# Anemia and Iron Status in Inuit Infants from Northern Quebec

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## A B S T R A C T

The iron status and diet of Inuit infants living in northern Quebec who were part of a prospective cohort study was described. The prevalence of anemia (hemoglobin values >2SD below the reference mean) was 21.1% (23/109), 47.4% (55/116) and 37.7% (46/122) at 2, 6 and 12 months, respectively. The corresponding prevalence of microcytic anemia was 0.0%, 4.3% and 21.3%. At 2, 6 and 12 months, iron-deficiency anemia (serum ferritin < 10 µg/L coupled with anemia) was present in 1.3% (1/79), 24.4% (21/86) and 26.3% (25/95) of infants, respectively. Compared with breastfeeding, the odds ratio for iron deficiency (serum ferritin < 10 µg/L) for bottle-feeding with cows' milk or low iron formula was 3.02 (95% CI 1.25-7.27) at 6 months and 3.05 (95% CI 1.28-7.28) at 12 months. This study shows iron-deficiency anemia to be a problem in Inuit infants as young as 6 months old. Breastfed infants were better protected against iron deficiency than infants fed cow's milk or low-iron formula.

## A B R É G É

Le statut nutritionnel en fer et les apports alimentaires chez les nourrissons vivant dans le nord du Québec qui faisaient parti d'une étude de cohorte ont été décrit. La prévalence de l'anémie (hémoglobine >2SD au-dessous de la référence moyenne) était de 21,1 % (23/109), 47,4 % (55/116) et 37,7 % (46/122) à 2, 6 et 12 mois respectivement. La prévalence correspondante d'anémie microcitique était de 0,0 %, 4,3 % et 21,3 %. À 2, 6 et 12 mois, l'anémie dû à la carence en fer (sérum ferritin < 10µg/L couplé à l'anémie) était respectivement présente chez 1,3 % (1/79), 24,4 % (21/86) et 26,3 % (25/95) des nourrissons. Comparativement à l'allaitement, les chances de carence en fer pour les enfants nourrissons nourris au lait de vache ou au lait maternisé faible en fer, était de 3,02 (95 % CI 1,25-7,27) à 6 mois et 3,05 (95 % CI 1,28-7,28) à 12 mois. Cette étude démontre que l'anémie dû à la carence en fer est un problème chez les nourrissons Inuits aussi jeune que 6 mois. Les nourrissons allaités étaient mieux protégés contre la carence en fer que les nourrissons nourris au lait de vache ou au lait maternisé faible en fer.

Nunavik, the northern part of the province of Quebec, is a predominantly Inuit region where clinicians perceive anemia to be a problem in infants but prevalence data are not available, nor has the cause of the problem been identified. This health issue requires attention because iron-deficiency anemia can lead to compromised intellectual development.[1,2] The purpose of this study was to use data from a prospective cohort study conducted in 1989-1990 to describe values for erythrocyte mean cell volume, hemoglobin and serum ferritin in the first year of life. From these variables, prevalence data for anemia, microcytic anemia, iron deficiency and iron-deficiency anemia were obtained. To understand the causes of anemia and iron deficiency, associations between hematologic variables, serum ferritin and dietary data were evaluated.

From a public health perspective, this study provides preliminary data on risk factors for anemia and iron deficiency, as well as population-specific baseline measures against which interventions to reduce anemia can be judged. The study is unique in that it is the first report of this kind in Inuit infants and it offers a longitudinal profile of anemia and iron deficiency in the first year of life.

## METHODS

Data gathered as part of a study to assess the impact of environmental contaminants on infant health[3,4] included hemoglobin, mean cell volume (MCV) and serum ferritin. The study covered the area served by the two community hospitals in the region of Nunavik. Subjects were infants born between July 15, 1989 and September 15, 1990 in these communities. Infants were followed longitudinally and were examined at approximately 2, 6 and 12 months of age. At each visit, blood was drawn if the infant was free from apparent illness. Qualitative information for dietary variables was obtained by questionnaire. Variables relevant to iron status included animal flesh (fish, game and marine mammals), juice, and breastmilk or bottled milks. Ethics approval was received from the health boards and CMDP (le Conseil des Médecins, Dentistes et Pharmaciens) of each hospital and the ethics committee of Laval University.

Infants were considered bottle-fed if they consumed formula or cow's milk (evaporated, UHT or homogenized). Only low-iron infant formula was available for purchase in stores. Infants were classified as breastfed if they received breastmilk exclusively or in combination with bottled milks and were further subdivided into exclusively breastfed and partially breastfed.

Hemoglobin and MCV measure hematopoietic activity, and ferritin is a protein whose concentration in plasma parallels body iron stores.[5] Hemoglobin and MCV

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were evaluated against age-specific values derived from infants without evidence for iron deficiency.[6] Data were considered abnormal when 2 standard deviations below the reference mean. The cutoff points for hemoglobin were 100 g/L (1 mo), 90 g/L (2 mo), 95 g/L (3-6 mo) and 105 g/L (0.5-2 years). Corresponding values for MCV were 85 fl, 77 fl, 74 fl and 70 fl. On the basis of these cutoff points, infants were categorized as anemic and as having microcytic erythrocytes. Microcytic anemia was anemia coupled with microcytes. Anemia was also defined as hemoglobin <100 g/L in infants 6 months and older, in recognition of recent concerns that hemoglobin cutoff points for infancy might need to be revised downward.[7,8] Ferritin <10 μg/L indicates depleted body iron stores[5] and was the basis for classifying infants as iron deficient. Iron-deficiency anemia was anemia coupled with iron deficiency.

The dietary predictors of iron status were studied using stepwise logistic regression. Variables were removed from the model if the likelihood ratio test for the difference between a full model and one without the variable indicated that the variable added little to the overall model. Results were considered significant if the 95% confidence intervals for the odds ratio excluded '1.0.' The Chi-square statistic was used to determine if there were significant differences between breast- and bottle-fed infants for the presence of solid food or juice. Mean differences for hemoglobin and serum ferritin between breast- and bottle-fed infants were tested using Student's t-tests and analysis of variance with Bonferroni post hoc multiple-comparison tests. For those infants who were followed longitudinally and had blood drawn at each test period, repeated measures ANOVA was used to assess any effect of age. To test if the number of these infants with anemia was independent of age, Cochran's Q was used. The significance level was set at 0.05. Values for ferritin were positively skewed; prior to statistical analysis the values were log transformed.

**TABLE I**
**Hemoglobin Concentration (Hb) and Erythrocyte Mean Cell Volume (MCV) in Inuit Infants and the Percentages with Values Below Age-specific Cut-off Points**

| | Hb (g/L) | MCV (fL) |
|---|---|---|
| 2 mo (n=109) | | |
| Mean (SD) | 103.6 (13.8) | 88.8 (6.4) |
| Range | 54.0-146.0 | 68.0-106.0 |
| Percent <2.5% cut-off* | 21.1 | 1.0 |
| 6 mo (n=116) | | |
| Mean (SD) | 105.8 (9.4) | 76.0 (4.5) |
| Range | 87.0-131.0 | 62.0-92.0 |
| Percent <2.5% cut-off* | 47.4 | 5.2 |
| 12 mo (n=122) | | |
| Mean (SD) | 106.3 (10.7) | 72.3 (5.4) |
| Range | 73.0-138.0 | 60.0-82.0 |
| Percent <2.5% cut-off* | 37.7 | 29.5 |

* The 2.5% cut-off values are greater than 2SD below the reference mean.[6]

**TABLE II**
**Hemoglobin Concentration (Hb), Erythrocyte Mean Cell Volume (MCV) and Serum Ferritin (SF) Concentration for Inuit Infants in the First Year of Life and the Percentage with Values Below Age-specified Cut-off Points**

| | Hb (g/L) | MCV (fl) | SF (μg/L) |
|---|---|---|---|
| 2 months (n=79) | | | |
| Mean (95% CI) | 102.5 (99.8-105.3) | 89.7 (87.3-90.2) | 91.1 (69.7-119.1) |
| Range | 67-146 | 68-106 | 1-768 |
| Percent <2.5% cut-off* | 24.1 | 2.5 | 3.8 |
| 6 months (n=86) | | | |
| Mean (95% CI) | 105.5 (103.5-107.5) | 75.9 (74.9-76.9) | 12.1 (9.0-16.4) |
| Range | 87-131 | 62-92 | 1-354 |
| Percent <2.5% cut-off* | 48.8 | 9.3 | 46.5 |
| 12 months (n=95) | | | |
| Mean (95% CI) | 106.0 (103.9-108.1) | 72.2 (71.1-73.3) | 8.7 (6.9-11.0) |
| Range | 77-138 | 60-82 | 1-192 |
| Percent <2.5% cut-off* | 37.8 | 32.6 | 60.0 |

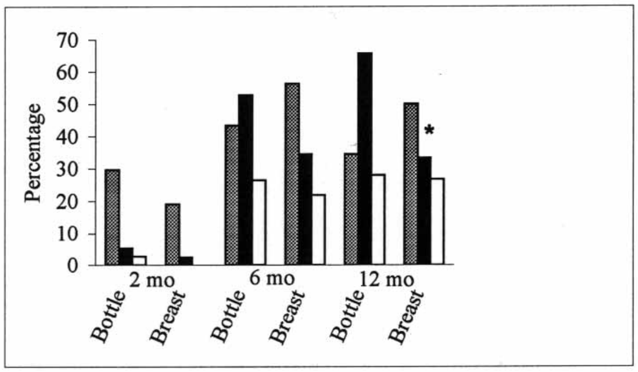
* The 2.5% cut-off values are greater than 2SD below the reference mean.[6]

## RESULTS

The mean birthweight of the 213 infants born in the study area was 3438.3 ± 470.7 g (mean ± SD); 3.1% of infants weighed <2500 g. The mean maternal age was 23.1 ± 5.3 years. At birth, 58.6% of infants were breastfed. At 6 months, 42.2% were breastfed and at 12 months 30.3% were breastfed. Infants who were breastfed had older mothers (24.2 vs. 21.9 years, p = 0.002). At 2, 6 and 12 months of age, 9.5%, 63.2% and 96.8% of infants, respectively, ate animal flesh. The corresponding figures for juice were 7.5%, 44.1% and 66.5%.

Blood was collected from 172 of the 213 infants born in the area, and 161 had both hemoglobin and MCV measured at least once (Table I). Fewer numbers of infants had all three of ferritin, hemoglobin and MCV measured (Table II). Sixty-five infants had hemoglobin determined at each of the three time points. Major reasons for non-participation were sickness of the infant and being outside of the community at the time of the appointment. The mean age of infants at each of the three blood draws were 2.7 ± 0.8 months, 6.7 ± 1.0 months, and 12.6 ± 1.1 months. The general characteristics of infants who had blood drawn did not differ from the total sample.

Mean hemoglobin, MCV and the percent of infants with values below the 2.5 percentile reference mean for these indicators are reported in Table I. The prevalence of microcytic anemia in these infants at 2, 6 and 12 months, respectively, was 0.0%, 4.3% and 21.3%. When 100 g/L was used as the hemoglobin cutoff for anemia, the prevalence at 6 and 12 months was 27.6% and 22.1%, respectively. At no age did breastfed and bottle-fed infants differ with respect to mean values for hemoglobin or MCV, or for risk of anemia or microcytic anemia. For the 65 infants who had hemoglobin measured at each of the




* At 12 months, the OR for iron deficiency for bottle-feeding was 3.31 (95% CI 1.33-8.23) compared with breastfeeding.

**Figure 1.** The percentage of breast- and bottle-fed Inuit infants followed longitudinally with anemia, iron deficiency and iron-deficiency anemia at 2, 6 and 12 months of age.

three time points, hemoglobin concentration did not change as they grew older. Consequently, the percent of infants with anemia increased significantly between 2 months and 12 months because hemoglobin normally rises in the second half of the first year of life (data not shown).

At 6 months, the OR for iron deficiency (ferritin <10 μg/L) was 3.02 (95% CI 1.25-7.27) for bottle-fed infants (n=57) compared with breastfed infants (n=37). At this age, bottle-fed infants had lower mean ferritin values than breastfed (9.0 vs. 21.0, p=0.006) and exclusively breastfed (n=27) infants (9.0 vs. 20.0, p=0.022). At 12 months, the OR for iron deficiency for bottle-fed infants (n=65) was 3.05 (95% CI 1.28-7.28) compared with breastfed infants (n=33), and 3.37 (95% CI 1.19-9.53) compared with exclusively breastfed infants (n=20). At this age, bottle-fed infants again had lower mean ferritin values than breastfed (6.0 vs. 15.0, p=0.012) and exclusively breastfed (6.0 vs. 16.0, p=0.027) infants. Exclusively and partially breastfed infants did not differ in mean ferritin concentration at any age.

Details on MCV, hemoglobin and ferritin for those infants who had all three measurements determined are found in Table II. The percentage of these infants who had anemia, iron deficiency and iron-deficiency anemia based on breast- or bottle-feeding is shown in Figure 1. The percent of infants with iron-deficiency anemia at 2, 6 and 12 months was 1.3%, 24.4% and 26.3%, respectively. The association of iron deficiency with breast- or bottle-feeding was similar in direction as the sample that included only ferritin, but due to fewer subjects the 95% confidence interval for the odds ratio for iron deficiency was significant only at 12 months.

Animal flesh and juice were not significant predictors of the dependent variables when modelled with milk group in stepwise linear regression (data not shown). At no age were there significant differences between breast- and bottle-fed infants for the presence of animal flesh or juice in the diet.

## DISCUSSION

This is the first research in Canada providing prevalence data for anemia, iron deficiency and iron-deficiency anemia, and associated dietary risk factors, in Inuit infants in the first year of life. The results of this study indicate that anemia is a major health concern in Inuit infants living in Quebec. The 21.1% (2 months), 47.4% (6 months) and 37.7% (12 months) prevalence of anemia in Inuit infants exceeds the 2.5% prevalence anticipated in a population of infants not experiencing iron deficiency.[6] When the hemoglobin cutoff of 100 g/L was used for anemia, approximately one-quarter of infants were anemic at 6 and 12 months of age.

Common childhood illnesses, particularly when recurrent, can depress hemoglobin.[9,10] Infants were free from apparent infection when blood was taken, limiting, but likely not eliminating, the influence of illness on hemoglobin given high levels of infant morbidity among Canadian Aboriginal infants.[11,12] By 12 months old, 21.3% of infants had anemia accompanied by microcytes. Microcytic anemia is relatively specific for iron-deficiency anemia of long duration.[5] Macrocytic anemia was not apparent, so it was unlikely that deficiencies of vitamin $B_{12}$ or folate contributed to anemia.[5] At 6 and 12 months of age, approximately one-quarter of infants had iron-deficiency anemia on the basis of anemia coupled with low serum ferritin. The evidence thus points to iron deficiency as the primary cause of anemia.

Iron-deficiency anemia has serious health repercussions. These include poor psychomotor development[2] and enhanced lead absorption and increased blood lead levels where there is environmental lead exposure.[13] Northern First Nations people are exposed to lead through the use of lead shot in hunting.[14,15] Infants are likely exposed to lead when they are fed game killed with shot and preventing iron-deficiency is essential in these infants to minimize lead absorption.

In 9-month-old Cree infants living in northern Quebec, no significant difference in hemoglobin values was found between infants consuming either breast or cow's milk.[16] In the present study, hemoglobin did not differ between breastfed infants and those bottle-fed with cow's milk or low-iron formula; however, breastfed infants had higher ferritin concentrations than did bottle-fed infants. Serum ferritin is a more sensitive indicator of iron stores than hemoglobin and provides a better indication of iron status.[5]

It is not clear why Inuit infants had such a high prevalence of anemia at 2 months of age despite a low prevalence of iron deficiency. Unless the mother is severely iron deficient during pregnancy, infants are normally born with sufficient iron stores to maintain erythropoiesis for 4 to 6 months, irrespective of dietary iron intake of the infant.[5] In early infancy, hemoglobin and serum ferritin are highly variable due to rapid postneonatal utilization of iron stores and fluctuations in rates of erythropoiesis,[5] perhaps altering the relationship between hemoglobin and body iron stores apparent later in life.

Juice and animal flesh did not contribute positively to iron status in the present study when modelled with milk. The ascorbic acid contained in juice and the proteins and iron contained in animal flesh both enhance iron absorption.[17,18] The quantities of animal flesh or juice consumed may have been insufficient to contribute positively to iron status. Juice offered no benefit and should be discouraged given the prevalence of baby bottle caries in the Inuit.

Given that one-quarter of Inuit infants in this study had iron-deficiency anemia by 6 months of age, systematic screening for iron deficiency using hemoglobin or serum ferritin should begin in Nunavik by this age. Parents need to be counselled to feed their infants iron-rich solids such as meat and iron-fortified cereals starting at 4 to 6 months of age. Breastfeeding should be encouraged in the first year of life and low-iron formula and cow's milk discouraged. Breastfeeding offers further positive health benefits to Canadian Aboriginal infants, such as lower morbidity.[19-21]

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