

Prevalence of anemia among James Bay Cree infants of northern Quebec

Noreen D. Willows, Johanne Morel, Katherine Gray-Donald

Abstract

Background: Anemia is common among First Nation infants in Canada, often as a result of iron deficiency, which places them at risk for psychomotor impairment. Prevalence data are unavailable, and the risk factors are unknown. This study assessed the prevalence of anemia and associated risk factors among 9-month-old Cree infants in northern Quebec.

Methods: Between January 1995 and October 1998, 6 of 9 Cree villages in the James Bay region adopted a screening protocol for anemia in 9-month-old infants. Cross-sectional data were obtained from medical charts. The data for babies of very low birth weight and those with fever or infection were excluded. Among the 386 babies whose hemoglobin concentration was known, the type of milk consumed at the time of screening was known for 354. Associations between hemoglobin concentration and mean cell volume at 9 months, and milk type and weight gain since birth were analysed.

Results: The mean hemoglobin concentration of the 386 infants was 114.1 (standard deviation [SD] 10.6) g/L. The prevalence of anemia was 31.9% (95% confidence interval [CI] 27.2%–36.7%) with a hemoglobin cutoff value of 110 g/L, 17.6% (95% CI 13.9%–21.7%) with a cutoff value of 105 g/L, and 7.8% (95% CI 5.3%–10.9%) with a cutoff value of 100 g/L. Babies exclusively fed formula at 9 months had a higher mean hemoglobin concentration (118.5 [SD 9.9] g/L) than those exclusively fed breast milk (109.9 [SD 10.0] g/L), cow's milk (112.5 [SD 10.1] g/L) or more than one type of milk (112.0 [SD 10.8] g/L) ($p < 0.05$). Compared with formula, the odds ratio (OR) for anemia was 7.9 (95% CI 3.4–18.2) for breast milk, 5.0 (95% CI 2.0–12.7) for cow's milk and 5.2 (95% CI 1.9–14.6) for mixed milks. Infants fed formula and those fed cow's milk had significantly greater weight gains since birth, by 724 g and 624 g respectively, than breast-fed infants ($p < 0.05$). When milk type was controlled for, weight gain since birth was significantly associated with the presence of microcytic erythrocytes (OR comparing highest tertile of weight gain to lowest tertile 2.9, 95% CI 1.2–6.6).

Interpretation: Iron-deficiency anemia is highly prevalent among James Bay Cree infants. Measures to increase iron intake are required.

Anemia is common among First Nations infants of aboriginal Canadian ancestry.^{1–3} First Nations infants with iron-deficiency anemia, the most frequent cause of anemia in infancy, are at risk for psychomotor impairment.⁴ Routine screening of infants at high risk, including aboriginal infants, optimally at 9 months of age, was recommended by the Canadian Task Force on the Periodic Health Examination.⁵ There are no prevalence data for infants who have participated in a screening protocol, and risk factors for anemia have not been assessed systematically.

Screening for anemia at 9 months of age was begun in Quebec Cree communities of James Bay in January 1995. The objective of our study was to estimate the prevalence of anemia and iron-deficiency anemia in infancy by reviewing the charts of babies who were screened. To understand the cause of anemia, we evaluated associations between hemoglobin concentration and mean cell volume at 9 months, weight gain between birth and 9 months, and type of milk consumed at the time of the 9-month well-baby clinic.

Research

Recherche

Ms. Willows and Dr. Gray-Donald are with the School of Dietetics and Human Nutrition, McGill University, Macdonald Campus, Ste-Anne-de-Bellevue, Que.; Dr. Morel is a pediatrician at the Montreal Children's Hospital, Montreal, Que., and a pediatric consultant to the Cree Board of Health and Social Services of James Bay.

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‡ See related article page 343

Methods

Between January 1995 and October 1998, 6 of 9 Cree villages in the James Bay region adopted a screening protocol for anemia in 9-month-old infants. Depending on the clinic, blood samples were venous or heel prick. The hemoglobin concentration was determined directly, and the mean cell volume was calculated (hematocrit/erythrocyte count). Data were collected for infants screened at 8.5 to 10.5 months to allow families who were away from their village at the time of the scheduled well-baby clinic to participate. The executive director of the Cree Board of Health and Social Services of James Bay provided permission for the chart review. The review was a prelude to a more in-depth study of anemia that received ethics approval from the Quebec Minister of Health and McGill University.

Of the 487 infants in the communities, 407 (83.6%) were screened. We excluded the results for 12 babies who had fever or infection, to eliminate cases of anemia of inflammation,⁶⁻⁸ and for 1 baby who weighed 1260 g at birth, because infants of very low birth weight have exceptionally poor iron status.⁹ The blood of 8 infants coagulated on the way to the testing centre. Among the 386 babies whose hemoglobin concentration was known, the type of milk consumed at the time of screening was known for 354. Complete information on hemoglobin concentration, milk type, and weight at birth and at screening was available for 344 babies.

Information on the type of milk consumed at the time of screening was obtained from well-baby clinic forms in the infants' charts. These forms give nurses the option of choosing boxes assigned "formula" or "formula + iron," or nurses can write the formula brand name. If "iron-fortified" was not stated with a written brand name, the infant was classified as having received formula not fortified with iron. Information on consumption of cow's and breast milk was obtained from checked boxes. Information on solid food intake was not available in a standardized format in the charts and was not recorded.

To determine the prevalence of anemia, we evaluated the proportion of hemoglobin values below 3 specified cutoff points: 110 g/L, which is the 2.5 percentile for healthy infants; 105 g/L, which eliminates some cases of "statistical anemia;" and 100 g/L, which corresponds with at least moderately severe anemia.⁹ Reporting the prevalence of anemia using 3 cutoff points facilitates comparisons with studies that use any of these definitions. A hemoglobin concentration less than 100 g/L was considered evidence for iron-deficiency anemia, as was microcytic anemia. Erythrocytes were classified as microcytic if they were less than 71 fL in size.⁹

We used analysis of variance to test whether hemoglobin concentration and weight variables differed by milk type. Logistic regression was used to test the association between milk type and weight gain for anemia or the presence of microcytic erythrocytes. Weight gain between birth and screening was entered as tertiles. We used the χ^2 statistic to test for independence among milk groups for anemia. For all statistical procedures the significance level was set at 0.05.

Results

The mean birth weight of the 386 infants included in the study was 3790 (standard deviation [SD] 552) g. A total of 1.3% of the infants were of low birth weight (less than 2500 g), and 30.4% were macrosomic (birth weight greater than 4000 g). The mean birth weight of the 80 unscreened babies was 3587 (SD 684) g, significantly lower than that of the babies in the study ($p = 0.005$); however, included among the 80 were infants from 4 sets of multiple births.

The mean age of the infants at the time of screening was 9.3 (SD 0.4) months.

The mean hemoglobin concentration was 114.1 (SD 10.6) g/L. The prevalence of anemia was 31.9% (95% confidence interval [CI] 27.2%–36.7%) with a hemoglobin cutoff value of 110 g/L, 17.6% (95% CI 13.9%–21.7%) with a cutoff value of 105 g/L, and 7.8% (95% CI 5.3%–10.9%) with a cutoff value of 100 g/L. The corresponding prevalence rates for microcytic anemia were 10.8% (95% CI 7.7%–14.3%), 9.4% (95% CI 6.6%–12.8%) and 5.6% (95% CI 3.5%–8.5%).

Of the 354 infants for whom information on milk type was available, 182 were formula fed, and, of these, 115 received iron-fortified formula. Since we found no significant differences in hematologic measures between infants fed iron-fortified formula and those fed unfortified formula, we grouped exclusively formula-fed infants together for analysis. We classified the babies into 4 groups based on milk type consumed at the 9-month well-baby clinic: exclusively formula-fed (152 [42.9%]), exclusively breast-fed (98 [27.7%]), exclusively fed cow's milk (64 [18.1%]) and consuming a mixture of milk types (40 [11.3%]). The 4 groups

Table 1: Mean hemoglobin concentrations of 9-month-old Cree infants in northern Quebec and proportion of infants with anemia by milk type consumed at 9 months

Milk type	Mean hemoglobin concentration (and SD), g/L	Hemoglobin cutoff value; % of infants with anemia (and 95% CI)*		
		< 110 g/L	< 105 g/L	< 100 g/L
Formula ($n = 152$)	118.5 (9.9)†	16.4 (10.9–23.3)	5.3 (2.2–10.1)	1.3 (0.2–4.6)
Breast milk ($n = 98$)	109.9 (10.0)	42.9 (32.9–53.2)	30.6 (21.6–40.7)	17.3 (10.4–26.3)
Cow's milk ($n = 64$)	112.5 (10.1)	40.6 (28.5–53.6)	21.9 (12.5–33.9)	9.4 (3.5–19.3)
Mixed milks ($n = 40$)	112.0 (10.8)	42.5 (27.0–59.1)	22.5 (10.8–38.4)	7.5 (1.5–20.3)
All ($n = 354$)	114.3 (10.7)	31.1 (26.2–36.1)	17.2 (13.4–21.5)	7.9 (5.3–11.2)

Note: SD = standard deviation, CI = confidence interval.

*Irrespective of hemoglobin cutoff value, anemia rates differed depending on type of milk consumed at 9 months ($p < 0.001$).

† $p < 0.05$ for difference between formula group and other milk groups.

were similar in age and sex ratio. Of the 40 babies in the last group, 14 consumed breast milk and iron-fortified formula, 10 consumed breast milk and cow's milk, 9 consumed breast milk and unfortified formula, 4 consumed cow's milk and unfortified formula, and 3 consumed cow's milk and iron-fortified formula.

The mean hemoglobin concentration and the prevalence of anemia by type of milk consumed at 9 months are given in Table 1. Irrespective of the hemoglobin cutoff value, rates differed depending on the type of milk consumed ($p < 0.001$). Formula-fed infants had a higher hemoglobin concentration than infants in the other milk groups ($p < 0.05$). There was no significant difference in hemoglobin concentration between the breast milk, cow's milk and mixed milk groups.

Table 2 shows the mean weight at birth and at 9 months by milk type. Babies who were formula-fed at 9 months weighed less at birth than did breast-fed babies ($p < 0.05$). At 9 months formula-fed infants weighed more than infants who received breast milk or mixed milks ($p < 0.05$). Babies who were formula-fed at 9 months had gained more weight since birth than those fed breast milk (mean difference 724 g) and those fed a mixture of milk types (mean difference 753 g) ($p < 0.05$). Similarly, babies fed cow's milk at 9 months had gained more weight since birth than those fed breast milk (mean difference 624 g) and those fed mixed milks (mean difference 653 g) ($p < 0.05$).

Logistic regression analysis showed that the odds ratio (OR) for anemia (hemoglobin concentration less than 105 g/L) was 7.9 (95% CI 3.4–18.2) for infants fed breast milk compared with those fed formula. The corresponding ORs for babies fed cow's milk and mixed milks were 5.0 (95% CI 2.0–12.7) and 5.2 (95% CI 1.9–14.6) compared with those fed formula. Compared with formula-fed infants, the OR for the presence of microcytic erythrocytes was 10.7 (95% CI 3.9–29.0) for those fed breast milk, 9.2 (95% CI 3.2–26.8) for those fed cow's milk and 7.3 (95% CI 2.2–23.9) for those fed mixed milks. These ORs remained largely unchanged after adjustment for weight gain since birth. Weight gain since birth was not significantly associated with anemia or the presence of microcytic erythrocytes in univariate analysis. When milk type was controlled for, however, weight gain since birth became significantly associated with the presence of microcytic erythrocytes (OR comparing highest tertile of weight gain to lowest tertile 2.9, 95% CI 1.2–6.6).

Interpretation

To our knowledge this is the first study to assess anemia in a large group of First Nations infants who participated in a screening protocol. The prevalence of anemia among James Bay Cree infants in our study (31.9% with a hemoglobin cutoff value of 110 g/L and 7.9% with a cutoff value of 100 g/L) is higher than the rates observed among healthy non-Native Canadian babies (8.0% with a hemoglobin cutoff value of 110 g/L and 1.1% with a cutoff value of 100 g/L).¹⁰

There are few adverse sequelae of mild to moderate anemia in the absence of iron deficiency; however, iron-deficiency anemia has been associated with psychomotor impairment.⁴ In our study, biochemical test data for iron deficiency were lacking, and we used a hemoglobin level of less than 100 g/L and a low mean cell volume as proxy measures for iron-deficiency anemia.⁹ These criteria are appropriate provided that anemia due to inflammation and lead poisoning and thalassemia minor are excluded.⁹ They give an estimated prevalence of iron-deficiency anemia of 5.6% to 10.8% among Cree infants. Thalassemia minor is not present in Cree babies, and there is insufficient knowledge about lead levels to suggest an influence on hemoglobin. The influence of inflammation was minimized by using data for infants screened at well-baby clinics and by excluding infants who had evidence of illness.

The prevalence of anemia was associated with type of milk consumed at 9 months. The relation may have been confounded by differences in the type and amount of solid food consumed within each milk group. Although information about solid food intake was not available, at well-baby clinics all women were counselled to start providing their babies with solid food between 4 and 6 months of age. For babies fed formula or cow's milk, we have no information on when these milks were introduced.

Formula-fed infants had the highest hemoglobin concentration and the lowest prevalence of anemia, and there were few estimated cases of iron deficiency in this group. In most cases the formula was iron-fortified, which confirms that such formula protects against anemia in 9-month-olds.¹¹ Babies fed cow's milk had a high prevalence of anemia. Cow's milk is low in bioavailable iron and can cause occult bleeding and anemia when introduced before 9 to 12 months of age.⁹ The early introduction of cow's milk has been associated with a low hemoglobin concentration in both infants and toddlers.^{10,12}

Table 2: Mean weight at birth and at 9 months by type of milk consumed at 9 months

Variable	Milk type; mean weight (and SD), g					p value
	Formula n = 145	Breast milk n = 96	Cow's milk n = 63	Mixed milks n = 40	All n = 344	
Birth weight	3 707 (570)*	3 916 (538)	3 767 (532)	3 845 (483)	3 792 (550)	0.03
Weight at 9 mo	10 502 (1 485)*†	9 987 (1 143)	10 462 (1 009)	9 887 (1 194)	10 279 (1 305)	0.003
Weight gain	6 795 (1 290)*†	6 071 (1 089)	6 695 (929)*†	6 042 (1 236)	6 487 (1 215)	< 0.001

* $p < 0.05$ for difference from breast milk group.

† $p < 0.05$ for difference from mixed milk group.

Nine-month-old breast-fed babies were observed to have a high prevalence of anemia. Exclusive breast-feeding protects against iron deficiency for the first 4 to 6 months of life, after which iron-rich foods are needed.⁹ However, anemia has been observed in older breast-fed infants provided with iron-rich food.¹³⁻¹⁶ The association between extended breast-feeding and anemia is an important observation that needs further study and should not be interpreted to suggest that extended breast-feeding is not beneficial to the health of the infant. Breast-fed babies experience fewer acute respiratory infections and episodes of diarrhea and otitis media than formula-fed babies,^{17,18} and this is important given the high prevalence of infections among First Nations infants.^{19,20} The issue of appropriate hemoglobin values to define anemia in breast-fed infants is significant given current Canadian recommendations that breast-feeding may continue up to 2 years of age and beyond.²¹ The problem of anemia in breast-fed babies may be exaggerated, since many breast-fed babies with mild anemia have no evidence of iron deficiency.¹⁴

When milk type was controlled for in our study, infants with the highest weight gain since birth were at elevated risk for the presence of microcytic erythrocytes. The fact that mean cell volume diminishes when iron deficiency becomes severe suggests that fast-growing infants were not getting enough iron. The blood volume expands in parallel with growth, increasing requirements for iron.^{22,23} High growth velocity in full-term babies has been previously associated with poor iron status and anemia.^{15,24}

Cree-specific growth curves illustrate the high weight of Cree babies as they grow.²⁵ In our study, growth was associated with type of milk consumed. The greater mean weight gain, by 724 g, between birth and 9 months for formula-fed infants compared with breast-fed infants exceeds previously reported differences in weight gain²⁶ and suggests that formula-fed Cree babies have very high weight gains. The slower growth of breast-fed infants is well documented, and there is no evidence of any adverse consequences for health.^{27,28} Breast-fed babies are less prone to obesity as children than babies never breast-fed,²⁹ and this slower growth may be advantageous for the Cree, among whom children are commonly overweight.³⁰

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Competing interests: None declared.

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Reprint requests to: Dr. Katherine Gray-Donald, School of Dietetics and Human Nutrition, Macdonald Campus, McGill University, 21-111 Lakeshore Rd., Ste-Anne-de-Bellevue QC H9X 3V9; fax 514 398-7739; gray-donald@macdonald.mcgill.ca