Iron Deficiency and Anemia Prevalence and Associated Etiologic Risk Factors in First Nations and Inuit Communities in Northern Ontario and Nunavut

Anna Christofides, MSc, RD
Claudia Schauer, ASc
Stanley H. Zlotkin, MD, FRCPC, PhD

ABSTRACT

Background: Anemia is common among children in Aboriginal communities in Canada. The objectives of this study were to determine the prevalence of anemia and to identify its associated risk factors among young children in Aboriginal communities in northern Ontario and Nunavut.

Methods: 115 children from one Inuit and two Cree First Nations communities participated. We collected information on demographic and dietary factors and measured hemoglobin (Hb), ferritin (SF), serum transferrin receptor (sTfR) and *Helicobacter pylori* IgG antibodies. Odds ratios and 95% confidence intervals were determined to examine risk factors associated with anemia and iron deficiency (ID) and further analyzed using stepwise regression procedures.

Results: Prevalence of anemia (Hb<110 g/L) was 36.0%. Iron deficiency (sTfR>8.5 mg/L) was present in 27.6% of the study population. Approximately 53.3% had depleted iron stores (SF<12 µg/L). Consumption of cow/evaporated milk was the only independent risk factor associated with anemia. Infection with *H. pylori* and prolonged consumption of breastmilk were also associated, although not independently, with anemia. Formula intake was negatively associated with ID.

Interpretation: The prevalence of anemia in Aboriginal children was eight times higher than among similar populations in urban Canada and was especially high among Inuit children. ID was the major cause of anemia, but not the only one, since 10% of anemic children were not iron deficient. Given that the consumption of cow/evaporated milk was found to be a significant independent risk factor associated with anemia, public health strategies should include promotion of breastfeeding, combined with iron-rich complementary foods, while addressing socio-economic conditions that may be preventing these practices from being adopted. *H. pylori* may be a major contributing factor to anemia, thus improvements in water quality and sanitation also need to be considered.

MeSH terms: Iron-deficiency anemia; Native Americans; Inupiats; risk factors

La traduction du résumé se trouve à la fin de l'article.

Research Institute, The Hospital for Sick Children, Toronto, ON
Correspondence and reprint requests: Dr. Stanley Zlotkin, Division of Gastroenterology, Hepatology and Nutrition, The Hospital for Sick Children, 555 University Avenue, Toronto, ON M5G 1X8, Tel: 416-813-6171, Fax: 416-813-4972, E-mail: stanley.zlotkin@sickkids.ca
Acknowledgements and sources of support: The authors thank the field supervisors: Melanie Phelps, Shelley Beattie, Weena Gerrard and Rayleen Swansen; and the field workers: Lorraine Koostachin, Evelyn Hookimaw, Anne Kataquaput, Lucy Qattalik, Janet Airut and Johnny Airut. Supported by a grant from Health Canada, First Nations and Inuit Health Branch (FNIHB) and the HJ Heinz Company Foundation.

Anemia is known to be a significant public health problem in Canadian Aboriginal communities, however the prevalence in northern Ontario and Nunavut is unknown and associated risk factors have not been sufficiently studied. The estimated prevalence of anemia is in the range of 14-50% in Canadian Aboriginal populations, compared to 4-5% in Canada as a whole.[1-5] Explanations for the higher prevalence include a movement away from traditional foods that are generally high in iron, to low-iron 'convenience' foods such as evaporated milk and 'junk' foods.[6-8] A small number of studies have found that the type of milk consumed (cow's, breastmilk or formula) affects iron status in these populations.[2,3] In addition, infection with the waterborne bacterium, *Helicobacter pylori,* has been suggested as a risk factor for anemia and ID, although the etiology remains unknown.[4,9-11] Understanding the specific factors affecting iron/haematologic status and their interactions will assist those involved with health promotion to develop and prioritize educational messages and policies aimed at the prevention of anemia in these communities.

As part of a prospective study examining the efficacy of a new iron supplement, "Sprinkles",[12] to prevent anemia in young Aboriginal children, a cross-sectional study was performed on baseline data, as reported here. The objectives of this study were to determine the prevalence of anemia and to identify associated risk factors among young children in Aboriginal communities in northern Ontario and Nunavut.

METHODS

A cross-sectional survey was conducted in three Aboriginal Canadian communities from December 2001 to June 2003. Two Cree communities on the west side of James Bay, Ontario (total population 441 and 1,293) and one Inuit community in Nunavut (total population 1,286) were included.[13] These communities are isolated with minimal access by road, limited to the winter months. Some traditional feeding practices still exist, particularly in the Inuit community. These include prolonged breastfeeding and pre-chewing of hunted meats such as caribou and seal that are then fed to the infant. The study was designed to include all eligible children

from all three communities. Ethics approval was received from the Hospital for Sick Children, Research Ethics Board, Toronto. Informed consent was obtained from the communities and hospitals involved and each child's legal guardian.

The local hospitals and health centres in the communities coordinated the fieldwork. Field workers were community health workers, trained by researchers from The Hospital for Sick Children and supervised by nurses at the hospitals/health centre. Lists of all infants between 4-18 months of age were compiled from health care records. These were checked for completeness within the community and those infants who had not been brought to use the local healthcare facilities were added. Eligible infants were those who consumed complementary foods (i.e., age-appropriate weaning foods) and were aged 4-18 months.

We collected information from caregivers via a structured, pre-coded questionnaire which included demographic characteristics and commonly consumed foods.[14] Food items to be included in the questionnaire were determined from Health Canada documents on Aboriginal foods and nutrition.[15] The food list was further validated for content and completeness by the nurses and field workers in each community to ensure that it was culturally appropriate. Caregivers were asked to identify foods from the list that the child had consumed in the past seven days. The food intake data were not quantified. Trained nurses collected finger-prick blood samples using standardized techniques. Hemoglobin was determined from a drop of blood using a portable HEMOCUE B-hemoglobin photometer.[16] The remaining blood sample (500 µL) was centrifuged for 10 min at 12,000 x g and plasma was separated before storage at -40° C. Serum ferritin (SF), soluble serum transferrin receptor (sTfR), C-Reactive Protein (CRP) and *H. pylori* were analyzed using standardized techniques.[17] Weight and length measurements were performed and recorded using standard instruments as previously described.[18]

Questionnaires were checked for completeness and data were entered in duplicate (to ensure accuracy) into Access 2000, a data entry program. Dietary data were grouped into categories including meat/liver/blood, fish/seafood, grains (biscuits, bread), green vegetable, orange vegetable, fruit, juice, tea, evaporated/cow's milk, breastmilk, formula, junk foods (chips, pop) and butter/margarine. Anemia was defined as Hb<110 g/L. Iron deficiency (ID) was defined as sTfR>8.5 mg/L. CRP was used as a marker for infection at concentrations above 8 ng/mL. Depleted iron stores was defined as SF<12 µg/L. Odds Ratios (ORs) and 95% confidence intervals (95% CIs) were determined to examine associations with anemia and ID. Results were considered significant where the 95% confidence intervals did not include 1.0. Variables were further analyzed using stepwise forward logistic regression. Data were analyzed with SAS, version 8.2, a data analysis program.

TABLE I

Characteristics of Study Population

Characteristic	Northern Ontario (n=65)	Nunavut (n=50)	P Value
Boys†	31 (48)	26 (52)	0.7
Girls†	34 (52)	24 (48)	0.7
Mean ± SD:			
Age in months	11.1±4.5	12.0±4.7	0.8
Age of weaning	4.3±2.3	4.9±2.2	0.9
Weight-for-age Z score	3.6±10.1	0.8±1.6	0.1
Height-for-age Z score	0.9±2.1	-0.3±1.4	0.001
Weight-for-height Z score	1.6±3.1	1.5±1.6	0.6
Hb ±SD (g/L)	118.1±12.0	111.2±12.0	0.07
Anemic (Hb<110 g/L)†	17 (26)	24 (48)	0.1
Ferritin (µg /L) *	17.8 (1.7-228.2) [61]	21.3 (3.4-321.5) [46]	0.3
Ferritin<12 µg /L†	17 (27.6)	17 (36.9)	0.9
sTfR (mg/L) *	7.0 (3.5-20.0) [61]	7.1 (4.3-20.9) [47]	0.5
sTfR>8.5 mg/L†	17 (27.7)	12 (25.5)	0.2
CRP Positive (>8 ng/mL)†	24 (40.0)	7 (14.9)	0.2
H. pylori Positive (O.D.>20)†	21 (33.9)	15 (31.9)	0.9

* Geometric mean, range and [n]
† Number of children (%)

TABLE II

Foods Consumed by Study Children in Past Seven Days

Food Item*	Northern Ontario (n=65)	Nunavut (n=50)
Evaporated/Cow's Milk	23 (35)	11 (22)
Formula	30 (46)	30 (60)
Meat/Liver/Blood	42 (65)	35 (70)
Fish/Seafood	10 (15)	12 (24)
Grains	49 (75)	36 (72)
Orange Vegetables	40 (62)	23 (46)
Green Vegetables	33 (51)	19 (38)
Fruit	51 (79)	35 (70)
Butter/Margarine/Oils	8 (12)	14 (28)
Tea	16 (25)	13 (26)
Breastmilk	9 (14)	20 (40)
Juice	44 (68)	32 (64)
Junk Foods	19 (29)	25 (50)

* Number of children (%)

TABLE III

Odds Ratios for Common Factors Associated with Anemia and ID (sTfR>8.5 mg /L)

Factor	Hb<110 g/L n (%)	OR (95% CI)†	sTfR>8.5 mg/L n (%)	OR (95% CI)‡
H. pylori (n=107)	9 (8.41)	3.10 (1.01-9.51)*	6 (5.22)	1.68 (0.56-5.03)
Cow's/Evaporated Milk	18 (15.65)	2.84 (1.24-6.50)*	11(9.57)	1.56 (0.65-3.78)
Prolonged Breastfeeding	14 (13.04)	2.47 (1.04-5.85)*	10 (8.70)	1.74 (0.70-4.34)
Fish/Seafood	11 (9.57)	2.10 (0.82-5.39)	5 (4.35)	0.80 (0.27-2.40)
Introduction of solids ≥8 mo.	3 (2.61)	1.54 (0.38-6.14)	4 (3.48)	1.71 (0.46-6.33)
Tea	11 (9.57)	1.14 (0.48-2.73)	8 (6.96)	1.11 (0.43-2.86)
Sex (Male)	20 (17.39)	0.95 (0.44-2.04)	17 (14.78)	1.47 (0.64-3.40)
Junk Foods	15 (13.04)	0.90 (0.41-1.97)	13 (11.30)	1.33 (0.57-3.11)
Formula	20 (17.39)	0.81 (0.38-1.74)	10 (8.70)	0.35 (0.15-0.84)*
Juice	24 (20.87)	0.6 (0.27-1.32)	17 (14.78)	0.58 (0.24-1.35)
Grains	27 (23.48)	0.53 (0.23-1.25)	22 (19.13)	0.96 (0.37-2.47)
Green Vegetable	14 (12.17)	0.49 (0.22-1.08)	13 (11.3)	0.90 (0.40-2.06)
Meat/Liver/Blood	23 (20.00)	0.47 (0.21-1.06)	19 (16.52)	0.80 (0.34-1.92)

* Significant at p<0.05
† Cow's/Evaporated milk was the only factor remaining significant in a stepwise model
‡ None of the factors remained significant in a stepwise model

RESULTS

A total of 170 children 4-18 months of age were screened for eligibility. Of these, 13% (22/170) did not meet the inclusion criteria and 19% (33/170) refused to participate. In total, 68% (115/170) of children participated. Study population characteristics are presented in Table I, by region.

The mean Hb concentration of the study population was 114.8 ± 12.2 g/L (n=115). The overall prevalence of anemia was 36% (41/115), with the highest prevalence in the Inuit community (48%, 24/50) as compared to the First Nations communities (26%, 17/65), however the difference was not significant (Table I). The prevalence of ID was similar between Inuit and First Nations communities (25.5% (12/50) and 27.7% (17/65), respectively). Depleted iron stores were present in 53.3% (56/105) of the study population. SF is an acute phase reactant and in the presence of inflammation and infection will be elevated.[19] An analysis of risk factors associated with depleted iron stores was therefore not performed due to the high prevalence of infection among the population (29% (31/108)). Prevalence of *H. pylori* infection was 39% (36/107).

The types of foods consumed varied somewhat between regions (Table II). The proportion of children who consumed low-iron and iron-inhibiting foods such as evaporated/cow's milk, junk foods and tea was 30%, 38% and 25%, respectively. However, the proportion of those who consumed iron-rich foods such as formula (52%), meat/liver/blood (67%) and iron-fortified grains (74%) was also high.

Age and sex were not associated with anemia or ID. Odds ratios for common risk factors associated with anemia and ID are presented in Table III. Infection with *H. pylori*, prolonged consumption of breastmilk and cow's/evaporated milks were significant risk factors associated with anemia. However, when analyzed in a stepwise regression model predicting anemia, the best-fitting model contained only cow's/evaporated milk consumption (OR: 2.84, 95% CI: 1.24-6.50). The only factor associated with ID was formula consumption (negative association), however its association did not reach significance when modeled in a stepwise regression.

DISCUSSION

Previous surveys in Canadian Aboriginal populations have found anemia prevalence to be high with significant variation among communities (14-50%).[2,6-8] This is the first survey to report the prevalence of anemia among Aboriginal communities in northern Ontario and Nunavut. In urban Canada, only 4-5% of infants are reported to have anemia, however in the current study, the prevalence was eight times higher at 36%.

Few studies have examined the risk factors associated with anemia and ID in Aboriginal populations in Canada. Results of the current study suggest that infection with *H. pylori,* consumption of cow's/evaporated milks and prolonged breastfeeding are major contributing factors. In a multivariate model, cow's/evaporated milk consumption was the only variable predicting anemia, suggesting it is an independently associated risk factor. Evaporated milk is low in iron and nutritionally incomplete.[20] Cow's milk contains only a small quantity of bioavailable iron, and its consumption in young infants may lead to occult blood loss and resulting anemia.[20] The low cost and ready availability of evaporated and cow's milks is a likely explanation for their routine use in these communities.

In the current study, formula use was negatively associated with ID. Similar results were found by Willows and colleagues in Inuit infants in Northern Quebec.[8] A similar study in Cree communities in Quebec also examined the type of milk consumed as a risk factor for anemia.[3] Infants consuming formula were 7.9 times less likely to develop anemia than those given breastmilk and 5 times less likely to develop anemia as compared to those given cow's milk.

Prolonged breastfeeding was shown to be a risk factor associated with anemia in the current study. If breastmilk is exclusively fed to infants after six months, iron stores are likely to become depleted without the addition of a bioavailable iron source from complementary foods.[21] Health Canada and the Canadian Pediatric Society advocate exclusive breastfeeding until 6 months of age, followed by the addition of iron-fortified cereals and formulas.

In the current study, the prevalence of *H. pylori* infection in each of the three communities was approximately 30%. These results are consistent with previous studies that show that First Nations and Inuit communities have a much higher prevalence of *H. pylori* infection compared to communities further south.[4,9-11] According to a survey among Nunavik infants, 27% were infected with *H. pylori* as compared to 10% in Southern Quebec.[4] In a First Nations adult population in Alaska, despite similar dietary iron intake, ID was 13-fold higher compared to the general U.S. population.[10] Of those who were anemic, 99% (68/69) were infected with *H. pylori.*[10] The reason for the high prevalence in these communities is unknown, although overcrowding and inadequate sanitation increase the risk of infection.[9]

Not all factors that were associated with anemia were associated with ID. A possible explanation for this observation is that the cut-off for iron deficiency is based on sTfR values taken from adult subjects. An appropriate cut-off for ID using sTfR has not been developed in children.[22] Thus the ability to detect ID using this measure may be limited. The rates of iron depletion that were detected in both First Nations and Inuit populations were quite high (27.6 and 36.9% respectively). However, because of the high prevalence of *H. pylori* infection and elevated CRP levels, we likely underestimated the prevalence. Our inability to accurately quantify the prevalence of iron depletion in populations which have high rates of infection is similar to others.[23] Since ferritin is an acute phase reactant which is up-regulated in the presence of infection or inflammation, high levels may indicate adequate iron stores or an acute infection. To date there is no way to distinguish between the two except for the concomitant measurement of markers of infection, like CRP. Since the number of infants with elevated CRP was quite high in the current study, we assumed that SF was not an accurate measure of iron stores.

An interesting observation from this study was the seemingly contradictory observations of high rates of anemia and ID yet widespread use of red meat and blood-containing foods. These types of foods are excellent bioavailable sources of iron, however their consumption was not associated with iron status. A limitation of this study was the type of dietary question-

naire used. Because the dietary questionnaire was not quantitative or descriptive, it was not possible to estimate the amount of meat/liver/blood consumed. It is possible that the cooking methods depleted the foods of heme-iron (e.g., the use of a dilute meat broth) or the quantities of meat ingested were quite small. An additional observation was the use of 'junk foods' in 38% of all children surveyed. Although not statistically related to anemia prevalence, their routine use in young children is inconsistent with current Canadian Paediatric Society guidelines.[24]

Results from this study confirm the high prevalence of anemia and ID among Canadian Aboriginal infants as serious public health problems. Both dietary factors and evidence of *H. pylori* infection were identified as associated risk factors. Current public health messages which stress the importance of feeding iron-rich complementary foods in addition to breastmilk or use of iron-fortified formula to replace evaporated or cow's milk in young children should be revitalized. Culturally appropriate strategies that promote the consumption of increased amounts of traditional iron-rich foods and improve access to iron-fortified infant products may further prevent anemia in these communities. Many of these strategies can be incorporated into existing prenatal nutrition programs within Aboriginal communities in combination with healthy eating practices. Strategies to improve sanitation and water quality in these communities may decrease the burden of *H. pylori* infection and thus decrease rates of anemia.

REFERENCES

1. Zlotkin SH, Ste-Marie M, Kopelman H, Jones A, Adam J. The prevalence of iron depletion and iron-deficiency anaemia in a randomly selected group of infants from four Canadian cities. *Nutr Res* 1996;16:729-33.
2. Willows N, Dewailly E, Gray-Donald K. Anaemia and iron status in Inuit infants from Northern Quebec. *Can J Public Health* 2000;91(6):407-10.
3. Willows N, Morel J, Gray-Donald K. Prevalence of anaemia among James Bay Cree infants of northern Quebec. *CMAJ* 2000;162(3):323-26.
4. Hodgins S, Dewailly E, Chatwood S, Bruneau S, Bernier F. Iron-deficiency in Nunavik: Pregnancy and infancy. *Int J Circumpolar Health* 1998;57(Suppl 1):135-40.
5. Sawchuk P, Rauliuk M, Kotaska A, Townsend S, Wilson E, Starr M. Infant nutrition program effectively prevents iron-deficiency anaemia in a First Nations community. *Int J Circumpolar Health* 1998;57(Suppl 1):189-93.
6. Neander WL, Morse JM. Tradition and change in the Northern Alberta Woodlands Cree: Implications for infant feeding practices. *Can J Public Health* 1989;80(3):190-94.
7. Moffatt MEK. Nutritional problems of native Canadian mothers and children. *Can Fam Phys* 1989;35:377-82.
8. Willows ND. Anaemia in James Bay Cree Infants of Northern Quebec. [Doctoral Thesis] Montreal, Quebec: McGill University, 2000.
9. McKeown I, Orr P, Macdonald S, Kabani A, Brown R, Coghlan G, et al. *Helicobacter pylori* in the Canadian arctic: Seroprevalence and detection in community water samples. *Am J Gastroenterol* 1999;94(7):1823-29.
10. Yip R, Limburg PJ, Ahlquist DA, Carpenter HA, O'Neill A, Kruse D, at al. Pervasive occult gastrointestinal bleeding in an Alaska native population with prevalent iron deficiency. Role of *Helicobacter pylori* gastritis. *JAMA* 1997;277(14):1135-39.
11. 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. *CDLI* 2000;7(6):885-88.
12. Christofides A, Zlotkin S, Schauer C. Impact of micronutrient sprinkles for the treatment and prevention of iron deficiency in Canadian first nations and Inuit infants 4-18 months old. *FASEB J* 2003;17A:S1102.
13. Statistics Canada. www.statcan.ca. Community Profiles. Census, 2001.
14. Gibson RS. *Principles of Nutritional Assessment.* New York, NY: Oxford University Press, 1990.
15. Native Foods and Nutrition. Ottawa, ON: Minister of Natural Health and Welfare, 1994.
16. Cohen AR, Seidi-Friedman J. HemoCue system for hemoglobin measurement. Evaluation in anemic and nonanemic children. *Am J Clin Pathol* 1988;90:302-5.
17. Miles LEM, Lipschitz DA, Bieber CP, Cook JD. Measurement of serum ferritin by a 2-site immunoradiometric assay. *Anal Biochem* 1974;61:209-24.
18. Zlotkin S, Antwi KY, Schauer C, Yeung G. Use of microencapsulated iron (II) fumarate sprinkles to prevent recurrence of anaemia in infants and young children at high risk. *Bull WHO* 2003;81(2):108-15.
19. Wieringa FT, Dijkhuizen MA, West CE, Northrop-Clewes CA, Muhilal. Estimation of the effect of the acute phase response on indicators of micronutrient status in Indonesian infants. *J Nutr* 2002;132:3061-66.
20. Friel JK, Andrews WL, Edgecombe C, McCloy UR, Belkhode S, L'Abbe M, et al. Eighteen-month follow-up of infants fed evaporated milk formula. *Can J Public Health* 1999;90(4):240-43.
21. Complementary feeding of young children in developing countries: A review of current scientific knowledge. Geneva, Switzerland: WHO, 1998.
22. Cook JD, Dassenko S, Skikne BS. Serum transferrin receptor as an index of iron absorption. *Br J Haematol* 1990;75(4):603-9.
23. Ritchie B, McNeil Y, Brewster DR. Soluble transferrin receptor in Aboriginal children with a high prevalence of iron deficiency and infection. *Trop Med Int Health* 2004;9(1):96-105.
24. Healthy Active Living Committee, Canadian Paediatric Society (CPS). Healthy active living for children and youth. *Paediatrics & Child Health* 2002;7(5):339-45.

Received: June 14, 2004
Accepted: March 10, 2005

RÉSUMÉ

Contexte : L'anémie est une affection courante touchant les enfants au sein des communautés autochtones du Canada. Cette étude visait à déterminer la prévalence de l'anémie et à cerner les facteurs de risque associés parmi les jeunes enfants des communautés autochtones du Nord de l'Ontario et du Nunavut.

Méthode : Cent quinze enfants d'une communauté inuite et de deux communautés des Premières nations cries ont participé. Des facteurs démographiques et diététiques ont été pris en compte, et les taux d'hémoglobine (Hb), de ferritine (FS), du récepteur soluble de la transferrine (Rs-TF) et des anticorps de type IgG dirigés contre *Helicobacter pylori* ont été mesurés. Des rapports de cotes (RC) et des intervalles de confiance à 95 % ont été déterminés pour examiner les facteurs de risque associés à l'anémie et à la carence en fer, puis analysés plus en détail avec des méthodes de régression multiple pas-à-pas.

Résultats : La prévalence de l'anémie (Hb<110 g/L) était de 36,0 %. La carence en fer (Rs-TF>8,5 mg/L) était présente dans 27,6 % de la population étudiée. Le stock de fer était épuisé dans approximativement 53,3 % des cas (FS<12 µg/L). La consommation de lait de vache ou de lait concentré était le seul facteur de risque indépendant associé à l'anémie. Les infections à *H. pylori* et la consommation prolongée de lait maternel étaient également associées, bien que non indépendamment, à l'anémie. La prise de préparations lactées pour nourrisson était inversement associée à la carence en fer.

Interprétation : La prévalence de l'anémie était huit fois plus élevée chez les enfants autochtones que chez les populations similaires du Canada urbain, et elle était particulièrement élevée parmi les enfants inuits. La carence en fer était la principale cause d'anémie, mais pas la seule, puisque 10 % des enfants anémiés n'avaient pas de carence en fer. Étant donné que la consommation de lait de vache ou de lait concentré s'est avérée être un facteur de risque indépendant significatif associé à l'anémie, les stratégies de santé publique devraient inclure la promotion de l'allaitement maternel, combinée à une alimentation complémentaire riche en fer, tout en tenant compte des conditions socio-économiques qui peuvent empêcher l'adoption de ces pratiques. *H. pylori* apparaît comme un facteur important contribuant à l'anémie, ainsi des améliorations de la qualité de l'eau et de l'hygiène doivent également être prises en compte.