

Short communications

Prevalence of Anemia and Iron Deficiency Anemia in late-preterm infants at a Tertiary Care Hospital

Nattakarn Numriskulrat,  Orapa Suteerajintrakool,  Piti Techavichit,  Therdpong Tempark* 

Department of Pediatrics, Faculty of Medicine, King Chulalongkorn Memorial Hospital, Bangkok, Thailand

Abstract

Background: In many countries, late-preterm infants do not receive iron supplementation on a routine basis. Whilst, the prevalence of anemia and iron deficiency anemia (IDA) in this population group is not well established.

Objective: This study aimed to determine the prevalence of anemia and IDA in late-preterm infants, as well as factors associated with anemia.

Methods: Late-preterm infants were defined as those born between gestational age of 34⁺⁰ and 36⁺⁶ weeks. In this cross-sectional study, we analyzed the prevalence of anemia and IDA in late-preterm infants, aged 6-9 months, using complete blood count. Anemia was diagnosed in subjects whose hemoglobin (Hb) < 11 g/dL and/or mean corpuscular volume (MCV) < 70 fl, and treated with ferrous fumarate 4-6 mg of elemental iron/kg per day. IDA was defined as Hb rise ≥ 1 g/dL per month after iron supplementation.

Results: Sixty-two late-preterm infants (mean age 7.8 ± 1.2 months) were enrolled during November 2018-2019. Most of the exclusively breastfed subjects (70.6%) never received iron supplementation. Mean Hb in the anemic and the non-anemic groups was 9.7 ± 1.1 g/dL and 11.8 ± 0.5 g/dL, respectively. Anemia and iron deficiency anemia were consequently present in 48.4% and 30.6% of the subjects. Exclusively breastfeeding was observed in 27.4% (n = 17/62) and related to anemia, aOR 3.97 (95%CI 1.14 – 13.86).

Conclusion: Anemia and IDA are common problems in late-preterm infants. Screening for anemia in all late-preterm infants at the age of 6-9 months should be ratified for early detection and prompt treatment of IDA.

Keywords: Anemia, iron deficiency anemia, late-preterm infant, prevalence.

***Correspondence to:** Therdpong Tempark, Department of Pediatrics, King Chulalongkorn Memorial Hospital, Bangkok 10330, Thailand.

Email: therdpmpu@yahoo.com

Received: April 13, 2026

Revised: July 10, 2026

Accepted: August 17, 2026

Late-preterm infants are those born between gestational age (GA) of 34 and 37 weeks. They are often treated by health care providers and their parents as though they are term infants.⁽¹⁾ Unlike the smaller preterm and the bigger full-term infants, they appear mature due to their larger size, yet different physiological conditions. By reason of the prematurity, late-preterm infants miss the period of iron accretion during the third trimester. They are at high risk for iron deficiency anemia (IDA) development owing to low iron storage, rapid growth, and iron loss via phlebotomy.^(2,3)

Iron is an essential micronutrient for the growth and development of central nervous system.⁽⁴⁾ Iron deficiency anemia may result in a long-term deleterious effect on cognition and psychomotor development despite later iron treatment.⁽⁵⁾

The American Academy of Pediatrics (AAP) recommends all preterm infants should obtain an iron intake at least 2 mg/kg/day through the first year of life. In particular, those fed with human milk should be supplemented by iron 2 mg/kg/day during the first month of age.⁽⁶⁾ Nevertheless, in many countries including Thailand, late-preterm infants do not receive iron supplementation due to the lack of specific recommendations about iron supplementation.⁽⁷⁾

Prevalence of anemia and IDA in late-preterm infants is not well established in Thailand. Our primary objective is thus to determine the prevalence of anemia and IDA in late-preterm infants. Secondary objectives are to identify feeding pattern and factors related to anemia, as well as to evaluate treatment outcome.

Materials and methods

Study design and study population

We conducted a cross-sectional study in infants born between gestational age of 34⁺⁰ and 36⁺⁶ weeks (late-preterm infants). The sample size was calculated based on the previous study of IDA prevalence in late-preterm infants. A number of 62 infants were sufficient to have a confidence level of 95% with the real value of $\pm 10.0\%$.

The Royal College of Pediatricians of Thailand recommended performing the screening for anemia in all infants at the age of 6-9 months, following the guideline and assessment of anemia prevalence in late-preterm infants at this age group. The inclusion criteria were healthy late-preterm infants, aged 6-9 months, who visited well-baby clinic of King Chulalongkorn

Memorial Hospital, Bangkok, Thailand, for routine child health visit and vaccination between November 2018 and 2019. Infants with congenital malformations, inherited metabolic diseases, history of blood transfusion, cyanotic heart diseases, chronic lung diseases, or known hematologic diseases, were excluded.

Anemia was defined as hemoglobin (Hb) < 11 g/dL and/or mean corpuscular volume (MCV) < 70 fL according to WHO definition of anemia.⁽⁸⁾ Iron deficiency anemia was defined as Hb rise ≥ 1 g/dL per month after treatment with iron supplementation of elemental iron 4-6 mg/kg/day. (**Figure 1**)

This study was approved by the Institutional Review Board, Faculty of Medicine, Chulalongkorn University (IRB no. 210/61).

Data collection

At first visit, 0.5 mL of venous blood samples was collected in Ethylenediaminetetraacetic acid (EDTA) tube and sent for complete blood count (CBC) analysis performed by automated hematology analyzers (Sysmex XN-10, Kobe, Japan). Anemic subjects were advised to consume iron-rich food and treated with oral ferrous fumarate (elemental iron 4-6 mg/kg/day). After a month of iron supplementation, infants were rechecked with CBC and assessed for compliance. Subjects whose Hb rise ≥ 1 g/dL per month after iron supplementation were classified as iron-responder and diagnosed with IDA. Responders were continuously treated with iron supplementation for 3 months. Whilst, non-responders were further assessed by Hemoglobin typing.

Perinatal data and maternal characteristics were recorded. The period of breastfeeding and/or formula feeding was collected. Exclusively breastfed was defined as infants receiving breast milk without formula and/or complementary food during the first six months of life.⁽⁸⁾

Statistical analyses

The sample size was calculated based on a previous study of prevalence of IDA in late-preterm infants (20.0%).⁽³⁾ A number of 62 infants would be sufficient to have a confidence level of 95% that real value is within $\pm 10.0\%$. We defined statistical significance as $P < 0.05$. The Statistical Package for the Social Sciences (SPSS) version 22.0 was used for statistical analysis. Descriptive data were presented using mean $\pm$ standard deviation (SD).

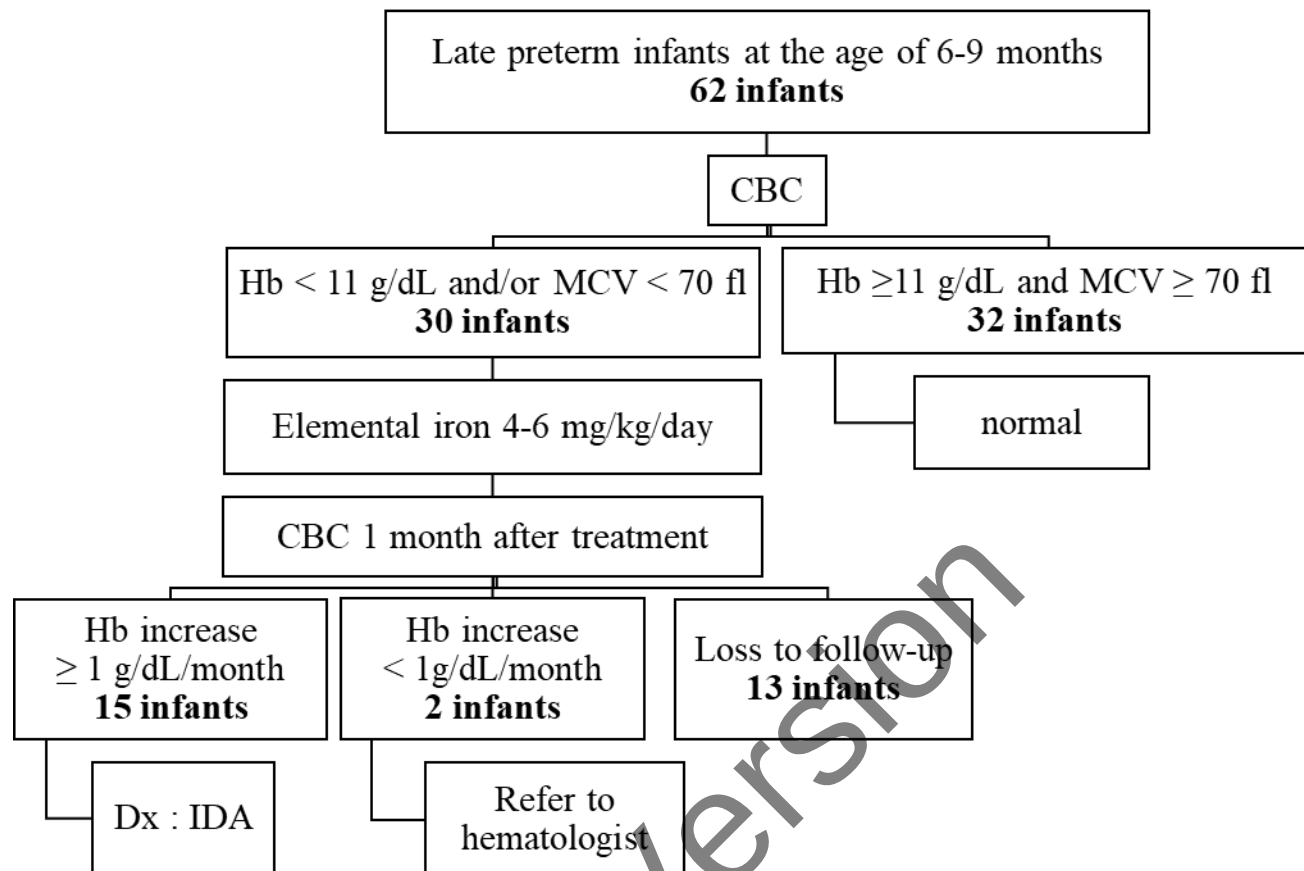


Figure 1. Algorithm of study population.

Continuous variables were compared between groups using the unpaired *t*-test, while categorical variables were compared using the Chi-square test. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated for each outcome variable. Univariate and multivariate analyses were performed to identify factors associated with iron deficiency anemia (IDA). The $P < 0.05$ was considered statistically significant.

Results

Demographic data of study population

The mean gestational age and birth weight were $35.1 (\pm 0.8)$ weeks and $2,467 (\pm 440.5)$ g, respectively. Approximately 51.6% of subjects were low birth weight (< 2500 g), with mean age of $7.8 (\pm 1.2)$ months (Table 1). Teenage pregnancy was noted in 8.0% of mothers ($n = 9/62$).

Prevalence of anemia

The prevalence of anemia in late-preterm infants, aged 6-9 months, was 48.4% (Figure 1). Mean Hb, Hct, and MCV in the anemic group was 9.7 ± 1.1 g/dL, $29.8 \pm 2.8\%$, and 62.8 ± 8.7 fL, respectively. The Hb (g/dL) (mean $\pm$ SD) in the non-anemic group was 11.8 ± 0.5 g/dL.

Prevalence of iron deficiency anemia

From the total number of 30 anemic infants, there were 15 infants diagnosed with IDA. While, 13 infants were lost to follow-up, and the others were no response to iron supplementation ($n = 2$). After excluding for loss to follow-up, the prevalence of iron deficiency anemia in late-preterm infants was 30.6% ($n = 15/49$). IDA infants yielded various responses to iron supplementation. The range of response to 1-month of iron supplementation with Hb rise was 1 to 3.5 g/dL. Hemoglobin typing were performed in 2 infants (non-responders) and shown as Hb E trait.

Feeding and medication pattern

The pattern of milk feeding was exclusively breastfeeding (27.4%) ($n = 17/62$), exclusively formula-feeding (12.9%) ($n = 8/62$), and mixed feeding 59.7% ($n = 37/62$). Regarding complementary feeding, 66.1% of all infants started complementary food at age of 4-6 months ($n = 41/62$), while 33.9% began at the age > 6 months ($n = 21/62$). Common types of complimentary food were rice (100.0%), green-leaf vegetables (70.0%), eggs (68.3%), and red-meat (60.0%).

Table 1. Demographic data of study population (62 infants).

Data	Results
Birth weight (g) (mean $\pm$ SD)	2,467 $\pm$ 440.5)
Gestational age (weeks) (mean $\pm$ SD)	35.1 $\pm$ 0.8)
Gender	
Male (n) (%)	36 (58.1%)
Female (n) (%)	26 (41.9%)
Age (months) (mean $\pm$ SD)	7.8 ($\pm$ 1.2)
Maternal age (years) (median/min-max)	31 (15-42)

Table 2. Characteristics of anemic and non-anemic infants.

	Non-anemic (n = 32)	Anemic (n = 30)	P-value
Birth weight (g) (mean $\pm$ SD)	2365 $\pm$ 403	2575 $\pm$ 458	0.179
Low birth weight (n) (%)	20 (62.5%)	12 (40.0%)	0.076
Gestational age (weeks) (mean $\pm$ SD)	35.0 $\pm$ 0.8	35.3 $\pm$ 0.9	0.658
Exclusively breastfeeding (n) (%)	5 (15.6%)	12 (40.0%)	0.032
Iron supplementation ever given (n) (%)	9 (28.1%)	6 (20.0%)	0.455

Table 3. Univariate and multivariate analysis of factors associated with anemia.

	OR (95%CI)	P-value	Adjusted OR (95%CI)	P-value
Exclusively breast feeding	3.60 (1.08 – 11.97)	0.037	3.97 (1.14 – 13.86)	0.030
Low birth weight	0.40 (0.14 – 1.14)	0.079	0.36 (0.12 – 1.06)	0.064

Approximately 75.8% (n = 47/62) received no iron supplementation at the age of 1 month. In the exclusively breastfed infants, 70.6% (n = 12/17) never received iron supplementation and 75.0% (n = 9/12) had anemia.

Factors associated with anemia

The characteristics of anemic and non-anemic infants were shown in **Table 2**. The pattern of exclusively breastfeeding was more likely observed in the anemic group than the non-anemic group ($P = 0.032$).

From multivariate analysis, the exclusively breastfeeding was associated with anemia (adjusted OR 3.97, 95%CI 1.14 – 13.86). (**Table 3**)

Discussion

In this study, the prevalence of anemia and IDA in late-preterm infants, aged 6-9 months, were 48.4% and 30.6%, respectively. When compared to a previous report on term infants in Thailand, the prevalence in our study was higher in the aspect of anemia. Tantracheewathorn S, *et al.* showed that 26.4% of term infants, aged 9-12 months, had anemia (Hb < 11 g/dL).⁽⁹⁾ Several risk factors for higher prevalence of anemia in preterm infants included iron transfer during the third trimester, lower iron storage

at birth, shorter red blood cell life span, frequent phlebotomy loss, and rapid growth during infant period.^(2,3) Additionally, our result was consistent with a previous study in Istanbul, Turkey which showed that the frequency of anemia in late-preterm infants at the age of 4 months was 42.8%.⁽³⁾

The prevalence of IDA was different in various studies due to diagnosis criteria, policy for breastfeeding, complementary food recommendation, and iron-rich food source. Ozdemir H, *et al.* showed that 21.0% of late-preterm infants had IDA at the age of 6 months.⁽³⁾ Berglund S, *et al.*⁽¹⁰⁾ revealed that the prevalence rate of IDA was 9.9% in marginally low birth weight infants (BW 2000 – 2500 g), yet with different criteria for diagnosis: Hb < 10.5 g/dL at 6 months of age, ferritin level < 12 ug/L, MCV < 71 fl, transferrin saturation < 10.0%, transferrin receptor level > 11 ug/L. Uijterschout L, *et al.* reported IDA in 9.1% of infants born between 32 and 37 weeks of gestational age.⁽¹¹⁾ The prevalence of IDA in our study was higher than previous studies.^(3, 10, 11)

Iron supplementation for infants could result in significant effects on hemoglobin.⁽¹⁰⁾ A previous study of Berglund S, *et al.* compared infants with marginally low birth weight between iron-supplement (elemental iron 2 mg/kg/day) and placebo groups. The prevalence rate of IDA in each group was 0.0% and 9.9%,

respectively.⁽¹⁰⁾ According to European and American recommendations, all preterm infants should be supplemented with elemental iron 2–3 mg/kg per day from 2–6 weeks to at least 6 months of age.^(5,12) In our study, only 24.1% of late-preterm infants received iron supplementation. In exclusively breastfed infants, the AAP guideline recommended taking iron supplementation at age of 1 month, while 70.6% of the infants had no iron supplementation. These reasons may explain why the prevalence of IDA in our study was higher than others. This could be inferred that most of healthcare providers and parents cared for late-preterm babies as full-term infants.⁽¹⁾ Policy about iron supplementation in late-preterm infants may be thus required to prevent iron deficiency anemia and adverse neurological outcome.

Several previous studies have shown that iron deficiency during infancy is associated with impaired cognitive, motor, behavioral, and socio-emotional development. Iron is essential for myelination, synaptogenesis, and neurotransmitter metabolism, all of which are critical for normal brain development.⁽¹³⁾ In addition to its neurodevelopmental role, iron is required for cellular proliferation, energy metabolism, and muscle function. Consequently, infants with IDA may experience slower weight gain, impaired linear growth, reduced physical activity, and poorer appetite than their iron-sufficient groups.⁽¹⁴⁾

In anemic infants, the lowest hemoglobin was 7 g/dL. Whilst, the diagnosis of IDA by therapeutic trial method was practical. About 88.2% of infants who came to recheck CBC after iron supplementation were iron-responders. In this group, the Hb was increased up to 3.5 g/dL. Two babies were classified as iron non-responders with Hb E trait. Besides IDA, thalassemia could be another common cause of anemia in Thailand. Infants with hypochromic microcytic anemia who showed no response to iron supplementation should be further investigated with Hb typing. Among the infants with loss to follow up, the main reasons were that parents brought their infants to the hometown in other provinces. If they were iron-responders, the prevalence of IDA in our study would be higher (45.1%). We also suggested the parents to have their babies recheck CBC at the nearest hospital after a month of iron supplementation.

Our study also showed the association of exclusively breastfeeding and anemia ($P < 0.05$), which was compatible to other studies^(10, 15, 16) Breast feeding was associated with higher prevalence of anemia, probably due to its low iron content when compared with infant formula. Other factors related to iron deficiency and IDA in late-preterm infants

were lower birth weight and shorter duration of formula feeding.^(2, 11) Contrary to our expectations, this study yielded no significant difference between birth weight and anemia or IDA, probably due to a small sample size.

From our study, most of the complimentary food choices that parents gave to subjects were low in iron content or contained mostly non-heme iron. Red meat, as a source of heme iron, was given to 60.0% of infants. Heme iron was better absorbed than non-heme iron. This pattern of complimentary feeding in infants may result in the high prevalence of IDA.

To the best of our knowledge, this was the first study in Thailand to evaluate the prevalence of anemia and IDA in late-preterm infants at the age of 6–9 months. We used CBC for the evaluation of anemia. The test allowed measurement of hemoglobin, hematocrit, and mean corpuscular volume, which made it easy to detect hypochromic microcytic anemia, the characteristics of red cells in IDA. Furthermore, we employed therapeutic trial with iron supplementation to make the diagnosis of iron deficiency anemia, which was practical in the limited-resource country.

The limitations of this study included a small sample size and loss to follow-up. The drop-out rate was 43.0%. More participants may be needed to elucidate factors associated with anemia. Moreover, this was a single-center study which may limit the generalizability of our study. Further studies with larger sample size should be thus recommended.

Thus, complete blood count should be performed in late-preterm infants at the age of 6–9 months to detect anemia and iron deficiency anemia. A therapeutic trial with iron supplementation (elemental iron 4–6 mg/kg/day) can also be an appropriate method for both diagnosis and treatment of iron deficiency anemia.

Conclusion

In many countries, late-preterm infants do not receive iron supplementation on a routine basis. Whilst, the prevalence of anemia and IDA in this population group is not well established. Our study found that the prevalence of anemia and IDA in late-preterm infants, aged 6–9 months, were 48.4% and 30.6%, respectively. The data also showed the association of exclusively breastfeeding and anemia. Other factors related to iron deficiency and IDA in late-preterm infants were lower birth weight and shorter duration of formula feeding. Screening for anemia in all late preterm infants at the age of 6–9 months should be ratified for early detection and prompt treatment of IDA.

Author contributions

Nattakarn Numsriskulrat and Therdpong Tempark contributed substantially to the concept and design of this study, acquiring the data, reviewing the literature, and its analysis and interpretation.

Nattakarn Numsriskulrat, Piti Techavichit and Therdpong Tempark contributed substantially to acquiring the data.

Nattakarn Numsriskulrat and Therdpong Tempark contributed to drafting the manuscript.

Orapa Suteerajtrakool, Piti Techavichit and Therdpong Tempark edited the manuscript critically for important intellectual content.

All authors approved the final version submitted for publication and take responsibility for statements made in the published article.

Acknowledgements

The authors would like to extend special thanks to all families of children who participated in the study. We will also like to thanks Ms. Sunatee Kessung for her assistance in editing and revising this manuscript.

Conflict of interest statement

All authors have completed and submitted the International Committee of Medical Journal Editors Uniform Disclosure Form for Potential Conflicts of Interest. All authors declare that they have no conflicts of interest.

Data sharing statement

Data sharing statement. All data generated or analyzed during the present study are included in this published article. Further details are available for noncommercial purposes from the corresponding author on reasonable request.

Declaration of artificial intelligence use

The authors declare that no AI tools or AI-assisted technologies were used in any part of the preparation, writing, editing, or revision of this manuscript.

ORCID

Nattakarn Numsriskulrat  <https://orcid.org/0000-0002-1222-9588>

Orapa Suteerajtrakool  <https://orcid.org/0000-0002-5989-2205>

Piti Techavichit  <https://orcid.org/0000-0002-1888-1446>

Therdpong Tempark  <https://orcid.org/0000-0001-5645-2135>

References

1. Stark AR. Levels of neonatal care. *Pediatrics* 2004; 114:1341–7.
2. Ferri C, Procianny RS, Silveira RC. Prevalence and risk factors for iron-deficiency anemia in very-low-birth-weight preterm infants at 1 year of corrected age. *J Trop Pediatr* 2014;60:53–60.
3. Ozdemir H, Akman I, Demirel U, Coskun S, Bilgen H, Ozek E. Iron deficiency anemia in late-preterm infants. *Turk J Pediatr* 2013;55:500–5.
4. Lozoff B, Beard J, Connor J, Barbara F, Georgieff M, Schallert T. Long-lasting neural and behavioral effects of iron deficiency in infancy. *Nutr Rev* 2006;64(5 Pt 2):S34–43; discussion S72–91.
5. Lozoff B. Iron deficiency and child development. *Food Nutr Bull* 2007;28(4 Suppl):S560–71.
6. Baker RD, Greer FR. Diagnosis and prevention of iron deficiency and iron-deficiency anemia in infants and young children (0–3 years of age). *Pediatrics* 2010;126: 1040–50.
7. Proceedings of the XX National Congress of the Italian Society of Neonatology. *Ital J Pediatr* 2014;40 Suppl 2:A1–a53.
8. World Health Organization (Ed.) *Iron Deficiency Anaemia: Assessment, Prevention and Control: A Guide for Programme Managers*; WHO: Geneva, Switzerland, 2001.
9. Tantracheewathorn S, Lohajaroensub S. Incidence and risk factors of iron deficiency anemia in term infants. *J Med Assoc Thai* 2005;88:45–51.
10. Berglund S, Westrup B, Domellof M. Iron supplements reduce the risk of iron deficiency anemia in marginally low birth weight infants. *Pediatrics* 2010;126:e874–83.
11. Uijtershout L, Domellof M, Abbink M, Berglund SK, van Veen I, Vos P, et al. Iron deficiency in the first 6 months of age in infants born between 32 and 37 weeks of gestational age. *Eur J Clin Nutr* 2015;69:598–602.
12. Agostoni C, Buonocore G, Carnielli VP, De Curtis M, Darmaun D, Decsi T, et al. Enteral nutrient supply for preterm infants: commentary from the European Society of Paediatric Gastroenterology, Hepatology and Nutrition Committee on Nutrition. *J Pediatr Gastroenterol Nutr* 2010;50:85–91.
13. Georgieff MK. Long-term brain and behavioral consequences of early iron deficiency. *Nutr Rev* 2011;69 Suppl 1(Suppl 1):S43–8.
14. Soliman AT, Al Dabbagh MM, Habboub AH, Adel A, Humaidy NA, Abushahin A. Linear growth in children with iron deficiency anemia before and after treatment. *J Trop Pediatr* 2009;55:324–7.
15. Meinzen-Derr JK, Guerrero ML, Altaye M, Ortega-Gallegos H, Ruiz-Palacios GM, Morrow AL. Risk of infant anemia is associated with exclusive breastfeeding and maternal anemia in a Mexican cohort. *J Nutr* 2006;136:452–8.
16. van de Lagemaat M, Ames EM, Schaafsma A, Lafeber HN. Iron deficiency and anemia in iron-fortified formula and human milk-fed preterm infants until 6 months post-term. *Eur J Nutr* 2014;53:1263–71.