

# Impact of Maternal Anemia on the Infant's Iron Status at 9 Months of Age

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## ABSTRACT

**Background:** Iron-deficiency anemia during pregnancy is still common in developed countries. The aim of this study was to evaluate the influence of maternal anemia on the infant's iron status at 9 months of age in Moncton, NB.

**Methods:** Mothers giving birth between April 1998 and February 1999 were selected from medical records. A letter was sent to invite them to participate. In total, 75 mothers with their infants were examined.

**Results:** The proportion of iron-deficiency anemia was higher ( $p = 0.055$ ) in the group born to anemic compared to non-anemic mothers. A positive association between the mother's haemoglobin and haematocrit during her 3<sup>rd</sup> trimester and her infant's haemoglobin and haematocrit was found at 9 months of age. These results are not explained by differences in feeding practices and socio-economic status between groups.

**Interpretation:** Infants born to mildly anemic mothers may be at risk of developing anemia.

Iron-deficiency anemia is one of the most common public health problems among pregnant women.<sup>1</sup> In industrialized countries, the prevalence is estimated to be approximately 18%.<sup>2</sup> The potential relationship between maternal anemia and the infant's iron status is a current subject of interest.

A number of studies have shown that varying degrees of anemia in young children are associated with poor psychomotor and cognitive development.<sup>3-5</sup> In animals, it was recently shown that even a marginal iron deficiency during pre- and post-natal development can result in functional changes in motor development.<sup>6</sup> The Canadian Task Force on the Periodic Health Examination (CTFPHE) recommends a screening for high-risk infants between 6 and 12 months of age, ideally around 9 months of age.<sup>7</sup> The infants identified at risk by the CTFPHE include: infants from low socio-economic status, Chinese and Aboriginal children, infants of low birthweight, and infants consuming whole cow's milk.<sup>7</sup> The Canadian Paediatric Society and Dietitians of Canada<sup>8</sup> recommend a screening between 6 and 8 months, for infants who 1) were not exclusively breastfed for at least 4 months, 2) were not introduced to food enriched with iron between 4 to 6 months, 3) did not receive infant formula enriched with iron for those not being breastfed, and 4) were introduced to cow's milk before 9 months of age. However, infants born to anemic mothers have not yet been identified as a high-risk group by those two expert groups.

Although there is still controversy, several researchers have found a positive relationship between maternal anemia and the newborn's iron status.<sup>1,9-12</sup> Only few prospective studies extended their results to older infants.<sup>13,14</sup> These investigators are suggesting that infants born to anemic mothers appear to be at increased risk of developing iron-deficiency anemia, undetected at birth.<sup>13,14</sup> To our knowledge, no study of that type has been carried out in a Canadian population.

The main objective of the present study was to investigate the relationship between maternal anemia and infant's iron status by the age of 9 months.

## METHODS

Potential participants were selected retrospectively from medical records of mothers

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

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and infants born at the Dr Georges-L. Dumont Regional Hospital in Moncton, New Brunswick (NB), during the period of April 23, 1998 to February 25, 1999. A total of 424 letters were sent to mothers to invite them to participate. Initially, 85 mothers with their infants (aged 39  $\pm$  2 weeks) accepted to be part of the study. The clinics took place between January 18, 1999 and November 23, 1999 at that same hospital. Both ethical committees of the Université de Moncton and the Dr Georges-L. Dumont Regional Hospital approved the research protocol.

The haemoglobin (Hb), haematocrit (Ht) and mean corpuscular volume (MCV) were measured on K<sub>3</sub> ethylenediaminetetraacetic acid (EDTA)-anticoagulated tube using a Technicon H2 or Technicon H3 (Bayer Corporation, Tarrytown, NY, USA). Serum ferritin (SF) was determined by using the Heterogenous Sandwich Magnetic Separation Assay (MSA), with a Technicon Immuno 1 (Bayer Corporation, Tarrytown, NY, USA). These analyses were carried out at the hospital's laboratories. The criterion used to divide subjects into anemic (n = 18) and non-anemic mothers (n = 57) was the presence of anemia during the last trimester. Maternal anemia was defined as both Hb <110 g/L and Ht <33%. The results comparing both groups and multiple regressions are presented for a total of 75 subjects; 7 of the initial 85 subjects had to be excluded because there were no laboratory data at 3<sup>rd</sup> trimester; and 2 infants born prematurely (<37 weeks gestation) and 1 born with a low birthweight (<2500 g) were also excluded from the analysis. Only infants from singleton pregnancies were included in this study. Infants were considered to be anemic if Hb was <110 g/L, and to have iron-deficiency anemia (IDA) if they had both Hb <110 g/L and SF <10  $\mu$ g/L. Infants were considered to have low iron stores if they had a SF of <10  $\mu$ g/L without IDA.

The family socio-economic background was assessed with a questionnaire. It included family status (single parent *vs.* two parents), age of other children, parents' education, employment status of the parents, family income, and history of nutritional supplementation during pregnancy. Infants' dietary habits were obtained with a 24-hour dietary recall

TABLE I

## Maternal Haematology: Mean Values in Subject and Control Groups

	First Trimester Hb† g/L	Ht‡ %	Second Trimester Hb g/L	Ht %	Third Trimester Hb g/L	Ht %	Post-partum Hb g/L	Ht %
Anemic mothers								
Subject group ( $\pm$ SD)	121.5 (6.1)	36.4 (2.5)	107.6 (7.5)	32.8 (1.9)	102.3 (7.1)	31.4 (1.6)	100.5 (16.2)	31.6 (5.1)
n	14	14	7	7	18	18	18	18
Non-anemic mothers								
Control group ( $\pm$ SD)	125.1 (8)	37.9 (2.6)	113.5 (6.5)	34.5 (2.0)	115.5 (6.1)	35.1 (1.7)	109.8 (13.0)	33.6 (4.0)
n	36	34	28	28	57	57	56	56
P-value§	0.15	0.08	0.05*	0.05	***	***	0.02*	0.09

† Haemoglobin

‡ Haematocrit

§ P-value for the 2-tailed t-test for equality means of independent groups, SPSS

\* Statistically significant

\*\*\* p &lt; 0.0005

TABLE II

## Infants Haematology: Mean Values in Subject and Control Groups

	Hb† g/L	Ht‡ %	MCV§ fL	SF   $\mu$ g/L
Subject group	111.2	33.5	77.5	24.3
( $\pm$ SD)	(3.7)	(1.5)	(3.5)	(19.7)
n	18	18	18	18
Control group	113.6	34.1	77.2	23.0
( $\pm$ SD)	(8.4)	(2.5)	(3.2)	(15.6)
n	57	57	57	57
P-value¶	0.25	0.28	0.78	0.77

† Haemoglobin

‡ Haematocrit

§ Mean corpuscular volume

|| Serum ferritin

¶ P-value for the 2-tailed t-test for equality means of independent groups, SPSS

accompanied by a food frequency questionnaire.<sup>15</sup> All questionnaires were administered by the registered dietitian. The nutritional intake analyses were carried out using the Food Processor for Windows, Version 7.02 (ESHA Research, Salem, OR, USA, 1997). Anthropometric measurements, including weight, length, head circumference and skinfold thickness (triceps, subscapular and abdominal), were also performed by that same dietitian.

Student's two sample *T*-test and Chi-squared test (Pearson Chi-square and Fisher exact test [two-tail]) were used to determine significant differences between infants grouped according to their mothers' status (anemic *vs.* non-anemic at their 3<sup>rd</sup> trimester) for observed variables. The same tests were also done to determine significant differences between infants grouped according to their laboratory data (Hb and/or SF below cut-off value *vs.* normal values) for nutritional variables. Multiple regressions (including analysis of variance, ANOVA) were used to determine

significant relationship between the mothers' laboratory values throughout pregnancy and their infants' at 9 months of age. These same analyses (regressions or ANOVA) were used to verify the effect of possible confounding factors (family income, mother's education, history of nutritional supplementation during pregnancy and infant's iron, vitamin C, calorie, protein, and carbohydrate intakes) on the infants' Hb and Ht. The coefficient of determination, *r*<sup>2</sup>, was used to measure the strength of associations when ANOVA or regression was used. All analyses were done using the SYSTAT 7.01 and/or 8.02 for Windows (Statistical Package for the Social Sciences - SPSS Inc., Chicago, IL, USA, 1997-1999).

## RESULTS

The mean age of the mothers was 29.4  $\pm$  4.1 years. Only 4% had not finished high school, 24% had completed high school only. The majority (72%) had some

TABLE III

**Infants Haematology:  
Infants with Below Cut-off Haematological Values in Subject and Control Groups**

	Hb† <110 g/L	Ht‡ <32,9%	MCV§ <70 fL	SF   <10 µg/L	Hb and SF¶
Subject group Number (%) n	6 (33.3) 18	8 (44.4) 18	0 (0.0) 18	4 (22.2) 18	2 (11.1) 18
Control group Number (%) n	14 (24.6) 57	15 (25.3) 57	1 (1.8) 57	8 (14.0) 57	0 (0.0) 57
P-value††	0.540	0.140	1.00	0.470	0.055*

† Haemoglobin

‡ Haematocrit

§ Mean corpuscular volume

|| Serum ferritin

¶ Both below cut-off values

†† P-value for the Fisher exact test (two-tail), SPSS

\* Statistically significant

TABLE IV

**Multiple Regressions Between Mothers' Hb and Ht Throughout Pregnancy  
and Infants' Hb, Ht and SF at 9 Months of Age**

	P-val.	Hb† r <sup>2</sup>	N	P-val.	Ht‡ r <sup>2</sup>	n	P-val.	SF§ r <sup>2</sup>	n
1 <sup>st</sup> trim.: Hb & Ht	0.25	0.05	54	0.03*	0.13	54	0.44	0.03	54
2 <sup>nd</sup> trim.: Hb & Ht	0.54	0.03	41	0.59	0.03	41	0.13	0.10	41
3 <sup>rd</sup> trim.: Hb & Ht	0.01*	0.11	75	0.05*	0.08	75	0.62	0.01	75

† Haemoglobin

‡ Haematocrit

§ Serum ferritin

r<sup>2</sup> from multiple regressions analysis and p-value from analysis of variance of these regressions

\* Statistically significant

post-secondary education. The mothers and their infants were all Canadians and were predominantly from middle and upper-middle class.

Table I shows maternal haematology during pregnancy and two days postpartum. Besides lower Hb and Ht between groups at the 3<sup>rd</sup> trimester ( $p < 0.0005$ ), anemic mothers also had significantly lower Hb at the 2<sup>nd</sup> trimester ( $p = 0.04$ ) and postpartum ( $p = 0.02$ ). There was no significant difference between anemic and non-anemic mothers with regard to their age, number of term pregnancies, estimated inter-pregnancy spacing, weight gain during pregnancy, gestational complications (arterial hypertension and gestational diabetes), education and family annual income.

The infants' mean values of Hb, Ht, MCV and SF were similar in subject and control groups at 9 months of age, as seen in Table II. Table III shows the number of infants (percentage) with below cut-off laboratory values in subject and control groups. Although not statistically signifi-

cant, the proportion of infants with below cut-off values for Hb, Ht and SF was consistently higher in the subject group. Moreover, the proportion of infants (2/18) suffering from IDA (Hb and SF below cut-off values) was higher ( $p = 0.055$ ) in the group born to anemic mothers compared to those born to non-anemic mothers (0/57).

There was also no significant difference between the two groups with regard to the anthropometric measurements (weight, length, head circumference and skinfold thickness) at 9 months of age.

Among this sample, 23% of mothers were anemic during their 3<sup>rd</sup> trimester, compared to 0% (0/56) during the 1<sup>st</sup> trimester and 7% (3/42) during the 2<sup>nd</sup> trimester. At postpartum, 45% of mothers were anemic. Among infants, 26% were anemic at 9 months of age, 17% had low iron stores, 2% had IDA.

A significant positive association was found between maternal Hb and Ht during the 3<sup>rd</sup> trimester and infant's Hb ( $p = 0.02$ ,  $r^2 = 0.10$ ) and Ht ( $p = 0.04$ ,

$r^2 = 0.08$ ) at 9 months of age ( $n = 75$ ) (Table IV). A significant positive association was also found between maternal Hb and Ht during the 1<sup>st</sup> trimester and infant's Ht ( $p = 0.03$ ,  $r^2 = 0.13$ ) (Table IV). No association was found between maternal Hb and Ht during pregnancy and infant's SF values. The possible confounding factors had no statistically significant effect on the infant's Hb, Ht, or SF (regressions or ANOVA with p-values from 0.15 to 0.98).

Detailed data concerning feeding practices of these infants will be submitted elsewhere for publication.

## DISCUSSION

Among the study sample of relatively well-educated middle and upper-middle class families in Moncton, NB, anemia was common in pregnant women (23%, during 3<sup>rd</sup> trimester) and their infants (26%, at 9 months of age). Whether this sample is a true reflection of the total population is unknown. However, we obtained comparable results in a retrospective study among 654 pregnant women from diverse socio-economic backgrounds, in the same area, between 1996-97.<sup>16</sup> A prevalence of 21% (Hb <110 g/L at the 1<sup>st</sup> and 3<sup>rd</sup> trimester and <105 g/L at the 2<sup>nd</sup> trimester) was found, most cases occurring at the 3<sup>rd</sup> trimester. Similar results were also obtained among 202 pregnant women who gave birth in Quebec City between 1993-94; 24% were anemic during their 3<sup>rd</sup> trimester (Hb <110 g/L).<sup>17</sup> The proportion of anemic infants in the present study is similar to that reported in Quebec<sup>18</sup> and Montreal<sup>19</sup> a few years ago, although their subjects were older (12-20 months and 10-14 months, respectively) and from low-income families. A study performed in Vancouver among 9-month-old infants ( $n = 434$ ) from a middle-class background reported a prevalence of 7% IDA,<sup>20</sup> as compared to the 2% IDA reported in this present study. The difference is likely due to a larger sample size and to the fact that families were coming from a wide range of ethnic groups.

Although the infants' mean values of Hb, Ht, MCV and SF were similar in subject and control groups at 9 months of age, the proportion of infants (2/18) suffering from IDA was higher ( $p = 0.055$ ) in the group of infants born to anemic mothers

compared to those born to non-anemic mothers (0/57). The two infants suffering from IDA consumed adequate amounts of iron and vitamin C, had been breastfed exclusively for 6 and 7 months respectively, and had been introduced to foods enriched with iron according to the recommendations.<sup>8</sup> Therefore, it seems that the IDA was not attributed to inadequate feeding practices in those two cases. Furthermore, a positive association ( $p = 0.01$ ) between the mother's Hb and Ht during their 3<sup>rd</sup> trimester and the infant's Hb at 9 months of age was noted. This was not explained by differences in socio-economic status and feeding practices. This association ( $r^2 = 0.10$ ), although modest, was observed in mothers coming from well-educated middle and upper-middle class families who were mildly anemic (most values ranging between 100 and 109 g/L; only 4 mothers had Hb values ranging from 80-97 g/L).

Most studies on the association between maternal anemia and infants' iron status have focused on newborns.<sup>9-12</sup> Fewer studies have investigated this relationship in older infants and our findings agree with those prospective studies.<sup>13,14</sup> In 1990, among 156 neonates from middle class urban families in Valencia, Spain, Colomer et al.<sup>13</sup> reported a significant relationship between the mother's iron deficiency and the development of iron deficiency in the infants during their first year of life. However, the iron status of those mothers was studied 24 hours after delivery and not during pregnancy. More recently, a prospective study was carried out in Jordan, in a lower-middle class urban population of Palestinian refugees where the prevalence of IDA among mothers and infants is estimated to be very high (50-65%).<sup>14</sup> The incidence of iron-deficient anemia (Hb <110g/L and either plasma ferritin <12 µg/L or zinc protoporphyrin > 350 µg/L) was significantly higher in infants born to anemic mothers (37<sup>th</sup> week of gestation) ( $n = 107$ ) at 3, 6, 9 and 12 months compared to infants born to non-anemic mothers ( $n = 125$ ). This association was undetected at birth. No significant difference was detected between groups in socio-economic status, feeding practices or infection rates to account for the increased prevalence in the subject group.

To our knowledge, this is the first Canadian study looking at the influence of maternal anemia on the infant's iron status. The results should be interpreted with caution as they are derived from a small number of subjects. Nevertheless, these data suggest that infants born to mildly anemic mothers may be at a higher risk of developing anemia. Whether every infant born to an anemic mother should be screened systematically remains to be answered. Results from a recent study have found a strong correlation between Hb at 8 months and performance of the locomotor subscale at 18 months.<sup>21</sup> These authors suggest that screening should be performed at 8 months of age or earlier. Further studies, using more sensitive indicators of iron status,<sup>12</sup> are needed in order to identify the optimal timing for screening, and the degree of maternal anemia that is required to impair development in the progeny. We propose to investigate the effect of maternal iron-deficiency anemia among disadvantaged families on the infant's iron status at 3 and 6 months of age following prenatal nutritional interventions by the Early Childhood Intervention program in New Brunswick.

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## RÉSUMÉ

L'anémie maternelle demeure fréquente dans les pays industrialisés. Le but de cette étude était d'évaluer l'influence de l'anémie maternelle sur le statut en fer des enfants âgés de neuf mois dans la région de Moncton au N.B. Les mères qui avaient accouchées entre avril 1998 et février 1999 furent sélectionnées à partir des dossiers médicaux. Une lettre leur était envoyée pour solliciter leur participation. Au total, 75 mères avec leur nourrissons furent étudiés. La proportion d'enfants avec une anémie ferriprive était plus élevée ( $P = 0,055$ ) dans le groupe né de mères anémiques. Une association positive entre l'hémoglobine et l'hématocrite de la mère au 3<sup>e</sup> trimestre et l'hémoglobine et l'hématocrite du nourrisson fut notée. Ces résultats ne sont pas expliqués par des différences au niveau des habitudes alimentaires et du statut socio-économique entre les groupes. Les résultats suggèrent que les enfants nés de mères légèrement anémiques sont peut-être à risque de développer une anémie.

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