Spillover Effects of Maternal Anemia on Neonatal Outcomes and Cord-Blood Ferritin: A Cross-Sectional Study at Ulin General Hospital, Banjarmasin

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ABSTRACT

Maternal anemia is a widespread condition whose downstream effects are a spillover impact on fetal development and iron reserves. Understanding its impact on neonatal outcomes and cord-blood ferritin in Indonesian settings is critical for improving perinatal care. To evaluate how maternal anemia affects neonatal anthropometry, outcomes, and cord-blood ferritin. We conducted a cross-sectional study (June–October 2023) at Ulin General Hospital. Sixty mother–newborn pairs were enrolled via convenience sampling. Mothers were stratified by third-trimester hemoglobin (<11 g/dL vs. ≥11 g/dL). Data normality was assessed with Shapiro–Wilk; continuous variables compared by independent t-test or Mann–Whitney U; categorical by χ^2 or Fisher's exact; correlations by Spearman's rank ($p < 0.05$). Among 60 mother–newborn pairs, demographic and clinical features were comparable except for maternal education: primary schooling was more frequent in anemic mothers (73.3% vs. 46.7%, χ^2=4.44; p=0.035). Newborns of anemic mothers had significantly lower median birth weight (2655 g [IQR 2459–2958] vs. 3103 g [IQR 2500–3300]; p=0.028) and length (47 cm [IQR 45.8–48] vs. 48 cm [IQR 46.4–49]; p=0.027). Cord-blood ferritin was markedly reduced in the anemia group (187 ng/mL [IQR 150–220] vs. 250 ng/mL [IQR 200–300]; p<0.001). Rates of preterm birth, survival to discharge, and median hospital stay did not differ between groups. Maternal hemoglobin correlated positively with neonatal ferritin (r_s=0.253; p=0.050). Maternal anemia exerts spillover effects on neonatal growth and iron stores at birth, manifesting as lower birth weight, length, and cord-blood ferritin.

Keywords: *Birth length, Birth weight, Cord-blood ferritin, Iron stores, Maternal anemia, Neonatal outcomes.*

1. INTRODUCTION

Anemia in pregnancy has been a significant health challenge in the world, with about half of all pregnant women in the world being affected by it Beckert, Baer, Anderson, Jelliffe-Pawlowski, and Rogers (2019). Anemia is one of the most common burden conditions during pregnancy in Indonesia, where it is 48.9% and the highest in women aged 15-24 years (Akhter et al., 2014). The first cause is iron deficiency, which causes approximately half of all anemia cases on earth, and in South Borneo (Kalimantan Selatan) the rate of anemia among pregnant women was 17.81% in 2018, and in certain districts such as Hulu Sungai Utara and Barito Kuala it is 29.92% and 28.95% respectively (Abioye et al., 2019; Beckert et al., 2019). Also, the rate of anemia among teenage girls in Kalimantan Selatan in 2018 was 52.98 percent, but it reduced to 32.44 percent following interventions with iron folic acid (IFA) supplements (Riskesdas, 2019). Maternal anemia poses dangerous effects on the health of both the mother and the baby, such as maternal and perinatal mortality, preterm births, and low birth weights (Young et al., 2023). As an example, one study in India discovered that maternal anemia was associated with a 2.5-fold elevation of the risk of preterm birth and a 3-fold elevation of the risk of low birth weight (Jana, 2023). A second study carried out in Bangladesh indicated that maternal anemia played a role in raising the chances of preterm birth by 1.8 times and low birth weight by 2.2

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times (Bhat & Adhisivam, 2013). In Ethiopia, babies born to anemic mothers were characterized by increasing birth asphyxia and decreased birth height of the babies (Bayih et al., 2020).
Ferritin is the principal intracellular iron-storage protein and serves as a reliable marker of total body iron reserves. In term neonates, normal cord blood ferritin levels range from 25 to 200 ng/mL (Christensen, Bahr, & Ward, 2022; Singh, Chaudhary, & Jassar, 2022). Factors such as gestational age, birth weight, and placental function can influence these levels (Benson, Shah, Frise, & Frise, 2021; Çıkım et al., 2022). Neonatal ferritin below the reference range signals depleted iron stores, predisposing infants to early-onset anemia and potential impairments in cognitive and motor Development (Kumar, Sharma, Marley, Samaan, & Brookes, 2022; Siddappa, Rao, Long, Widness, & Georgieff, 2007; Singh et al., 2022). Several studies have shown that maternal anemia can lead to lower ferritin levels in newborns, potentially impacting their Development. One study conducted in India found that newborns of anemic mothers had significantly lower ferritin levels than those of non-anemic mothers (Tambi, Sharma, & Rajoria, 2019).
This study aims to compare neonatal anthropometry, neonatal outcomes, and cord-blood ferritin levels between anemic and non-anemic mothers at Ulin General Hospital, Banjarmasin. This study hypothesizes that maternal anemia affects neonatal ferritin and growth parameters, even after accounting for maternal education and parity.

2. METHOD

2.1. Study Design and Participant

This observational cross-sectional study was conducted at Ulin General Hospital, Banjarmasin, from June to October 2023. Due to time and resource constraints, convenience sampling was employed. Sample size was estimated using the formula for comparing two independent means.

$n = ((Z_{(\alpha/2)} + Z_{(\beta)})^2 \times 2\sigma^2) \div \Delta^2$

$Z_{(\alpha/2)} = 1.96$

$Z_{(\beta)} = 0.84$

$\sigma = 80$ ng/mL

$\Delta = 63$ ng/mL

> Steps:

1) $Z_{(\alpha/2)} + Z_{(\beta)} = 1.96 + 0.84 = 2.80$
2) $(2.80)^2 = 7.84$
3) $2\sigma^2 = 2 \times (80)^2 = 2 \times 6400 = 12\ 800$
4) Numerator = $7.84 \times 12\ 800 = 100\ 352$
5) Denominator = $(63)^2 = 3969$
6) $n = 100\ 352 \div 3969 \approx 25.29 = 26$ subjects per group.

A total of 60 mother–newborn pairs were enrolled and stratified by third-trimester maternal hemoglobin: anemic (<11 g/dL, n = 30) and non-anemic (≥11 g/dL, n = 30).

2.2. Inclusion Criteria

- Singleton pregnancy.
- Gestational age 34–41 weeks.
- Primiparous or multiparous mothers.
- Vaginal or cesarean delivery.
- Complete maternal and neonatal medical records.

2.3. Exclusion Criteria

If a potential sample that meets the inclusion criteria is found to have any of the following conditions, it will be excluded from the study.

- Neonates with major congenital anomalies.
- Mothers with antepartum hemorrhage, eclampsia, HIV, or chronic gestational conditions (diabetes, heart, kidney, lung disease, hypertension).
- Pelvic inflammatory disease within 3 months prior to conception.
- Bleeding disorders.
- Lack of consent or discharge on parental request before care completion.

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2.4. Operational Definitions

- Maternal anemia: Hemoglobin <11 g/dL in the third trimester.
- Non-anemic mother: Hemoglobin ≥11 g/dL in the third trimester.
- Low birth weight (LBW): Neonatal weight <2500 g.
- Normal birth weight (NBW): Neonatal weight ≥2500 g and ≤4000 g.
- Excessive birth weight (EBW): Neonatal weight >4000 g.
- Birth asphyxia: Apgar score <7 at 5 minutes.
- Preterm birth: Gestational age <37 weeks.
- Term birth: Gestational age ≥37 weeks.
- Small/appropriate/large for gestational age (SGA/AGA/LGA): Classified by Lubchenco's growth curves.
- Cord-blood ferritin: Measured by ELISA; normal range 25–200 ng/mL.
- Neonatal anthropometry: Weight (g), length (cm), and head circumference (cm) measured by trained staff

2.5. Data Collection

Maternal Hb levels and characteristics, including age, parity, occupation, educational background, mode of delivery, preexisting conditions, and a history of routine iron supplement use, were recorded from medical records. Newborn clinical features, including Apgar scores, sex, birth weight, length, head circumference, maturity (gestational age), and Lubchenco's were recorded by trained healthcare personnel using standardized procedures. These characteristics were then classified into various categories for a structured analysis. The data have been organized and analyzed using Microsoft Excel.

2.6. Sample Collection and Analysis

The cord blood samples were collected immediately after delivery using a five cc syringe and prepared for serum by centrifuging at 2000 rpm for 10 minutes with an LC 0-4s 8-hole Oregon centrifuge. Serum ferritin levels were measured using the Ichroma™II device. To analyze, 150 µL of diluent was added to the detector tube, followed by 30 µL of the serum sample. The tube with the detector was shaken and stirred approximately 20 times. The sample well of the test cartridge was then pipetted with 75 µL of the mixture. The cartridge was placed in a temperature-controlled chamber and incubated for over 12 minutes, then scanned with the Ichroma™ III device. The outcomes were immediately entered into a Microsoft Excel sheet, along with the subject's identity, to create a well-organized dataset.

2.7. Statistical Analysis

The SPSS 21 was used to analyze data. The data was summarized using descriptive statistics such as mean or median, standard deviation or interquartile range, frequency, and percentage. Independent t-tests were employed to compare continuous variables (e.g., ferritin levels, birth weight, birth height) between anemic and non-anemic groups. Chi-square tests were used to compared categorical variables (e.g., incidence of prematurity, low birth weight, birth asphyxia) between the groups, with Fisher's exact test applied when assumptions for the Chi-square test were not met. Pearson correlation or Spearman's rank correlation was conducted to assess the relationship between maternal Hb levels and newborn ferritin levels, depending on the normality of the data. P-value <0.05 was considered statistically significant.

2.8. Ethical Considerations

The study was approved by the Ethics Committee of Ulin General Hospital (No.24/II-Reg Riset/RSUDU/23). Informed consent was obtained from all participants before data collection. Confidentiality and anonymity of the participants were maintained throughout the study.

3. RESULT

3.1. Characteristics of Anemic and Non-Anemic Mothers

The study included two groups of mothers: Those diagnosed with anemia and those without anemia. The average age of mothers was nearly similar between the groups (anemic: 28.9±7.12 years, non-anemic: 30±5.79 years; $t=0.65$, $p=0.512$). Most mothers were multiparous (55%), with no significant difference between the groups ($\chi^2=0.06$,

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p=0.524). The sample consisted of primarily housewives (60%), but the proportion of anemic and non-anemic is higher in the former (66.7%) and the latter (53.3%) respectively. Other occupations showed no significant differences. Educational levels revealed a notable difference: primary education was more common in the anemic group (73.3%) compared to the non-anemic group (46.7%), while college education was more prevalent in the non-anemic group (53.3%) compared to the anemic group (26.7%) (χ^2=4.44, p=0.035). Cesarean sections were more frequent among anemic mothers (63.3%) than non-anemic mothers (46.7%), though this difference was not statistically significant (χ^2=1.68, p=0.194). Ferrous sulfate consumption during pregnancy was reported by all mothers, though not daily, with no significant differences between the groups.

Table 1. Maternal characteristics from anemic and non-anemic mothers.

No	Variable	Total (n=60)	Anemic mothers (n=30)	Non-Anemic mothers (n=30)	t value; χ^2 value	p-value
1	Age (year)$^{\alpha}$	29.45±6.46	28.9±7.12	30±5.79	0.65	0.512
2	Hemoglobin (g/dl)$^{\alpha}$	10.95±1.18	9.99±0.67	11.91±0.70	10.7	0.000*
3	Parity, n(%)					0.795
	Primipara	27 (45)	14 (53.3)	13 (43.3)	0.06	
	Multipara	33 (55)	16 (46.7)	17 (56.7)		
4	Occupation, n(%)$^{\gamma}$					0.524
	Housewife	36 (60)	20 (66.7)	16 (53.3)	-	
	Government employees	4 (6.7)	1 (3.3)	3 (10)		
	Health worker	6 (10)	2 (6.7)	4 (13.3)		
	Private employees	14 (23.3)	7 (23.3)	7 (23.3)		
5	Educational level, n(%)					0.035
	Primary education	36 (60)	22 (73.3)	14 (46.7)	4.44	
	College	24 (40)	8 (26.7)	16 (53.3)		
6	Mode of delivery, n(%)					0.194
	Pervaginam	27 (45)	11 (36.7)	16 (53.3)	1.68	
	Sectio cessaria	33 (55)	19 (63.3)	14 (46.7)		
7	Ferrous sulfate (SF) consumption during pregnancy, n(%)					
	Yes, but not everyday		30	30		0

Note: $^{\alpha}$Mean ± standard deviation; data distributed normally; difference test using Independent T-Test (t value).
$^{\beta}$Median (IQR); data not distributed normally; difference test using Mann-Whitney Test.
Categoric variables were analyzed with the Chi-square test (χ^2 value).
$^{\gamma}$Data assumtions not met; computed with Fisher's exact test.
*Statistically significant ($p < 0.05$).

3.2. Characteristics of Newborn from Anemic and Non-Anemic Mothers

There was no significant difference in the sex distribution of the babies between the two groups (χ^2=1.08, p=0.297). Birth weight and birth length were significantly different between the groups. Babies born to anemic mothers had a median birth weight of 2655 grams (IQR: 2458.75-2957.50), while those born to non-anemic mothers had a median birth weight of 3102.5 grams (IQR: 2500-3300) (p=0.028*). Similarly, the median birth length was 47 cm (IQR: 45.75-48) for babies of anemic mothers and 48 cm (IQR: 46.36-49) for babies of non-anemic mothers (p=0.027*). There was no significant difference in birth head circumference (p=0.277).

Most babies were appropriate for gestational age (anemia group: 90%, non-anemia group: 93.3%). The prevalence of small for gestational age was slightly higher in the anemia group (10% vs. 6.7%), but not statistically significant (p=0.306). Both groups had a similar preterm birth rate of 26.7% (p=0.61). Although the median birth weight in grams was significantly different, the classification of birth weight (normal, low, or excessive) did not show a significant difference (χ^2=0.37, p=0.542). The detailed data is available in Table 2.

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Table 2. Characteristics of the newborn from anemic and non-anemic mothers.

No.	Variable	Total (n=60)	Anemic mothers (n=30)	Non-Anemic mothers (n=30)	t value; χ^2 value	p-value
1	Sex, n(%)					0.297
	Male	34 (56.7)	15 (50)	19 (63.3)	1.08	
	Female	26 (43.3)	15 (50)	11 (36.7)		
2	Birth weight(grams)$^{\beta}$	2800 (2500-3225)	2655 (2458.75-2957.50)	3102.5 (2500-3300)	-	0.028*
3	Birth length (cm)$^{\beta}$	47 (46-49)	47 (45.75-48)	48 (46.36-49)	-	0.027*
4	Birth head circumference (cm)$^{\beta}$	33 (31-34)	33 (31-34)	33 (31.75-35)	-	0.277
5.	Birth weight classification					
	Normal birth weight (NBW)	43 (71.7)	22 (73.3)	24 (80)	0.37	0.542
	Low birth weight (LBW)	17 (28.3)	8 (26.7)	6 (20)		
	Excessive birth weight (EBW)	0	0	0		
6	Prematurity, n(%)					
	Term	45 (75)	22 (73.3)	23 (76.7)	0.089	0.766
	Preterm	15 (25)	8 (26.7)	7 (23.3)		
7	Lubchenco's curve, n(%)$^{\gamma}$					0.5
	Small for gestational age (SGA)	5 (8.3)	3 (10)	2 (6.7)	-	
	Appropriate for gestational age (APA)	55 (91.7)	27 (90)	28 (93.3)		
	Big for gestational age (BGA)	0	0	0		

Note: $^{\beta}$Median (IQR); data not distributed normally; difference test using Mann-Whitney Test.
Categoric variables were analyzed with the Chi-square test (χ^2 value).
$^{\gamma}$Data assumtions not met; computed with Fisher's exact test.
*Statistically significant ($p < 0.05$).

3.3. Association of Mother's Hemoglobin Level and Ferritin Levels of Newborn

Our study revealed a significant association between maternal hemoglobin levels and ferritin levels in newborns. Newborns from anemic mothers had a median ferritin level of 187 ng/ml (IQR: 148.64-312.95 ng/ml), whereas those from non-anemic mothers had a higher median ferritin level of 250 ng/ml (IQR: 149.62-212.20 ng/ml). This was statistically significant (p=0.043). The levels of maternal hemoglobin and those of ferritin in newborns had a positive relationship (r_s=0.253, p=0.050*) with better levels of maternal hemoglobin being linked to better levels of ferritin in the newborns.These details are available in Table 3 and Table 4.

Table 3. Ferritin levels in the blood cord of the newborn from anemic vs non anemic mothers.

No.	Variable	Total (n=60)	Anemic mothers (n=30)	Non-Anemic mothers (n=30)	p-value
1	Ferritin (ng/ml)$^{\beta}$	196.90 (148.64-312.95)	187.00 (149.62-212.20)	250.28 (140.26-498.19)	0.043*

Note: $^{\beta}$Median (IQR), data not distributed normally.
*Statistically significant ($p<0.05$).

Table 4. Spearman correlation results between maternal hemoglobin and newborn ferritin levels.

No	Variable	Value	Correlation coefficient (r_s)	p-value
1	Ferritin (ng/ml)$^{\beta}$	187 (10.57-360.63)	0.253	0.050*
2	Hemoglobin (g/dl)$^{\alpha}$	10.95±1.18		

Note: $^{\alpha}$Mean ± standard deviation; data distributed normally.
$^{\beta}$Median (min-max), data not distributed normally.
*Statistically significant ($p<0.05$).

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3.4. Association of Mother's Hemoglobin Level and Neonatal Outcomes

The median length of hospital stay for newborns from anemic mothers was 3 days (IQR 1-4 days), while for newborns from non-anemic mothers, it was 2 days (IQR 1-4.25 days). The difference in length of stay between the two groups was not statistically significant (p=0.976). Regarding survival rates, 93.3% of newborns from anemic mothers survived, compared to 96.7% of newborns from non-anemic mothers. This difference in survival rates was not statistically significant (p=0.500).

Table 5. Outcomes of newborn of anemic and non-anemic mothers.

No	Variable	Total (n=60)	Anemic mothers (n=30)	Non-Anemic mothers (n=30)	t value; χ^2 value	p-value
1	Length of stay (day)$^{\beta}$	2 (1-4)	3 (1-4.25)	2 (1-4.25) $^{\beta}$	-	0.976
2	Survival, n(%)$^{\gamma}$					0.500
	Death	3 (5)	2 (6.7)	1 (3.3)	-	
	Survived	57 (95)	28 (93.3)	29 (96.7)		

Note: $^{\beta}$Median (IQR), data not distributed normally.
Categoric variables were analyzed with the Chi-square test (χ^2 value).
$^{\gamma}$Data assumtions not met; computed with Fisher's exact test.

4. DISCUSSION

4.1. Characteristics of Anemic Mothers and Non-Anemic Mothers

Maternal factors between the anemic and non-anemic populations were also mostly similar and the differences between them were not significant in terms of age, parity, occupation, mode of delivery, and the use of ferrous sulfate during pregnancy. This homogeneity also improves internal validity of the study because it reduces confounding variables. The difference in the level of education was also large. Anemic mothers (73.3%) had higher primary education than the non-anemic mothers (46.7%), whereas college education was more common in the non-anemic group (53.3%) than the anemic group (26.7%) (χ^2=4.44, p=0.035). This indicates that the level of education of less than a junior high school may be linked to more prevalent rates of anemia which is probably because of disparity in health knowledge and access to resources (OR=1.203) (Beckert et al., 2019; Qiao et al., 2024). This is supported by a multi-center cohort study that reported that the absence of a junior high school education level was significantly higher in increasing the chances of anemia amongst pregnant women (OR=1.203) (Qiao et al., 2024). Also, a study in Lhokseumawe, Indonesia, reported a positive, yet statistically insignificant, relationship between poor maternal education and anemia (OR=3.15,95%CI: 0.81-12.27, p=0.099) (Aritonang, Helliyana, & Sanusi, 2019). The rate of cesarean section was higher among anemic mothers (63.3) than it was among non-anemic mothers (46.7) but did not differ significantly (kh2=1.68, p=0.194). There are some studies that prove the correlation between maternal anemia and a predisposition toward cesarean sections. A population-based study established that anemic mothers had higher odds to have cesarean birth because of certain complications that included hypertension and placental abruption with odds ratio of 1.5 (95% CI: 1.2-1.9) (Beckert et al., 2019). A systematic review also highlighted the increased risk of cesarean delivery in anemic pregnancies, with an overall odds ratio of 1.3 (95% CI: 1.1-1.5) (Adam, Salih, & Hamdan, 2023). Furthermore, research indicates that women undergoing cesarean sections are at a higher risk of postpartum anemia, exacerbated by pre-existing anemia and increased risk of postpartum hemorrhage, with an odds ratio of 2.0 (95% CI: 1.5-2.6) (Butwick, Walsh, Kuzniewicz, Li, & Escobar, 2017). The insignificant result in this study could be due to the relatively small sample size or other medical conditions and variations in clinical practice that were not controlled in the study.

4.2. Characteristics of Newborn from Anemic and Non-Anemic Mothers

The sex distribution of the newborns did not significantly differ between the two groups (χ^2=1.08, p=0.297). Birth weight and birth length, however, were significantly different. Babies born to anemic mothers had a median birth weight of 2655 grams (IQR: 2458.75-2957.50), while those born to non-anemic mothers had a median birth weight of 3102.5 grams (IQR: 2500-3300) (p=0.028*). Similarly, the median birth length was 47 cm (IQR: 45.75-48) for babies of anemic mothers and 48 cm (IQR: 46.36-49) for babies of non-anemic mothers (p=0.027*). These large disparities are indicative of the fact that maternal anemia affects fetal growth in a negative way probably because of the lack of oxygen and nutrients available to the developing child (Arabzadeh et al., 2024). There is evidence to support the

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fact that maternal anemia is linked to increased chances of low birth weight. A population based research revealed that maternal anemia is a risk factor of low birth weight with odds ratio of 1.5 (CI: 1.2-1.9) (Qiao et al., 2024). Another study from Jiangxi Province, China, reported that the risk of low birth weight increases with the severity of maternal anemia (Xiong et al., 2023). Additionally, an umbrella review, which synthesizes findings from multiple systematic reviews and meta-analyses, identified anemia as a significant risk factor for low birth weight (Arabzadeh et al., 2024). There was no significant difference in birth head circumference between the two groups (p=0.277). Several factors could explain the lack of significant differences in other neonatal characteristics, such as relatively small sample size or other uncontrolled confounding factors. Furthermore, all mothers in this research consumed ferrous sulfate during pregnancy, which may have mitigated potential impacts on the newborns. In terms of Lubchenco's curve, the majority of newborns in both groups were appropriate for gestational age. However, the prevalence of small for gestational age was marginally greater in the anemia group compared to the non-anemia group.

4.3. Association of Mother's Hemoglobin Level and Ferritin Levels of Newborn

Our study revealed a significant association between maternal hemoglobin levels and ferritin levels in newborns. Newborns from anemic mothers had a median ferritin level of 187 ng/ml (IQR: 148.64-312.95 ng/ml), whereas those from non-anemic mothers had a higher median ferritin level of 250 ng/ml (IQR: 149.62-212.20 ng/ml). This was a statistically significant difference (p=0.043*). The levels of ferritin in newborns were found to be positively correlated with maternal hemoglobin levels (r s=0.253, p=0.050) which implies that the higher the level of hemoglobin in the mother, the higher the levels of ferritin in the newborns. These results are in line with past studies. A Bangladesh study reported a significant positive correlation to be observed between maternal serum ferritin and cord ferritin levels (r=0.94, p<0.001) (Akhter et al., 2014). A Japanese study with 368 hospitalized newborns revealed maternal hemoglobin levels significantly predicted the level of newborn ferritin with a median serum ferritin level of 149 µg/L (IQR: 81–236). The health care implications among newborns are high. The consequences of iron deficiency in newborns may include cognitive and motor developmental deficiencies, reduced hippocampal development, and neurotransmitter distributions and myelination patterns around the brain. Such deficiencies may be long-lived and they include low IQ, school performance and behavior in adulthood as long-term outcomes of infancy iron deficiency (Bernhardt, Jhancy, Shivappa, Bernhardt, & Pinto, 2021; Christensen et al., 2022). A study in the BMJ has shown that infancy iron deficiency is linked with long-term consequences that include asthma, depressive sleep, impaired motor functions and schizophrenia in adulthood (Insel, Schaefer, McKeague, Susser, & Brown, 2008). Moreover, iron deficiency anemia in infancy is linked with a higher level of susceptibility to infection and the retardation of psychomotor developmental changes (Benson et al., 2022; Wang, 2016). Proper nutrition and supplementation of iron levels among pregnant women is essential to avoid these negative effects and guarantee optimal development of newborns (Benson et al., 2022). Nevertheless, the research has several flaws such as limited sample size and one-hospital environment. These need to be proved by future studies carried out on bigger, more diverse groups.

4.4. Association of Mother's Hemoglobin Level and Neonatal Outcomes

In this research, the median length of stay of newborns by both anemic and non-anemic mothers was 3 days (1-4) and 2 days (1-4.25), respectively. It is necessary to take into account the clinical implications, although the difference was not statistically significant (p=0.976). Past research has revealed that complications of maternal anemia may encompass preterm birth and low birth weight that consumes more time in hospitals by the newborns (Zage, Nas, Ali, & Aliyu, 2024). he non-significance of the difference may however indicate that the level of anemia in the mothers did not have the severity to influence the length of stay significantly. Survival of infants born of the anemic mothers and those born of the non-anemic mothers was 93.3% and 96.7% respectively, but no statistically significant difference existed (p=0.500). This observation is in agreement with certain earlier studies that found out that mild to moderate cases of maternal anemia might not have a significant impact on the neonatal mortality rates. As an example, a review by Zage AU et al. concluded that severe maternal anemia is an important risk factor to reduce the neonatal birth weight, and neonatal mortality, but mild anemia might not have a significant effect on the neonatal outcome (Zage et al., 2024). On the same note, a study by Chen Y et al. indicated that preterm birth, low birth weight and small for gestational age (SGA) were related to maternal anemia in early pregnancy, but the severity of anemia was a determinant of preterm birth (Chen et al., 2024). All these studies presuppose that the severity of maternal anemia is one of the most critical factors that may dictate the results of neonatal outcomes.

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5. CONCLUSION

This study demonstrates that maternal anemia is associated with lower maternal educational attainment and adverse neonatal outcomes. Newborns of anemic mothers exhibited significantly reduced birth weight, length, and cord-blood ferritin levels, reflecting compromised fetal growth and diminished iron stores. These findings underscore the critical need for routine anemia screening and proactive iron supplementation during pregnancy to safeguard neonatal health. Future research should involve larger, multi-center cohorts to validate these associations and assess how varying degrees of maternal anemia influence long-term child development.

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INSTITUTIONAL REVIEW BOARD STATEMENT

The Ethical Committee of the Ulin General Hospital, Indonesia has granted approval for this study on 20 February 2023 (Ref. No. 24/II-Reg Riset/RSUDU/23)). Informed consent was obtained from all participants before data collection. Confidentiality and anonymity of the participants were maintained throughout the study.

TRANSPARENCY

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

COMPETING INTERESTS

The authors declare no competing interests.

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