Dietary assessment of Canadian Arctic women

ORIGINAL ARTICLE

DIETARY ASSESSMENT OF INDIGENOUS CANADIAN ARCTIC WOMEN WITH A FOCUS ON PREGNANCY AND LACTATION

Peter R. Berti 1, Rula Soueida 2, Harriet V. Kuhnlein 2

1HealthBridge, Ottawa, Canada
2Centre for Indigenous Peoples’ Nutrition and Environment, McGill University, Sainte-Anne-de-Bellevue, QC, Canada
pberti@healthbridge.ca

Received 23 January 2008; Accepted 15 July 2008

ABSTRACT

Objectives. To assess the diet of Indigenous women, including pregnant and lactating women, in the Canadian Arctic in terms of dietary adequacy, and to assess the contribution of traditional food to the diet.

Study design. Population-based cross-sectional design, using 24-hour dietary recalls.

Methods. Twenty-four hour quantitative dietary recalls were collected in 47 communities in 5 surveys between 1987 and 1999, including non-pregnant and non-lactating women (n=1300), pregnant women (n=74) and lactating women (n=117). Unique methods of assessment were undertaken using Software for Intake Distribution Assessment (SIDE) partitioned intra- and interindividual variance that allowed the estimation of the distribution of usual daily nutrient intakes for comparison to North American dietary reference intakes.

Results. Contributions of traditional Arctic food to energy intakes varied and the prevalence of inadequacies were generally high for magnesium, vitamin A, folate, vitamin C and vitamin E. Supplement use was infrequent. Many women met their needs for iron, and some exceeded the recommended upper limit for iron with food alone. Average intakes of manganese and vitamin D met recommended levels, but calcium did not.

Conclusions. These results are the only data to date reporting an assessment of the dietary intakes of pregnant and lactating Canadian Arctic Indigenous women. Special attention is required for inadequacies of magnesium, zinc, calcium, folate, and vitamins E, A and C; and for use of supplements during pregnancy. Most pregnant and lactating women met iron needs without supplements.

(Int J Circumpolar Health 2008; 67(4):349-362)

Keywords: dietary assessment, Arctic Indigenous women, pregnant, lactating, Canada
INTRODUCTION

Dietary change among all northern Indigenous Peoples has accelerated in the last several decades with the reduced use of traditional food system species and the increased use of purchased market food. This phenomenon has resulted in young people consuming less of the nutrient rich traditional food than older people, and for both young and old this decrease in traditional foods has reduced the overall nutritional quality of their diets (1–4). Research with Inuit in Alaska and Greenland, as well as with Nunavut and Nunavik in Canada, has highlighted the need to improve dietary quality, most importantly by increasing the use of traditional food when possible (5,6). At the same time food security is eroding and obesity, diabetes, cardiovascular disease and other chronic diseases are increasing for both men and women (7–10). There are few data on the quantitative dietary assessment of pregnant or lactating Arctic women. In fact, only one report to date suggests that pregnant Inuit women had poor dietary iron that resulted in anemia (11), but other nutrient data were not reported. There are no published data on the dietary assessment of lactating Arctic women.

Our objective in this article is to assess the diet of Indigenous women, including pregnant and lactating women, in the Canadian Arctic in terms of adequacy and the contribution of traditional food to the diet. We report on dietary analysis of Arctic women using 4-hour recall data collected from communities throughout the Canadian Arctic between 1987 and 1999. These included Yukon First Nation, Dene, Métis and Inuit communities from the Yukon Territories, the Northwest Territories, Nunavut and Labrador. These results represent the most detailed assessment conducted to date of micronutrient adequacy of Arctic women and include pregnant and lactating women. In addition to standard methods, we used a variant of a new analytical method, applied by using SIDE software (Software for Intake Distribution Estimation, version 1, 1996, Iowa State University) to determine the distribution of nutrient intakes of groups with relatively small sample sizes and few or no repeat observations per person.

MATERIAL AND METHODS

Sampling and participation

Dietary data of adult women, including pregnant and lactating women, collected during 5 different studies between 1987 and 1999 in Canadian Arctic Indigenous communities were combined. These studies took place in the Inuit community of Qikiqtarjuaq (Broughton Island) (1987–1988), the Dene and Métis communities of K’asho Got’ine (Fort Good Hope) and Behdzi Ahda First Nation (Colville Lake, also noted as K’ahbamitué) (1988, 1990), 16 Dene and Métis communities (1994), 10 Yukon First Nation communities (1995) and 18 Inuit communities (1998–1999). The sample sizes and references for previously published methods are summarized in Table I. Hereafter, communities are referred to by their names in the local language.

To briefly review methods of data collection reported earlier (2,3,12,13), 24-hour dietary recalls (14) were collected from individuals in 7 (Qikiqtarjuaq), 3 (K’asho Got’ine/Behdzi Ahda First Nation) or 2 seasons, thus capturing, at least, the seasons of highest (September–November) and lowest (February–April) traditional food use. Studies with each cultural
group were separately reviewed by the Human Research Ethics Committee of McGill University, science licenses were obtained from the responsible Territorial authorities, and collective consent was obtained from the Council of Yukon First Nations, Dene Nation, Métis Nation (Northwest Territories) and the Inuit Tapiriit Kanatami. Informed consent was obtained from each individual prior to data collection. Research agreements were maintained with each community to ensure equitable responsibilities for conduct of the research (15).

In the Qikiqtarjuaq and K’asho Got’ine/Behdzi Ahda studies, all community households were approached for adult participants, and response rates were between 61% and 100%. There were few refusals and most non-participants were difficult to reach because of seasonal activities. Non-response bias for traditional food use was controlled for by ensuring that households interviewed fit the community distribution of households with high, medium or low use of traditional food as determined by focus-group discussions that included community wildlife harvest officers.

In the multicommunity surveys, households were randomly selected, and 1 adult man and 1 adult woman within households were selected by convenience and interviewed. Participation was voluntary and confidential, and interviews were conducted in the traditional language or in English by trained community research assistants. Participation rates were above 75% in all communities. Alcohol intake was recorded when stated, but not probed, and not included in the analyses. In all, we report data from 24-hour recalls from 1,300 non-pregnant and non-lactating women, 74 pregnant women and 117 lactating women.

**Data entry and databases**

A random subset of 10% of the data were double entered and checked and analyses were conducted with SAS, versions 6 and 8 (SAS Institute). Food composition data were drawn from our own analysis of Arctic foods (16–22) and from Agriculture Handbook 8 (23), adjusted for Canadian fortification levels including folate, updated for carotenoid content (24), adjusted for requirements of the Dietary Reference Intakes (DRIs) (25,26) and new nutrient data from USDA (26). There were no foods with missing composition data in this analysis.

| Study communities | Number of communities | Years of data collection | Sample size: n individuals (average number of 24-hour recalls per individual) |
|------------------|-----------------------|--------------------------|--------------------------------------------------------------------------------|
| Qikiqtarjuaq (3) | 1                     | 1987-88                  | 166 (4.3) 17 (5.8) 18 (6)                                                      |
| K’asho Got’ine/Behdzi Ahda First Nation (12) | 2                     | 1988, 1990               | 205 (1.6) 7 (1.1) 8 (1.4)                                                     |
| Dene/Métis (13) | 16                    | 1994                     | 276 (1) 14 (1) 9 (1)                                                           |
| Yukon First Nations (2) | 10                    | 1995                     | 248 (1) 5 (1) 5 (1)                                                            |
| Inuit (2)       | 18                    | 1998-9                   | 405 (1.1) 31 (1.2) 77 (1.2)                                                    |

*There were also women who were both pregnant and lactating, but too few to be representative and hence were dropped from the data set.

**Non-pregnant, non-lactating women.**
Dietary assessment of Canadian Arctic women

Analysis
To estimate the prevalence of nutrient inadequacy, population distributions of usual intakes, not intakes from a single observation, were determined. Three methods were used with the data sets to estimate usual intakes.

(1) When there were multiple observations (e.g., 4 or more) per individual, each individual’s daily average intake over the 4 plus days was used as an estimate of their usual intake. This was possible only with the data for Qikiqtarjuaq non-pregnant non-lactating, pregnant and lactating women.

(2) When there were two or more observations per individual for at least some of the individuals in the group (e.g., 20 or more individuals), it was possible to use SIDE to estimate usual nutrient intake distributions. SIDE estimates the population usual nutrient intake distributions through a 4-step process.
   (i) The data are adjusted to change the mean and variance of the repeat recalls so that they are equal to those of the first recalls. (ii) The data are transformed to normality. (iii) Within and between individual variances of intake are estimated and then, through mathematical modelling the intra-individual variance is in effect removed, leaving the inter-individual variation which thus represents the population distribution of usual intakes. (iv) The usual intake distribution obtained in step (iii) is transformed back to the original scale (27–29). This was used on data for Qikiqtarjuaq non-pregnant non-lactating and pregnant and lactating women, K’asho Got’ine/Behdzi Ahda non-pregnant non-lactating women, and Inuit non-pregnant non-lactating women.

(3) When there were too few individuals with 2 or more observations, or even if there was only 1 observation for all individuals, it was possible to use SIDE if there was a group with sufficient number of observations for which the variance characteristics can be assumed to be similar (based on sex, age, partial reliance on traditional food, similar quality of market food available). To execute this, first SIDE was run on the “assumed similar” group, and the variance of measurement error, the scaled fourth moment of measurement error and number of individuals with repeat observations were recorded, and then those parameters were applied to the group with only one observation per individual. This was used with data for the Inuit pregnant and lactating women (using variance characteristics of Inuit non-pregnant non-lactating women), and with Dene/Métis, Yukon and K’asho Got’ine/Behdzi Ahda non-pregnant non-lactating and pregnant and lactating women (using variance characteristics of Fort Good Hope/Colville Lake non-pregnant non-lactating). These populations were analysed together, as they have similar diets (Arctic traditional foods and limited variety in purchased foods), and there were insufficient data to analyse pregnant and lactating groups separately. We used this strategy in earlier analyses on vitamin intakes of Arctic indigenous adults (21,30). This is the first time it is applied to pregnant and lactating women.

These methods were used to determine the distributions of usual intakes for energy, 8 minerals [calcium (Ca), copper (Cu), iron (Fe), magnesium (Mg), manganese (Mn), phosphorus (P), selenium (Se), zinc (Zn)] and 7 vitamins (vitamin A, riboflavin, vitamin B6, folate, vitamin C, vitamin D, vitamin E). These were then referenced to the Dietary Reference Intakes (DRIs), a system of nutrition recommendations that replaced the Recommended Dietary Allowances (RDAs) in the United
States and the Recommended Nutrient Intakes (RNIs) in Canada, namely, the Estimated Average Requirement (EAR), the Adequate Intake (AI) and the Upper Level (UL). Nutrients for which requirements are well known have an established EAR and distribution of requirements. Using what is called the “cut-point method” (31), the percent of individuals with intakes less than the EAR is approximately equal to the percent of individuals with inadequate intakes. Nutrients with effects/inadequacies less well understood have an AI. If the group average intake is greater than the AI, then the group is expected to have adequate intakes. The UL is the upper safe level of intake, available for some nutrients, and there may be a health risk when usual intakes exceed the UL (31–33).

The women included in the analyses were between 15 and 40 years old. For most nutrients the EAR/AIs are slightly higher for those less than 18 years old, but there were few individuals between 15 and 18, and the EAR/AIs of the 19–30 or 19–50 year-old group were used.

The cut-point method cannot be applied for iron in non-pregnant and non-exclusive breastfeeding young women, because the iron requirement distribution is skewed, and the cut-point method assumes symmetrical requirement distribution. Therefore, for non-pregnant non-lactating women we used an alternative method by calculating the percent of intakes within specific ranges, multiplied this by the probability of inadequacy of those with intakes within each range, summed across all ranges (31,34,35), and arithmetically corrected to represent prevalence of adequacy, as was done previously (30).

RESULTS

The population distributions of reported energy intakes in pregnant women are shown in Figure 1, where the probability density function is on the vertical axis and energy intake on the horizontal axis (non-pregnant non-lactating women and lactating not shown). All population groups had approximately normally distributed intakes. The means and standard deviations of energy, protein and fat intake of each group are shown in Table II.

Approximately 5% of non-pregnant non-lactating women, half of pregnant women and 15% of lactating women reported using a micronutrient supplement. For these approximately 80 recalls there were 23 different types or brands of supplements listed with varying and often unknown composition and schedule of use. Nutrient intakes from supplements were not included in these analyses, but the implications are discussed.

The prevalence of dietary micronutrient inadequacy is shown in Table III. While there were a few differences between groups, overall they were quite similar. Inadequacies ranged from 0% for many minerals, to very high for Mg, vitamin E and folate. Iron intakes were lower than required for most pregnant Dene/Métis, Yukon and K’asho Got’ine/Behdzi Ahda (hereafter, DM/Y/KG/BA) women. While in the other groups iron intakes were far greater than required (greater than 30 mg/d), the intakes in DM/Y/KG/BA women were around 18 mg/d, sufficient for the non-pregnant non-lactating and lactating women (for whom the EAR is 8.1 mg/d and 6.5 mg/d, respectively), but insufficient for the pregnant women (for whom the EAR is 23 mg/d). The pregnant DM/Y/KG/BA women also had lower prevalence of inadequacy.
Dietary assessment of Canadian Arctic women

of Mg and vitamin A than the other groups. Pregnant women in each population group had higher prevalence of inadequacy of Zn and folate than non-pregnant non-lactating women; lactating women had higher prevalence of inadequacy of vitamin A, folate and vitamin C than non-pregnant non-lactating women.

For three nutrients studied, Ca, Mn and vitamin D, the mean intake was compared to the AI in Table IV. The mean Ca intake of most groups was about one-half the AI; the Mn and vitamin D mean intakes of all groups

![Figure 1. Distribution of reported usual energy intakes (kJ/d) in pregnant women in 3 Arctic populations (*Dene, Métis, Yukon First Nations, K’asho Got’ine, Behdzi Ahda First Nation).](image)

**Table II. Energy, protein and fat intakes [mean (SD)] in Inuit women from Qikiqtarjuaq, 18 Inuit communities and a combined data set of Dene, Métis and Yukon First Nations.**

|                | Qikiqtarjuaq | Inuit  | DM/Y/KG/BA* |
|----------------|--------------|--------|-------------|
| **Energy (kJ/d)** |              |        |             |
| Women <40      | 9,892 (988)  | 8,468 (1,042) | 8,895 (1,289) |
| Pregnant       | 7,602 (908)  | 7,786 (883)   | 11,315 (2,955) |
| Lactating      | 8,309 (1,926) | 9,209 (925)   | 11,319 (2,281) |
| **Protein (g/d)** |              |        |             |
| Women <40      | 120.7 (9.2)  | 108.2 (12.6) | 130.6 (34.6) |
| Pregnant       | 136.8 (38.6) | 86.8 (13.1)  | 142.8 (44.1) |
| Lactating      | 115.1 (20.7) | 130.6 (19.9) | 159.5 (58.8) |
| **Fat (g/d)**  |              |        |             |
| Women <40      | 99.4 (15.0)  | 75.6 (14.1)  | 85.2 (14.8)  |
| Pregnant       | 80.9 (32.2)  | 60.2 (11.4)  | 112.7 (24.3) |
| Lactating      | 71.4 (18.2)  | 78.0 (11.2)  | 108.5 (20.8) |

* Dene, Métis, Yukon First Nations, K’asho Got’ine, Behdzi Ahda First Nation.
was much greater than the AI. The risk of excessive intakes was considered through estimating the prevalence of individuals with usual intakes greater than the ULs in Table V. A large number of women exceeded the UL for Fe, less so for Se and a few for Zn.

Method validation
Our method of using the pattern of intake distribution from the non-pregnant non-lactating women group to model the distribution in the pregnant and lactating group in Inuit and DM/Y/KG/BA allowed us to generate distributions for

Table III. Prevalence of dietary micronutrient inadequacy in Arctic Indigenous women from Qikiqtarjuaq, 18 Inuit communities and a combined data set of Dene, Métis and Yukon First Nations.

| Micronutrient | Inuit | DM/Y/KG/BA |
|---------------|-------|------------|
| Cu (µg/d)     |       |            |
| F<40 Pr Lac   |       |            |
| 700 800 1000  | 0.0%  | 0.6% 3.0% |
| 2.0% 1.3% 0.5%| 0.0%  | 0.0% 0.0% |
| Fe (mg/d)     |       |            |
| F<40 Pr Lac   |       |            |
| 8.1 23 6.5   | 0.5%  | 3.7% 0.0% |
| <1% 13% 0.0% | 0.0%  | 84.1% 0.0%|
| P (mg/d)      |       |            |
| F<40 Pr Lac   |       |            |
| 580 580 580  | 0.0%  | 0.0% 0.0% |
| 12.2% 1.5% 0.0%| 0.0%  | 0.0% 0.0% |
| Mg (mg/d)     |       |            |
| F<40 Pr Lac   |       |            |
| 255 290 255  | 84.4% | 92.3% 84.0%|
| 6.0% 81.3% 42.3%| 48.0%| 10.4% 0.0%|
| Se (µg/d)     |       |            |
| F<40 Pr Lac   |       |            |
| 45 49 59     | 0.0%  | 0.2% 1.5% |
| 0.1% 0.0% 0.0%| 0.0%  | 0.4% 0.0% |
| Zn (mg/d)     |       |            |
| F<40 Pr Lac   |       |            |
| 6.8 9.5 10.4 | 0.0%  | 10.7% 0.0%|
| 0.5% 23.2% 1.9%| 0.0%  | 7.7% 2.0% |

Vitamin A (µg/d): 500 550 900 44.1% 44.9% 95.4% 55.0% 94.8% 100% 68.3% 12.0% 98.6%
Riboflavin (mg/d): 0.9 1.2 1.3 0.3% 8.0% 1.9% 0.0% 5.5% 2.0% 0.0% 0.0% 1.4%
Folate (µg/d): 320 520 450 21.6% 89.8% 100% 44.0% 94.2% 87.9% 59.3% 96.2% 96.9%
Vitamin B6 (mg/d): 1.1 1.6 1.7 0.0% 1.0% 14.7% 10.6% 37.5% 9.1% 0.3% 1.3% 6.0%
Vitamin C (mg/d): 75 85 120 93.5% 91.6% 97.8% 24.0% 11.2% 46.6% 40.0% 0.4% 69.7%
Vitamin E (mg/d): 12 12 16 100% 100% 100% 100% 100% 100% 100% 100% 100%

Table IV. Comparison of mean daily nutrient intakes to adequate intakes in Arctic Indigenous women from Qikiqtarjuaq, 18 Inuit communities and a combined data set of Dene, Métis and Yukon First Nations.

| Micronutrient | Inuit | DM/Y/KG/BA |
|---------------|-------|------------|
| Calcium (mg/d) |       |            |
| Women <40    | 1000  | 578        | 420  | 550 |
| Pregnant     | 1000  | 512        | 571  | 903 |
| Lactating    | 1000  | 438        | 487  | 1036|
| Manganese (mg/d) |     |            |
| Women <40    | 2     | 3.3        | 2.5  | 2.9 |
| Pregnant     | 2     | 3.3        | 2.5  | 2.7 |
| Lactating    | 3     | 3.5        | 2.9  | 7.6 |
| Vitamin D (µg/d) |      |            |
| Women <40    | 5     | 11.4       | 9.1  | 5.7 |
| Pregnant     | 5     | 11.8       | 10.6 | 18.7|
| Lactating    | 5     | 20.4       | 9.4  | 10.6|

* Adequate intakes.
** Dene, Métis, Yukon First Nations, K’asho Got’ine, Behdzi Ahda First Nation.
Dietary assessment of Canadian Arctic women

Using only the Qikiqtarjuaq data set, we calculated the distribution of energy intakes using 4 methods (see Figure 2, whose axes are that of Figure 1). (1) We calculated the 1 day distribution (not using repeat measures) — the “unadjusted distribution.” (2) We used SIDE to describe the usual distribution of intakes, as per the normal SIDE method — the “correct distribution.” (3) We used the variance components from the non-pregnant non-lactating women and applied them to the unadjusted distribution, analogous to what we did with the Inuit and DM/Y/KG/BA pregnant and lactating women’s distributions — the “new method distribution.” (4) We calculated the average intake of those pregnant women with 4 or more days of data, and plotted the results — the “conventional distribution.” The similarities between the “correct distribution” and the “new method distribution” demonstrate that the new method is appropriate and can yield reasonable results.

Table V. Usual daily intakes exceeding Upper Levels in women (%) from Qikiqtarjuaq, 18 Inuit communities and a combined data set of Dene, Métis and Yukon First Nations.

| Nutrient  | Qikiqtarjuaq UL* | Qikiqtarjuaq F<40** | Qikiqtarjuaq Pr | Qikiqtarjuaq Lac | Inuit F<40 | Inuit Pr | Inuit Lac | DM/Y/KG/BA*** | DM/Y/KG/BA F<40 | DM/Y/KG/BA Pr | DM/Y/KG/BA Lac |
|-----------|-----------------|--------------------|----------------|----------------|-----------|--------|---------|--------------|----------------|--------------|--------------|
| Fe (mg/d) | 45              | 62%                | 73%            | 41%           | 0%        | 1%     | 0%      | 0%           | 0%             | 0%           | 35%          |
| Se (µg/d) | 400             | 57%                | 0%             | 1%            | 0%        | 0%     | 0%      | 0%           | 0%             | 0%           | 0%           |
| Zn (mg/d) | 40              | 0%                 | 0%             | 0%            | 0%        | 0%     | 0%      | 0%           | 0%             | 0%           | 0%           |
| Vit A (µg/d) | 3000          | 0%                 | 4%             | 0%            | 0%        | 0%     | 0%      | 0%           | 0%             | 0%           | 0%           |

* Upper Levels.
** F<40: non-pregnant, non-lactating women less than 40 years; Pr: pregnant women; Lac: lactating women.
*** Dene, Métis, Yukon First Nations, K’asho Got’ine, Behdzi Ahda First Nation.

Figure 2. Energy intake in non-pregnant non-lactating Qikiqtarjuaq women using 4 methods.
DISCUSSION

The analyses presented here provide an understanding of dietary inadequacy of women throughout the Canadian Arctic. While the data are somewhat dated, this provides the advantage of documenting the northern diet before the most dramatic climate changes, and resulting changes in wildlife, have occurred (36,37). These data may serve as a benchmark against which dietary change can be evaluated as Arctic climate change continues.

The micronutrient intakes observed are consistent with a high-meat diet: Cu, Fe, Zn and riboflavin intakes are all high, and folate and vitamin C intakes are low. Vitamin B12 intake, which is not analysed due to an incomplete composition database, would have undoubtedly been high. Although some locally available animal source foods are excellent sources of vitamins A and E (21), Arctic women do not consume sufficient quantities to prevent dietary inadequacy. However, vitamin A intake is notoriously difficult to assess from 24-hour recalls due to high concentrations in a few foods, for example caribou, seal, fish or fowl liver (38). Other research on vitamin A status in Arctic populations indicates that serum retinol levels are low, but deficiency is not common (39,40). Dietary inadequacy of vitamin E appears universal, but similar to vitamin A, other research on vitamin E status has not found widespread deficiency (41). In fact, clinical deficiency of vitamin E and concomitant neuropathy is almost unheard of in any population; rather, there is concern that intakes less than the EAR may promote chronic disease, especially heart disease (32).

Iron intakes were high, and yet there are widespread reports of Fe deficiency in Arctic populations — in pregnant women (42), children (42–44), all ages (45). We do not have evidence that the anemia is due to low Fe intakes and, as reported in similar populations (45), it could possibly be due to high rates of *Helicobacter pylori* infection. We do not advocate increased Fe intakes, particularly from supplements, without further research into the causes of anemia in these populations.

Low vitamin C intakes raise the concern that diets were very low in fruits and vegetables, and thus missing their numerous benefits beyond vitamin C (46). Furthermore, vitamin C requirements are higher in smokers and the EAR is 35 mg/d higher for smokers, a factor not included in the results presented here. Although the smoking rate is high in these populations (47), we did not collect smoking data from the respondents.

The energy intakes in some groups were less than 6,000 kilojoules (kJ) in Qikiqtarjuaq pregnant and lactating women and Inuit pregnant women in the larger study, suggesting that there may have been some under-reporting in these groups. Some energy intakes of Dene and Yukon non-pregnant non-lactating women were unexpectedly high — it is unlikely that there were so many women with intakes greater than 12,000 kJ. These may be methodological errors introduced by SIDE, over-reporting or a biased sample that included a disproportionate number of very high consumers. If there indeed was under-reporting of energy intake, the true micronutrient intakes may be higher and the prevalence of inadequacy may be lower. Alternatively, there may be
unreported consumption of low quality “junk food” or alcohol, which would have minimal effect on micronutrient intake. Under-reporting and other issues related to misreporting have been discussed (48). It is of note that the dietary data were taken from women at various stages of pregnancy, including early pregnancy when appetite may have been reduced.

Supplement use
Multivitamins/minerals were the most frequently reported supplement, but of varying composition; and single nutrient supplements of Fe and Ca and vitamins C and E were reported by a few users. Not incorporating supplement use in these analyses will have contributed to some level of underestimating of nutrient intakes. But for most nutrients reported here we expect the contribution to error in our estimates of inadequacy will be minimal. Most of the multi-supplement vitamins will contain Fe and B vitamins, for which prevalence of inadequacy is already low when considering intake from food alone (Fe, Cu, riboflavin, vitamin B6) or not reported (thiamin, niacin, vitamin B12). Many of the multi-supplements would contain vitamin C and vitamin A, and thus we expect that the prevalence of inadequacy would be lower than we report in Table III, especially in pregnant women. A key uncertainty is the frequency of consumption of folate-containing supplements. The prevalence of inadequacy of folate in pregnant women may have been significantly lower than we report. We do not expect there to be very much difference for the remaining nutrients.

Differences among northern Indigenous populations
The traditional food available in the North is generally of higher quality and more nutrient dense than available market food. Access to traditional food has been shown to be a key determinant of dietary adequacy in the Arctic (2); therefore, differences among the groups in consumption of traditional food is a key consideration. As shown in Figure 3, consumption of traditional food was highest in Qikiqtarjuaq Inuit providing over 25% of dietary energy, and lowest in the Dene and Métis where it provided as little as 5%. Nonetheless, the differences in traditional food consumption did not relate to differences in prevalence of inadequacy between the groups, presumably because micronutrients supplied in greatest level by traditional food are minerals, riboflavin and vitamin D, and mineral intake was high in all groups, whether they consumed traditional food or not. Since most traditional food consumed is animal source food, those who do not consume traditional meats usually substitute (or supplement) with market beef, pork or chicken. While of inferior quality, they are still excellent sources of most minerals and riboflavin. The micronutrients found more often in plant-sourced foods (folate, vitamin C and pro-vitamin A) are not found in substantive quantity in the traditional animal source food, although some excellent sources exist (16,21,22).

Differences in traditional food consumption did relate to differences in the number exceeding the UL. High traditional food intake in Qikiqtarjuaq yielded high intakes of Fe, such that over half of the women exceeded the UL. The UL for Fe was set at 45 mg/d after
observing some minor GI irritation and constipation at 70 mg/d of supplemental (non-food) Fe. Supplemental and food-source iron are handled differently by the gut, and food-source iron is not known to irritate the gut. Therefore, exceeding the UL in these circumstances is not of concern, especially since these foods are important for cultural, economic and nutrition reasons, and have been so for millennia in Arctic populations.

Differences among non-pregnant non-lactating, pregnant and lactating women

Pregnant or lactating women had a higher prevalence of inadequacy for a number of nutrients than non-pregnant non-lactating women. As shown in Table III, this was usually the case for folate, vitamin C, vitamin A and Zn. This higher prevalence of inadequacy is usually not a function of pregnant and lactating women having lower intakes of these nutrients. Rather, the intakes of the pregnant women were usually similar to or even higher than the non-pregnant non-lactating women, but not high enough to cover the increased requirements. For example, pregnant Inuit women had intakes of folate 30% higher than non-pregnant non-lactating women, but the folate EAR during pregnancy was 63% higher than in non-pregnancy. In the DM/Y/KG/BA iron intakes during pregnancy were the same as in non-pregnant non-lactating women, but the iron EAR was 2.8 times higher. A similar pattern exists for other nutrients. This would indicate that a special emphasis on nutrition during pregnancy and lactation, including nutrition education and promotion of supplements, could benefit the nutritional status of the pregnant and lactating Arctic women. However, it is also worth considering whether or not the presumed nutrient requirements for women are accurate. It seems unlikely that the real physiological requirements of various nutrients change

Figure 3. Percent of dietary energy from traditional food, by region and group (*K’asho Got’ine, Behdzi Ahda First Nation, **Dene and Métis, ***Yukon First Nations).
Dietary assessment of Canadian Arctic women

immediately upon conception and remain at elevated levels until birth. Thus, the reported higher levels of inadequacy during pregnancy may be, in part, artifacts of the DRI.

Study limitations
In addition to some of the limits of the 24-hour recall method already mentioned, this study was limited by relatively small sample sizes of pregnant and lactating women. The sample sizes of 74 pregnant women and 117 lactating women would be ample if they were from a homogenous population, but this article describes the diet across the Canadian Arctic over a 10-year period. This limit is addressed in part by our method of using the pattern of intake distribution from the non-pregnant non-lactating women group to model the distribution in the pregnant and lactating group in Inuit and DM/Y/KG/BA (see “Analysis” under Materials and Methods above). While this allows us to generate distributions for those groups with small samples and/or few repeats, and was internally validated by the analyses represented in Figure 2, it has not been independently validated elsewhere.

Conclusions
In this article we have shown that dietary intake data without repeat observations on some of the subjects can be used to describe intake distributions for many micronutrients and correctly apply the DRIIs for Arctic pregnant and lactating women. There may be moderate public health concern for low intakes of vitamins A, C, E and folate. Low intakes of vitamins A, C and E could be addressed through increased intake of select, locally available traditional foods (16,21,38) and better use of better quality market foods.

These data from Indigenous young women throughout the Canadian Arctic provide the most thorough assessment of micronutrient intake of pregnant, lactating and non-pregnant non-lactating Arctic women. In addition to the value of these data for nutrition programs in the Arctic, we also note the value of the data for monitoring dietary change in women which may be accelerated by reduced traditional food use as a result of changing climate and socio-economic factors.

Acknowledgements
The authors acknowledge the many participants for their patience during the research. We especially thank the community leaders, the Inuit Tapiriit Kanatami, Council of Yukon First Nations and the Dene Nation for facilitating community agreements for conducting the research. We acknowledge with appreciation the contributions to data collection and analysis of Dr. Olivier Receveur. For research funding we acknowledge Health Canada, the Arctic Environmental Strategy and Northern Contaminants Program of Indian and Northern Affairs Canada, and the Canadian Institutes of Health Research, Institute of Aboriginal Peoples' Health and Institute of Nutrition, Metabolism and Diabetes.

REFERENCES
1. Kuhnlein HV, Receveur O, Chan HM. Traditional food systems research with Canadian Indigenous Peoples. Int J Circumpolar Health. 2001;60(2):112–122.
2. Kuhnlein HV, Receveur O, Soueida R, Egeland GM. Arctic indigenous peoples experience the nutrition transition with changing dietary patterns and obesity. J Nutr 2004;134(6):1447–1453.
3. Kuhnlein HV, Soueida R, Receveur O. Baffin Inuit food use by age and gender. J Can Diet Assoc 1995; 56(4):175–183.
4. Kuhnlein HV, Receveur O. Local cultural animal food contributes high levels of nutrients for Arctic Canadian Indigenous adults and children. J Nutr 2007;137(4):1110–1114.

5. Bersamin A, Luick BR, Ruppert E, Stern JS, Zidenberg-Cherr S. Diet quality among Yup’ik Eskimos living in rural communities is low: the Center for Alaska Native Health Research Pilot Study. Am J Diet Assoc 2006;106(7):1055–1063.

6. Bjerregaard P, Young TK, Dewailly E, Ebbesson SO. Indigenous health in the Arctic: an overview of the circumpolar Inuit population. Scand J Public Health 2004;32(5):390–395.

7. Lambden J, Receveur O, Kuhnlein HV. Traditional food attributes must be included in studies of food security in the Canadian Arctic. Int J Circumpolar Health 2007;66(4):308–319.

8. Lambden J, Receveur O, Marshall J, Kuhnlein HV. Traditional and market food access in Arctic Canada is affected by economic factors. Int J Circumpolar Health 2006;65(4):331–340.

9. Healey GK, Meadows LM. Inuit women’s health in Nunavut, Canada: a review of the literature. Int J Circumpolar Health 2007;66(3):199–214.

10. Young TK, Bjerregaard P, Dewailly E, Risica PM, Jorgensen ME, Ebbesson SE. Prevalence of obesity and its metabolic correlates among the circumpolar Inuit in 3 countries. Am J Public Health 2007;97(4):691–695.

11. Godel JC, Pabst HF, Hodges PE, Johnson KE. Iron status and pregnancy in a northern Canadian population: relationship to diet and iron supplementation. Can J Public Health 1992;83(5):339–343.

12. Kuhnlein HV, Receveur O, Morrison NE, Appavoo DM, Soueida R, Pierrot P. Dietary nutrients of Sahtú Dene/Métis vary by food source, season and age. Ecology of Food and Nutrition. 1995;34(3):183–195.

13. Receveur O, Boulay M, Kuhnlein HV. Decreasing traditional food use affects diet quality for adult Dene/Métis in 16 communities of the Canadian Northwest Territories. J Nutr 1997;127(11):2179–2186.

14. Gibson RS. Principles of nutritional assessment. 2nd ed. New York: Oxford University Press; 2005. 908 pp.

15. Sims J, Kuhnlein HV. Indigenous peoples and participatory health research: planning and management / preparing research agreements. Geneva: Centre for Indigenous Peoples’ Nutrition and Environment (CINE) and World Health Organization (WHO); 2003. 35 pp.

16. Fediu K, Hidiroglou N, Madere R, Kuhnlein HV. Vitamin C in Inuit traditional food and women’s diets. J Food Compost Anal 2002;15:221–235.

17. Kuhnlein HV, Appavoo D, Morrison N, Soueida R, Pierrot P. Use and nutrient composition of traditional Sahtú (Hareskin) Dene/Métis foods. J Food Compost Anal 1994;7:144–157.

18. Kuhnlein HV, Soueida R. Use and nutrient composition of traditional Baffin Inuit foods. J Food Compost Anal 1992;112:112–126.

19. Kuhnlein HV, Kubow S, Soueida R. Lipid components of traditional Inuit foods and diets of Baffin Island. J Food Compost Anal 1991;4:227–236.

20. Kuhnlein HV, Chan HM, Leggee D, Barthet V. Macronutrient, mineral and fatty acid composition of Canadian Arctic traditional food. J Food Compost Anal 2002;15:545–566.

21. Kuhnlein HV, Barthet V, Varren A, Falahi E, Leggee D, Receveur O, et al. Vitamins A, D, and E in Canadian Arctic Traditional Food and Diets. J Food Compost Anal 2006;19:495–506.

22. Morrison N, Kuhnlein HV. Retinol content of wild foods consumed by the Sahtú (Hareskin) Dene/Métis. J Food Compost Anal 1993;6:10–23.

23. Murphy SP, Gross KR. The UCB mini-list diet analysis system. M$-DOS version user’s guide. Berkeley: The Regents of the University of California; 1987. 117 pp.

24. Holden JM, Eldridge AL, Beecher GR, Buzzard JM, Bhagwat S, Davis C, et al. Carotenoid content of U. S. foods: an update of the database. J Food Compost Anal 1999;12:169–196.

25. Murphy SP. Changes in dietary guidance: implications for food and nutrient databases. J Food Compost Anal 2001;14:269–278.

26. Nutrient Database for Standard Reference; 2006 [cited 2006 Jan 13]. Available from: http://nal.usda.gov/fnic/cgi-bin/nut_search.pl.

27. Carriquiry AL. Assessing the prevalence of nutrient inadequacy. Public Health Nutr 1999;2(1):23–33.

28. Carriquiry AL. Estimation of usual intake distributions of nutrients and foods. J Nutr 2003;133(2):601S–608S.

29. Nusser SM, Carriquiry AL, Dodd KW, Fuller WA. A semiparametric transformation approach to estimating usual daily intake distributions. J Am Stat Assoc 1996;91:1440–1449.

30. Kuhnlein HV, Receveur O, Soueida R, Berti PR. Unique patterns of dietary adequacy in three cultures of Canadian Arctic indigenous peoples. Public Health Nutr 2008 Apr;11(4):349-360.

31. Institute of Medicine. Dietary reference intakes: applications in dietary assessment. Washington, DC: National Academy Press; 2000. 289 pp.

32. Institute of Medicine. Dietary reference intakes for vitamin C, vitamin E, selenium and carotenoids. Washington, DC: National Academy Press; 2000. 509 pp.

33. Institute of Medicine; National Research Council. Dietary reference intake for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc. Washington, DC: National Academy Press; 2000. 773 pp.

34. Murphy SP, Guenther PM, Kretsch MJ. Using the dietary reference intakes to assess intakes of groups: pitfalls to avoid. J Am Diet Assoc 2006;106(10):1550–1553.
35. Murphy SP, Barr SI. Challenges in using the dietary reference intakes to plan diets for groups. Nutr Rev 2005;63(8):267–271.

36. Symon C, Arris L, Heal B. Arctic climate impact assessment. New York: Cambridge University Press; 2005. 1042 pp.

37. Walton D. Dragonflies, open water reveal rapid Arctic change. Globe and Mail [cited 2007 Oct 4] Available from: http://www.theglobeandmail.com/servlet/story/RTGAM.20071003.wwarm1004/BNStory/Clim- 

38. Egeland GM, Berti P, Soueida R, Arbour LT, Receveur O, Kuhnlein HV. Age differences in vitamin A intake among Canadian Inuit. Can J Public Health 2004; 95(6):465–469.

39. Dallaire F, Dewailly E, Shademani R, Laliberte C, Bruneau S, Rhaids M, et al. Vitamin A concentration in umbilical cord blood of infants from three separate regions of the province of Quebec (Can-ada). Can J Public Health 2003;94(5):386–390.

40. Godel JC, Basu TK, Pabst HF, Hodges RS, Hodges PE, Ng ML. Perinatal vitamin A (retinol) status of northern Canadian mothers and their infants. Biol Neonate 1996;69(3):133–139.

41. Godel JC. Vitamin E status of northern Canadian newborns: relation of vitamin E to blood lipids. Am J Clin Nutr 1989;50(2):375–380.

42. Hodgins S, Dewailly E, Chatwood S, Bruneau S, Bern-ier F. Iron-deficiency anemia in Nunavik: pregnancy and infancy. Int J Circumpolar Health 1998;57 Suppl 1:135–140.

43. Christofides A, Schauer C, Zlotkin SH. Iron defi-ciency and anemia prevalence and associated etiologic risk factors in First Nations and Inuit communities in northern Ontario and Nunavut. Can J Public Health 2005;96(4):304–307.

44. Willows ND, Dewailly E, Gray-Donald K. Anemia and iron status in Inuit infants from northern Que-bec. Can J Public Health 2000;91(6):407–410.

45. Parkinson AJ, Gold BD, Bulkow L, Wainwright RB, Swaminathan B, Khanna B, et al. High prevalence of Helicobacter pylori in the Alaska native population and association with low serum ferritin levels in young adults. Clin Diagn Lab Immunol 2000;7(6):885–888.

46. Heber D. Vegetables, fruits and phytoestrogens in the prevention of diseases. Postgrad Med 2004;50(2):145–149.

47. Millar WJ. Smoking prevalence in the Canadian Arctic. Arctic Med Res 1990;49(Suppl 2):23–28.

48. Maurer J, Taren DL, Teixeira PJ, Thomson CA, Lohman TG, Going SB, et al. The psychosocial and behavioral characteristics related to energy misreporting. Nutr Rev 2006;64(2 Pt 1):53–66.

Peter R. Berti
HealthBridge
1 Nicholas Street, Suite 1105
Ottawa, Ontario
KIN 7B7
CANADA
Email: pberti@healthbridge.ca