachman (Eds), *Bacterial infections of humans: Epidemiology and control*, 3rd ed. New-York: Plenum Medical Books; 1998. p. 583-595.

Gallagher D, Heymsfield SB, Heo M, Jebb S, Murgatroyd P, Sakamoto Y. Body mass index guidelines: Corresponding % Fat Standards Based on Three-Country Study. *International Journal of Obesity*. 1999;**223**:S42-S43.

Gauch HG. *Multivariate analysis in community ecology*. Cambridge UK: University Press; 1982.

Genest J, Frohlich J, Fodor G, McPherson R. (2003). Recommendations for the management of dyslipidemia and the prevention of cardiovascular disease: summary of the 2003 update. *Cmaj.* 2003;**169**(9):921-924.

Glynn AW, Granath F, et al. Organochlorines in Swedish women: determinants of serum concentrations. *Environ Health Perspect.* 2003;**111**(3):349-55.

Gostin LO, Lazzarini Z, Neslund VS, Osterholm MT. Water quality laws and waterborne diseases: *Cryptosporidium* and other emerging pathogens. *Am J Public Health* 2000;**90**:847-853.

Grandjean P, Murata K, Budtz-Jorgensen E, Weihe P. Cardiac autonomic activity in methylmercury neurotoxicity: 14-year follow-up of a Faroese birth cohort. *J Pediatr.* 2004;**144**(2);169-176.

Gray-Donald K, Jacobs-Starkey L, Johnson-Down L. Food habits of Canadians: reduction in fat intake over a generation. *Can J Public Health.* 2000 Sep-Oct;**91**(5):381-5.

Greenberg L, Blake JD, Connell MF. An immunological study of the Canadian Indian. *Can Med Assoc J.* 1957;77:211-216.

Grover SA, Dorais M, Paradis G, Fodor JG, Frohlich JJ, McPherson R, Coupal L, Zowall H. Lipid screening to prevent coronary artery disease: a quantitative evaluation of evolving guidelines. *Cmaj*. 2000;**163**(10):263-1269.

Grun F and Blumberg B. Environmental obesogens: organotins and endocrine disruption via nuclear receptor signaling. *Endocrinology*. 2006;**147**(6 Suppl): S50-5.

Guo SS and Chumlea WC. Tracking of BMI in children in relation to overweight in adulthood. *Am J Clinical Nutrition.* 1999;**70**:145s-148s.

Hallal PC, Victoro CG. Reliability and validity of the International Physical Activity Questionnaire (IPAQ). *Medicine and Science in Sports and Exercise*. 2004;**36**(3):556.

Harris SB, Gittelsohn J, Hanley A, Barnie A, Wolever TM, Gao J, Logan A, Zinman B. The prevalence of NIDDM and associated risk factors in native Canadians. *Diabetes Care.* 1997;**20**(2):185-187.

Heindel JJ. Endocrine disruptors and the obesity epidemic. *Toxicol Sci.* 2003;**76**(2):247-9.

Henriksen GL, Ketchum NS, et al. Serum dioxin and diabetes mellitus in veterans of Operation Ranch Hand. *Epidemiology* 1997;**8**(3):252-8.

Higgins R. Zoonoses en émergence. *Le médecin vétérinaire du Québec*. 1999;**29**:7-13

Hollowell JG, Staehling NW, Flanders WD, Hannon WH, Gunter EW, Spencer CA, Braverman LE. Serum TSH, T(4), and thyroid antibodies in the United States population (1988 to 1994): National Health and Nutrition Examination Survey (NHANES III). *J Clin Endocrinol Metab.* 2002;**87**(2):489-499.

Holvoet P, Peeters K, Lund-Katz S, Mertens A, Verhamme P, et al. Arg123-Tyr166 domain of human ApoA-I is critical for HDL-mediated inhibition of macrophage homing and early atherosclerosis in mice. *Arterioscler Thrombosis Vasc Biol.* 2001;**21**:844-848.

Hoogendoorn EH, Hermus AR, de Vegt F, Ross HA, Verbeek AL, Kiemeney LA, Swinkels DW, Sweep FC, den Heijer M. (2006). Thyroid function and prevalence of anti-thyroperoxidase antibodies in a population with borderline sufficient iodine intake: influences of age and sex. *Clin Chem.* 2006;**52**(1):104-111.

Hornick RB. Tularemia. In Evans AS and Brachman PS (Eds), *Bacterial infections of humans: Epidemiology and control*, 3rd ed. New-York: Plenum Medical Books; 1998. p. 823-837.

Houde M, Martin JW, Letcher RJ, Solomon KR, Muir DC. Biological monitoring of polyfluoroalkyl substances: A review. *Environ Sci Technol*. 2006;**40**(11):3463-73.

Institute of Medicine (IOM) and Food and Nutrition Board (FNB). Dietary Reference Intakes: Applications in dietary assessment. Washington D.C.: National Academy Press; 2000a.

Institute of Medicine (IOM) and Food and Nutrition Board (FNB). Dietary Reference Intakes. Applications in dietary planning. Washington D.C.: National Academy Press; 2003.

Institute of Medicine (IOM) and Food and Nutrition Board (FNB). Dietary reference intakes for Calcium, Magnesium, Vitamin D, and Iodine. Washington D.C.: National Academy Press; 1997.

Institute of Medicine (IOM) and Food and Nutrition Board (FNB). (2005) Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (Macronutrients). Washington D.C.: National Academy Press; 2005.

Institute of Medicine (IOM) and Food and Nutrition Board (FNB). Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B6, Folate, Vitamin B12, Pantothenic Acid, Biotin, and Choline. Washington D.C.: National Academy Press; 1998.

Institute of Medicine (IOM) and Food and Nutrition Board (FNB). Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Washington D.C.: National Academy Press; 2000b.

Institute of Medicine (IOM) and Food and Nutrition Board (FNB). Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids. Washington D.C.: National Academy Press; 2000c.

IPAQ. Guidelines for data processing and Analysis of the International Physical Activity Questionnaire (IPAQ) – Short and Long Forms November 2005 http://www.ipaq.ki.se/dloads/IPAQ%20LS%20Scoring%20Protocols_Nov05.pdf accessed Feb 28 2005

IPAQ. International Physical Activity Questionnaire. Retrieved February 1, 2005, from http://www.ipaq.ki.se/IPAQ.asp?mnu_sel=BBA&pg_sel=JJA

Jahns L, Arab L, Carriquiry A, and Popkin B.M. The use of external within-person variance estimates to adjust nutrient intake distributions over time and across populations. *Public Health Nutrition*. 2004;**8**(1):69–76.

Koopman-Esseboom C, Morse DC, Weisglas-Kuperus N, Lutkeschipholt IJ, Van Der Paauw CG, Tuinstra LGMT, et al. Effects of dioxins and polychlorinated biphenyls on thyroid hormone status of pregnant women and their infants. *Pediatrics Research*. 1994;**36**(4):468-473.

Ksiazek TG, Peters CJ, Rollin PE, Zaki S, Nichol S, Spiropoulou C, Morzunov S, Feldmann H, Sanchez A, Khan AS, et al. Identification of a new North American hantavirus that causes acute pulmonary insufficiency. *Am J Trop Med Hyg*. 1995 Feb;**52**:117-23.

Kuczmarski RJ, Flegal KM. Criteria for definition of overweight in transition: background and recommendations for the United States. *Am J Clin Nutr.* 2000;**72**(5):1074-1081.

Lamarche B, St-Pierre AC, Ruel IL, Cantin B, Dagenais GR, Despres JP. A prospective, population-based study of low density lipoprotein particle size as a risk factor for ischemic heart disease in men. *Can J Cardiol*. 2001 Aug;**17**(8):859-65.

Lane NE. Epidemiology, etiology, and diagnosis of osteoporosis. *Am J Obstet Gynecol*. 2006;**194** Suppl 2:S3-11.

Langer P. Review: persistent organochlorinated pollutants (POPs) and human thyroid – 2005. *Endocr Regul*. 2005;**39**(2):53-68.

Leiter LA, Genest J, Harris SB, Lewis G, McPherson R, Steiner G, Woo V, Lank CN, and Committee, f. t. C.D.A.C.P.G.E. Dyslipidemia in Adults with Diabetes. *Canadian journal of diabetes.* 2006;**30**(3):230-240.

Lemarchand K, Lebaron P. Occurrence of *Salmonella* spp. and *Cryptosporidium* spp. in a French coastal watershed: relationship with fecal indicators. *FEMS Microbiol Lett.* 2003;**218**: 203-209.

Lepage G, Roy CC. Direct transesterification of all classes of lipids in a one-step reaction. *J Lipid Res*. 1986;**27**:114-120

Lévesque B, De Serres G, Higgins R, D'Halewyn MA, Artsob H, Grondin J, Major M, Garvie M, Duval B. Seroepidemiologic Study of Three Zoonoses (Leptospirose, Q Fever, and Tularemia) among Trappers in Québec, Canada. *Clinical and Diagnostic Laboratory Immunology*. 1995;**2**:496-8.

Lindsay R, Meunier PJ, editors. Osteoporosis International. *Osteoporos Int*. 2000;**11** Suppl:1-64.

Lleo MM, Bonato B, Tafi MC, Signoretto C, Boaretti M, Canepari P. Resuscitation rate in different enterococcal species in the viable but non-culturable state. *J Appl Microbiol.* 2001;**91**:1095-1102.

Lleo MM, Pierobon S, Tafi MC, Signoretto C, Canepari P. mRNA detection by reverse transcription-PCR for monitoring viability over time in an *Enterococcus faecalis* viable but nonculturable population maintained in a laboratory microcosm. *Appl Environ Microbiol*. 2000;**66**:4564-4567.

Loge FJ, Thompson DE, Call DR. PCR detection of specific pathogens in water: a risk-based analysis. *Environ Sci Technol*. 2002;**36**:2754-2579.

Longnecker MP, Daniels JL. Environmental contaminants as etiologic factors for diabetes. *Environ Health Perspect.* 2001;**109** Suppl 6:871-6.

Longnecker MP, Michalek JE. Serum dioxin level in relation to diabetes mellitus among Air Force veterans with background levels of exposure. *Epidemiology*. 2000;**11**(1): 44-8.

Longnecker MP, Taylor PR, Levander OA, Howe M, Veillon C, McAdam PC, Patterson KY, Holden JM, Stampfer MJ, Morris JS, Willett WC. Selenium in diet, blood and toenails in relation to human health in a seleniferous area. *Am. J Clin. Nutr.* 1991;**53**:1288-94.

Lonn E. Use of carotid ultrasound to stratify risk. *Can J Cardiol.* 2001;**17** Suppl A, 22A-25A.

Lopez A, Dietz V, Wilson M, Navin JR, Jones JL. Preventing congenital toxoplasmosis. *MMWR Recomm Rep.* 2000,**49**(RR-2):59-68.

Loukaides F, Hadjichristodoulou C, Soteriades ES, Kolonia V, Ioannidou MC, Psaroulaki A, Tselentis Y. Active surveillance of Q fever in human and animal population of Cuprus. *BMC Infect Dis.* 2006;**6**:48.

Lunar Corporation. Achille+ ultrasound bone densitometer: parts list and specifications. Madison Wisconsin: The Corporation; 1995.

Marrie TJ, Haldane EV, Faulkner RS, Kwan C, Grant B, Cook F. The importance of *Coxiella burnetii* as a cause of pneumonia in Nova-Scotia. *Can J Public Health.* 1985;**76**:233-236.

Marrie TJ, Raoult D. *Coxiella Burnetii.* In Mandell GL, Bennett JE and Dolin R (Eds), *Mandell, Douglas and Bennett's principles and practices of infectious disease,* 6th Ed., Churchill Livingstone; 2004. p. 2296-2303.

Marshall AL. Measuring physical activity in urban indigenous Australians: final report 2004. Brisbane: The University of Queensland.

(http://www.health.gov.au/internet/wcms/publishing.nsf/Content/health-pubhlth-strateg-active-links.htm-copy3/$File?indigenous.pdf

Martin T, Holmes IH, Wobeser GA, Anthony RF, Greefkes I. Tularemia in Canada with a focus on Saskatchewan. *Can Med Assoc J*. 1982;**127**:279-82.

Meigs JB, Jacques PF, Selhub J, Singer DE, Nathan DM, Rifai N, D'Agostino RB Sr, Wilson PW. Framingham Offspring Study. Fasting plasma homocysteine levels in the insulin resistance syndrome: the Framingham offspring study. *Diabetes Care*. 2001 Aug;**24**(8):1403-10.

Meisinger C, Baumert J, Khuseyinova N, Loewel H, Koenig W. Plasma oxidized low-density lipoprotein, a strong predictor for acute coronary heart disease events in apparently healthy, middle-aged men from the general population. *Circulation*. 2005 Aug 2;**112**(5):651-7.

Ministère de la Santé et des Services Sociaux du Québec. Surveillance de la mortalité au Québec: Année 1996. (Surveillance of mortality in Quebec: year 1996.). Québec: Gouvernement du Québec; 1998.

Mongeau L, Audet N, Aubin J, Baraldi R. *L'excès de poids dans la population québecoise de 1987 à 2003*. Québec: INSPQ; 2005.

Moore B. Scientific services in the water industry: public health aspects. *Water Treat Exam*. 1974;**23**:269-274.

Mumford CF. Leptospirosis and water sports. *Br J Hosp Med.* 1989;**41**:519.

NAMS: Management of osteoporosis in postmenopausal women: 2006 position statement of The North American Menopause Society. *Menopause*. 2006;**13:**340-67.

Nash JQ, Chissel S, Jones J, Warburton F, Verlander NO. Risk factors for toxoplasmosis in pregnant women in Kent, United Kingdom. *Epidemiol Infect*. 2005;**133**:475-83.

Niang M, Parola P, Tissot-Dupont H, Baidi L, Brouqui P, Raoult D. Prevalence of antibodies to *Rickettsia conorii, Rickettsia africae, Rickettsia typhi* and *Coxiella burnetii* in Mauritania. *Eur J Epidemiol.* 1998;**14**:817-818.

Northern Contaminants Program (NCP). Canadian arctic contaminants assessment report II: highlights and contaminant levels, trends and effects in the biological environment. Ottawa, Canada: Ministry of Indian Affairs and Northern Development; 2003.

Okabayashi T, Hasebe F, Samui KL, Mweene AS, Pandey SG, Yanase T, Muramatsu Y, Ueno H, Morita C. Short report: prevalence of antibodies against spotted ferver, murine typhus, and Q ferver rickettsiae in humans living in Zambia. *Am J Trop Med Hyg.* 1999;**61**:70-72.

Oliver JD, Bockian R. *In vivo* resuscitation, and virulence towards mice, of viable but nonculturable cells of *Vibrio vulnificus*. *Appl Environ Microbiol.* 1995;**61**:2620-2623.

Oliver JD, Hite F, McDougald D, Andon NL, Simpson LM. Entry into, and resuscitation from, the viable but nonculturable state by *Vibrio vulnificus* in and estuarine environment. *Appl Environ Microbiol*. 1995;**61**:2624-2630.

Olyphant GA, Whitman RL. Elements of a predictive model for determining beach closures on a real time basis: the case of 63rd Street Beach Chicago. *Environmental Monitoring Assessment*. 2004;**98**(1-3):175-90.

Olyphant GA. Statistical basis for predicting the need for bacterially induced beach closures: Emergence of a paradigm. *Water Res.* 2005;**30**(20): 4953-60.

Onyemelukwe NF. A serologic survey for leptospirosis in the Enugu area of eastern Nigeria among people at occupational risk. *J Trop Med Hyg.* 1993;**96**:178-182.

Orcel P. Facteurs de risque et prévention de l'ostéoporose post-ménopausique. Revue du praticien (Paris) 1995;**45**:1107-13.

Papandreou D, Mavromichalis I, Makedou A, Rousso I, Arvanitidou M. Reference range of total serum homocysteine level and dietary indexes in healthy Greek schoolchildren aged 6-15 years. *Br J Nutr*. 2006 Oct;**96**(4):719-24.

Pascual-Velasco F, Montes M, Marimon JM, Cilla G. High seroprevalence of *Coxiella burnetii* infection in Eastern Cantbria (Spain). *Inter J Epidemiol.* 1998;27:142-145.

Pauwels A, Cenijn PH, Schepens PJ, Brouwer A. Comparison of chemical-activated luciferase gene expression bioassay and gas chromatography for PCB determination in human serum and follicular fluid. *Environ Health Perspect*. 2000;**108**(6):553-7.

Pesatori AC, Zocchetti C, et al. Dioxin exposure and non-malignant health effects: a mortality study. *Occup Environ Med.* 1998;**55**(2):126-31.

Philip RN, Huntley B, Lackman DB, Comstock GW. Serologic and skin test evidence of tularemia infection among Alaskan Eskimos, Indians and Aleuts. *J Infect Dis*. 1962;**110**:220-30.

Piché ME, Lemieux S, Weisnagel SJ, Corneau L, Nadeau A, Bergeron J. Relation of high-sensitivity C-reactive protein, interleukin-6, tumour necrosis factor-alpha, and fibrinogen to abdominal adipose tissue, blood pressure, and cholesterol and triglyceride levels in healthy postmenopausal women. *Am J Cardiol.* 2005;1;**96**(1):92-7.

Pirro M, Bergeron J, Dagenais GR, Bernard PM, Cantin B, Despres JP, et al. Age and duration of follow-up as modulators of the risk for ischemic heart disease associated with high plasma C-reactive protein levels in men. *Arch Intern Med*. 2001;**161**(20):2474-80.

Pollex RL, Hanley AJ, Zinman B, Harris SB, Khan HM, Hegele RA. Metabolic syndrome in aboriginal Canadians: prevalence and genetic associations. *Atherosclerosis.* 2006;**184**(1):121-129.

Pols MA, Peeters PHM, Kemper HCG, Grobbee DE. Methodological aspects of physical activity assessment in epidemiological studies. *European Journal of Clinical Nutrition*. 1998;**14**(1):63-70.

Pommepuy M, Butin M, Derrien A, Gourmelon M, Colwell RR, Cormier M. Retention of enteropathogenicity by viable but nonculturable *Escherichia coli* exposed to seawater and sunlight. *Appl Environ Microbiol*. 1996;**62**: 4621-4626.

Pruzzo C, Tarsi R, Lleo MM, Signoretto C, Zampini M, Colwell RR, Canepari P. *In vitro* adhesion to human cells by viable but nonculturable *Enterococcus faecalis*. *Curr Microbiol.* 2002;**45**:105-110.

Rahman I, Shahamat M, Chowdhury MAR, Colwell RR. Potential virulence of viable but nonculturable *Shigella dysenteriae* type 1. *Appl Environ Microbiol.* 1996;**62**:115-120.

Rahman I, Shahamat M, Kirchman PA, Russek-Cohen E, Colwell RR. Methionine uptake and cytopathogenicity of viable but nonculturable *Shigella dysenteriae* type 1. *Appl Environ Microbiol*. 1994;**60**:3573-3578.

Raine KD. Overweight and Obesity in Canada: A Population Health Perspective. Ottawa: Canadian Institute for Health Information; 2004.

Raoult D, Fenollar F, Stein A. Q fever during pregnancy diagnosis, treatment, and follow-up. *Arch Intern Med.* 2002;**162**: 701-704.

Ratnam S, Everard CO, Alex JC, Suresh B, Thangaraju P. Prevalence of leptospiral agglutinins among conservancy workers in Madras City, India. *J Trop Med Hyg.* 1993;**96**: 41-45.

Reiff FM, Roses M, Venczel L, Quick R, Witt VM. Low-cost safe water for the world: a practical interim solution. *J Public Health Policy*. 1996;**17**:389-408.

Remillard RB, Bunce NJ. Linking dioxins to diabetes: epidemiology and biologic plausibility. *Environ Health Perspect*. 2002;**110**(9):853-8.

Retnakaran R, Zinman B, Connelly PW, Harris SB, Hanley AJ. Nontraditional cardiovascular risk factors in pediatric metabolic syndrome. *J Pediatr.* 2006;**148**(2):176-182.

Ridker PM, Buring JE, Cook NR, Rifai N. C-reactive protein, the metabolic syndrome, and risk of incident cardiovascular events: an 8-year follow-up of 14 719 initially healthy American women. *Circulation*. 2003 Jan 28;**107**(3):391-7.

Ryan JJ, Dewailly E, Gilman A, Laliberté C, Ayotte P, Rodrigue J. Dioxin-like compounds in fishing people from the lower north shore of the St. Lawrence River, Québec, Canada. *Arch Environ Health.* 1997;**52**(4):309-316.

Rylander L, Rignell-Hydbom A, et al. A cross-sectional study of the association between persistent organochlorine pollutants and diabetes. *Environ Health.* 2005;**4**:28.

Salonen JT, Seppanen K, Lakka TA, Salonen R, Kaplan GA. Mercury accumulation and accelerated progression of carotid atherosclerosis: a population-based prospective 4-year follow-up study in men in eastern Finland. *Atherosclerosis.* 2000;**148**(2):265-273.

Sandau CD, Ayotte P, Dewailly E, Duffe J, Norstrom RJ. Analysis of hydroxylated metabolites of PCBs (OH-PCBs) and other chlorinated phenolic compounds in whole blood from Canadian Inuit. *Environmental Health Perspectives*. 2000;**108**(7):611-6.

Santé Canada. Lignes directrices canadiennes pour la classification du poids chez les adultes - Guide de référence rapide à l'intention des professionnels. 2003.

Santé Québec. *Report of the Santé Québec Health Survey of the James Bay Cree:1991*. Montréal: Ministère de la Santé et des services sociaux, Gouvernement du Québec; 1994.

Schuur AG, Brouwer A, Bergman A, Coughtrie MW, Visser TJ. Inhibition of thyroid hormone sulfation by hydroxylated metabolites of polychlorinated biphenyls. *Chemico-Biological Interactions*. 1998;**109**(1-3):293-7.

Schuur AG, Legger FF, van Meeteren ME, Moonen MJ, van Leeuwen-Bol I, Bergman A, et al. In vitro inhibition of thyroid hormone sulfation by hydroxylated metabolites of halogenated aromatic hydrocarbons. *Chemical Research in Toxicology*. 1998;**11**(9):1075-81.

Schuur AG, van Leeuwen-Bol I, Jong WM, Bergman A, Coughtrie MW, Brouwer A, et al. In vitro inhibition of thyroid hormone sulfation by polychlorobiphenylols: isozyme specificity and inhibition kinetics. *Toxicological Sciences*. 1998;**45**(2):188-94.

Shaikh NA, Downar E. Time course change in porcine myocardial phospholipid levels during ischemia. A reassessment of the lysolipid hypothesis. *Circ Research*. 1981;**49**(2):316-25.

Simon A, Gariepy J, Chironi G, Megnien JL, Levenson J. Intima-media thickness: a new tool for diagnosis and treatment of cardiovascular risk. *J Hypertens.* 2002;**20**(2):159-169.

Sinton LW, Finlay RK, Hannah DJ. Distinguishing human from faecal contamination in water: a review. *N Z J Mar Freshwater Res.* 1998;**32**:323-348.

Snyder MJ. Immune response to Francisella. In Rose NR and Friedman H (Eds.), *Manual of clinical Immunology*, 2nd ed. Washington D.C.: American Society of Microbiology; 1980. pp. 479-81.

Sonnenschein C, Soto AM. An updated review of environmental estrogen and androgen mimics and antagonists. *J Steroid Biochem Mol Biol*. 1998;**65**(1-6):143-50.

Sorensen N, Murata K, Budtz-Jorgensen E, Weihe P, Grandjean P. (1999). Prenatal methylmercury exposure as a cardiovascular risk factor at seven years of age. *Epidemiology.* 1999;**10**(4):370-375.

SPSS version 13. SPSS Inc. 233 S. Wacker Drive, 11th floor Chicago, Illinois, U.S.A. 2006.

Steenland K, Calvert G, et al. Dioxin and diabetes mellitus: an analysis of the combined NIOSH and Ranch Hand data. *Occup Environ Med.* 2001;**58**(10):641-8.

Stewart SJ. Tularemia. In Balows A and Hausler WJ Jr (Eds.), *Diagnostic procedures for bacterial, mycotic, and parasitic infections*, 6th ed. Washington D.C.: American Public Health Association; 1981. pp. 705-14.

Stewart SJ. Tularemia. In Hausler WJ Jr (Ed.), *Diagnostic procedures for bacterial, mycotic, and parasitic infections* (6th ed., pp. 705-714). Washington D.C.: American Public Health Association; 1981.

St-Pierre AC, Ruel IL, Cantin B, Dagenais GR, Bernard PM, Despres JP, et al. Comparison of various electrophoretic characteristics of LDL particles and their relationship to the risk of ischemic heart disease. *Circulation*. 2001;**104**(19):2295-9.

Surks MI, Ortiz E, Daniels GH, Sawin CT, Col NF, Cobin RH, Franklyn JA, Hershman JM, Burman KD, Denke MA, Gorman C, Cooper RS, Weissman NJ. Subclinical thyroid disease: scientific review and guidelines for diagnosis and management. *Jama.* 2004;**291**(2):228-238.

Sylvester DM, Taylor R, LaHann TR. Viable but nonculturable bacteria: a public health threat? *Infect Dis Rev.* 2001;**3**:70-82.

Tabb MM, Blumberg B. New modes of action for endocrine-disrupting chemicals. *Mol Endocrinol*. 2006;**20**(3):475-82.

Talwar D, Ha TKK, Cooney J, Brownlee C, JO'Reilly D. A routine method for the simultaneous measurement of retinol, a-tocopherol and five carotenoids in human plasma by reverse phase HPLC. *Clin Chim Acta.* 1998;**270**(2):85-100.

Tanner CE, Staudt M, Adamowski R, Lussier M, Bertrand S, Prichard RK. Seroepidemiological Study for Five Different Zoonotic Parasites in Northern Quebec. *Canadian Journal of Public Health*. 1987;**78**:262-6.

Task Force of the European society and cardiology and the North American Society of Pacing and Electrophysiology. Heart rate variability, standards of measurement, physiological interpretation, and clinical use. *European Heart Journal.* 1996;**17**.

Tenter AM, Heckeroth AR, Weiss LM. Toxoplasma gondii: from animals to humans. *Int J Parasitol*. 2000;**30**:1217-58.

Touyz R, Feldman R, Tremblay G, Milot A. Hypertension: Recommandations canadiennes 2006. *Bulletin de l'alliance Québécoise pour la santé du cœur.* Été 2006:1-8.

Tremblay MS, Katzmarzyk PT, Wilms JD. Temporal trends in overweight and obesity in Canada, 1981-1996. *International Journal of Obesity*. 2002;**26**(4):538-543.

Tremblay MS, Willms JD. Is the Canadian childhood obesity epidemic related to physical inactivity. *International Journal of Obesity*. 2003;**27**(9):1100-1105.

Tsuji LJS, Wainman BC, Martin ID, Weber J-P, Sutherland C, Nieboer E. Abandoned Mid-Canada Radar Line sites in the western James Bay region of northern Ontario Canada: A source of organochlorines for First Nations people? *Science of the Total Environment*. 2006;**370**:452-466.

U.S. Environmental Protection Agency. Ambient water quality criteria for bacteria - 1986. EPA440/5-84-002. Washington (DC): Office of Water Regulations and Standards Criteria and Standards Division; 1986. 18 p.

U.S. Environmental Protection Agency. Improved enumeration methods for the recreational water quality indicators: enterococci and *Escherichia coli*. EPA/821/R-97/004. Washington (DC): Office of Science and Technology, United States Environmental Protection Agency; 2000a. 49 p.

U.S. Environmental Protection Agency. Method 1623: *Cryptosporidium* and *Giardia* in water by filtration/IMS/FA. EPA 821-R-01-025. Washington (DC): Office of Water (4603), United States Environmental Protection Agency; 2001. 52 p.

U.S. Environmental Protection Agency. Method 1603: *Escherichia coli* (*E. coli*) in water by membrane filtration using modified membrane-thermotolerant *Escherichia coli* agar (modified mTEC), EPA 821-R-02-023 Office of water (20460). Washington (DC): United States Environmental Protection Agency; 2002. 13 p.

U.S. Environmental Protection Agency. National Primary Drinking Water Regulations: Ground Water Rule; Proposed Rules. Washington (DC): Federal Resister 40 CFR Parts 141 and 142; 2000b. 80 p.

U.S. Environmental Protection Agency. Preventing waterborne disease - A focus on EPA's research. EPA/640/K-93/001. Washington (DC): Office of Research and Development, United States Environmental Protection Agency; 1993. 20 p.

Vanderpump MP, Tunbridge WM, French JM, Appleton D, Bates D, Clark F, Grimley Evans J, Hasan DM, Rodgers H, Tunbridge F, et al. The incidence of thyroid disorders in the community: a twenty-year follow-up of the Whickham Survey. *Clin Endocrinol (Oxf)*. 1995;**43**(1):55-68.

Van Oostdam J, Donaldson SG, Feeley M, Arnold D, Ayotte P, Bondy G, et al. Human health implications of environmental contaminants in Arctic Canada: A review. *Sci Total Environ*. 2005;351-352:165-246.

Vasiliu O, Cameron L, et al. Polybrominated biphenyls, polychlorinated biphenyls, body weight, and incidence of adult-onset diabetes mellitus. *Epidemiology.* 2006;**17**(4):352-9.

Wood WJ. A study based on the incidence of positive agglutination tests against *P. tularensis* in the Indian population of Manitoba and North-Western Ontario. *Manit Med Rev.* 1951;**31**: 641-644.

World Health Organization. Assessment of fracture risk and its application to Screening for postmenopausal osteoporosis. WHO Technical Report Series 843. Geneva; The Organization; 1994.

World Health Organization. *Obesity: Preventing and Managing the Global Epidemic*. Report of a WHO Consultation on Obesity 2000. Geneva: World Health Organization.

Young LS, Bicknell DS, Archer BG, Clinton JM, Leavens LJ, Feeley JC, Brachman PS. Tularemia epidemia: Vermont, 1968. Forty-seven cases linked to contact with muskrats. *N Engl J Med.* 1969;**280**(23):1253-1260.

Zimmet P, Alberti KG, et al. Global and societal implications of the diabetes epidemic. *Nature*. 2001;**414**(6865):782-7.

Zimmet P, Magliano D, et al. The metabolic syndrome: a global public health problem and a new definition. *J Atheroscler Thromb* 2005;**12**(6):295-300.