Prevalence of anemia among Inuit women in Nunavik, Canada

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ABSTRACT

Objectives. To assess the prevalence and main types of anemia present among non-pregnant Inuit women of Nunavik using a representative sample.

Study design. A cross-sectional population-based study.

Methods. Iron status was assessed in 466 women aged 18–74 who participated in the 2004 Nunavik Inuit Health Survey. The presence of different types of anemia has been evaluated based on available biochemical indicators of vitamins and of iron status. The correlation between iron status indicators, vitamin status parameters, inflammation markers and heavy metal concentrations was also assessed.

Results. Anemia was present in 43% of the Inuit women in Nunavik and 21% suffered from iron deficiency anemia (IDA). The main type of anemia present among women 18–49 years old was IDA (61% of anemia cases) while anemic women 50 years and over suffered mainly from anemia related to chronic inflammation (ACI) (42%). Over 99% of women had normal values for vitamin A, vitamin B₁₂ and folate. Of interest is that ferritin was positively correlated with blood mercury and lead levels.

Conclusion. The prevalence of anemia in Nunavik women is similar to levels observed in non-industrialized countries and represents a severe public health problem that should be further investigated. The most prevalent type of anemia in these women shifted from IDA to ACI with age. Vitamin A, vitamin B₁₂ and folate deficiencies do not constitute a widespread problem and their contribution to anemia is probably minimal. Sources of heavy metals are also major sources of iron in the diet of Nunavik women which could explain the positive association found between heavy metals and iron status.

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Keywords: anemia, Inuit, women, Nunavik, prevalence, iron deficiency
INTRODUCTION

According to the World Health Organization (WHO), over 2 billion people around the world suffer from anemia, of which 1.3 billion cases are due to iron deficiency (1). Women are among the high-risk groups for iron deficiency anemia (IDA) (1). IDA can have a negative impact on the immune system, physical work capacity, cognitive performance and national socioeconomic development, as well as on personal health and self-fulfilment (1–3). Among women, IDA is primarily prevalent during childbearing years and adversely impacts pregnancy outcomes (4).

In 1990–1995, the prevalence of anemia among women was estimated at 10% in industrialized countries and 42% in non-industrialized countries (1). In Canada, data on the iron status of adult women are scarce (5). The last data available were collected in 1973 during the Nutrition Canada Survey. According to these data, the prevalence of anemia was 5.2% among Canadian women and 13.2% among Inuit women in the Northwest Territories. Although more recent data should be available in 2011 from the Canadian Health Measures Survey, this study excluded residents of remote regions such as Nunavik (6). To our knowledge, the only study available in Nunavik women was conducted from 1989 to 1991 using prenatal follow-ups from one Nunavik village, Puvirnituq. It indicated a 39% prevalence of anemia during the first trimester of pregnancy (7).

The etiology of anemia is often complex and multifactorial (1,8). The main cause of anemia is iron deficiency, which may be related to inadequate iron intake, poor bioavailability, high iron needs or high loss of iron. Other nutrient deficiencies such as vitamin A, vitamin B₁₂ and folate deficiencies as well as inflammation or infection can also affect the hemoglobin concentration. Indeed, vitamin A deficiency can affect iron metabolism and iron store mobilization, which may lead to anemia (9,10). Both vitamin B₁₂ and folate deficiencies may cause megaloblastic anemia characterized by large, immature and dysfunctional red blood cells (9). Also, infections, inflammatory disorders, and some malignancies often lead to the development of anemia of inflammation (11). The liver then produces increased amounts of hepcidin which decrease iron absorption, recycling and iron stores release (11). However, anemia remains pathophysiologically unexplained in about a third of the anemic elderly (12). Unexplained anemia was found to be characterized by low levels of erythropoietin and of pro-inflammatory markers (13).

Finally, studies indicate that heavy metals, such as lead and mercury, are related to iron metabolism (14–16). Although the strong positive correlations observed between iron status indicators and mercury concentrations remain to be explained (15), the inverse associations found with lead may be caused by many factors including lead’s interference with heme biosynthesis in the bone marrow (17), increased absorption of lead in iron-deficient individuals due to the up-regulation of divalent metal transporters (18) and decreased absorption of iron through competitive inhibition by lead (19).

The main objective of this study was to assess the prevalence and main types of anemia present among non-pregnant Inuit women in Nunavik using a representative sample of non-pregnant Inuit women as part of the Nunavik Inuit Health Survey 2004.
MATERIAL AND METHODS

Study population
Nunavik is a northern region of the province of Quebec, Canada, located north of the 55th parallel. In 2004, an extensive health survey was conducted among the Inuit population of Nunavik. Data collection was performed on the Canadian Coast Guard ship Amundsen, which visited the 14 villages of Nunavik. The health survey has been approved by the Comité d'éthique de la recherche de l'Université Laval (Laval University Research Ethics Committee) and the Comité d'éthique en santé publique (Quebec Public Health Ethics Committee).

The target population of the health survey was permanent residents of Nunavik, excluding residents of collective dwellings and households in which there were no Inuit aged 18 years or older. Details of the study design and methodological aspects are reported elsewhere (20). Briefly, the study sample was selected by a stratified random sample of private Inuit households with proportional allocation corresponding to the size of each village. This sample represented 20% of the whole adult female population of Nunavik and was made representative of this population by computing sampling weights (20). Blood parameters were available for 502 women aged between 18 and 74 years resulting in an individual participation rate of 74%. For the purpose of this study, 36 women have been excluded because they were pregnant (n=26), Caucasian (n=5) or/and because they took supplements that may have contained iron (n=6) (one women had 2 exclusion criteria). Thus, the final study sample for iron status parameters comprised 466 women.

Blood sampling and laboratory analyses
Blood samples were obtained after an overnight fast (8 hours minimum). Hematological parameters included hemoglobin (Hb), serum ferritin (SF), serum iron (SI), transferrin saturation (TSAT), total iron binding capacity (TIBC), serum retinol, vitamin B\textsubscript{12}, folate and blood lead and mercury levels. Hb analysis has been performed on a Beckman-Coulter GEN-S automatic analyzer (Beckman-Coulter, Miami, FL, USA). SF, serum B\textsubscript{12} and serum folate have been carried out using an Elecsys-2010 System (Roche Diagnostics Corp., Indianapolis, IN, USA). SI, TSAT and unsaturated iron binding capacity (UIBC) were measured in frozen centrifuged blood at Laval Hospital's Biochemical Centre (Quebec City) using a Modular P from Roche Diagnostics Corp. The sum of UIBC and SI was used to calculate the TIBC. The C-reactive protein (CRP), which is an acute-phase reactant indicating the presence of an infection or inflammatory state, is a marker commonly used in conjunction with biochemical parameters of iron status (21). CRP was measured in EDTA-treated plasma using the (highly sensitive) Latex-Enhanced CRP essay using a BM Prospec (Dade Behring, Marburg, Germany). Serum retinol was determined by the high-performance liquid chromatography method at the laboratories of the Lipid Research Center, Centre Hospitalier Universitaire de Québec, using a Waters HPLC system equipped with an autosampler, a reverse-phase column (ProntoSil-C18SH) and electrochemical detection (Coulochem III) (Waters Corporation, Milford, MA, USA).

The heavy metal content of the blood samples was analysed by inductively coupled plasma mass spectrometry using Perkin Elmer Sciei instruments (Waltham, MA, USA) at INSPQ’s toxicology laboratory. Lead levels were measured using the ICP-MS Elan 6000 (INSPQ...
method: M-557) and total mercury concentration was quantified on the Elan DRC II. Detection limits were 0.001 µmol/L for lead and 0.5 nmol/L for total mercury. Accuracy and precision were measured using reference materials from external quality assessment schemes of the Centre de Toxicologie (INSPQ, Quebec) (22).

Assessment of iron status and anemia
The multiple-indices model of Patterson et al. (23) was used to determine the prevalence of iron deficiency. According to this model, women are considered iron deficient (ID) if they have depleted iron stores (SF <15 µg/L) or if they have low iron stores (SF 15–20 µg/L), plus at least 2 abnormal values among the 3 following biochemical parameters: SI<10 µmol/L, TIBC≥68 µmol/L, TSAT<15%. Women with CRP≥10 mg/L and SF<50 µg/L are also classified as iron deficient since serum ferritin levels increase in the presence of infection or inflammation (21). This criterion was added to Patterson’s model.

In the present study, anemia has been defined as an Hb concentration of <120 g/L (1). Iron deficiency anemia (IDA) has been defined as anemia coexisting with iron deficiency. Also, the presence of low serum iron (SI<10 µmol/L) and anemia, without evidence of iron deficiency, was considered suggestive of an anemia of chronic inflammation (ACI) (12,24). The cut-off values for total plasma retinol, serum folate and vitamin B₁₂ were 1.05 µmol/L, 9.5 nmol/L and 145 pmol/L, respectively. The upper limit of acceptable blood lead levels corresponded to a value ≥48 µmol/L as recommended by the Centers for Disease Control (CDC) (25). For mercury, the obligatory declaration level for medical and research laboratories, which is based on the daily tolerable intake recommendation by Health Canada (60 nmol/L), was used as the cut-off value (26).

Data analysis
Since Hb concentration increases in smokers because of inhaled carbon monoxide (which may mask anemia), this value was adjusted based on self-reported cigarette use according to WHO criteria (27). Also, since all communities in this study are near sea level, no adjustment in hemoglobin levels due to altitude has been applied.

Analyses were carried out using SAS software (28). In order to generate estimations representative of the whole population under study and not just the sample, all data were weighted for the probability of selecting each individual as induced by the survey design, as well as for the rate of non-response and differences between the sample and the population. Descriptive statistics have been used (mean, median and prevalence) and sample variance was calculated using the bootstrap technique. When a variable was not normally distributed, the natural logarithm was considered for statistical analyses and the geometric mean was calculated as the measure of central tendency along with the medians, since these are less affected by extreme values. Hence, a log-transformation was applied to all blood parameters, with the exception of Hb, folate and retinol, which were normally distributed. Bivariate correlations were examined using the Pearson’s correlation test. Statistical analyses have been conducted at a threshold of \( \alpha = 0.05 \).

The coefficient of variation (CV) has been used to quantify the accuracy of estimates, and the scale of Statistics Canada has been used to qualify the accuracy of estimates. In the tables, the presence of an “E” footnote next to an estimate indicates a marginal estimate (CV between 16.6% and 33.3%) and constitutes a warning for subsequent users of the high variability of that data. Estimates with unreliable levels of accuracy (CV>33.3%) are not presented and have been replaced by the letter “F”.
RESULTS

Iron status among Nunavik women
The mean age of the sample was 37 years old. Distribution and prevalence of abnormal values for biochemical indicators are shown in Table I. Anemia was present in 43% of Nunavimmiut women. The majority of anemia cases (88.5%) were mild (Hb=100–119.9 g/L) and 9.1% were moderate (Hb=70–99.9 g/L), while women with severe anemia (Hb<70 g/L) were too few to report their results (CV>33.3%) (data not shown). As indicated in Table I, SI, TSAT and SF were also abnormally low, with respectively 42%, 29% and 30% of the women having levels below the cut-off values. A high level of TIBC, which indicates low iron status, was present in 14% of women. Over 99% of women had normal values for vitamin A, vitamin B₁₂, and folate. The proportion of insufficient levels for these nutrients was very low and did not permit further statistical analyses. High CRP levels were present in 6.6% of Nunavik women. Results showed that 7.5% of women had a blood lead level higher than the threshold (>0.48 µmol/L). Mercury concentrations over 60 nmol/L were found in nearly half of the Inuit women. The use of age-specific thresholds resulted in mercury levels higher than the acceptable blood concentration in 72.3% (>28.9 nmol/L) of women of childbearing age and in 30.5% (>99.7 nmol/L) of women 40 and over (data not shown). However, the prevalence of anemia in subjects with high lead or mercury levels was not higher than that observed in the rest of the sample (data not shown).

A Venn diagram of the iron status of Inuit women in Nunavik is presented in Figure 1. Forty-three percent of the women were anemic and the prevalence of iron deficiency (ID) reached 36% (Figure 1). More precisely, most women categorized as ID had depleted iron stores (95%), while 2.4% of women had low iron stores (SF 15–20 µg/L) combined with at least 2 abnormal values among the 3 biochemical parameters of iron status used (data not reported). In addition, 2.8% were classified as ID on the basis of a SF <50 µg/L and an elevated CRP concentration, indicative of infection or inflammation (data not reported). IDA was found in 21% of Inuit women. ID without anemia and non-iron-deficient anemia were found in 15% and 22% of subjects, respectively (Figure 1). Cases of non-iron-deficient anemia were divided between anemia of chronic inflammation and

| Table I. Distribution and prevalence of abnormal values for biochemical indicators among Inuit women in Nunavik. |
|---------------------------------------------------------------|
| **n** | **Median** | **Mean** | **CI 95%** | **Cut-off point** | **Prevalence** |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Hemoglobin (g/L) | 449 | 122.0 | 120.9 | 119.9–121.9 | <120 | 42.5 |
| Serum iron (µmol/L) | 464 | 10.0 | 10.2 | 9.77–10.65 | <10 | 42.1 |
| TSAT (%) | 464 | 19.0 | 18.0 | 17.0–19.0 | <15 | 28.8 |
| TIBC (µmol/L) | 464 | 56.8 | 56.8 | 55.99–57.59 | ≥68 | 13.6 |
| Serum ferritin (µg/L) | 464 | 24.8 | 23.7 | 21.96–25.47 | <15 | 30.2 |
| CRP (mg/L) | 458 | 1.35 | 1.29 | 1.16–1.44 | ≥10 | 6.6 |
| Plasma retinol (µmol/L) | 454 | 2.01 | 2.05 | 2.01–2.09 | <1.05 | F |
| Serum vitamin B₁₂ (pmol/L) | 464 | 391 | 381 | 370–393 | ≤145 | F |
| Serum folate (nmol/L) | 436 | 26.7 | 27.5 | 26.79–28.14 | <9.5 | F |
| Blood lead (µmol/L) | 464 | 0.16 | 0.17 | 0.16–0.18 | >0.48 | 7.5 |
| Blood mercury (nmol/L) | 464 | 61.0 | 59.6 | 55.5–64.1 | >60 | 48.8 |

CI=Confidence interval; TSAT=Transferrin saturation; TIBC=Total iron binding capacity; CRP=C-reactive protein.

a Number of participants for which data are available is indicated for informational purposes only since all results were weighted.

b Adjusted for smoking frequency.

c Arithmetic mean was calculated instead of geometric mean since the distribution of values was normal.

F Unreliable estimate.

Data source: Nunavik Inuit Health Survey 2004.
unexplained anemia. A high proportion of unexplained anemia (14%) was found.

Figure 2 shows the main types of anemia present in Nunavik women according to their age group. IDA was the main type of anemia in women of childbearing age. Among anemic women aged 50 to 74, 42% seemed to suffer from ACI. Indeed, the proportion of anemia attributable to chronic inflammation was 3.5 times higher among older women (data not shown). Unexplained anemia also seemed more prevalent among older women. The percentage of anemia that was coexistent with vitamin A, vitamin B$_{12}$ or folate deficiency was too low to be reported.

The prevalence of biochemical measurements indicative of ID was also varied by age group, as shown in Figure 3. Indeed, low Hb indicative of anemia was more prevalent among women aged 50 to 74, reaching 60% among this age group. In contrast, abnormal values of SF and TIBC were significantly more prevalent in women aged 18 to 29 years compared with women aged 30 to 49.

Similar results were observed for TSAT, although the difference between age groups was not significant. The prevalence of abnormal values of SI seemed to increase with age but the difference between age groups was not significant. Finally, over 94% and 97% of women aged 50 and over had normal values for SF and TIBC, respectively.

Correlation between biochemical parameters of iron status and vitamin A, vitamin B$_{12}$ and folate status, CRP (infection/inflammation) level and concentrations of heavy metals are presented in Table II. Hb and SF levels are positively associated with all the other iron status parameters, whereas TIBC exhibited the expected inverse correlation with the other parameters. Among measured vitamins, retinol is the most correlated, having significant positive correlation with all the iron status parameters except TIBC. Lead and mercury were both positively correlated with SF and inversely correlated with TIBC. Finally, a positive association is observed between blood mercury levels and TSAT.

Figure 1. Venn diagram of the iron status among Inuit women in Nunavik.
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**Figure 2.** Main types of anemia according to age groups among Inuit women in Nunavik.

Table II. Pearson’s correlation coefficients between biochemical indicators of iron status and C-reactive protein (CRP), vitamin A, vitamin B₁₂ and folate status and heavy metals levels.

|        | Hb   | Iron | TIBC | TSAT | Ferritin | CRP | Retinol | Vit. B₁₂ | Folate | Lead | Mercury |
|--------|------|------|------|------|----------|-----|---------|----------|--------|-------|---------|
| Hb     | 1.00 | 0.46 | -0.16 | 0.47 | 0.35 | 0.07 | 0.11 | 0.03 | 0.04 | 0.04 |
| Iron   | 0.46 | 1.00 | -0.07 | 0.95 | 0.36 | -0.08 | 0.25 | 0.15 | 0.00 | 0.06 |
| TIBC   | -0.16 | -0.07 | 1.00 | -0.38 | -0.47 | -0.19 | 0.06 | -0.12 | 0.01 | -0.20 | -0.23 |
| TSAT   | 0.47 | 0.95 | -0.38 | 1.00 | 0.48 | -0.02 | 0.22 | 0.14 | 0.06 | 0.13 |
| Ferritin| 0.35 | 0.36 | -0.47 | 0.48 | 1.00 | 0.40 | 0.37 | 0.17 | 0.10 | 0.27 | 0.29 |

Hb=Hemoglobin; TIBC=Total iron binding capacity; TSAT=Transferrin saturation; CRP=C-reactive protein; Vit.=Vitamin.

* A log transformation was applied to these parameters.

**p** value <0.05

**p** value <0.0001
DISCUSSION

Prevalence of iron deficiency and anemia

The prevalence of anemia (42.5%) and iron deficiency (35.6%) found in our sample population is high. Our results are consistent with the prevalence of anemia (39%) and the mean level of Hb (122 g/L) previously observed in Nunavik among a group of women during their first trimester of pregnancy (7). The prevalence of anemia found in the present study is 3 times higher than the level observed in 1973 among Inuit in the Northwest Territories. In 1973, the prevalence of anemia (13%) in the Northwest Territories was already 2.6 times higher than the level reported for the general Canadian population at that time (5%) (29). These results suggest that a great disparity may still exist between Inuit communities and the rest of the Canadian population. Also, it is important to emphasize the fact that the sampling method allowed us to have a representative sample of the whole population in Nunavik.

The prevalence of iron depletion encountered in our study (30.2%) is similar to the prevalence reported in Canadian women during the 70s (30) and in Native communities of Alaska in the 80s (31). Compared with the general female population of the USA, the prevalence of ID and IDA in Nunavik is respectively 3 and 5 times higher (32). Moreover, the prevalence of anemia among Inuit women in Nunavik is higher than that among high-risk ethnic groups in the U.S., like African-American and Mexican-American women (32). Also, when compared with more recent data from the National Health and Nutrition Examination Survey (NHANES) on the prevalence of ID among American women of childbearing age (20–49 years old), the prevalence of ID among adult Inuit women under 50 years old in Nunavik is 2.7 times higher. However, it is important to mention that different multiple-indices models were used to define ID in these studies. In our study, a low level of ferritin was sufficient to classify a subject as iron deficient and 2 other criteria were used to include individuals with borderline ferritin who had other measures indicative of iron deficiency or had inflammation. Therefore, our model was probably more sensitive to the detection of iron deficiency than that used in NHANES, in which abnormal values for at least 2 of the 3 measures of iron status used (SF, TSAT and free erythrocyte protoporphyrin) were necessary to diagnose ID.

Furthermore, the prevalence of anemia among Inuit women in Nunavik is much higher than that usually observed in industrialized countries. The WHO estimates that 10.3% of women in industrialized countries are anemic, as compared with 42.3% in non-industrialized countries (1). Thus, it seems that the prevalence of anemia found in Nunavik (42.5%) is similar to that reported in non-industrialized countries and 4 times higher than the prevalence reported in industrialized countries. In developing countries, 25–30% of women have depleted iron stores (1). We have found a similar prevalence of iron depletion in our population with 30% of women having a serum ferritin level below 15 µg/L. Also, our study found a 21% prevalence of IDA in Nunavik women; similar prevalences were found among women in Cote d’Ivoire (20%) (33) and Mexico (17.6%) (34).

Characterization of iron status

Iron deficiency anemia is a major type of anemia affecting almost half of the anemic women in this study. These results are in agreement with the findings of the WHO, which estimates that approximately 50% of anemia cases worldwide...
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are due to iron deficiency. Even though there are many causes of anemia, dietary iron deficiency is usually either the main or a major contributing factor (1).

In our study, the prevalence of anemia was higher in older women (60%) compared to the rate observed among women of childbearing age (38%), as was reported in other studies (12,35). Also, the main types of anemia differed among age groups. For example, IDA was more prevalent in women of reproductive age (61%) than in women aged 50 to 74 (14%). Thus, anemia was less frequently associated with ID among older women. This may reflect lower iron needs and a higher consumption of iron-rich traditional foods such as caribou or seal meat in older people (36,37). Furthermore, women of childbearing age are especially at risk for iron deficiency because of iron losses during menstruation and the burden of repeated pregnancies (1,38). The prevalence of ID among women aged 18 to 49 was much higher than that observed in menopausal women (aged 50 and over). Hence, older women are at lower risk of iron deficiency than women of childbearing age. However, the detection of iron deficiency may have been obscured by the high prevalence of inflammatory disorders in this age group, especially in older women. For that purpose, a third criterion (SF=15-50 µg/L and CRP≥10 mg/L) was added to the multiple-indices model to diagnose iron deficiency. Nevertheless, some women with high serum ferritin values due to inflammation may have been misclassified as not iron deficient. Indeed, using marrow examination, North et al. observed that all patients with SF<30 µg/L were iron deficient, as well as the majority of hospitalized patients with SF 30 to 100 µg/L and one-third of those with SF between 100 and 200 µg/L (39).

Anemia classification

The WHO classifies a prevalence of anemia ≥40% as a severe public health problem (1). Therefore, the prevalence of anemia in Nunavik reaches the level of a severe public health problem. Moreover, according to WHO recommendations, “when the prevalence of IDA reaches the 20–30% level in the age-gender group under evaluation, it may be more effective – and possibly more efficient – to provide universal supplementation to that entire group than to screen for individual case-management purposes” (1). A similar recommendation was put forward by a decision analysis based on the U.S. national survey (40). Thus, universal supplementation among women of childbearing age without individual screening could be recommended in Nunavik.

We observed a very low prevalence of vitamin A, vitamin B_{12} and folate deficiency in Nunavik women; the contribution of these deficiencies to anemia is probably minimal. However, retinol was positively correlated with Hb values. Similar results were found in the literature, where subnormal values of retinol were more frequent among anemic pregnant women (41).

A high proportion of women in this study had a blood mercury level above the threshold value. Also, mercury and lead levels were positively correlated with SF and negatively with TIBC, indicating that a better iron status was found among women with higher blood metal levels. The relationships between blood lead and mercury and sociodemographic and dietary data have already been studied in this population (22). In the 2004 Nunavik Health Survey, mercury and lead concentrations in adults were mainly explained by age. The most important source of exposure to mercury was marine mammal meat consumption, whereas blood lead
concentrations increased slightly with higher annual wildfowl consumption (22). These food sources of heavy metals are also major sources of iron in the diet of Nunavik women (42), which could explain the positive association observed between blood levels of heavy metals and iron status.

Study limitations
A number of methodological considerations and potential limitations need to be taken into account when interpreting our study. First, misclassification of IDA may have occurred among older women, since ferritin levels and chronic inflammation rapidly increase at the beginning of menopause (21), and because both conditions (IDA and ACI) can be present in the same individual. The measurement of serum transferrin receptors would have been very helpful in distinguishing IDA from ACI. Red cell indices, such as the mean corpuscular volume (MCV) and red cell distribution width (RDW), would have helped in the differential diagnosis of hypochromic anemia (related to IDA) and megaloblastic anemia (in case of folate or/and vitamin B\textsubscript{12} deficiency). Furthermore, the analyses presented in this article are mostly descriptive and do not take into account the different factors associated with iron deficiency. These will be published at a later date.

The number of missing data for biochemical measurements varies because of technical problems. This bias is considered negligible as it accounts for less than 5%. Also, the mean level of folate may be slightly underestimated since the value 45.2 nmol/L has been given to measurements that were above the upper detection limit (>45.2 nmol/L, n=12 or 2.75%).

CONCLUSION
The prevalence of iron deficiency anemia was high in the non-pregnant Inuit women who participated in the 2004 Nunavik Inuit Health Survey. The WHO recommends universal iron supplementation when the prevalence of IDA is between 20% and 30%. Since iron supplementation is a short-term solution and compliance is low, a long-term nutrition intervention program needs to be implemented in Nunavik. Moreover, targeting women in the prenatal period, particularly for teen pregnancies, should be given high priority since it is important to prevent iron deficiency before pregnancy.

Among women over 50 years old, ACI was the most prevalent type of anemia. Treatment of this type of anemia involves controlling the underlying medical condition causing the inflammation. Also, vitamin A, vitamin B\textsubscript{12} and folate deficiencies did not constitute a widespread problem, and the contribution of these deficiencies to anemia was probably minimal. The positive association found between iron status indicators and heavy metals in the blood was possibly related to the fact that sources of heavy metals are also major sources of iron in the diet of Inuit women (marine mammal meat and wildfowl). In Nunavik, anemia represents a severe public health problem that should be further investigated.

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Conflict of interest statement
Authors report no conflict of interest.

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