

Original article

Prevalence of anemia and associated risk factors among late preterm infants, aged 6 to 12 months at Thammasat University Hospital

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Abstract:

Objective: The study aimed to determine the prevalence of anemia and associated risk factors among late preterm infants aged 6-12 months at Thammasat University Hospital. **Materials and methods:** A retrospective chart review was conducted of infants born between October 2016 and October 2020. A total of 127 late preterm infants with complete blood count results at 6-12 months were included. Maternal and infant factors were analyzed using logistic regression to identify associations with anemia. **Results:** The prevalence of anemia was 22.83%, with 55.17% mild, 41.38% moderate and 3.45% severe cases. Iron deficiency was observed in 42.39% and iron deficiency anemia in 14.13% of those with available ferritin data. A significant risk factor for anemia was primigravidity (adjusted OR = 3.25, 95%CI: 1.18-8.89, $p = 0.022$), while higher maternal hematocrit was a protective factor (adjusted OR = 0.83, 95%CI: 0.72-0.95, $p = 0.007$). Iron supplementation was also protective (adjusted OR = 0.26, 95%CI: 0.09-0.66, $p = 0.005$). No significant difference was found between low-dose (< 3 mg/kg/day) and therapeutic-dose (3-6 mg/kg/day) supplementation. **Conclusion:** Anemia is prevalent among late preterm infants. Primigravidity increases the risk, whereas higher maternal hematocrit and infant iron supplementation are protective. These findings highlight the importance of optimizing maternal hematologic status and ensuring adequate iron supplementation in late preterm infants.

Keywords : ● Anemia ● Iron deficiency anemia ● Late preterm ● Risk factors ● Iron supplementation

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นิพนธ์ต้นฉบับ

ความชุกของภาวะโลหิตจางและปัจจัยเสี่ยงในทารกเกิดก่อนกำหนดระยะท้าย อายุ 6 ถึง 12 เดือนที่โรงพยาบาลธรรมศาสตร์เฉลิมพระเกียรติ

สารยุทธ์ ลีลาพิรพงศ์ พชรพรรณ สุรพลชัย ผกาทิพย์ ศิลปมงคลกุล วัลลี ลัทยาคัย และ ทัสมา พูทรงชัย
ภาควิชากุมารเวชศาสตร์ คณะแพทยศาสตร์ มหาวิทยาลัยธรรมศาสตร์

บทคัดย่อ

วัตถุประสงค์ เพื่อศึกษาความชุกของภาวะโลหิตจางและปัจจัยเสี่ยงที่เกี่ยวข้องในทารกคลอดก่อนกำหนดระยะท้าย อายุ 6-12 เดือนที่โรงพยาบาลธรรมศาสตร์เฉลิมพระเกียรติ **วิธีการศึกษา** การศึกษาย้อนหลังจากเวชระเบียนของทารกที่คลอดระหว่างเดือนตุลาคม 2559 ถึงตุลาคม 2563 รวมจำนวน 127 ราย ที่มีผลตรวจความสมบูรณ์ของเม็ดเลือด (CBC) ขณะอายุ 6-12 เดือน วิเคราะห์ปัจจัยมารดาและทารกโดยใช้ logistic regression **ผลการศึกษา** พบความชุกของภาวะโลหิตจางร้อยละ 22.83 โดยมีภาวะโลหิตจางระดับเล็กน้อยร้อยละ 55.17 ปานกลางร้อยละ 41.38 และรุนแรงร้อยละ 3.45 พบภาวะขาดธาตุเหล็กร้อยละ 42.39 และภาวะโลหิตจางจากการขาดธาตุเหล็กร้อยละ 14.13 ปัจจัยเสี่ยงที่มีนัยสำคัญคือการตั้งครรภ์ครั้งแรก (adjusted OR = 3.25, $p = 0.022$) และพบว่าระดับฮีมาโตคริตของมารดาที่สูงเป็นปัจจัยป้องกัน (adjusted OR = 0.83, $p = 0.007$) ขณะที่การได้รับยาเสริมธาตุเหล็กมีผลป้องกันการเกิดภาวะโลหิตจาง (adjusted OR = 0.26, $p = 0.005$) โดยไม่พบความแตกต่างอย่างมีนัยสำคัญระหว่างกลุ่มที่ได้รับธาตุเหล็กในขนาดต่ำกับขนาดรักษา **สรุป** ภาวะโลหิตจางยังคงพบได้บ่อยในทารกคลอดก่อนกำหนดระยะท้าย การตั้งครรภ์ครั้งแรกเป็นปัจจัยเสี่ยงสำคัญ ในขณะที่การมีระดับฮีมาโตคริตของมารดาสูงและการได้รับธาตุเหล็กเสริมมีผลช่วยป้องกัน ผลการศึกษาชี้ให้เห็นความสำคัญของการดูแลภาวะทางโลหิตวิทยาของมารดาและการเสริมธาตุเหล็กในทารกกลุ่มนี้

คำสำคัญ : ● โลหิตจาง ● โลหิตจางจากการขาดธาตุเหล็ก ● ทารกเกิดก่อนกำหนดระยะท้าย ● ปัจจัยเสี่ยง ● ยาเสริมธาตุเหล็ก

วารสารโลหิตวิทยาและเวชศาสตร์บริการโลหิต. 2569;36:201-12.

Introduction

Anemia is a common medical condition among children and a major global health problem, particularly in developing countries. The condition is most prevalent among children under 2 years,^{1,2} with a global prevalence of 47.4% among children under 5 years³ and 46-66% in developing countries.⁴ The problem is especially pronounced among infants, particularly those born preterm, with anemia prevalence at six months as high as 38.5%.⁵

Iron deficiency anemia (IDA) is the most common type and has serious consequences for child health and development. IDA in infancy negatively affects immune function,⁶ physical growth,⁷ and neurodevelopment,^{8,9} including cognitive function, behavior, memory, learning and sensory processing.^{8,10} Infants under one year of age with IDA are at increased risk of motor and psychological developmental delays, particularly in language, balance and executive function, which can create long-term effects on quality of life and learning potential.¹¹⁻¹³

Iron is essential for hemoglobin, which transports oxygen. Infants obtain iron from fetal stores, red blood cell breakdown and diet intake. Fetal iron stores mainly accumulate during the third trimester, placing preterm infants at higher risk of anemia and potentially affecting brain development during the first two years of life.¹⁴ Other factors influencing iron storage include intrauterine growth restriction and maternal conditions such as gestational diabetes, hypertension and maternal iron deficiency.

Preterm infants have higher iron requirements due to rapid growth, and frequent blood sampling further increases the risk of anemia.^{15,16} Anemia is particularly common between 6 and 12 months of age when iron stores are depleted and complementary foods become important sources of iron.

Guidelines recommend iron supplementation of 2-3 mg/kg/day in very preterm infants (< 32 weeks), starting at 2-6 weeks and continuing until 6 months.¹⁷⁻¹⁹ However, clear recommendations for late preterm infants (34-36⁺⁶

weeks) are lacking. Some studies suggest benefits in infants weighing 2,000-2,500 grams, although excessive supplementation may carry risks.¹⁹⁻²¹

At Thammasat University Hospital, no clear guidelines exist for iron supplementation in late preterm infants. This study aims to investigate the prevalence of anemia and associated risk factors in this population, providing baseline data to support practical guidelines for prevention and management.

Materials and methods

Study design and population

This retrospective chart review included infants born between October 2016 and October 2020 at Thammasat University Hospital. Data were obtained from the hospital's E-Phis system and manual medical records. The study aimed to determine the prevalence of anemia among late preterm infants (34-36⁺⁶ weeks' gestation) aged 6-12 months. Ethical approval was granted by the Human Research Ethics Subcommittee, Faculty of Medicine, Thammasat University (Protocol No. MTU-EC-PE-0-129/63, August 28, 2020).

A total of 127 late preterm infants aged 6-12 months were included. The sample size was calculated based on a study by Huang, et al., which reported a 30% prevalence of anemia in a similar age group. Using an alpha error of 0.05 and a beta error of 0.20, the required sample size was 80 participants.

The inclusion criteria comprised infants born at Thammasat University Hospital between October 2016 and October 2020 with a gestational age 34-36⁺⁶ weeks who attended follow-up at the Pediatric Outpatient Department between 6 and 12 months of age and had laboratory results including complete blood count (CBC) during this period.

The exclusion criteria comprised infants with chronic diseases such as bronchopulmonary dysplasia, inborn errors of metabolism, chromosomal abnormalities, multiple anomalies or dysmorphic features suggestive of genetic syndromes.

Data collection

Data were retrospectively extracted from the E-Phis and patient charts using a structured data collection form. Information included both maternal and infant data. Maternal data included age, gestational age, parity, mode of delivery, anemia status, antenatal hemoglobin levels, pre-existing conditions and pregnancy complications.

Infant data included sex, birth weight and length, postnatal complications, hemoglobin levels after birth, feeding practices, iron supplementation (dose and duration), anthropometric data at 6-12 months and laboratory results. CBC was performed immediately after blood collection using an automated cell counter (UniCel DxH 800, Beckman Coulter, USA). Data on serum ferritin were collected when available and were analyzed using UniCel Dxl 800 (Beckman Coulter, USA). Anemia was defined according to WHO criteria, and iron deficiency was determined based on standard literature.

Statistical analysis

Data were analyzed using STATA version 14 (StataCorp, USA). Descriptive statistics were used to summarize baseline characteristics: categorical variables were presented as percentages, and continuous variables as mean $\pm$ standard deviation (SD) or median [IQR]. Comparisons between infants with and without anemia were performed using the Chi-square test or Fisher's exact test, as appropriate. Logistic regression (univariable and multivariable) was used to identify factors associated with anemia. A p -value < 0.05 was considered statistically significant.

Definitions

Neonatal anemia: hematocrit $< 45\%$.

Anemia: hemoglobin < 11 g/dL (WHO guidelines, 2005).

Iron deficiency: serum ferritin < 30 mcg/L.²²

Iron deficiency anemia: hemoglobin < 11 g/dL and serum ferritin < 30 mcg/L.

Late preterm infant: gestational age 34-36⁺⁶ weeks.

Birth asphyxia: APGAR score at 1 minute < 7 .

Anemia in pregnancy: hematocrit $< 33\%$.

Results

A total of 127 late preterm infants who attended follow-up visits at the Pediatric Outpatient Department, Thammasat University Hospital, between 6 and 12 months of age and had complete blood count (CBC) results available were included in the study. Data were categorized according to sex, mean age, weight and maternal and infant characteristics, as summarized in Table 1.

At follow-up, the mean age of infants at follow-up was 8.92 ± 2.03 months, with a higher proportion of males (61.42%). The mean weight and length of the infants were 7.93 ± 1.49 kg and 68.70 ± 4.44 cm, respectively, with an average monthly weight gain of 0.66 kg.

The mean maternal age was 31.85 ± 5.89 years. Primigravida accounted for 55.56% of pregnancies. Pregnancy complications were observed in 37.01% of mothers, including gestational diabetes (18.11%) and pregnancy-induced hypertension (12.60%). Cesarean delivery was more common than vaginal delivery (66.93% vs. 33.07%), and the majority of infants were singleton births (77.95%). The mean maternal hematocrit was $36.62 \pm 3.58\%$, with 11.81% of mothers experiencing anemia during pregnancy.

The mean birth weight was 2223.81 ± 455.83 g. Low birth weight ($< 2,500$ g) was observed in 69.29% of infants, while 6.30% had very low birth weight ($< 1,500$ g). Infants classified as small for gestational age (SGA) accounted for 26.77% of the cohort. Postnatal complications were common, affecting 82.68% of infants. The mean hematocrit concentration within the first 48 hours of life was $50.56 \pm 7.02\%$, and 21.26% of infants were anemic at birth.

Iron supplementation was provided to 86 of 127 infants (67.72%). Among these, 26 received a low dose (< 3 mg/kg/day), whereas 60 received a therapeutic dose (3-6 mg/kg/day). The mean duration of supplementation was 4.99 ± 3.06 months.

The mean duration of exclusive breastfeeding was two months. Complementary feeding was typically introduced at around six months of age, and iron-rich

Table 1 Demographic data

Demographic data	N = 127	Percentage or Median [IQR]
Mean age at follow up (months), mean $\pm$ SD	8.92 $\pm$ 2.03	
Gender		
Male	78	61.42
Female	49	38.58
Weight (kg) at follow up, mean $\pm$ SD [N = 119]	7.93 $\pm$ 1.49	
Length (cm) at follow up, mean $\pm$ SD [N = 112]	68.70 $\pm$ 4.44	
Weight gain per month (g), mean $\pm$ SD [N = 119]	659.53 $\pm$ 134.06	
Z score W/A, mean $\pm$ SD [N = 119]	-0.75 $\pm$ 1.31	Median -0.66 [-1.71, 0.05]
Z score L/A, mean $\pm$ SD [N = 112]	-1.01 $\pm$ 1.28	Median -0.99 [-1.80, -0.19]
Z score W/L, mean $\pm$ SD [N = 112]	-0.26 $\pm$ 1.22	Median -0.21 [-1.11, 0.53]
Maternal factors		
Maternal age (years), mean $\pm$ SD [N = 126]	31.85 $\pm$ 5.89	
Gravidity [N = 126]		
Primigravidity	70	55.56
Multigravidity	56	44.44
Obstetric complications [N = 127]		
No	80	62.99
Yes	47	37.01
GDM	23	18.11
PIH	16	12.60
PPROM	16	12.60
Maternal underlying disease [N = 127]	24	18.90
Delivery mode [N = 127]		
Vaginal delivery	42	33.07
Cesarean section	85	66.93
Number of fetus [N = 127]		
Singleton	99	77.95
Twin	27	21.26
Triplet	1	0.79
Mean maternal hematocrit (%), mean $\pm$ SD [N = 127]	36.62 $\pm$ 3.58	
Maternal anemia (number)	15	11.81
Neonatal factors [N = 127]		
Birth weight (g), mean $\pm$ SD	2,223.81 $\pm$ 455.83	
Normal [$\geq$ 2,500]	31	24.41
Low [$<$ 2,500]	88	69.29
Very low [$<$ 1,500]	8	6.30
Size for gestational age		
SGA	34	26.77
AGA	93	73.23

Table 1 Demographic data (continue)

Demographic data	N = 127	Percentage or Median [IQR]
Mean gestational age (weeks), mean $\pm$ SD	35.50 $\pm$ 0.86	
APGAR at 1 min, mean $\pm$ SD	8.46 $\pm$ 1.49	
APGAR at 5 min, mean $\pm$ SD	9.75 $\pm$ 0.90	
Birth asphyxia [APGAR at 1 min < 7]	11	8.66
Neonatal complications		
No	22	17.32
Yes	105	82.68
TTNB	34	26.77
Hypoglycemia	27	21.26
IUGR	22	17.32
Neonatal jaundice	48	37.80
Early onset sepsis	52	40.94
RDS	8	6.30
Mean Hct at 48 hours (%), mean $\pm$ SD	50.56 $\pm$ 7.02	
Neonatal anemia (number)	27	21.26
Median LOS of hospital stay (days)	7 (4, 16)	
Iron supplement [N = 127]		
No	41	32.28
Yes	86	67.72
Low (< 3 mg/kg/day)	26	20.47
Therapeutic (3-6 mg/kg/day)	60	47.24
Dose Iron supplement (mg/kg/day), mean $\pm$ SD [N = 86]	3.70 $\pm$ 1.04	
Duration Iron supplement (months), mean $\pm$ SD [N = 86]	4.99 $\pm$ 3.06	
Duration of exclusive breastfeeding (months), mean $\pm$ SD [N = 103]	2.44 $\pm$ 2.97	
Age starting complementary food (months), mean $\pm$ SD [N = 99]	6.32 $\pm$ 1.53	
Age starting iron rich food (months), mean $\pm$ SD [N = 92]	7.80 $\pm$ 2.36	

GDM, gestational diabetes mellitus; PIH, pregnancy-induced hypertension; PPROM, preterm premature rupture of the membranes; SGA, small for gestational age; AGA, appropriate for gestational age; TTNB, transient tachypnea of the newborn; IUGR, intra-uterine growth restriction; RDS, respiratory distress syndrome; Hct, hematocrit; LOS, length of stay

foods, such as meat and organ meats, were introduced at a mean age of 7.80 $\pm$ 2.36 months.

The hematologic laboratory results of infants aged 6-12 months are summarized in Table 2. The mean hematocrit and hemoglobin levels were 35.60 $\pm$ 4.49% and 11.59 $\pm$ 1.38 g/dL, respectively. Anemia was identified in 22.83% of the infants.

Anemia was classified into mild (hemoglobin 10-10.9 g/dL), moderate (hemoglobin 7-9.9 g/dL), and severe (hemoglobin < 7 g/dL), accounting for 55.17%, 41.38% and

3.45% of cases, respectively. Regarding iron status, data were available for 92 infants. The mean serum ferritin level was 45.50 $\pm$ 37.88 ng/mL. Among these infants, 42.39% met the criteria for iron deficiency, and 14.13% met the criteria for iron deficiency anemia (Table 2). Five cases were classified as having moderate anemia.

Based on the analysis, the infants were categorized into two groups: those with anemia (N = 29) and those without anemia (N = 98), as shown in Table 3. With respect to baseline characteristics, including age, sex,

Table 2 Hematologic outcomes

Hematologic outcomes	N = 127	Percentage
Hct at follow up (%), mean $\pm$ SD	35.60 $\pm$ 4.49	
Hb at follow up (g/dL), mean $\pm$ SD [N = 122]	11.59 $\pm$ 1.38	
Anemia, N (percentage)	29	22.83
Mild [Hb 10-10.9 g/dL]	16	55.17
Moderate [Hb 7-9.9 g/dL]	12	41.38
Severe [Hb < 7g/dL]	1	3.45
MCV, N (percentage) [N = 122]		
Microcytic [MCV < 70 fL]	52	42.62
Normocytic [MCV 70-100 fL]	70	57.38
Ferritin (mcg/L), mean $\pm$ SD [N = 92]	45.50 $\pm$ 37.88	Median 36.20 [19.55, 61.00]
Iron deficiency, N (percentage) [N = 92]	39	42.39
Iron deficiency anemia, N (percentage) [N = 92]	13	14.13

Hct, hematocrit; Hb, hemoglobin; MCV, mean corpuscular volume

Table 3 Factors associated with infant anemia

Characteristic data	Anemia [N = 29]	Non-anemia [N = 98]	p-value
Mean age at follow up (mo), mean $\pm$ SD [N = 127]	9.08 $\pm$ 2.19	8.87 $\pm$ 1.99	0.629
Male, N (%)	18 (62.07)	60 (61.22)	1.000
Weight at follow up (kg), mean $\pm$ SD [N= 119]	7.81 $\pm$ 1.36 [N = 29]	7.98 $\pm$ 1.53 [N = 90]	0.879
Length at follow up (cm), mean $\pm$ SD [N= 112]	68.41 $\pm$ 4.52 [N = 29]	68.79 $\pm$ 4.44 [N = 83]	0.692
Z score W/A, mean $\pm$ SD [N=119]	-0.97 $\pm$ 1.31 [N = 29] Median -0.72 [-1.62, -0.18]	-0.68 $\pm$ 1.31 [N = 90] Median -0.60 [-1.76, 0.16]	0.527
Z score L/A, mean $\pm$ SD [N=112]	-1.24 $\pm$ 1.28 [N = 29]	-0.93 $\pm$ 1.28 [N = 83]	0.360
Z score W/L, mean $\pm$ SD [N=112]	-0.31 $\pm$ 1.40 [N = 29]	-0.24 $\pm$ 1.24 [N = 83]	0.917
Weight gain per month (g), mean $\pm$ SD, [N=119]	629.38 $\pm$ 120.62 [N = 29]	669.24 $\pm$ 137.32 [N = 90]	0.159
Maternal factors	Anemia [N=28]	Non-anemia [N=98]	p-value
Mean maternal age (years), mean $\pm$ SD	31.93 $\pm$ 5.05 [N = 28]	31.83 $\pm$ 6.13 [N = 98]	0.940
Gravidity, N (%)	[N = 28]	[N = 98]	
Primigravidity	21 (75)	49 (50)	0.030
Multigravidity	7 (25)	41 (50)	
Obstetrics complication, N (%)	10 (34.48) [N = 29]	37 (37.76) [N = 98]	0.829
GDM	5 (17.24)	18 (18.37)	1.000
PIH	4 (13.79)	12 (12.24)	0.760
PPROM	3 (10.34)	13 (13.27)	1.000
Delivery mode, N (%)	[N = 29]	[N = 98]	
Vaginal delivery	6 (20.69)	36 (36.73)	0.121
Cesarean section	23 (79.31)	62 (63.27)	
Number of fetus, N (%)	[N = 29]	[N = 98]	
Singleton	20 (68.97)	79 (80.61)	0.380
Twin	9 (31.03)	18 (18.37)	
Triplet	0	1 (1.02)	

Table 3 Factors associated with infant anemia (continue)

Maternal factors	Anemia [N = 28]	Non-anemia [N = 98]	p-value
Mean maternal hematocrit (%), mean $\pm$ SD	35.03 $\pm$ 4.21 [N = 29]	37.08 $\pm$ 3.25 [N = 98]	0.014
Maternal anemia, N (%)	4 (13.79%)	11 (11.22%)	0.746
Neonatal factors	Anemia [N = 29]	Non-anemia [N = 98]	p-value
Birth weight (g), mean $\pm$ SD	2243.59 $\pm$ 431.75	2217.96 $\pm$ 464.70	0.792
Normal [$\geq$ 2,500 g], N (%)	9 (31.03)	22 (22.45)	0.625
Low [$<$ 2,500 g], N (%)	19 (65.52)	69 (70.41)	
Very low [$<$ 1,500 g], N (%)	1 (3.45)	7 (7.14)	
Size for gestational age			
SGA, N (%)	8 (27.59)	26 (26.53)	1.000
AGA, N (%)	21 (72.41)	72 (73.47)	
Mean gestational age (weeks), mean $\pm$ SD	35.55 $\pm$ 0.87	35.49 $\pm$ 0.86	0.734
Asphyxia [APGAR at 1 min $<$ 7], N (%)	2 (6.90)	9 (9.18)	1.000
Neonatal factors	Anemia [N = 29]	Non-anemia [N = 98]	p-value
Neonatal complication, N (%)			
No	5 (17.24)	17 (17.35)	1.000
Yes	24 (82.76)	81 (82.65)	
TTNB	11 (37.93)	23 (23.47)	0.153
Hypoglycemia	9 (31.03)	18 (18.37)	0.195
IUGR	4 (13.79)	18 (18.37)	0.781
Neonatal jaundice	11 (37.93)	37 (37.76)	1.000
Sepsis	12 (41.38)	40 (40.82)	1.000
RDS	0 (0)	8 (8.16)	0.197
Mean Hct at 48 hours (%), mean $\pm$ SD,	49.47 $\pm$ 6.66	50.88 $\pm$ 7.12	0.345
Neonatal anemia, N (%)	8 (27.59)	19 (19.39)	0.438
Duration of hospital stay (days), median [IQR]	7 [3,11]	7 [4,17]	0.382
Iron supplement, N (%)			
No	16 (55.17)	25 (25.51)	0.006
Yes	13 (44.83)	73 (74.49)	
Low dose ($<$ 3 mg/kg/day)	1 (7.69)	25 (34.25)	
Therapeutic dose (3-6 mg/kg/day)	12 (92.31)	48 (65.75)	
Duration iron supplement (months), mean $\pm$ SD [N = 86]	4.69 $\pm$ 2.10 [N = 13]	5.05 $\pm$ 3.21 [N = 73]	0.912
Duration of exclusive breast feeding (months), mean $\pm$ SD [N = 103]	3.36 $\pm$ 3.51 [N = 25]	2.14 $\pm$ 2.73 [N = 78]	0.176
Age starting complementary food (months), mean $\pm$ SD [N = 99]	6.69 $\pm$ 1.46 [N = 23]	6.21 $\pm$ 1.54 [N = 76]	0.149
Age starting iron rich food (months), mean $\pm$ SD [N = 92]	7.96 $\pm$ 2.22 [N = 23]	7.75 $\pm$ 2.42 [N = 69]	0.590

weight and length, no statistically significant differences were observed between the two groups.

Comparison of maternal characteristics revealed no significant difference in mean maternal age between the groups. However, primigravity was significantly more frequent among mothers of anemic infants (75%) than among mothers of non-anemic infants (50%) ($p = 0.03$). No significant differences were observed between the groups with respect to pregnancy complications, mode of delivery or plurality.

Regarding maternal hematologic status, the mean hematocrit level was lower among mothers of anemic infants (35.03%) than among mothers of non-anemic infants (37.08%), and this difference was statistically significant ($p = 0.014$). Nevertheless, the overall prevalence of maternal anemia did not differ significantly between the two groups.

The mean birth weight was comparable between the two groups, at 2243.6 g in the anemia group and 2218.0 g in the non-anemia group. Low birth weight was prevalent in both groups, accounting for 65.52% and 70.41%, respectively. The proportion of small-for-gestational-age infants was also similar between groups (27.59% vs. 26.53%). Neonatal complications were observed in approximately 83% of infants in both groups, including transient tachypnea of the newborn (TTNB), hypoglycemia, intrauterine growth restriction (IUGR), neonatal jaundice, and sepsis, with no significant difference between the groups.

The prevalence of neonatal anemia, defined as hematocrit $< 45\%$ at 48 hours of life, did not differ

significantly between the groups. Although the mean hematocrit level at 48 hours was slightly lower in the anemia group (49.47%) than in the non-anemia group (50.88%), the difference was not statistically significant. The average length of hospital stay for late preterm infants was approximately seven days.

Iron supplementation was significantly more frequent in the non-anemia group (74.49%) than in the anemia group (44.83%) ($p = 0.006$). However, no significant differences were observed between the two groups regarding the initial dosage or duration of supplementation.

With respect to feeding practice, no significant differences were observed between the groups in the duration of exclusive breastfeeding (2-3 months), the age at initiation of complementary feeding (6 months) or the age at introduction of iron-rich foods (7 months).

In this study, primigravity, maternal hematocrit level and iron supplementation were identified as significant factors associated with infant anemia. Univariable and multivariable logistic regression analyses were performed to evaluate these associations (Table 4).

Among maternal factors, primigravity was associated with an increased risk of infant anemia, with an odds ratio (OR) of 3.0. This finding indicates that late preterm infants born to primigravid mothers had a threefold higher risk of developing anemia at 6-12 months of age compared with those born to multigravid mothers ($p = 0.022$). Maternal hematocrit was inversely associated with infant anemia (OR = 0.86), suggesting that each 1% increase in maternal hematocrit was associated with a 14% reduction in the risk of infant anemia ($p = 0.007$).

Table 4 Univariable and multivariable regression analyses of factors associated with infant anemia

Potential factors	Univariable regression			Multivariable regression		
	Crude OR	95%CI	p-value	Adjusted OR*	95%CI	p-value
Maternal factors						
Primigravity	3.0	1.17, 7.70	0.022	3.25	1.18, 8.89	0.022
Maternal Hematocrit (for each 1%-increase)	0.86	0.76, 0.96	0.011	0.83	0.72, 0.95	0.007
Infant factor						
Iron supplement	0.28	0.12, 0.66	0.004	0.26	0.09, 0.66	0.005

Regarding infant factors, iron supplementation demonstrated a strong protective effect ($OR = 0.28$), indicating that infants who received supplementation had a 72% lower risk of anemia ($p < 0.05$). Multivariable logistic regression analysis confirmed the independent significance of these three factors.

For clinical application, we further explored whether the initial dose of iron supplementation influenced the risk of infant anemia. Subgroup analysis revealed no significant difference between infants receiving a low dose (< 3 mg/kg/day; $N = 26$) and those receiving a therapeutic dose (3-6 mg/kg/day; $N = 60$) ($p = 0.097$). These findings suggest that iron supplementation, regardless of dose, is beneficial in preventing anemia among late preterm infants. Notably, the number needed to treat (NNT) was 4.18, indicating that providing iron supplementation to approximately five late preterm infants could prevent one case of anemia.

Discussion

This study investigated late preterm infants aged 6-12 months at Thammasat University Hospital and found an anemia prevalence of 22.83%. This prevalence was slightly lower than that reported by Huang Z, et al. in Hunan, China (29.73%) among children aged 6-23 months,²³ and also lower than the South East Asia Nutrition Survey (SEANUTS), which found a prevalence of 25.9% among Thai children aged six months to five years.²⁴ The relatively lower prevalence observed in our cohort may be explained by the high proportion of infants who received iron supplementation (68%).

The prevalence of iron deficiency anemia in this study was 14.13%, which is lower than the 25.7% previously reported in a study conducted among healthy children at Thammasat University Hospital. This discrepancy may be attributable to differences in study populations, as the previous study excluded children receiving iron supplementation, whereas the present study focused specifically on late preterm infants. Notably, our findings are consistent with those of Uijterschout, et al., who

reported a 9.1% prevalence of iron deficiency anemia among late preterm infants aged 4-6 months, supporting the relevance of our results in this high-risk population.

Regarding risk factors, primigravidity, maternal hematocrit level, and infant iron supplementation were identified as significant determinants of anemia. Primigravidity was associated with a threefold higher risk of infant anemia compared with multigravidity. A possible explanation is that primigravid mothers may have less experience with adequate nutrition and supplementation during pregnancy, as well as limited knowledge regarding infant feeding and postnatal care. However, due to incomplete information in the medical records, this hypothesis warrants further investigation.

Maternal hematocrit during pregnancy also demonstrated a protective effect, with each 1% increase associated with a 14% reduction in the risk of infant anemia. This finding suggests that maintaining higher maternal hematocrit levels—beyond the conventional threshold of 33% used to define maternal anemia—may provide additional protection against anemia in offspring.

Iron supplementation in late preterm infants significantly reduced the risk of anemia, with no significant difference observed between low-dose (< 3 mg/kg/day) and therapeutic-dose (3-6 mg/kg/day) regimens. This finding suggests that low-dose supplementation may be sufficient in clinical practice for this population. Notably, this study found that providing iron supplementation to approximately five late preterm infants could prevent one case of anemia.

This study provides baseline data for a population that has not been extensively studied in Thailand. The findings may serve as a foundation for future research and for the development of evidence-based guidelines for the care and follow-up of late preterm infants, including consideration of low-dose iron supplementation to effectively prevent anemia while minimizing potential side effects and costs.

There are several limitations in this study. This study included only late preterm infants who attended

the Pediatric Outpatient Department at Thammasat University Hospital during a specific period. Therefore, the findings may not be generalizable to other populations or settings. The relatively small sample size may have limited the ability to detect associations with other potential risk factors. In addition, some data were incomplete due to the retrospective chart review design, as certain medical records or entries were not fully documented or systematically stored.

Increasing the sample size and collecting comprehensive data on associated factors would allow a clearer understanding of variable relationships. Prospective data collection may improve completeness and accuracy, including information on adherence to iron supplementation and continuous follow-up of late preterm infants.

Conclusion

The prevalence of anemia among late preterm infants aged 6-12 months at Thammasat University Hospital was 22.83%. Primigravidity was identified as a significant risk factor, whereas higher maternal hematocrit levels and infant iron supplementation were protective factors against anemia. These findings highlight the importance of optimizing maternal hematologic status during pregnancy and ensuring appropriate iron supplementation in late preterm infants to reduce the burden of anemia.

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Conflict of Interest

The authors declare that they have no conflicts of interest related to this study.

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