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Research Paper

The Association of Maternal Hemoglobin Concentration with The Placental Weight and Placental Weight to Fetal Weight Ratio: A Hospital Based Study

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ABSTRACT:

BACKGROUND:

There is disagreement among studies regarding the association between maternal hemoglobin levels and adverse pregnancy outcome. This includes low birth weight, increased placental weight and a high placental to-birth weight ratio.

OBJECTIVE:

The aim of this study was to determine the relationship between the concentration of maternal hemoglobin in 37-42 weeks pregnant women with neonatal birth weight, placental weight, and placental to birth weight ratio.

PATIENTS AND METHODS:

Five hundred pregnant women in labour were enrolled in this cross-sectional study from 1 February 2024 to 30 August 2024 at the labour ward of Maternity Teaching Hospital, Erbil city, Kurdistan region, Iraq. Demographic data were collected, maternal hemoglobin was tested, placenta and baby were weighed separately after birth, and placental weight to birth weight were estimated.

RESULTS:

Fifty-two percent of the study group were anemic, with 1% having moderate anemia and 51% having mild anemia. Anemic women had a mean placental weight of 753.9 ± 94.1 g. Significant differences were found in placental weight and birth weight between anemic and non-anemic groups. The placental-to-birth weight ratio (PWR) was highest in pregnancies with maternal hemoglobin <110 g/L ($p < 0.05$).

CONCLUSION:

Neonatal birth weight decreases with lower maternal hemoglobin levels. Placental weight and the placental-to-birth weight ratio were higher in pregnancies with low maternal hemoglobin compared to those with normal levels.

KEYWORDS: Maternal hemoglobin, Pregnancy, Birth weight, Placental weight.

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INTRODUCTION:

Hemoglobin is essential for transporting oxygen from the lungs to the body's tissues and returning carbon dioxide to the lungs for exhalation. An imbalance in hemoglobin levels can lead to serious health complications. During pregnancy, maintaining normal hemoglobin concentrations ensures sufficient oxygen supply for both the mother and fetus. Abnormal hemoglobin levels—whether high or low—require urgent medical attention. Low levels typically indicate anemia, which can arise from various causes, while elevated levels often develop gradually without obvious symptoms but may result in severe complications, such as blood clots, if untreated. [1].

Anemia is a broad term encompassing various conditions characterized by a fall in red blood cells (RBC) and/or hemoglobin concentration below a set threshold, impairing the body's ability to transport oxygen and carbon dioxide. This significant and highly prevalent blood disorder results from three categories of pathologies: blood loss, increased destruction of RBCs (hemolysis), and decreased production of RBCs [2].

In pregnancy, anemia has a significant impact on the health of the mother and fetus and is associated with increased rates of maternal [3] and perinatal mortality [4], premature delivery [5], as well as considerable adverse outcomes, including low birth weight [6] and small for gestational age [7]. Thus, maintaining normal hemoglobin concentration during pregnancy has often been recommended for a normal course of pregnancy and better outcomes [8].

Although the high prevalence of maternal anemia in Kurdistan region of Iraq and its established correlation with adverse neonatal outcomes, including low birth weight and preterm delivery, are well-documented [9-11], a notable gap remains in elucidating the direct influence of maternal hemoglobin concentration on placental weight and the placental weight-to-fetal weight ratio.

Several key predisposing factors can increase the risk of anemia in pregnant women, impacting both maternal health and fetal development. These factors include inadequate iron intake, vitamin B_{12} and folate deficiency, multiple pregnancies, multiparity, closely consecutive pregnancies, as well as previous history of anemia. Moreover, low socioeconomic status, teenage pregnancy and morning sickness were among the other implicated factors [12].

However, the literature is conflicting regarding the association between anemia and perinatal outcomes. Some studies have identified a significant link between low hemoglobin levels before delivery and various adverse outcomes, including preterm birth, low birth weight, intrauterine growth retardation, small for gestational age, and anemia [3-7]. However, other research has not found any such association [13].

Focused research has targeted the relationship between maternal hemoglobin concentration and placental weight because of its potential effects on fetal development and health outcomes. Logically, normal pregnancy birth weight and placental weight, which reflect placental functioning, are highly correlated, as a well-functioning placenta is essential for favorable fetal maturation by facilitating nutrient acquisition, gas exchange, and the performance of its varied endocrinologic functions [14].

Although placental weight is a good indicator of placental function, placental weight relative to birth weight (PWR) is estimated to be more appropriate than placental weight alone because placental weight is strongly associated with fetal birth weight. A high PWR, resulting from a disproportionately heavy placenta compared to birth weight, is correlated with a higher risk for adverse birth outcomes [15].

Ultimately, recognizing, addressing, and treating maternal anemia early in pregnancy can be crucial for ensuring optimal placental function and fetal growth. To address this, iron supplementation, management of underlying causes of anemia, and monitoring placental size and function throughout pregnancy are standard interventions [16].

AIMS AND OBJECTIVES:

This study aims to evaluate the association of maternal hemoglobin concentration with placental weight and the placental weight-to-fetal birth weight ratio. Furthermore, it seeks to investigate the impact of specific parameters on these correlations.

PATIENTS AND METHODS:

Study design and setting: This cross-sectional study performed from 1st February 2024 to 30th of August 2024 at the labour ward of Maternity Teaching Hospital, Erbil city, Kurdistan region, Iraq.

Sample size: This study included 500 women undergoing vaginal delivery or cesarean section. The sample size was determined based on: (1) the anticipated 50% prevalence of maternal anemia from regional epidemiological data [9-11], and (2) alignment with sample sizes (200-1,000 participants) used in comparable studies of maternal hemoglobin and birth outcomes [17-20]. A convenience sampling approach was adopted due to the hospital-based design of this study, which introduced inherent feasibility, ethical, and logistical constraints regarding time-limited recruitment during delivery admissions.

Inclusion criteria: Eligible participants were pregnant mothers aged 18-40 years old with a single viable fetus at term (37–42 weeks) who accepted to participate in the study.

Exclusion criteria:

- Women with preterm or post term deliveries.
- Multiple gestation.
- Mothers delivering newborns weighing less than 500 grams.
- Retained placenta or morbidly adherent placenta.
- Placenta or cord anomalies like blobbed placenta and placenta with double cord.
- Mothers with a history of diabetes, hypertension, congestive heart disease, pulmonary embolism, chronic obstructive lung disease.
- Mothers with a history of IUGR or Rh incompatibility.
- Mothers not willing to participate in the study.

Ethical considerations:

Ethical approval for the study protocol was taken from Scientific Council of Obstetrics& Gynecology / Iraqi Board for Medical Specializations 2024. The data collection for this study was authenticated by the scientific committee of the Maternity Teaching Hospital in Erbil city. Since the study only involved standard clinical procedures like hemoglobin tests and placental/birth weight measurements, informed verbal consent was deemed sufficient and was obtained from all participants. The confidentiality of their information was strictly maintained.

Data collection procedure:

Data were collected through a structured questionnaire to collect information about the demographic (age, occupation, residency, education, and smoking) and clinical characteristics (gestational age, parity, weight before pregnancy, antenatal care, history of medical disease, drug history as well as blood group of the mother and her husband.)

Furthermore, placental weight, birth weight and newborn outcome were also recorded.

Definitions:

1. **Gestational age:** Determined on the basis of the menstrual history and was confirmed using first trimester ultrasound at 11-14 weeks (9).
2. **Anemia:** Women were classified based on their Hb level into being not anemic (Hb ≥110 g/L) and Anemic (Hb <110 g/L) groups. The severity of anemia was classified as mild anemia (Hb, 100-109 g/L), moderate anemia (Hb, 71-99 g/L) and severe anemia (Hb ≤70 g/L) using the WHO criteria(10).
3. **Birth weight:** According to the WHO (11), Low Birth Weight LBW was defined as birth weight <2500 g, and newborn weighing 4 kg or above was regarded as macrosomic (overweight). Neonates with a birth weight between 2500-4000 g are typically considered to be of normal weight.
4. **Placental weight:** Placentae cleaned by trimming away the membranes and umbilical cord at the placental margin, leaving only the disc-shaped placental tissue. The placental-birth weight ratio (PWR) was calculated as the ratio of placental weight to neonatal weight multiplied by 100 (12).
5. **Anthropometric measurements of the pregnant mothers:** Weight, height, and blood pressure were measured for each participant using standardized techniques by trained personnel.
6. **Blood Tests:** Maternal blood samples were collected during labor, and hemoglobin levels were determined using an automated hematology analyzer.

Statistical analysis:

The collected data were statistically analyzed using SPSS 21.0. The collected quantitative data were summarized in terms of Mean ± Standard Deviation, while qualitative data were presented as number and percentage. Correlation analysis to determine the association between variables was performed, using Pearson correlation coefficient (r). Multivariable linear regression was performed to adjust for potential confounders. Statistical significance in this work was ($p \leq 0.05$).

RESULTS:

1. Study Population and Recruitment

A total of 548 pregnant women met the inclusion criteria for this study. Of these, 48 women (8.8%) declined participation due to severe pain, resulting in a response rate of 91.2% and a final study population of 500 participants. This sample size provided adequate power for detecting significant associations in our primary outcomes.

2. Demographic and Clinical Characteristics

The study population consisted of 500 women aged 18–40 years (mean age: 30.2 ± 6.3 years), stratified into three age groups: <20 years (3.2%, n=16), 20–35 years (72.6%, n=363), and >35 years (24.2%, n=121). The majority of participants were employed (56%, n=280), while 44% (n=220) identified as housewives. Geographically, 61.4% (n=307) resided in urban areas, and 38.6% (n=193) in rural settings. Educational attainment varied, with 34.6% (n=179) holding college degrees, 29% (n=145) completing secondary school, and 6.2% (n=31) being illiterate. Only 1.6% (n=8) reported smoking.

Clinically, antenatal care attendance differed: 24.2% (n=121) had >8 visits, 55% (n=275) had <8 visits, and 20.8% (n=104) received no care. Delivery outcomes included spontaneous vaginal delivery (78.4%, n=392), elective cesarean section (17.8%, n=89), and emergency cesarean (3.8%, n=19). Reproductive history revealed a mean parity of 1.7 ± 0.5, with 8% (n=40) of women reporting a prior stillbirth.

3. Maternal Anemia Prevalence and Correlates

Maternal hemoglobin levels in the study population ranged from 89 to 123 g/L, with a mean of 109 ± 6 g/L. Anemia was prevalent in 52% of participants, predominantly mild (51%), while moderate anemia accounted for only 1%. Significant demographic disparities were observed: housewives had a higher prevalence of anemia compared to employed women (73.2% vs. 35.4%, $p < 0.001$), and rural residents exhibited a greater burden than urban counterparts (78.8% vs. 35.2%, $p < 0.001$). A strong inverse relationship was noted with education level—illiterate women had the highest anemia prevalence (97.5%), whereas college graduates had the lowest (24.8%, $p < 0.001$).

Clinically, all smokers (1.6% of participants) were anemic ($p = 0.005$), and women with fewer than eight antenatal visits had significantly higher anemia rates ($p = 0.012$). No associations were found with maternal age, mode of delivery, or antepartum hemorrhage (APH). These findings highlight socioeconomic and healthcare access disparities as key determinants of anemia in this population.

Table 1 details anemia correlates with demographic factors.

Table 1: Correlation of demographic characteristics with anemia, N=500.

		Anemic		Not Anemic		Total	P Value
		No.	%	No.	%		
Age	<20 years	5	31.3	11	68.8	16	NS
	20-35 years	198	54.5	165	45.5	363	
	>35 years	57	47.1	64	52.9	121	
Occupation	Housewife	161	73.2	59	26.8	220	0.000
	Employed	99	35.4	181	64.6	280	
Residence	urban	108	35.2	199	64.8	307	0.000
	Rural	152	78.8	41	21.2	193	
Education	Illiterate	39	97.5	1	2.5	40	0.000
	Read/write	56	80.0	14	20.0	70	
	Primary school	65	67.7	31	32.3	96	
	Secondary school	62	44.0	79	56.0	141	
	College or above	38	24.8	115	75.2	153	
Smoking	No	252	51.2	240	48.8	492	0.005
	Yes	8	100.0	0	0.0	8	

4. Pregnancy Outcomes by Anemia Status

Anemic women exhibited distinct pregnancy outcomes compared to their non-anemic counterparts. The mean gestational age was significantly longer in the anemic group (39.8 ± 1.62 weeks vs. 38.9 ± 1.53 weeks, $p < 0.05$). Neonates born to anemic mothers had a lower mean birth weight (3278 ± 274 g vs. 3965 ± 261 g, $p < 0.001$). Placental characteristics also differed markedly, with anemic women delivering heavier placentas (742.9 ± 94.2 g vs. 629.5 ± 95.1 g, $p < 0.05$) and demonstrating a higher placental-to-birth weight ratio (PWR: 22.96 ± 4.39 vs. 15.99 ± 2.91, $p < 0.05$). Notably, macrosomia was exclusively observed in neonates of non-anemic mothers, accounting for 15.2% of births in this group. These findings suggest that maternal anemia is associated with altered fetal growth patterns and compensatory placental adaptations.

Table 2 compares pregnancy outcomes by anemia status.

Table 2: Pregnancy outcomes by anemia status, N=500.

		Anemic		Not Anemic		Total	P Value
		No.	%	No.	%		
Placental weight	< -1 SD	21	15.2	117	84.8	138	0.000
	-1 SD to +1 SD	173	60.9	111	39.1	284	
	> +1 SD	66	84.6	12	15.4	78	
Birth weight	Low Birth Weight	5	100.0	0	0.0	5	0.000
	Normal Weight	255	60.9	164	39.1	419	
	Macrosomic	0	0.0	76	100.0	76	
PWR	< -1 SD	1	1.0	98	99.0	99	0.000
	-1 SD to +1 SD	181	56.0	142	44.0	323	
	> +1 SD	78	100.0	0	0.0	78	

5. Correlation and Risk Analysis

A. Pearson correlation: revealed a significant positive association between maternal hemoglobin levels and neonatal birth weight ($r = 0.457$), indicating that higher hemoglobin concentrations were correlated with increased birth weight. Conversely, hemoglobin showed significant negative correlations with both placental weight ($r = -0.482$) and the placental-to-birth weight ratio (PWR, $r = -0.605$), suggesting that lower maternal hemoglobin levels were associated with heavier placentas and a disproportionately higher placental weight relative to fetal weight. These findings highlight the inverse relationship between maternal hemoglobin and placental growth dynamics, potentially reflecting compensatory mechanisms in response to reduced oxygen availability. Table 3 presents correlation coefficients

Table 3: Correlations of maternal hemoglobin with birth weight, placental weight, and placental-to-birth weight ratio (PWR).

Variable Pair	Pearson's Correlation (r*r*)	Interpretation
Hb% vs. Birth Weight	0.457	Moderate correlation
Hb% vs. Placental Weight	-0.482	Moderate negative correlation
Hb% vs. PWR	-0.605	Moderate negative correlation

B. Risk analysis: revealed that moderate anemia was associated with a 56-fold higher likelihood of low birth weight (OR = 56.0, p < 0.001). Additionally, placental weight showed a positive correlation with both parity and gestational age, indicating that higher parity and longer gestation were linked to increased placental weight. These findings highlight the significant impact of maternal anemia and reproductive factors on fetal and placental development (Table 4).

Table 4: Association between maternal anemia severity and low birth weight.

Hb% Status	Low Birth Weight	Normal Birth Weight	Total	Odds ratio (OR)
Moderate Anemia	2	3	5	56.0
Mild Anemia	3	252	255	
Total	5	255	260	

6. Regression Analysis Controlling for Confounders

A. Adjusted Regression Analysis for Birth Weight: each 10 g/L increase in maternal Hb was associated with a 42.1 g increase in birth weight (p<0.001). Parity, rural residence, and fewer ANC visits were independently linked to lower birth weight, while gestational age had the strongest positive effect.

Table 4: Adjusted Regression Analysis for Birth Weight.

Variable	Coefficient (β)	95% CI	p-value
Maternal Hb (per 10 g/L)	42.1	(28.6, 55.6)	<0.001
Gestational age	112.3	(98.7, 125.9)	<0.001
Parity (vs. primiparous):			
Multiparous	-85.2	(-120.3, -50.1)	<0.001
Grand multiparous	-132.6	(-185.4, -79.8)	<0.001
Antenatal care (vs. none):			
<8 visits	62.4	(25.1, 99.7)	0.001
≥8 visits	78.9	(38.2, 119.6)	<0.001
Rural residence	-56.7	(-91.3, -22.1)	0.001

B. Adjusted Regression Analysis for Placental Weight: Lower maternal Hb was associated with higher placental weight (β=−31.8 per 10 g/L Hb, p<0.001), suggesting compensatory placental hypertrophy. Parity and gestational age were also significant predictors (Table 6).

Table 5: Adjusted Regression Analysis for Placental Weight.

Variable	Coefficient (β)	95% CI	p-value
Maternal Hb (per 10 g/L)	-31.8	(-45.2, -18.4)	<0.001
Gestational age	24.5	(10.9, 38.1)	<0.001
Parity (vs. primiparous):			
Multiparous	38.6	(12.7, 64.5)	0.004
Grand multiparous	52.3	(9.8, 94.8)	0.016
Antenatal care (vs. none):			
<8 visits	-15.2	(-43.1, 12.7)	0.286
≥8 visits	-8.7	(-39.6, 22.2)	0.580

C: Adjusted Regression Analysis for PWR: Each 10 g/L decrease in Hb was associated with a 1.2% increase in PWR ($p<0.001$), indicating disproportionate placental growth in anemia. Parity remained a significant confounder (Table 7).

Table 6: Adjusted Regression Analysis for PWR.

Variable	Coefficient (β)	95% CI	p-value
Maternal Hb (per 10 g/L)	-1.2	(-1.6, -0.8)	<0.001
Gestational age	-0.3	(-0.7, 0.1)	0.102
Parity (vs. primiparous):			
Multiparous	0.9	(0.3, 1.5)	0.003
Grand multiparous	1.4	(0.5, 2.3)	0.002
Antenatal care (vs. none):			
<8 visits	-0.5	(-1.2, 0.2)	0.180
≥8 visits	-0.6	(-1.4, 0.2)	0.140

DISCUSSION:

This cross-sectional study revealed that primiparous women (24%) delivered heavier neonates than grand-multiparas regardless of the gestational age and newborn's gender which hypothetically may be due to uterine vascular changes [21], though conflicting data exist [22,23]. Maternal age further modulated parity effects: primiparas ≥35 years had lower BW than younger counterparts, which is linked to age-related complications [24–27]. PW and PWR rose with parity, supported by Norwegian data [28], but contradicted by Chinese studies which provides strong evidence that multiparity is associated with lower risks of all adverse birth outcomes, and eventually, recommended paying special attention for nulliparous mothers during antenatal care in order to reduce the risks of adverse birth outcomes [29]. Mean gestational age (GA) was 39.4 weeks, with BW declining post-40 weeks, that goes in agreement with the finding of Hamilton cohort study which suggested an increased risk of adverse perinatal outcomes with late-term delivery [30]. Yet, inconsistence with our results, the final report of a meta-analysis by Santi concluded that the relationship between maternal anemia and LBW in neonates delivered at term is not significant [31]

Unlike our findings, which show no association between mode of delivery and birth weight, previous studies have reported conflicting or inconsistent results. Elter study pointed to the difference in birthweights between babies born vaginally and those born by cesarean section and found that babies born vaginally were significantly lighter than those born through cesarian section [32]. On the other hand, more recent reports have suggested a lower birth weight for babies delivered by cesarean section than those delivered by vaginal delivery [33].

Mean PW (688.5g) exceeded Western Europe (643g), Nigeria (590g), and Asia (588g) [34,35], possibly due to methodological differences [36]. PWR (19.6%) mirrored Western Europe (20%) but surpassed Asia (19.5%) and Thailand (17.1%) [35], serving as a placental efficiency marker [37]. Elevated PWR indicates placental dysfunction (e.g., from anemia or smoking) [38], while low PWR suggests reduced fetal reserve [28].

Mean maternal Hb (109g/L) matched Erbil (9) and Bangladesh [39] studies. Anemia prevalence (52%, mostly mild [98.1%]) was lower than in

India (88%) but higher than Sri Lanka (39%) [40], with rates fluctuating locally [9,10,11,41]. Hb levels were significantly affected by socio-economic status, smoking, GA, parity, and antenatal care (ANC), echoing Mitsuda's [14] socio-economic status-Hb link and Saapiire's [42] ANC benefits. Parity's impact on Hb in our study supporting previous Iranian study [43] while the negative relationship between gestational age and Hb levels was noted by a U.S cohort study [30], although some studies disputed gravidity's role[10].

The current study provided clear evidence for a significant association between low maternal hemoglobin concentration at term and neonatal birth weight though no consensus has been achieved by previous literatures, with some showing U-shaped Hb-BW relationships [44], while Liu [45], based on a cluster-randomized controlled trial, tied severe anemia to LBW and, Kozuki [46] in a meta-analysis linked moderate to severe, but not mild, maternal anemia to LBW.

Lastly, maternal Hb inversely correlated with Placental Weight, suggesting placental hypertrophy compensates for hypoxia [47], as seen in Larsen's [32] and Lao's [48] works. Though, inconsistence with our conclusion, some studies manifested a correlation for maternal anemia with low placental weight [49].

Study results elicited a moderate negative correlation between maternal hemoglobin concentration with mean PWR, supporting Japan Environment and Children's Study [14], but disputing Norwegian population-based cohort study which did not find a difference in the PWR for women with mild anemia in comparison to women with normal hemoglobin levels [28].

Limitations:

The research suffers from multiple limitations as its cross-sectional design obstructs causal determination. The choice of convenience sampling could introduce selection bias while studying only one hospital restricts the ability to generalize findings. Potential influences on the observed associations between maternal hemoglobin levels and pregnancy outcomes stem from unaccounted confounders such as dietary habits and underlying health conditions.

Authorship and Financial Disclosure Statement

The author certifies that there are no actual or potential conflicts of interest related to this work. No financial, professional, or personal competing interests influenced the research or its outcomes. This study was conducted independently without external funding or institutional support. The author assumes full responsibility for all aspects of the work.

CONCLUSION:

The study concluded that low maternal hemoglobin concentration at term significantly correlates with adverse pregnancy outcomes, including reduced neonatal birth weight. Notably, anemic mothers delivered infants with lower birth weights compared to non-anemic mothers. Furthermore, pregnancies with maternal anemia exhibited increased placental weight and a higher placental-to-birth weight ratio, suggesting compensatory placental adaptation to maternal iron deficiency.

RECOMMENDATIONS:

To optimize pregnancy outcomes, healthcare providers should actively encourage and support pregnant women in attending preconception clinics and regular antenatal visits, with close monitoring of hemoglobin levels to promptly identify and manage anemia, ensuring proper placental function and fetal development. Concurrently, further research is needed to elucidate the complex interplay between maternal hemoglobin levels and pregnancy outcomes, enabling more targeted interventions and improved clinical guidelines.

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