Assessment of Dietary Exposure to Trace Metals in Baffin Inuit Food

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Chronic metal toxicity is a concern in the Canadian Arctic because of the findings of high metal levels in wildlife animals and the fact that traditional food constitutes a major component of the diet of indigenous peoples. We examined exposure to trace metals through traditional food resources for Inuit living in the community of Qikiqtarjuaq on Baffin Island in the eastern Arctic. Mercury, cadmium, and lead were determined in local food resources as normally prepared and eaten. Elevated concentrations of mercury (>50 µg/100 g) were found in ringed seal liver, narwhal mattak, beluga meat, and beluga mattak, and relatively high concentrations of cadmium and lead (>100 µg/100 g) were found in ringed seal liver, mussels, and kelp. Quantified dietary recalls taken seasonally reflected normal consumption patterns of these food resources by adult men and women (>20 years old) and children (3–12 years old). Based on traditional food consumption, the average daily intake levels of total mercury for both adults (65 µg for women and 97 µg for men) and children (38 µg) were higher than the Canadian average value (16 µg). The average weekly intake of mercury for all age groups exceeded the intake guidelines (5.0 µg/kg/day) established by the Joint Food and Agriculture Organization/World Health Organization Expert Committee on Food Additives and Contaminants. The primary foods that contributed to metal intake for the Baffin Inuit were ringed seal meat, caribou meat, and kelp. We review the superior nutritional benefits and potential health risks of traditional food items and implications for monitoring metal contents of food, clinical symptoms, and food use. *Key words*: cadmium, Canada, diet, exposure assessment, Inuits, lead, mercury. *Environ Health Perspect* 103:740–746 (1995)

Trace metals occur naturally in the earth's crust and can neither be created nor destroyed by humans. However, human activities such as mining, industrial use, sewage disposal, and hydro-projects have greatly increased the mobilization and bioavailability of metals and increased the chance of exposure to harmful concentrations (*1*). Natural baseline levels of trace metals in air, soil, rivers, lakes, and oceans are usually low, but in certain forms and at sufficiently high concentrations, trace metals can be toxic to living organisms. The major source of human exposure to trace metals from the environment is from food (*2*).

The Canadian north is richly endowed with metal deposits. Natural withering of ore and mining activities are major sources of trace metal contamination in the Canadian Arctic (*3*). There is some evidence for deposition of aerosol lead (*4*), suggesting long-range transport may also be a possible source of lead contamination. In 1986, 14 mines were producing lead, zinc, silver, gold, copper, cadmium, and arsenic in the Canadian Arctic; before 1986, 68 mines had been developed and abandoned (*5*). Mining sites can be local point sources of metal contamination because elevated levels of metals are present in sludge, tailings, waste rock, dusts, and gaseous emissions from smelting and refining. Moreover, withering and leaching of trace metals in abandoned mine tailings may have a long-term impact on the environment. Severe metal pollution is found in rivers and lakes near abandoned mining sites in the Northwest Territories (*6*). For example, tailings from the Discovery gold mine, which operated between 1950 and 1969, were contaminated with mercury, which affected fish in adjacent lakes. The levels of lead, zinc, nickel, arsenic, and mercury are still high (*7*). The Nanisivik mine on Baffin Island is one of the two operating lead–zinc mines in the Canadian Arctic. Concentrations of lead, zinc, cadmium, and arsenic in ocean sediments near the Nanisivik mine are higher than predevelopment levels (*8*), and relatively high metal concentrations have been reported in biota of various trophic levels in Strathcona Sound near Nanisivik (*9*). The long-term effects of the elevated metal levels on the ecosystem, including wildlife food resources, is still unknown.

In the Canadian Arctic, cadmium, lead, and mercury contamination is of major concern (*10*), partly because of bioaccumulation in the food chain. Elevated levels of these metals have been reported in terrestrial, fresh-water, and marine biota (*5,11,12*). For example, high concentrations of cadmium were found in kidney of narwhal (6360 µg/100 g) (*13*) and of caribou (16,600 µg/100 g) (*14*). Although concentrations of metals in the biota are generally lower in the Arctic than in southern Canada, there is considerable concern for their possible adverse effects on human health, particularly for indigenous peoples living in remote areas dependent on wild animals and plants for food. Because of the nutritional benefits and cultural significance of these traditional food items (*15–26*), their consumption is encouraged by native leaders, health professionals, and government agencies. It was estimated that the average annual per capita consumption of traditional food among Inuits is more than twice the estimated Canadian average annual consumption of meat and fish (*27*). Preliminary estimations of metal intake from diet based on harvest data and metal contents in wildlife samples suggest that some indigenous peoples may have undesirable levels of metal exposure from their traditional diet (*14,28,29*). Therefore, more detailed and reliable studies on dietary intake are required to assess the health risks of trace metals on indigenous peoples. The best way to assess risk from multiple contaminants is a comprehensive dietary survey and chemical analysis of contaminant contents in the food collected from the community (*30*).

In this paper we report the levels of cadmium, lead, and mercury in traditional food items collected from Qikiqtarjuaq (Broughton Island) on eastern Baffin Island, Northwest Territories (Fig. 1). The levels of dietary exposure from traditional food to cadmium, lead, and mercury for inhabitants in Qikiqtarjuaq were estimated. The related health risks and benefits of traditional foods are discussed.

Methods

Community Dietary Survey and Food Sampling

We conducted 24-hr recall interviews as described in Kinloch et al. (*15*). Briefly, interviews were conducted in 6 bimonthly seasons representing the entire year in Qikiqtarjuaq (population 586), a community selected to represent the Baffin Inuit, during 1987–1988. All members of the community were asked to participate, and nonparticipation bias was controlled. In

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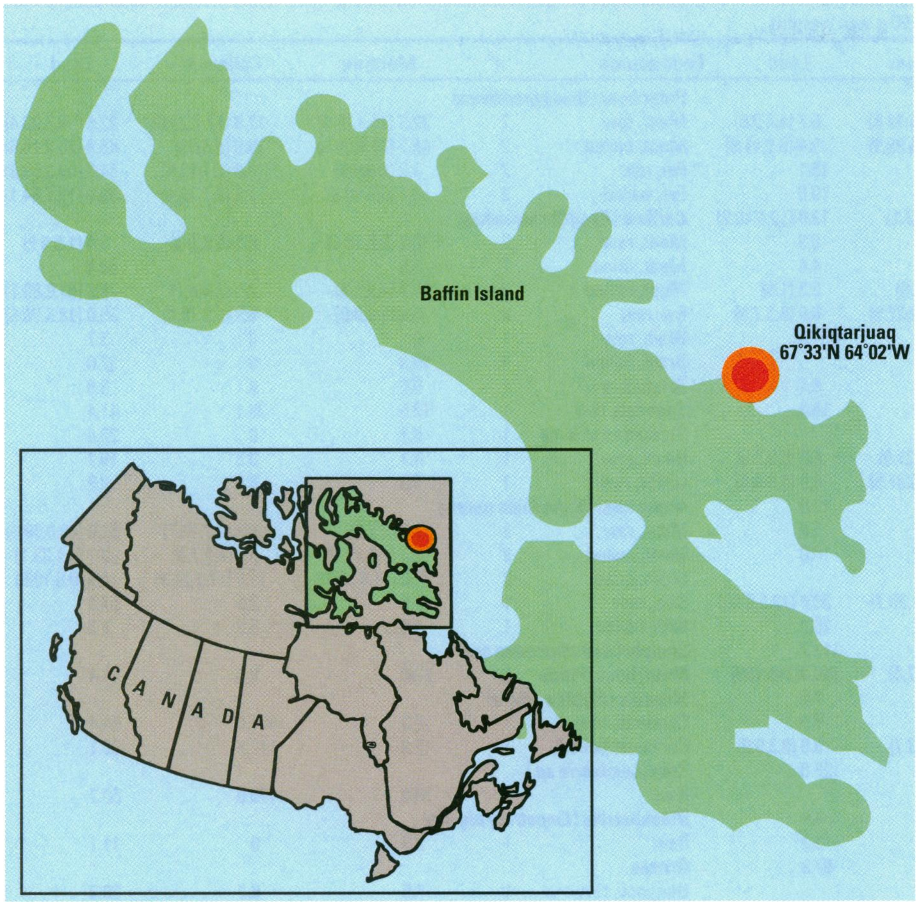

Figure 1. Map of Qikiqtarjuaq, Baffin Island, Northwest Territories, Canada.

all, 90 adult females (nonpregnant/nonlactating), 89 adult males, and 104 children (age 3–12) were interviewed during the year for a total of 1153 recalls (401, 301, and 451, respectively). Not all subjects recalled eating traditional food. The subset of 734 subjects (291 female, 229 male, and 214 children) who recalled eating traditional food items were used for evaluation of metal intake.

Food samples were collected and prepared by Inuit project assistants in the forms in which the foods were normally consumed (*21*) during the interviewing periods. At least three subsamples were taken from different areas of the organs and combined as one sample. Raw and prepared food samples may not be from the same animals.

We calculated daily metal intake levels by multiplying the amount of food item consumed during the day of interview by the average metal concentration of the food item. The respective contributions to trace metal exposure were then summed over all traditional food consumed for each food recall.

During the course of the research, the community was encouraged to participate by keeping the Hamlet Council informed of progress and by regular radio messages. Results were returned to the Baffin Regional Inuit Association and to the Hamlet Council of Qikiqtarjuaq. A report was written for the community and translated into Inuktitut.

Analysis of Food Samples

Nitric acid (ultrapure grade) was obtained from J.T. Baker (Baxter, Missassagua, Ontario). Metal standards were prepared daily by diluting commercial standard solutions (1000 ppm; ACP chemicals, St. Leonard, Quebec) with 40% nitric acid (same acid concentrations as samples). All glassware used was acid washed with 20% hydrochloric acid overnight.

Food samples were sampled, portioned, and stored at -20°C until analyzed for cadmium, lead, and mercury. For analysis, the samples were thawed and two aliquots of approximately 1.0 g of each sample were weighed and dried to constant weight (in a vacuum oven at 60°C and at a pressure of approximately 30 Pa for 24 hr). Dried samples were weighed and digested with 2 mL nitric acid at room temperature overnight. The samples were then heated to 60°C for 2 hr. After the digests were cooled to room temperature, 2 mL nitric acid were added and they were heated to 60°C for 2 hr to complete the digestion.

The digested samples were made up to 10 mL with deionized water, and the metal contents were analyzed using a Hitachi Z-8200 atomic absorption spectrophotometer with Zeeman background correction and a SSC-110 autosampler. Metal contents were measured by flameless mode with a platform graphite furnace with external reference standards. Palladium (50 ppm) was used as modifier for lead analysis. Total mercury was measured by cold vapor generation with a Hitachi HFS-2 continuous flow injection hydride formation system. The detection limits (three times the standard deviation of the blanks) are 0.5 ppb (0.05 µg/100 g tissue) for cadmium, 5 ppb (0.5 µg/100 g tissue) for lead, and 0.2 ppb (0.02 µg/100 g) for mercury. Food sample concentrations below the detection limits were regarded as zero.

Two sample blanks were analyzed together with each batch of samples. Concentrations of the three metals in blanks were below the detection limits in all analysis. A spiked blank was analyzed during each analysis to ensure day-to-day reproducibility. Each standard and sample was measured in duplicate, and the sample was reanalyzed if the relative standard deviation of the two measurements was higher than 5%. Coefficients of variations of the three replicates of the samples were generally less than 10%, and the mean was used as the representative value for the sample. Standard reference materials from the National Institute of Standards and Technology (oyster tissue SRM 1566a, apple leaves SRM 1515, and bovine liver SRM 1577b) were digested and analyzed with each batch of samples. Results of the metal concentrations always fell within 1 SD of the certified values. Our laboratory also participated in interlaboratory comparison exercise organized by the Arctic Environmental Strategy of the Department of Indian Affairs and Northern Development of Canada.

We tested differences in contaminant intakes across age groups by ANOVA followed by Bonferroni *t*-tests. Differences in food intake according to exposure categories were tested by Student's *t*-tests. Because food and contaminant intake distributions are positively skewed in these data sets, all data were transformed [log (value + 1)] before performing statistical tests (SAS/STAT, version 6, SAS Institute Inc., Cary, North Carolina). A *p*-value of <0.05 was considered significant in all statistical tests.

Results

Cadmium, mercury, and lead were detected in 87 out of 90 food samples measured; their concentrations are presented in Table 1. The "action levels" established by Agriculture

Table 1. Trace metal concentrations in Inuit food (μg/100 g wet weight)

Food source	n[a]	Mercury	Cadmium	Lead
Ringed seal (*Phoca hispida*)				
Meat, raw	2	30.9 (11.4,50.3)[b]	44.2 (34.5,53.8)	6.7 (4.4,9.0)
Meat, boiled	2	26.7 (18.7, 34.7)	66.2 (32.5,99.9)	9.4 (6.9,11.9)
Meat, aged	1	16.9	42.9	18.1
Blubber, raw	1	9.9	11.6	10.6
Blubber, aged	2	11.9 (10.7,16.4)	3.7 (4.3,3.1)	12.8 (15.4,10.2)
Blubber, boiled	1	10.0	2.0	8.9
Broth	1	8.3	4.2	4.4
Liver, raw	3	429.3 (471.5)	213.6 (147.8)	3.3 (1.6)
Heart, raw	2	15.8 (7.8,23.9)	23.7 (20.2,27.5)	6.9 (6.5,7.3)
Brain, raw	1	7.9	11.5	861.9
Ringed seal pup				
Meat, raw	1	18.2	1.2	6.1
Meat, boiled	1	45.5	1.0	10.0
Bearded seal (*Erignathus barbatus*)				
Meat, raw	2	17.2 (16.7,17.9)	13.7 (6.4,21.0)	6.9 (5.9,7.9)
Meat, boiled	2	28.0 (25.6,30.4)	28.0 (24.5,31.5)	6.0 (5.6,6.4)
Broth	1	3.5	8.3	10.5
Intestine, raw	1	21.6	98.7	5.5
Intestine, boiled	1	33.4	96.5	10.0
Narwhal (*Monodon monoceros*)				
Meat, dried	2	90.1 (7.5,172.7)	60.9 (85.1,36.7)	33.6 (12.6,54.6)
Blubber, raw	1	13.0	5.2	26.7
Blubber, aged	1	12.3	8.1	111.7
Blubber, boiled	2	11.1 (10.4,11.7)	8.1 (8.8,7.4)	149.8(149,150)
Mattak, raw	1	55.9	5.8	7.6
Mattak, aged	1	195.0	2.8	8.9
Mattak, boiled	2	73.5 (59.7,87.3)	2.4 (1.1,3.7)	9.6 (9.3,9.9)
Flippers, aged	1	10.8	30.5	125.0
Beluga (*Delphinapterus lecas*)				
Meat, dried	1	796.9	41.7	4.5
Mattak, raw	1	103.5	1.2	3.2
Blubber, raw	1	12.8	4.0	97.3
Walrus (*Odobenus rosmarus*)				
Meat, raw	2	16.9 (12.4,21.5)	15.6 (12.8,18.5)	24.8 (22.0,27.6)
Meat, aged	2	12.1 (11.3,12.9)	21.7 (20.5,22.8)	15.5 (8.4,22.6)
Meat, boiled	2	25.2 (11.6,38.7)	26.0 (22.8,29.2)	29.1 (27.6,30.6)
Blubber, raw	2	6.4 (10.1,2.8)	2.1 (1.8,2.3)	25.8 (12.3,39.3)
Blubber, aged	2	6.6 (4.4,8.8)	6.9 (1.9,11.8)	35.9 (11.4, 60.4)
Blubber, boiled	1	11.6	1.4	7.1
Mattak, raw	2	2.7 (1.4,4.0)	3.8 (2.7,4.8)	20.4 (4.0,36.8)
Mattak, aged	1	5.8	4.4	75.4
Polar bear (*Ursus maritimus*)				
Meat, raw	2	22.3 (17.7,26.9)	17.9 (12.2,23.5)	22.6 (16.8,28.4)
Meat, boiled	2	45.7 (26.8,64.5)	19.3 (5.5,33)	45.9 (15.2,16.6)
Fat, raw	2	7.2 (6.0,8.5)	3.6 (2.7,12.4)	54.3 (49.3,59.3)
Fat, boiled	2	8.4 (6.6,10.8)	7.6 (2.7,12.4)	39.9 (15.7,64.1)
Caribou (*Rangifer tarandus*)				
Meat, raw	2	10.2 (3.8,16.6)	5.5 (5.6,5.4)	3.4 (1.6,5.2)
Meat, dried	1	3.8	1.7	68.4
Meat, boiled	2	5.7 (4.5,6.8)	3.5 (2.9,4.1)	78.3 (67.5,89.1)
Fat, raw	2	5.8 (2.6,9.0)	5.3 (0.2,10.4)	35.0 (13.5,56.5)
Brain, raw	1	0	0	5.7
Brain, boiled	1	10.3	0	37.0
Tongue, raw	1	9.6	0.1	3.8
Stomach, raw	1	12.5	26.1	41.4
Stomach contents	1	6.1	0	22.4
Heart, raw	1	4.1	0.3	19.1
Lungs, raw	1	9.8	3.7	9.7
Arctic char (*Salvelinus naresi*)				
Meat, raw	2	3.5 (0,7.0)	6.7 (2.7,10.7)	54.3 (49.0,59.6)
Meat, boiled	2	17.9 (7.5,28.4)	5.6 (4.2,7.0)	20.1 (7.1,33.1)
Meat, dried	2	23.6 (11.6,35.7)	19.5 (17.2,21.8)	14.5 (9.5,19.5)
Skin, raw	1	9.5	2.9	57.6
Skin, boiled	1	4.3	5.8	7.5
Sculpin (*Acanthocottus sp.*)				
Meat, bone, inside	1	22.0	2.3	43.4
Mussels (*Mytilus edulis*)				
Contents, raw	1	8.2	101.9	54.4
Contents, boiled	1	17.3	111.3	100.1
Kelp (*Laminaria sp.*)				
Raw	1	10.6	173.0	50.7
Blackberries (*Empetrum nigrum*)				
Raw	1	2.9	0	11.1
Greens				
Oongooli, raw	1	4.5	6.2	26.2
Okowyot, raw	1	4.3	31.3	29.2
Action level		50	100	200

[a]Number of independently harvested samples, except where noted.
[b]Mean (sample values).

Canada to monitor the potential contamination of the three metals are also presented for comparison. Agriculture Canada may initiate on-farm inspections and feed analysis to assess potential problems for animals and human health when action levels are exceeded (*31*). If sufficient magnitude of a residue level is established, the Agri-Food Safety Division of Agriculture Canada will recommend to Health and Welfare Canada that the food not be used for human or pet food products. The mean, median, and range of mercury in all food samples were 37.9, 11.5, and 0–796.9 μg/100 g, respectively. Concentrations of mercury in ringed seal liver, narwhal mattak, beluga meat, and beluga mattak were higher than the action level of 50 μg/100 g or 0.5 ppm set by Agriculture Canada. The mean, median, and range of cadmium in all food samples were 22.4, 6.0, and 0–213.6 μg/100 g, respectively. The corresponding figures for food composites found in Canada are 1.37, 0.54, and 0.007–29.7, respectively (*32*). Concentrations of cadmium in ringed seal liver, mussels, and kelp were higher than the action level of 100 μg/100 g or 1.0 ppm. The mean, median, and range of lead were 41.2, 18.6, and 3.2–861.9 μg/100 g, respectively. The corresponding figures for food composites found in Canada are 2.99, 1.47, and 0.142–40.7, respectively (*32*). Concentrations of lead in ringed seal liver, mussels, and kelp were higher than the action level of 100 μg/100 g or 1.0 ppm.

In Table 2, food items are classified into five major categories, and their metal concentrations are compared to the values of Canadian food composites. Like Canadian food, higher concentrations of all three metals measured were found in organ meats of traditional food. Moreover, cadmium and lead levels in shellfish and mercury levels in meat were also high. Although average levels of the three metals in the traditional food items measured in this study were generally higher than those of Canadian market food, the ranges of levels of lead in meats and vegetables, cadmium in organ meats, and mercury in fish were similar. Because of the relatively small sample size in each food category, the average levels can be strongly influenced by certain food items. For example, the mean cadmium level in vegetables was much higher than the Canadian value because of the high cadmium concentrations found in kelp. Similarly, the high level of mercury in meat was a result of the high concentrations found in the meat of marine mammals.

The seasonal average daily metal intakes during days of traditional food consumption for both men and women across three age groups (20–40, 41–60, and >60 years) were compared, and no significant differences were found (data not shown). Therefore, the results from all three age groups were pooled, and the results of average daily intake are presented in Table 3. The data are not normally distributed. A log transformation was performed; the geometric means and 95% confidence levels are presented. Data for children 3–12 years of age are also shown. The intake values were compared to the Canadian average intake levels (*30*). The daily mercury intake levels from traditional food for both adults and children were higher than the Canadian average. Cadmium levels were similar and lead levels were lower than the Canadian average.

Table 2. Trace metal levels in food categories (µg/100 g)

Food		n		Mercury	Cadmium	Lead
Meat	This study	17	Mean	52	24	23
			Median	22	19	16
			Range	4–797	1–66	3–78
	Canada[a]	18	Mean		0.9	5
			Median		0.4	2
			Range		0.1–7	0.3–27
Organ meats	This study	27	Mean	51	53	86
			Median	12	4	11
			Range	4–429	3–2140	3–862
	Canada[b]	12	Mean	4	271	9
			Median	2	17	9
			Range	1–1880	1–18500	4–297
Fish	This study	4	Mean	17	9	33
			Median	18	7	33
			Range	4–24	2–20	14–54
	Canada[a]	5	Mean		11	5
			Median		0.5	2
			Range		0.1–8	0.7–17
Shellfish	This study	2	Mean	8	107	77
			Median	8	107	77
			Range	7–8	101-111	54–100
	Canada[a]	1	Mean		30	30
			Median			
			Range			
Vegetables	This study	4	Mean	6	53	29
			Median	5	31	29
			Range	3–10	0–173	11–51
	Canada[a]	37	Mean		2	49
			Median		1	5
			Range		0.2–12	0.3–254

[a]Calculated from data in WHO document (*33*); data for mercury not available.
[b]Calculated from data in Dabeka and McKenzie (*32*).

Table 3. Trace metal daily intake (µg/day) on days with traditional food for Inuit in Qikiqtarjuaq

Group		Mercury	Cadmium	Lead
Women >20 years (*N* = 291)	Arithmetic[a]	122 ± 155	144 ± 204	67 ± 93
	Geometric	65 (56–75)	56 (47–67)	43 (38–48)
	Median	76	56	44
Men >20 years (*N* = 229)	Arithmetic	166 ± 177	169 ± 235	85 ± 104
	Geometric	97 (84–114)	76 (63–91)	54 (47–61)
	Median	110	73	54
Children 3–12 years (*N* = 214)	Arithmetic	66 ± 75	89 ± 159	35 ± 51
	Geometric	38 (33–44)	34 (28–42)	23 (20–26)
	Median	39	31	21
Canada[b]		16	69	125

[a]Values are arithmetic means ± SD and geometric means with 95% confidence intervals in parentheses.
[b]From Conacher and Mes (*30*).

Table 4. Comparison of calculated weekly intake to the provisional tolerable weekly intake (PTWI) (µg/kg body weight/week)[a]

Group	Mercury	Cadmium	Lead
Women >20 years (*N* = 401)	6.6	5.8	4.4
Men >20 years (*N* = 301)	8.0	6.2	4.4
Children 3–12 years (*N* = 451)	6.3	5.7	4.6
PTWI[b]	5.0	7.0	25.0

[a]Geometric mean of daily intake × 7 × probability of consuming traditional food on any given day/body weight (50 kg for women, 65 kg for men, and 20 kg for children). The probability of consuming traditional food was calculated as the proportion of all food recalls containing traditional food (291/401, 229/301, and 214/451 for women, men, and children, respectively).
[b]From WHO (*33*).

Assuming the average body weights of women, men, and children are 50, 65, and 20 kg, respectively, and that the probability of consuming traditional food on any given day is 0.73, 0.76, and 0.48 for adult females, males, and children, respectively (based on the proportion of food recalls with traditional food mentioned), the average weekly intake was calculated (geometric mean of daily intake × probability of consuming traditional food × 7/body weight) and compared to the provisional tolerable weekly intake (PTWI) levels established by the Joint Food and Agriculture Organization/World Health Organization Expert Committee on Food Additives and Contaminants (*33*) (Table 4). The weekly mercury intake levels for all age groups exceeded the safe intake guidelines.

The most consumed traditional foods in Qikiqtarjuaq expressed as percentages of the total weight of traditional food mentioned in the food recalls and their contribution to metal exposure as percentages of total intake of each metal are presented in Tables 5–7. For all individuals studied, ringed seal *(Phoca hispida)* meat was the most frequently consumed item. It constituted about one-third by weight of all traditional food eaten by both adults and children. It was also the major contributor to all three metals studied: about 40% for mercury, 70% for cadmium, and 20% for lead. Little bearded seal (*Erignathus barbatus*) was consumed in comparison to ringed seal. Ringed seal meat and liver and narwhal *(Monodon monoceros)* mattak together contributed about 75%, 71%, and 70% of mercury in women, men, and children, respectively. Ringed seal meat was the single major contributing food item for cadmium in the diet; caribou (*Rangifer tarandus)* meat and kelp *(Rhodymenia* or *Laminaria* spp.) also contributed to approximately 10% of cadmium in the diets of both adults and children. For lead, the major contributing food items were ringed seal meat, caribou meat, and Arctic char *(Salvelinus alpinus)* meat. Together, these items accounted for about 50% of lead in the adult diets and over 60% of lead in the diets of children.

Discussion

The high concentrations of cadmium, lead, and mercury found in some of the food items (e.g., exceeding the action level set by Agriculture Canada) (*31*) deserve concern. Because of limited resources, only one or two samples of each food item were

Table 5. Proportionate distribution of metals intake from traditional food most consumed by Baffin Inuit women >20 years old in Qikiqtarjuaq[a]

Food	Contribution (%) to total intake			
	Traditional food	Mercury	Cadmium	Lead
Ringed seal meat	31.6	40.7	71.9	23.5
Caribou meat	24.1	7.2	3.4	10.0
Narwhal mattak	8.9	21.5	1.7	5.4
Ringed seal broth	6.0	2.2	0.9	2.2
Artic char meat	5.8	2.7	1.4	18.4
Walrus meat	4.2	2.3	3.1	5.6
Ringed seal blubber	3.0	1.4	0.7	2.5
Blackberries	2.5	0.3	0.0	1.9
Bearded seal meat	2.4	1.8	1.3	1.1
Ringed seal pup meat	2.2	0.8	0.0	0.5
Walrus blubber	1.4	0.4	0.4	4.3
Kelp	1.3	0.4	5.8	3.8
Narwhal meat	1.1	3.1	1.8	2.2
Caribou fat	0.8	0.2	0.1	2.1
Ringed seal liver	0.6	11.9	5.0	0.2
Narwhal blubber	0.5	0.3	0.1	1.7
Total	96.4	97.2	98.0	85.4

[a]Data from a total of 291 food recalls containing traditional food are pooled and the relative contribution of each food item is expressed as the percentage of the total intake. Traditional food is by weight.

Table 6. Proportionate distribution of metals intake from traditional food most consumed by Baffin Inuit men >20 years old in Qikiqtarjuaq[a]

Food	Contribution (%) to total intake			
	Traditional food	Mercury	Cadmium	Lead
Ringed seal meat	27.6	33.6	72.9	22.0
Caribou meat	23.5	8.6	5.0	11.0
Narwhal mattak	11.1	27.2	2.9	8.0
Artic char meat	7.7	4.4	2.3	22.9
Ringed seal broth	4.8	1.7	0.9	2.0
Ringed seal blubber	3.3	1.4	0.9	2.9
Ringed seal pup meat	3.0	4.9	0.1	2.5
Bearded seal meat	2.5	2.6	2.6	1.5
Walrus meat	2.5	2.0	2.6	5.2
Blackberries	1.5	0.2	0.0	1.6
Narwhal blubber	1.0	0.5	0.3	4.7
Mussels	0.7	0.2	3.2	3.5
Walrus blubber	0.7	0.2	0.2	0.3
Polar bear meat	0.6	1.3	0.6	2.7
Caribou fat	0.4	0.1	0.1	1.5
Kelp	0.4	0.2	3.5	2.1
Total	91.3	89.1	98.1	94.4

[a]Data from a total of 229 food recalls containing traditional food are pooled and the relative contribution of each food item is expressed as the percentage of the total intake. Traditional food is by weight.

Table 7. Proportionate distribution of metals intake from traditional food most consumed by Baffin Inuit children 3–12 years old in Qikiqtarjuaq[a]

Food	Contribution (%) to total intake			
	Traditional food	Mercury	Cadmium	Lead
Ringed seal meat	34.6	46.6	75.3	28.8
Caribou meat	22.4	8.1	3.4	12.9
Narwhal mattak	8.2	23.1	1.6	6.1
Arctic char meat	8.2	6.1	1.8	20.5
Blackberries	7.8	1.1	0.0	8.2
Ringed seal broth	6.4	2.6	1.0	2.7
Ringed seal blubber	2.1	1.0	0.5	1.9
Kelp	1.6	0.8	10.0	7.8
Blueberries	1.2	0.0	0.0	0.0
Narwhal meat	0.8	3.7	1.9	2.7
Total	93.3	93.1	95.5	91.6

[a]Data from a total of 214 food recalls containing traditional food are pooled and the relative contribution of each food item is expressed as the percentage of the total intake. Traditional food is by weight.

collected and measured in this study. For those food items with more than one sample, relatively high values of relative standard deviation (5–136%; Table 1) were found, suggesting that there is a high level of intravariation in metal concentrations in foods. Nevertheless, the concentrations of cadmium, lead, and mercury found in the raw food samples in this study are comparable to those of wildlife reported in the literature (*9,11,13,29*). For example, cadmium and total mercury in ringed seal meat collected from the Baffin region were reported to range from 0.05 to 0.71 µg/g and 0.04 to 0.69 µg/g, respectively (compared to 0.44 µg/g and 0.31 µg/g found in this study). It has to be emphasized that the samples of this study were collected by Inuit in the community for food use, and prepared food samples were included in this study. Therefore, they may better represent the typical levels of metals in food than the samples collected by wildlife biologists for environmental studies. However, because of the high coefficients of variations of metal concentrations in food, the dietary intake estimations based on these values should be interpreted with caution.

Metal levels in many types of traditional food were higher than in corresponding market food (Table 2). However, the difference of components in the traditional food groups and those of the market food makes the direct comparison of the levels of metals difficult. For example, market meats are all from domesticated land animals (beef, pork, etc.), whereas meats of traditional food in Baffin are mainly marine mammals such as seal, narwhal, walrus, beluga, etc. It is known that cadmium and mercury can bioaccumulate in the Canadian Arctic food chain (*11*). Therefore, animals on higher trophic levels tend to accumulate higher metal levels than those of lower trophic level. Marine mammals are usually on the third or fourth trophic level in the food chain (*9,34*), whereas cattle raised in Canadian farms are mainly on the first or second trophic level. Therefore, average concentrations of cadmium and mercury in some traditional foods were higher in comparison to the levels of comparable market foods (Table 2). The reason for generally higher lead level in traditional food groups is not known. However, there is a general trend that the prepared food items have higher lead concentrations than the raw samples (Table 1). Contamination by cooking utensils may be a factor and should be further investigated.

There are some similarities between metal levels found in traditional and market food. For example, high cadmium and mercury concentrations can be accumulated in meat organs and shellfish (*35,36*) and cadmuim and mercury levels of these two groups are similar to the values found in market food. The fact that cadmium concentrations in green vegetables other than kelp (e.g., oongooli and okowyot) were low and comparable to the average values of market food is a good sign, since concentrations in leafy vegetables are generally a good indicator of cadmium in the local soil (*35*). The high cadmium concentration in kelp could be due to fast growth rate of this species and probably a high absorption rate of cadmium from seawater. It is important to determine typical cadmium concentrations in kelp because it constituted a significant percentage (10%) of cadmium in the diet of children (Table 7).

Because of the difference of metal levels in different food groups between market and traditional food, the importance of food groups in terms of their contribution to the metal levels in the diet also differ. In a market food diet, the major sources of metals are cereals and vegetables for cadmium; spices and herbs, canned food, and shellfish for lead; and fish for mercury (*37*). However, in the traditional diet in Qikiqtarjuaq, the major sources of both cadmium, mercury, and lead are from meat and organ meats.

From the results of these studies, it was found that the estimated average levels of mercury derived from the traditional food in Qikiqtarjuaq exceeded the provisional PTWI levels set by the Joint FAO/WHO Expert Committee on Food Additives (Table 4) (*33*). The PTWI has been adopted by the WHO for unavoidable food pollutants such as trace metals. It is designed to level out the great variation between daily intakes and avoid the need to abandon certain food items which have high levels of pollutants but are not consumed frequently, thereby protecting the consumer. These levels were set in the hope that the situation would improve and that it would be possible at a later time to set daily maximum intake recommendations. Therefore, the safety considerations are not as conservative as for acceptable daily intake level. Our results indicate potential health effects due to mercury exposure. A daily intake of 3–7 µg methylmercury/kg body weight may cause adverse effects on the nervous system, manifested as an approximately 5% increase in the incidence of paraesthesia (*36*). Assuming 80% of the total mercury is in the form of methylmercury (*11*), and average daily intake is equal to the average weekly intake (Table 4) divided by 7, the average daily intake of methylmercury will be 0.75 µg/kg body weight for women, 0.91 µg/kg body weight for men, and 1.5 µg/g body weight for children. These values are higher than the no-adverse-effect level of 0.48 µg methylmercury/g body weight. Moreover, the children also have relatively higher intake of lead (23 µg/day or 4.6 µg/kg/week) compared to adults. Therefore, potential effects on the central nervous system during development may be of concern (*38*).

Tobacco is a major source of cadmium, and smoking is common among the inhabitants of Qikiqtarjuaq. The average Canadian cadmium intake level is high (69 µg/day) (*31*), indicating there may be substantial contribution of dietary cadmium intake from Canadian market food. Although cadmium intake from traditional food was lower than the PTWI in this study, studies of health status of the people in Qikiqtarjuaq related to cadmium intake would be prudent.

Because ringed seal meat is such an important component of the traditional diet and also a contributor to metal intake (70% for cadmium, 20% for lead, and 40% of mercury), metal concentrations in this food should be monitored. The levels of mercury in narwhal mattack, lead in Arctic char meat, and lead and cadmium in kelp could also be included in monitoring programs. A high lead concentration (862 µg/100 g) was found in ringed seal brain. Because seal brain was not a regular component of the traditional diet, it was not a major source of lead in the diet. Similarly, even though the mercury concentrations in beluga meat (797 µg/100 g) and cadmium concentrations in ringed seal liver (214 µg/100 g) were high, they do not contribute significantly to the total dietary exposure of mercury and cadmium reported here.

It has to be emphasized that the objective of this study was to identify potential health risk from metal exposure at a community level. The arithmetic means of daily metal level were much higher than the geometric means and the medians (Table 3). The skewed distribution suggests that high intake levels are results of some interviewees consuming food items with high cadmium concentrations (e.g. caribou liver or kidney) on the interviewing days. For example, the maximum intakes were 1833 µg Cd/day for women and 2051 µg Cd/day for men. These results suggest that some individuals may have much higher average weekly metal intake than the average level presented in this study. Monitoring programs to further assess the body burden and potential health risks, including the use of various biological markers such as urine (cadmium), blood (lead), and hair (mercury) could be considered. Any recommendations on traditional food consumption should take into account the importance of cultural, social, and nutritional values of traditional food, as discussed elsewhere (*39*).

It is also important to note that both diet and contaminant levels vary among communities (*40*). Metal intake levels presented in this study may or may not necessarily reflect food use and metal exposure in other communities in the region. Further research is needed to clarify this important issue.

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