Appendix 4:

Health and Environment Issues with Canada's Aboriginal Communities
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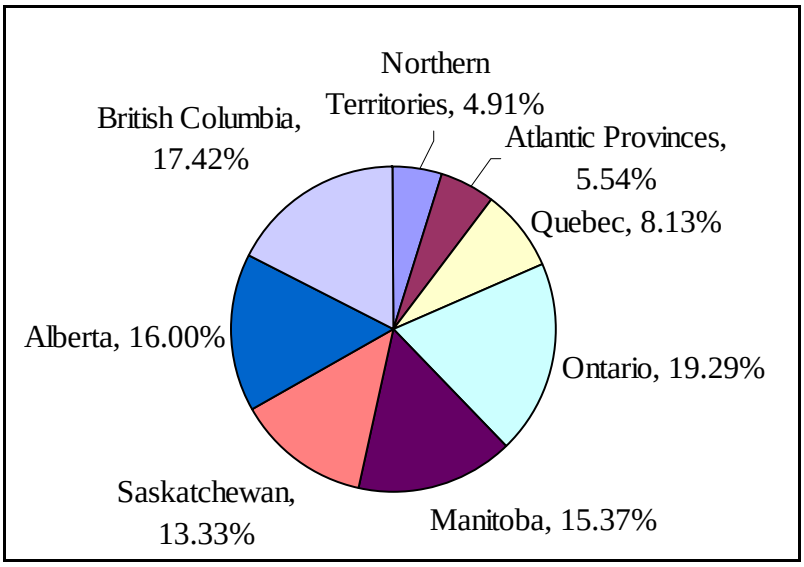
1. Introduction

The objective of this technical paper is to provide a 'snap shot' on a number of health and environmental issues among Aboriginal communities in Canada. Aboriginal people's traditional consumption of wildlife and fish could potentially be a high risk activity due to chemical contaminants in the natural environment. Thus, this paper will focus specifically on the anthropogenic effects of pollution in a Canadian nationwide study of Aboriginal health and the environment. A brief discussion on risk assessment and risk communications is included. The author also made a number of recommendations to facilitate the advancement of Aboriginal Environmental Health Research in Canada. Commissioned by Health Canada and Environment Canada, this paper serves as a Canadian contribution to the Health and Environment Linkages Initiative (HELI) of the World Health Organization.

Information is obtained from primary literature through an extensive search using MEDLINE and PUBMED using the search terms Aboriginal, Indian, Native American, pollution, health, contamination, environment, Canada, neuro, cancer, toxic, great lakes, industry, mining, coasts, fish, bioaccumulation, etc. Grey literature published on the internet is also included.

According to the 2001 Canadian census[1], approximately one million (3.3%) Canadians broadly identified themselves as Aboriginal. Specifically, the Aboriginal population is comprised of 62% First Nations people, 30% Métis, 5% Inuit, and 3% that identified with more than one group. Aboriginal people were found widely throughout Canada with the highest number living in Ontario, Canada's most populous province. However, Aboriginal people in Ontario account for less than 2% of the total provincial population. British Columbia was also host to a large Aboriginal population (170,025 people), which reflected 4.4% of the total BC population. The highest concentration of Aboriginal people was located in the Northern and Prairie regions. Aboriginal people embodied 85% (22,720) of the total population of Nunavut, making Nunavut the jurisdiction most densely populated by Aboriginal people in the country. Aboriginal people represent approximately one-half (51%) of the population of the Northwest Territories, and nearly one-quarter (23%) of the population of the Yukon.

Chart 1: Geographic Distribution of Aboriginal Population across Canada, 2001 [1]



In 2001, close to one-half (49%) of the total Aboriginal population lived in urban areas. Of the remainder, 31% of Aboriginal people lived on Indian reserves and settlements while 19.5% lived in rural non-reserve areas. This paper will focus on Aboriginal people who live on reserves, rural areas or Northern Canada.

Table 1. Population reporting Aboriginal identity, Canada, provinces and territories, 2001[1]

	Total Population	Total Aboriginal Population	Aboriginal Population Density[1]
Canada	30,007,094	976,310	3.25%
Newfoundland and Labrador	512,930	18,780	3.66%
Prince Edward Island	135,294	1,345	0.99%
Nova Scotia	908,007	17,015	1.87%
New Brunswick	729,498	16,990	2.33%
Quebec	7,237,479	79,400	1.10%
Ontario	11,410,046	188,315	1.65%
Manitoba	1,119,583	150,040	13.40%
Saskatchewan	978,933	130,190	13.30%
Alberta	2,974,807	156,220	5.25%
British Columbia	3,907,738	170,025	4.35%
Yukon Territory	28,674	6,540	22.81%
Northwest Territories	37,360	18,725	50.12%
Nunavut	26,745	22,720	84.95%

Environmental health issues that are of great concern to Aboriginal peoples include the safety of drinking water, chemical contaminants in traditional food supply, water and soil contamination, indoor air quality and household mold. The aim of this paper is to identify the linkages between Aboriginal health and environmental chemical contaminants to better understand the direct and indirect consequences of chemical pollution in the food and water supply. Therefore, hygiene and sanitation of the water supply as well as household mold are beyond the purview of this paper. Instead, a diversity of regional environmental contaminant issues will be examined as pertaining to the health and well being of Canadian Aboriginal populations.

2. Major Health Issues

The health status of Aboriginal peoples is generally below the Canadian average. There is a significant gap of 6.1 years in life expectancy between the First Nations peoples and Canadian populations in 2001. Ischemic heart disease was the most common cause of death for First Nations adults ages 45-64 (17%) and for those 65 and older (20%). On an age-standardized basis, the First Nations and Inuit rate for heart disease was approximately three times higher than that of the Canadian population. This was similar for diagnosed high blood pressure as the rate of hypertension in First Nations and Inuit males and females were 2.8 and 2.5 times higher than the Canadian population, respectively[2, 3]. Cancer is a leading cause of death for the First Nations after circulatory diseases, injury and poisoning. The First Nations mortality rate for all cancers in 1999 was 141.5 deaths per 100,000, as compared to 186.5 for non-Aborginal Canada, men and women combined[4]. In 1999, the infant mortality rate was 8.0 deaths per 1,000 live births among First Nations, which exceeds the Canadian rate of 5.3 by 1.5 times[5]. In 1999, 22% of the 8,125 recorded First Nations births were classified at a high birth weight. This rate is nearly double the Canadian incidence of 12.2% high birth rate during the period 1992 to 1996[6]. However, First Nation low birth weights (6.0%) were similar to the Canadian rate of 5.6%. Despite the statistical similarity with the Canadian rate, low birth weight has been considered a much more serious problem for First Nations communities because it is often a precursor of infant mortality[6]. Both high and low birth weights place infants at a higher risk for developing neurological and intellectual deficits[7].

MacMillan et al.[6] report in the FNIRHS that the most frequently reported disorder for all ages and both genders were ear problems (15%), followed, in decreasing frequency, by allergies (13%), asthma (12%), bronchitis (7%) and overweight problems (7%). In 2000, Otitis media was the most frequent disease for Inuit infants from Nunavik (Arctic Quebec, Canada), with 80% of breast-fed and 81.3% of bottle-fed infants experiencing at least one episode during the first year of life[8]. It has been found that Aboriginal children generally have a weakened immune system as compared to non-Aboriginals.

Before the 1950s, type 2 diabetes was uncommon in Aboriginal populations. Within the past 2 decades a rapid increase in prevalence has been documented in regions with continuous surveillance such as the Sioux Lookout Zone of northwestern Ontario and in Saskatchewan[9]. In Sioux Lookout, the prevalence increased by 45% over a 10-year period and in Saskatchewan the rate doubled between 1980 and 1990[10, 11]. Nationally, there is more than a 5-fold risk of death

from diabetes among women residents on reserves compared to the general Canadian population[12]. However, the prevalence of diabetes is regionally specific, and inconsistent in prevalence east to west and north to south[13]. Diabetes also varies according to language group, culture area, geographic location and degree of isolation, nationally and regionally [14, 15].

There is increasing prevalence of type 2 diabetes observed in children and adolescents[16]. In the year 2000, 22% of total live First Nations births were born equal to, or greater than, 4000 grams as compared to 12.2% in Canada[17] . High birth weight is a strong predictor of gestational diabetes in newborns, which predisposes future diabetes[18]. It has been shown that nearly 13% of pregnancies among Aboriginal women in northern Ontario and Quebec with gestational diabetes have had possible complications[19].

The prevalence of suicide is significantly higher in health regions with high aboriginal populations[20]. It has been suggested that a primary cause of mental illness, particularly in young men, is may be in part due to the deteriorating environment and consequent loss of traditional roles and values associated with community hunting and fishing[21, 22].

In summary, nationwide statistics indicate that the greatest distinction between Aboriginal people and their Canadian counterparts is a higher incidence of heart disease, high blood pressure, kidney cancer in men, cervical and pancreas cancer in women, diabetes, high birth weight and infant mortality. In addition, children are seemingly immunocompromised exhibiting a higher incidence of otitis media and longer hospital stays than Non-Aboriginal Canadian children. Because health is the product of many variables (e.g. the physical environment, lifestyle and genetic makeup of a population), understanding the Aboriginal physical environment and lifestyle may help to better illustrate why this population suffers from certain ailments more so than the general population.

3. Summary of Environmental Issues

Increasing global industrialization, especially in the last 50 years, has caused pollution of all of the world's ecosystems. This has left First Nations and Inuit at particularly high risk for environmental contaminant exposure because of their subsistence lifestyle and traditional diet. Primary health concerns for contaminant exposure are cancer (arsenic, organochlorines, dioxin, radionuclides), neurological development (lead, mercury, organochlorines), immune function (organochlorines, mercury), diabetes (dioxin), anemia (lead), kidney and bone function (cadmium), and reproduction (organochlorines)[4, 23-25]. Persistent contaminants are detected throughout northern and Arctic ecosystems - in air, fresh water, seawater, snow, sediments, birds, fish, plants, and terrestrial and sea mammals [4, 23, 26-29]. Contaminants may impact locally or be deposited widely through atmospheric, marine, freshwater or terrestrial routes.

The local/regional point sources are primarily related to mineral extraction and tailing disposal (particularly heavy metals such as mercury and arsenic), local geology (such as mercury and cadmium), abandoned military and sites (PCBs), pesticide use (e.g. DDT and toxaphene)[13, 30, 31], and industry effluents (heavy metals, PCBs and dioxin). In addition, development of a hydroelectric project or soil erosion due to clear cut forestry may lead to an increase in mercury

in the aquatic ecosystem. Most radionuclide contaminants are the result of nuclear testing or contaminant release from nuclear power stations, nuclear satellites or abandoned mine sites[26].

Even small amounts of these contaminants in the environment may be a threat depending on their accumulation through food species. The bioavailability of contaminants found in soils, sediments, plants, or water is dependent on factors such as concentration, physical and chemical forms, and physicochemical factors, for example, pH and organic-carbon content. Once an organism in the food chain assimilates a contaminant, it can either be subject to bioaccumulation or it can facilitate the transfer of the contaminant to another organism. Factors that influence bioaccumulation include inertness of the chemical, solubility in lipid or water, and speciation for metals. In addition, human consumption of contaminants is dependent on the length of the food chain and the number of species that the contaminant passes through; this process is otherwise known as biomagnification, the successive buildup of a chemical contaminant through the foodchain.

The highest degree of biomagnification occurs in a predator-prey interaction such as the consumption of fish by marine mammals or sea birds[28, 32]. The toxicity of contaminants present in marine, freshwater, or terrestrial wild food species consumed differs according to environmental and biological variability. Mercury and toxaphene are considered among the most important contaminants in freshwater fish, marine fish, and mammals. In addition, cadmium is a significant contaminant in the liver and kidney of important food land mammals such as caribou and moose, and of shellfish. The organochlorides DDT, PCBs and chlordane are significant contaminants of piscivorus marine mammals, waterfowl and their eggs, while radionuclides are mostly found in caribou.

Regional differences regarding the level of the contamination of country/traditional food species depends on local mineralogy and mining, military radar sites, and proximity to heavy industrialization (e.g. the Great Lakes and St. Lawrence estuary). More local differences in contamination rely on the ages and genders of the animals. For example, older, larger animals contain greater concentrations of contaminants, and male animals generally accumulate more organochlorines than do young-bearing female animals[28, 33, 34] .

With changes in the world economy, Aboriginal People have expanded the scope of their communities to take advantage of resources beyond those available in their local environments. However, the extent of economic development and cultural transformation in these communities has not been consistent. Although many still rely on their traditional food resources, much of their diet is being replaced with market food [35].

The transition to market food is not only a result of the transition to a more consumer-based society, but could also due to environmental contamination. A good example is the increase of mercury in the fish in the James Bay area due to the hydro-electric development in the 1970s. This led to the virtual disappearance of fish in the local diet which in turn is believed to be a major factor for the high risks for obesity, hypertension and diabetes mellitus among the Crees in the area[36].

Perceptions of changes and the disruption of the special relationship that Aboriginal people perceive themselves to have with the environment can also have impacts on their social, cultural, spiritual and economic well-being. These qualitative impacts are not easily measured with standard social indicators[37, 38]. Activities such as hunting, fishing, and gathering of wild resources are important to strengthening and maintaining the social fabric among individuals, families and generations within a community[23]. In a study by Kuhnlein et al.[39], adult Inuit of the Canadian Arctic believe that harvesting and using traditional/country food provide a number of benefits such as physical fitness, community well-being and the dissemination of cultural knowledge such as survival skills and lessons in food preparation.

Despite the direct health risks associated with consuming contaminated traditional/country food, there are potentially even greater risks stemming from the loss of this very important component of Aboriginal tradition. It is generally feared that radical dietary changes will result in the loss of traditions that have kept these communities cohesive and healthy.

4. Environmental threats on Aboriginal Communities

Canadian Aboriginal communities from different geographical areas face their own unique environmental problems due to the nature of the point sources and the degree to which their diet is obtained from subsistence living. In this paper, environmental concerns among Aboriginal communities are divided into 4 main regions; The Great Lakes, Arctic, Coastal and mid-Canada. The Great Lakes region includes communities along the shores of Lake Ontario, Lake Erie, Lake Huron, Lake Superior and the St. Lawrence River in Ontario and Quebec. Arctic communities are represented in the Yukon, Northwest Territories, Nunavut and Northern Quebec (Nunavik). Coastal communities are found along the coast of Labrador, British Columbia and the Maritime provinces. Finally, mid Canada, the Boreal Forest and the Pairies, include communities in the northern rural areas of the provinces.

a. Great Lakes

The southern Great Lakes are home to an abundance of agricultural and industrial activities. Due to the nature of these industries, this region harbors excessive amounts of toxic chemicals, such as PCB and mercury, resulting from the use and release of these contaminants[40] . The Great Lakes provinces and states use millions upon millions of kilograms of pesticides every year, including toxins known to be endocrine disruptors, carcinogens, and reproductive toxins that leach into the groundwater, often at levels exceeding health risk limits[41] . However, environmental pollution control efforts in the last 20 years have lowered the levels of pollutants in the Great Lakes environment[40]. In addition, many Aboriginal communities have decreased consumption of traditional food due to urbanization and fear of contaminant exposure. As health concerns regarding the direct, visible impacts of environmental contaminants decline, new health concerns have emerged regarding the more indirect impacts of contaminants on people and the environment.

The EAGLE (Effects on Aboriginals from the Great Lakes Environment) Project began in 1990 as a comprehensive study designed to explore physical health, effects of contaminants on

traditional resource-based activities and the resulting socio-cultural well-being of First Nations people and communities of First Nations in the Great Lakes environment[42]. The EAGLE project provided a comprehensive overview of contaminant issues faced by the First Nation communities in the Great Lakes area. However, there was little follow up to monitor these communities with the exception of research activities conducted by the Mohawk Nation of Akwesasne in Lake Ontario[1]. In addition, the Saint Lawrence 2000 program that also began in the late 90s, supported studies along the St. Lawrence River in Quebec. It was found overall that environmental control measures have taken effect resulting in declining levels of contaminants in fish in recent years[41] . However, results are site specific and although exposure was found to be low in some communities such as the Mohawk Nation of Kanawake, it was still high among other communities in the North Shore of the Gulf of St. Lawrence[43].

The greatest potential for human exposure to toxic substances in the Great Lakes is due to the consumption of fish. Fish consumption presents the greatest risk of toxicity as compared to other activities such as drinking tap water or swimming, given the high concentrations of contaminants in sport fish in the Great Lakes area. Therefore, Quebec and Ontario governments have strict guidelines regarding fish originating from the Great Lakes with primary concern for PCB and mercury. However, because there is no information documenting the number of Aboriginal peoples consuming fish, there is no approximation as to the number of those exceeding the guideline levels.

b. Arctic

Environmental contaminants such as organochlorines and heavy metals are found in the Arctic environment as a result of long-range atmospheric and oceanic transport, as well as local sources such as mining activities, old Distance Early Warning lines and other military sites[26]. Studies conducted on contaminant movement and accumulations in northern ecosystems have shown that subsistence fishers and hunters of marine mammals are particularly at risk because of their reliance on animals high in the food web[6, 15, 16, 18, 43-47]. In response to international studies that show the presence of long-range contaminants in the Arctic, the Northern Contaminant Program (NCP) has supported extensive study of the Arctic over the past 10 years. Through this research it has been found that many contaminants present in animals at the top of the Arctic food chain and in humans do not have Arctic sources.

Aboriginal populations have since been monitored for contaminant exposure with extensive dietary exposure assessment and body burden measurement[48]. The Inuit who consume marine mammals have the highest risk of organochlorine and mercury exposure. Detailed strategic plans have been developed by the partners of the NCP to continue monitoring the situation and to initiate a cohort study to investigate the relationship between contaminants and health effects among the Inuit. The most recently funded initiative, ArcticNet, will also contribute to the health study among the Inuit communities.

The threat of radionuclides exposure is generally low[48]. However, in the community of Deline there is some local concern in respect to radionuclides because of uranium tailing.

c. Coasts

Relatively little information is available regarding the environmental health of coastal Aboriginal communities. The most informative studies have been directed at monitoring the dietary patterns of different communities and are used to extrapolate the level of contamination in foods. The Centre for Indigenous Peoples' Nutrition and Environment (CINE) has conducted a detailed dietary study in four communities along the coast of Labrador[39] and 2 communities in the Bay of Fundy[49]. The main species of fish consumed by the coastal communities are salmon, cod, haddock, halibut, and sole, all of which have very low levels of contaminants. Therefore, health risks associated with consuming local fish are generally low. There is no comparable information available for coastal communities in British Columbia. There are some concerns on the elevated levels of cadmium found in shellfish such as oysters, clams and mussels[50]; however, there is no dietary information or body burden data to characterize the risk among the Aboriginal communities. There are also concerns regarding point source pollution due to local industry, e.g. an aluminum plant located at the head of Kitimat Arm, British Columbia that has been discharging polyaromatic hydrocarbon (PAH). Elevated levels were found in dungeness crabs; however, the health impact to the people of the nearby Haisla First Nation has not been characterized. There was a preliminary study investigating dioxin and furan exposure in a coastal community but the exposure data were not available[51].

d. Mid-Canada

Most of the major cities in Canada are located within 100 km of the US border, while most of the Aboriginal reserves are located in the vast area of the northern and rural areas of the provinces. Despite their often isolated northern location, these Aboriginal communities and their traditional hunting and fishing grounds often share the burden of the majority of Canada's resource based industry. This industry threatens the safety of traditional food for these communities as industrial effluents create major point sources of environmental pollution that permeate into community hunting and fishing grounds through local and long-range transport. Major anthropogenic activities and their associated contaminants include: a) Mining (heavy metals); b) pulp and paper (PAH and dioxin); c) forestry (polychlorophenol, PCP, mercury); d) hydroelectric projects (mercury); and e) incinerator facilities (PCB, dioxin, mercury). Localized point sources in and around the communities include local dump sites (heavy metals), industrial abandoned sites (PCB and heavy metals) and local garbage incinerators (dioxin).

5. Linkages between environmental threats and health outcomes

As described in the previous sections, anthropogenic activities feed local and long-distance chemical pollutants into the environment, which are bioaccumulated, biomagnified, and eventually consumed by Aboriginal communities. Currently, there are no conclusive reports of deleterious effects among Aboriginal peoples as a result of consuming traditional food. However, there is some epidemiological evidence that exposure of contaminants at levels found in some traditional food may result in adverse health effects in humans, particularly during early development.

Neurobehavioral studies have shown that subtle changes in performance, measured in exposed populations represent both warning signs of possible increased risk for future illness and diminished capacity with potential long lasting effects. For example, increased lead exposure *in*

utero is associated with a decrease in children's intellectual ability and an increase in adolescent delinquent behaviour[52, 53] .

Neurobehavioral effects have been recognized as a result of prenatal exposure of PCBs from consumption of contaminated fish. Two prospective longitudinal studies, one in North Carolina and the other in Michigan have investigated PCB exposure most extensively[54]. The North Carolina study found poorer gross motor function during infancy in relation to prenatal PCB exposure; the Michigan study found poorer infant visual-recognition memory. However, cognitive deficits found at 4 years of age in Michigan were not seen in North Carolina, possibly owing to a different pattern of exposure or a different congener mix.

Two other controlled, longitudinal studies investigated effects of prenatal Hg exposure from seafood consumption on child neurodevelopment[55-57]. The first study, conducted in the Republic of Seychelles, showed that no adverse outcomes at 66 months were associated with either prenatal or postnatal methyl mercury exposure. The second study, conducted in the Faeroe Islands, showed that children whose mothers had a hair Hg concentration of 10–20 ppm showed mild decrements in the domains of motor function, language, and memory. Studies of infants in Nunavik have shown that that prenatal exposure to PCB can affect their neurodevelopment and performance[58, 59].

The exposure and effects of mercury (Hg) have been tested ranging from the initial research in Minamata and Niigata, Japan in the 1950s[60] to remote population groups in the Amazon in the 1990s[61-63]. Testing for neurobehavioral outcomes have proven useful in detecting the early effects of Hg in adults. Subtle changes in nervous system functions can have important repercussions on a community in terms of learning capacities, behaviour and adaptation to stress. In addition, a negative association was observed between neurobehavioral outcomes and PCB and DDE body burden in a population in Northern Ontario (D. Mergler, personal communications).

Recently, a case–control study conducted in eight European countries and Israel (684 men with a first diagnosis of myocardial infarction and 724 men as control) showed that toenail Hg level was directly associated with the risk of myocardial infarction, and high Hg content may diminish the cardioprotective effect of fish intake[64] . However, another study published in the same issue of the journal reported contradictory results and found no association between Hg in toenail and risk of coronary heart diseases using a nested case–control study with 33,737 male health professionals between 40 to 75 years of age[65] . Further studies are clearly needed. However, there are no data on toenail Hg levels available in among Aboriginal peoples in Canada for comparison.

Dewailly et al.[43] reported that otitis media increased with prenatal exposure to insecticides p,p'-DDE, hexachlorobenzene, and dieldrin among Inuit children. The authors concluded that prenatal organochlorine exposure could be a risk factor for acute otitis media in Inuit infants.

The evidence for environmental chemicals causing cancer is unequivocal with the exception of arsenic and radiation exposure. Swallowing arsenic has been reported to increase

the risk of cancer in the liver, bladder, kidneys, prostate, and lungs[66] . The International Agency for Research on Cancer (IARC) has determined that inorganic arsenic is carcinogenic to humans and both the EPA and the National Toxicology Program (NTP) have classified inorganic arsenic as a known human carcinogen. Certain types of cancer in humans, such as cancer of the liver and biliary tract have been associated with PCB exposure in the workplace[66]. The effect of environmental exposure to organochlorines is not as clear. Pavuka[67] reported that high environmental exposure to organochlorines may be associated with higher rates of certain cancers, particularly stomach and lung cancer. Ritchie et al[68] reported an association of PCB180 and oxychlordane and an increased risk of prostate cancer after adjusting for age, body mass index, and a history of prostatitis. Although, there are a number of studies showing evidence of a relationship between PCB exposure and breast cancer, a recent critical review concluded that results from the more methodologically sound retrospective and nested studies do not provide strong support for a role of PCBs in breast cancer development[69] in a critical review.

2,3,7,8-tetrachlordibenzo-p-dioxin (TCDD) has been designated as a Group 1 carcinogen by the International Agency of Research on Cancer (IARC). TCDD acts as a pluripotential carcinogen by modestly increasing human risk for all cancer while not increasing the risk for any single cancer at least moderately. IARC moved TCDD to Group 1 based on mechanistic considerations focusing on the Ah receptor. The epidemiologic studies of occupational exposures, pesticide applicators, and community exposures following industrial accidents, notably in Seveso, Italy, have generated overall relative risks of all cancer of only about 1.0 or no significant elevated risk. Only case-control studies of soft-tissue sarcoma and non-Hodgkin's lymphoma reported elevated risk from TCDD exposure. However, these results have not been replicated. The justification of the recognition of TCDD as a carcinogen for humans was critically reviewed by Cole et al[70] .

There is some evidence that organic pollutants may be associated with increased prevalence of diabetes[71-73], although it is not clear whether organic pollutants contribute as one of the causative agents to diabetes or whether metabolic changes that occur in diabetes increase the uptake or reduce the elimination of organic pollutants.

There is emerging public concern over certain contaminants that mimic hormones in the human body, with the potential effect of altering sexual characteristics and other hormonal functions. DDT, one of several chlorinated organic compounds that can weakly mimic estrogen, is under investigation for potential linkages to breast cancer[74-76]. As well, studies are examining the potential of TCDD, a form of dioxin, to mimic estrogen, with the potential results of feminization of sex organs in males and disruption in the development of other sexual characteristics. There are also questions about the effects of estrogen-like compounds on sperm quality[77-79].

Current research is raising important questions regarding the safety of toxic contaminants in the environment. As for Aboriginal people, it has been suggested that major health problems (e.g. cancer, diabetes, low infant weight) may be related to the amount of chemical contaminants in the environment[25, 68-70, 80-82]. There are also fears of new health problems developing with the consumption of food contaminated with chemicals that have not been fully characterized. However, the risks and benefits of traditional food must be better understood before recommendations can be made.

6. Uncertainties and gaps in current research

The effect of chronic low-dose exposure among human populations remains controversial due to inconsistent findings among different studies and populations. Most evidence for cause-effect relationships in human studies was obtained at high dose range observed in occupational exposure or accidental exposure. The use of either the linear, "hockey stick" or a similar non-linear model for low-dose extrapolation has many shortcomings which are well recognized. Moreover, the potential exists that multiple factors such as smoking, substance abuse and general malnutrition can confound the health impact of a particular contaminant. Also, the majority of traditional food resources that contain heavy metals or organochlorine contaminants also contain multiple other contaminants making it difficult to test for just one[83, 84]. There have been few studies researching body burden or the biological effects of multiple simultaneous contaminants in the food supply.

Risk characterization of exposure to multiple chemicals poses a major challenge for toxicologists because the majority of risk assessments address only a single chemical. Information on toxicologic interactions of environmental contaminants and their combined effects on health is very limited. However, there is ample evidence of supra-additive and intra-additive interactions among environmental contaminants[85] . Because many of these contaminants affect the same target organ, the symptoms observed may be the result of interactive effects of a mixture of contaminants. Potential compounding factors such as nutrients in the diet and disease status of subjects further complicate the risk characterization process. For example, it has been hypothesized that high levels of zinc and antioxidants such as selenium and vitamin E in the traditional diet[86] may play a protective role against contaminant toxicity[87]. On the other hand, common diseases amongst Aboriginal populations such as diabetes and alcoholism[88, 89] may potentiate the toxicity of certain contaminants. Unfortunately, these co-founders are not usually included in risk assessment for contaminant exposure.

The conventional use of uncertainty factors to interpret animal data often results in uncertainty in the risk assessment model. Recent advances in biology and risk assessment methods have tremendously increased the use of mechanistic data in risk assessment. Toxicokinetic data has improved the extrapolation of data from animals to humans in characterizing human variability. Improved methods in tissue dosimetry, derived from chemical-specific data, have allowed for the use of uncertainty factors in developing physiologically based pharmacokinetic models.

The lack of a comprehensive data archive is one of the major factors prohibiting a meaningful literature review needed to identify gaps in the current research. Data collection and comparison is made difficult due to the ownership of databases by different departments and researchers. This data is not easily accessed by the public, even the relevant communities, as some data is in the form of internal memos or part of private collections. In addition, data is spread out into many organizations making it difficult to know where and if the data exists. For example, fish contaminant data may be collected by the Department of Fisheries and Oceans, Environment Canada, the Provincial Ministry of Environment or private consulting firms for

industries. In addition, health indicator data may have been collected by Health Canada or Statistics Canada. It will be very useful to establish a meta-database describing database collected and stored format.

Figure 1. Map of NFNECP Projects 2000 - 2004

There is a general gap between the understanding of the state of the environment and the health outcomes in Aboriginal communities. For example, a better understanding of the relationship between contaminant exposure and infant immune functions is needed. Dioxin exposure data is still scarce in most communities and the relationship between contaminant exposure and cancer is still an enigma. A comprehensive research on possible relationship between contaminant sources and health surveillance data will be very useful.

Geographically, there is much support offered to communities in the Territories and northern Quebec due to the Northern Contaminant Program. However, other Northern communities south of the 60^{o} receive relatively less support. The First Nations Environmental Contaminants Program (FNECP) launched in 1999 is the main research program for over 600 Aboriginal communities. The FNECP is a collaborative program between the Assembly of First Nations (AFN) and Health Canada (HC). Its goal is to assess the extent of environmental contaminants exposure and the potential for associated risk to the health and well-being of Aboriginal peoples across Canada. In the period 2000 - 2005, 26 projects have been funded amounting to almost $3.75 million. Figure 1 shows the locations where projects have been conducted during the period 2000 - 2004. In the year 2004 - 2005, additional projects were funded from British Columbia, Ontario, Saskatchewan and Nova Scotia. There is a need to expand the FNECP to support the concerns on environmental health issues of more Aboriginal communities across the country.

Another potential problem is the lack of continuity. Many previous programs were funded for a certain period of time (3-5 years), e.g. the EAGLE project, St. Lawrence 2000 program and the Toxic Substance Research Initiative. Because there was no follow-up after the programs were completed much learned experience, corporate memory, and trained expertise were lost within the communities. A more successful case is the Northern Contaminant Program (NCP) which has been running for over 10 years. The NCP program provides opportunities to plan more long term monitoring, to train research partners, to archive samples and data, and to translate research results into education and intervention programs.

7. Risk assessment and management

Risk assessment cannot be based on contaminants alone as there are many other factors that contribute to Aboriginal people's health and well-being. Many studies have been conducted amongst First Nation communities highlighting the importance of traditional food in their diet[10, 90, 91]. Traditional food is nutritious, healthy and important in preventing the development of diabetes cardiovascular diseases and obesity, which are all important health issues in Canadian Indigenous communities[92-103]. An important consideration is that in imposing dietary advisory on limitation of traditional food, public health officials and/or scientists may influence communities to transition towards a completely market based diet[104].

If market food availability is poor and/or of poor quality, this behavior path will lead to dietary patterns known to contribute to increasing obesity, diabetes, and other chronic diseases. The balance between contaminant risks and various benefits of traditional food system use is not easily achieved and cuts across the disciplines of nutrition, toxicology, environmental policy, and public health practice.

When a food is taken from the wild and there is no life-threatening property, the food is not subject to food industry regulations and decisions are usually left to the harvester and consumer. Health Canada and/or provincial/territorial/regional health authorities may issue consumption advisories based on contaminant residue limits. However, unless these advisories are widely circulated and respected, consumption of the food will continue. There is a gap in the literature due to the absence of Aboriginal perspective with regards to the benefits and risks of traditional food use. Currently there is little information regarding how personal food choice decisions are made in the context of family and community life, specifically, the social and cultural factors that influence the choice to continue using a food despite advisories.

In order for a risk management plan to be effective it has to be conducted with full participation of the stakeholders. A good example is the newly formed Niqiit Avatittinni Committee (NAC) in Nunavut. NAC is composed of representatives from various departments in the federal and territorial governments as well as national and regional Aboriginal partners. Each representative is actively involved in either environmental or human health activities and provides knowledge that enables the Committee to make decisions on most contaminant related issues. These issues vary, relating to the environment (biotic and abiotic) and/or human health in Nunavut. Members of the Niqiit Avatittinni Committee include representatives from:

- Department of Indian and Northern Affairs, Canada (INAC)

- Department of Health and Social Services, Government of Nunavut (DHSS)
    - Regional Health and Nutrition Specialists
    - Community Health Representatives
    - Environmental Health Officers
    - Chief Medical Health Officer
- Inuit Tapiriit Kanatami (ITK)
- Nunavut Tunngavik Incorporated (NTI)
- Center for Indigenous Nutrition and Environment (CINE)
- Nunavut Research Institute (NRI)
- Nunavut Tunngavik Incorporated (NTI)

8. Recommendations on future research priorities:
    - Hot spots
    - Surveillance data
    - Longitudinal study
    - Industry and health study
    - Coordination of research program
    - Ecosystem Health approach
    - Aboriginal Environmental Health Forum
    - Country Food Safety Monitoring Program

The following research priorities are recommended:

a) *To identify the hot spot sources of pollution and concurrent communities affected*. In order to effectively survey the state of the environment across Canada, the participation of provincial and federal government departments and agencies is necessary to consolidate information regarding primary resource industries such as forestry, hydroelectricity and mining into an Aboriginal health database. In addition, industrial and waste data such as that from the National Pollutant Release Inventory (NPRI) and areas of known contamination should be included. Hot spots can be characterized by ranking these sites in terms of pollution level in order to clarify whether the perceived risk is equal to the calculated risk in the context of the entire country. It will be useful to map out all the major known polluted sites in the country in relation to Aboriginal communities to build a complete picture of contaminant threats.

b) *To create a nationwide health surveillance*. The lack of community and/or regional health surveillance data has been a major handicap in the development of environmental epidemiology in the country. It is important to create a central database that will collect detailed health surveillance data and made available to the research community. The relationship between exposure to contaminants and diseases outcomes can be identified once the surveillance data are available.

c) *To conduct longitudinal cohort studies*. A longitudinal cohort study would help to better understand the relationship between diet, lifestyles and environmental risk factors along with maternal and child health in Aboriginal communities in order to better characterize the health risks of environmental contaminants. There is only one cohort study currently being undertaken to study effects of prenatal exposure to environmental contaminants on

neurobehaviour outcomes in Nunavik. More studies will be needed when the exposed populations are identified.

d) *To build capacity and preparedness of Aboriginal communities* to participate in the Environmental Health Impact Assessment (EHIA). EHIA provides one of the few structured and legally mandated vehicles for environmental decision making for industry and development. It is generally structured to encourage public participation; however, the public participation is often reactive – that is, emerging only from the stimulus of a project proposal that may pose a threat to a community. Various "evolutionary" developments in impact assessment (IA) – such as Social IA, Human IA, Cumulative IA, Regional IA and Strategic Environmental Assessment – indicate a wide recognition of the desirability of carrying EHIA expertise into more comprehensive and inclusive applications. These advances in IA will provide new opportunities for community participation.

e) *To develop a collaborative strategy for environmental health research of Aboriginal communities.* There are multiple government departments at the federal and provincial/territorial level that conduct research activities concerning Aboriginal people's health. The three federal councils all have programs funding Aboriginal environmental health research. It will be very cost effective to pool some resources to fund an inter-department, multidisciplinary research program for Aboriginal environmental health research.

f) *To adopt an ecosystem approach to human health.* The holistic nature of the ecosystem approach to human health brings the non-indigenous researchers closer to the approach put forward by Aboriginal peoples. Aboriginal people feel that the health of the community is determined by the condition of the environment around and in the community [105]. The ecosystem approach to human health requires the establishment of a research partnership that recognises the history of relationships between Aboriginal and non-Aboriginal peoples and seeks not only to fulfill certain scientific goals but also to integrate community ones as well. The relationship between the partners is based on principles of mutual respect, mutual equity, mutual empowerment and the recognition that both parties possess knowledge that could add to the understanding of contaminants issue[106, 107].

g) *To develop an Aboriginal Environmental Health Forum.* Many aboriginal communities have identified local environmental problems, but do not know where to obtain information or further help. It will be useful to establish an on-line discussion forum where all aboriginal peoples can voice their concern. The regular participation of health and environmental professionals from both the federal and provincial governments and relevant researchers may provide an opportunity to exchange information and identify where new studies are warranted.

h) *Establishment of a nationwide country food monitoring program.* It will be useful to establish a program that has a mandate similar to that of the Canadian Food Inspection Agency for market food. Wild foods that make up a considerable portion of a community diet must be monitored with the same health and safety guidelines as applied to market foods. A program must be implemented that would send major traditional food items

from aboriginal communities from across the country to test for environmental contaminants.

9. Conclusion

The impact of environmental contaminants on human health is a global issue. Many of the contaminants such as persistent organic pollutants and mercury can distribute globally and affect populations in remote regions such as northern Canada. Our resource-based economy is threatening the environmental health of relatively untouched lands in the North through the presence of highly contaminating point sources of pollution. The presence of these contaminants in the traditional food poses a real threat to the health and culture of the aboriginal peoples. The food safety and food security issues are basic human rights issues and have to be addressed with immediate attention.

Canada has a very strong scientific community in environmental research. With the proper funding support and coordination of a nationwide strategy, a strong partnership can be established with the Aboriginal communities to address these issues.

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