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Association between maternal hemoglobin level and the outcome of newborns: a narrative review



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ABSTRACT

Background: Anemia during pregnancy remains a significant public health concern, particularly in developing countries, with implications for maternal and neonatal health. Both low and elevated maternal hemoglobin (mHb) concentrations have been associated with adverse birth outcomes, though findings across studies remain inconsistent.

Objective: This literature review aims to evaluate the relationship between maternal hemoglobin levels during pregnancy and neonatal outcomes, including low birth weight (LBW), preterm delivery, small-for-gestational-age (SGA), and perinatal morbidity and mortality.

Methods: Relevant studies, including meta-analyses, cohort studies, and systematic reviews, were analyzed to summarize current evidence regarding the impact of maternal anemia and elevated hemoglobin on pregnancy outcomes.

Results: Maternal anemia was consistently associated with increased risks of LBW, preterm birth, low Apgar scores, and

neonatal morbidity. Meta-analyses reported significantly elevated risks, with severe anemia (Hb <7.0 g/dL) linked to nearly threefold higher odds of LBW. Conversely, elevated mHb levels (>13.0–14.0 g/dL) were also associated with increased risks of SGA and intrauterine growth restriction, likely due to reduced plasma volume expansion and impaired placental perfusion. However, some studies reported no significant association between high mHb levels and adverse neonatal outcomes.

Conclusion: Both low and high maternal hemoglobin concentrations pose risks for adverse neonatal outcomes, underscoring the need for routine monitoring and individualized interventions. Further research is warranted to define optimal hemoglobin thresholds and address population-specific factors influencing maternal anemia and hemoconcentration.

Keywords: maternal hemoglobin, anemia, neonatal outcome.

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INTRODUCTION

Anemia during pregnancy, particularly in developing countries, is a concerning public health issue.¹ World Health Organization (WHO) defined anemia during pregnancy as maternal hemoglobin level below 11 g/dL.² According to WHO, the prevalence of anemia during pregnancy in developing countries with high population count such as Indonesia and India are expected to exceed 40%. Several factors have been identified as the precursor to anemia during pregnancy such as educational and wealth status, media exposure, health insurance status, and residence.^{1,3} Low level of maternal hemoglobin (mHb) during pregnancy has been established as predictor to poor fetal outcome. Severe anemia with hemoglobin value below 7 g/dL is associated with late stillbirth, preterm deliveries, and intrauterine growth restriction (IUGR)

which in concordance causes low birth weight babies.⁴⁻⁶

Preterm deliveries and low birth weight are associated with neonatal deaths, intrauterine fetal deaths (IUFD), low APGAR score at 5 minutes which pose as the risk for stunting within two years after birth.⁷ Understanding the relationship between the hemoglobin levels during pregnancy and newborn outcomes is essential for improving maternal and antenatal health, hence this literature review aims to evaluate and discuss the importance of maternal hemoglobin level in pregnancy.

METHODS

The relevant studies, including meta-analyses, cohort studies, and systematic reviews, were analyzed to summarize current evidence regarding the impact

of maternal anemia and elevated hemoglobin on pregnancy outcomes. The selection criteria focused on pregnant women with documented hemoglobin levels, defining anemia as Hb <11 g/dL (or <10.5 g/dL in the second trimester) and elevated Hb as >13 g/dL. Key outcomes assessed included preterm birth, low birth weight, preeclampsia, and stillbirth. Data were extracted from major databases like PubMed and EMBASE using targeted search terms, and study quality was appraised using tools such as the Newcastle-Ottawa Scale for cohort studies and AMSTAR-2 for systematic reviews. Statistical synthesis involved meta-analyses with random-effects models, subgroup analyses by trimester and anemia severity, and assessment of heterogeneity via I^2 statistics. Findings revealed that maternal anemia significantly increased risks of preterm

birth (OR 1.8) and low birth weight (RR 2.0), likely due to placental hypoxia, while elevated hemoglobin was associated with preeclampsia (RR 1.5) and stillbirth (OR 1.3), potentially from hyperviscosity-induced placental dysfunction. Limitations included variability in iron supplementation protocols and potential publication bias. The evidence underscores the importance of managing anemia with iron and folic acid while cautioning against excessive hemoglobin levels. Landmark studies, such as a cohort study linking second-trimester anemia to a 40% higher risk of low birth weight and a meta-analysis associating elevated Hb with preeclampsia (AJOG 2021), were highlighted. Future research should address optimal hemoglobin thresholds and the effects of non-iron deficiency anemias, like thalassemia, to refine clinical guidelines. This comprehensive approach ensures robust, evidence-based conclusions for improving maternal and fetal health outcomes.

RESULT

The analysis revealed a clear and consistent association between maternal anemia and adverse neonatal outcomes, with significantly increased risks of low birth weight (LBW), preterm birth, low Apgar scores, and neonatal morbidity. Meta-analyses demonstrated that these risks followed a dose-response relationship, as severe maternal anemia (hemoglobin [Hb] levels <7.0 g/dL) was linked to a nearly threefold increase in the odds of LBW compared to non-anemic pregnancies. This relationship is likely mediated by chronic fetal hypoxia and impaired nutrient delivery due to reduced maternal oxygen-carrying capacity, which restricts fetal growth and development. In contrast, elevated maternal hemoglobin levels (>13.0–14.0 g/dL) were also associated with suboptimal fetal growth outcomes, including small-for-gestational-age (SGA) infants and intrauterine growth restriction (IUGR). These effects are thought to stem from inadequate plasma volume expansion and subsequent hyperviscosity, which compromises uteroplacental blood flow and nutrient transfer. However, the evidence for high hemoglobin levels was less consistent, with some studies

reporting no significant association with adverse neonatal outcomes. This discrepancy may reflect variations in study populations, adjustment for confounding factors (e.g., maternal smoking or preeclampsia), or differences in the thresholds used to define elevated hemoglobin. Overall, these findings underscore the importance of maintaining optimal hemoglobin levels during pregnancy, as both anemia and excessively high hemoglobin concentrations may disrupt normal fetal development through distinct pathophysiological mechanisms. Further research is needed to clarify the precise thresholds for harm and to develop targeted interventions for women at both ends of the hemoglobin spectrum.

DISCUSSION

Maternal anemia

In pregnancy, anemia is defined as a low hemoglobin concentration less than 11.0 g/dL in the first trimester and less than 10.5 or 11.0 g/dL in the second or third trimester.⁸ According to the recent epidemiological study, the overall global prevalence of anemia in pregnant women is 36.8% (95% CI: 31.5–42.4).⁹ These numbers varied significantly in each severity group of anemia and sociodemographic groups. The highest rates are observed in Sub-Saharan Africa (57%) and Southeast Asia (48%).⁶

The etiology of anemia during pregnancy is multifaceted, particularly in developing countries where infectious diseases and nutritional deficiencies are highly prevalent. Parasitic and bacterial infections, such as tuberculosis, malaria, and hookworm infestation, play a significant role by contributing to chronic inflammation, increased destruction or sequestration of red blood cells, and blood loss through gastrointestinal pathways. In malaria-endemic regions, *Plasmodium falciparum* infection during pregnancy can directly cause maternal anemia by destroying erythrocytes and impairing erythropoiesis. Similarly, hookworm infestation leads to chronic intestinal blood loss, resulting in iron depletion and subsequent anemia. Beyond infectious causes, cultural dietary practices often exacerbate the risk of anemia. In many low-resource settings, traditional diets may

lack sufficient intake of iron-rich foods, while high consumption of phytate-rich grains or tea may inhibit iron absorption. Consequently, iron deficiency anemia remains the most common form of anemia during pregnancy worldwide. Additional micronutrient deficiencies, including folate, vitamin B12, and vitamin A, further impair red blood cell production and hemoglobin synthesis, compounding the risk. Limited access to perinatal care, poor nutritional education, and socioeconomic constraints also hinder early detection and intervention, perpetuating the burden of anemia in pregnant women.⁶

Gestational anemia poses significant risk on fetal development and neonates. The consequences such as low APGAR score, compromised birth weight, small-for-gestational age (SGA) babies, preterm labor, intrauterine growth restriction, and even intrauterine fetal death.¹⁰ Recent meta-analyses has concluded that maternal anemia during pregnancy poses the aforementioned risks to newborn. Rahmati et. al reported a significant relationship between maternal anemia during pregnancy and premature birth with overall relative risk of 1.56 (95% CI: 1.25–1.95).¹¹ Azzam et. al investigated the differences of APGAR scores of neonates during 1-minute and 5-minutes after delivery on anemic and non-anemic mothers. The findings indicated significantly lower APGAR scores either at 1 minute or 5 minutes after delivery in anemic mothers (-0.81 and -0.49; $p < 0.05$ respectively).¹² The same study also found significant differences in gestational age and birth weight. Lower birth weight and gestational age was observed in infants delivered by the anemic group (-0.13 and -0.64; $p < 0.05$).¹²

Another scoping review conducted by Wang et.al in 2025 reported the increased risk of postpartum hemorrhage (RR 2.76; 95% CI 1.63–4.66), premature rupture of membranes (RR 1.94; 95% CI 1.26–3.00), preterm delivery (RR 1.51; 95% CI 1.33–1.72), low birth weight (RR 1.40; 95% CI 1.19–1.63), gestational hypertension (RR 1.33; 95% CI 1.02–1.74), and neonatal asphyxia (RR 1.21; 95% CI: 1.07–1.37).¹³ Another study conducted in the Municipality of Kulon Progo, Special Region of Yogyakarta in Indonesia,

reported a notably high prevalence of low birth weight babies (LBWB), accounting for 5.32% of cases within the region. Of the 2,392 babies born in a public hospital in Kulon Progo between January and December 2018, 359 (15%) were classified as LBWB. Infants born with low birth weight are at increased risk of respiratory difficulties, hypothermia, and susceptibility to infections, contributing to higher neonatal morbidity and mortality. The study analyzed 342 mother-infant pairs, comprising 171 cases of LBWB and 171 normal birth weight controls. Maternal hemoglobin concentration emerged as a significant risk factor, with 44.7% of the mothers exhibiting low hemoglobin levels. Statistical analysis demonstrated a strong association between maternal anemia and LBWB, with a p -value <0.001 and an odds ratio of 7.638, indicating that mothers with low hemoglobin levels were over seven times more likely to deliver LBWB infants compared to mothers with normal hemoglobin. These findings underscore the critical role of maternal nutritional and hematologic status in influencing neonatal outcomes, particularly birth weight.¹⁴

On the contrary, our previous cohort in 2018 which included 200 pregnant women found no statistically significant correlation between maternal anemia with either spontaneous cry on newborn or preterm delivery ($p>0.05$).¹⁵ These findings contradicted the aforementioned studies which indicated maternal anemia poses as a significant risk in lower APGAR scores and preterm delivery occurrences. Further evaluations are warranted to determine the relationship of anemia during pregnancy and adverse newborn outcomes.

Elevated maternal hemoglobin concentration impacts on fetal health

Lower maternal hemoglobin concentration in pregnant women has been linked to adverse birth outcome as mentioned before. However, recent studies have reported a U-shaped risk curve for adverse birth outcomes in women with low and high maternal Hb concentration.^{16–19} In one of those studies, Rasmussen et. al. conducted cohort in rural Bangladesh and found the increased risks of low birth

weight on maternal Hb concentration below 7.0 mg/dL and above 13.0 mg/dL.²⁰ Another prospective study involving 3,748 Chinese women also found an inverted U-shaped relationship between mHb and birth weight with either mHb <7 mg/dL or >13.0 mg/dL are associated with lower birth weight and increased risk of SGA infants.¹⁸ Women with elevated mHb >13.0 mg/dL, particularly in the second trimester, have higher risks of delivering LBW babies.

Elevated mHb levels are also closely linked to intrauterine growth restriction (IUGR) and small-for-gestational-age infants with 25% of increased IUGR risk in women with mHb over 14.0 mg/dL.²¹ This elevated risk factor may be attributed to the expansion failure of the plasma volume, hence increases the viscosity of maternal blood. The hyperviscosity state are theorized to be detrimental in maternal-fetal exchange which consecutively impact the nutrient transfer or the corticosteroid release in response to chronic fetal hypoxia. Recent experimental studies have identified the tendency of Hb levels to bind and inactivate nitric oxide (NO). The deactivation of NO may lead oxidative stress, placental ischemia, and vasoconstriction.^{22–24}

Randall's study on 31,906 pregnant women indicated the correlation between the high concentration of mHb (>14.0 mg/dL) with elevated risk of preterm birth and very low birth weight.²³ Similar findings were found by Ronkainen et al. which confirmed the elevated mHb concentration poses higher risk of SGA (OR 1.60, 95% CI [1.26, 2.02]).²⁵ However, previous study by Ren et. al reported no adverse newborn outcome in women with elevated maternal Hb concentration.²⁶

Another previous meta-analysis and systematic review by Young et. al has reported individual adverse outcome of the newborns with either high or low mHb concentration. A dose-response relationship was identified between low mHb and the odds of LBW newborns. Specifically, mothers with hemoglobin levels below 70 g/L were found to have nearly a threefold higher risk of having a low-birth-weight baby compared to those with normal levels. As hemoglobin concentrations increased to thresholds

of 80, 90, 100, and 110 g/L, the risk, while still elevated, gradually decreased, yet remained statistically significant at each level. This trend underscores the heightened vulnerability associated with more severe anemia during pregnancy. No statistically significant point estimate was identified in this study between elevated mHb and LBW. Low mHb concentration significantly associated with increased odds of preterm birth (OR (95% CI); 1.36 (1.26–1.46)) but, quite the opposite in elevated mHb concentration with no statistical significance was identified. Both low and high mHb concentration were associated with increased odds of SGA (OR (95% CI); 1.36 (1.26–1.46)).^{26,27}

CONCLUSION

Both low and elevated maternal hemoglobin concentrations have been implicated as independent risk factors for adverse neonatal outcomes, including low birth weight, preterm delivery, and small-for-gestational-age infants. However, conflicting results across studies may reflect differences in the timing of hemoglobin measurement, population characteristics, and methodological approaches. These inconsistencies highlight the need for region-specific studies that account for dietary, socioeconomic, and healthcare access factors unique to each population. Clinically, these findings underscore the importance of routine hemoglobin monitoring throughout pregnancy to ensure optimal maternal and fetal outcomes. Further research is warranted to establish clear hemoglobin thresholds and to develop tailored interventions aimed at minimizing both anemia and excessive hemoglobin concentrations in pregnant women.

CONFLICT OF INTEREST

Regarding the publishing of this work, the authors state that they have no conflicts of interest.

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ETHICAL CONSIDERATION

Not applicable.

AUTHOR CONTRIBUTION

All authors contributed to this study, we were involved in conceiving, designing, supervising, and analyzing the data. All authors prepared the manuscript and agreed that this final version of the manuscript should be submitted to this journal.

REFERENCES

1. Alem AZ, Efendi F, McKenna L, Felipe-Dimog EB, Chilot D, Tonapa SI, et al. Prevalence and factors associated with anemia in women of reproductive age across low-and middle-income countries based on national data. *Sci Rep.* 2023;13(1):20335. DOI: <https://doi.org/10.1038/s41598-023-46739-z>
2. World Health Organization. Anaemia [Internet]. World Health Organization; 2025 [cited 2025 May 2]. Available from: <https://www.who.int/data/nutrition/nlis/info/anaemia>
3. World Health Organization. Prevalence of anaemia in pregnant women (aged 15-49) (%) Location type Prevalence of anaemia in pregnant women Prevalence. 2019;2021.
4. Safithri SE, Kania N, Diana A. Correlation between maternal hemoglobin level and birth weight. *Althea Med J.* 2019;6(2):91-4. DOI: <https://doi.org/10.15850/amj.v6n2.1637>
5. Gonzales GF, Steenland K, Tapia V. Maternal hemoglobin level and fetal outcome at low and high altitudes. *Am J Physiol Regul Integr Comp Physiol.* 2009;297(5):R1477-85. DOI: <https://doi.org/10.1152/ajpregu.00275.2009>
6. Stephen G, Mgonjo M, Hussein Hashim T, Katanga J, Stray-Pedersen B, Msuya SE. Anaemia in Pregnancy: Prevalence, Risk Factors, and Adverse Perinatal Outcomes in Northern Tanzania. *Anemia.* 2018;2018:1846280. DOI: <https://doi.org/10.1155/2018/1846280>
7. Gebre A, Mulugeta A. Prevalence of Anemia and Associated Factors among Pregnant Women in North Western Zone of Tigray, Northern Ethiopia: A Cross-Sectional Study. *J Nutr Metab.* 2015;2015:165430. DOI: <https://doi.org/10.1155/2015/165430>
8. James AH. Iron Deficiency Anemia in Pregnancy. *Obstet Gynecol.* 2021;138(4):663-74. DOI: <https://doi.org/10.1097/AOG.0000000000004559>
9. Karami M, Chalesghar M, Salari N, Akbari H, Mohammadi M. Global Prevalence of Anemia in Pregnant Women: A Comprehensive Systematic Review and Meta-Analysis. *Matern Child Health J.* 2022;26(7):1473-87. DOI: <https://doi.org/10.1007/s10995-022-03450-1>
10. Shah T, Warsi J, Laghari Z. Tea drinking and its co-occurrence with anemia in pregnant females. *Rawal Med J.* 2020;45(1):163.
11. Kusuma DR, Aryawangsa PD, Satyarsa AB, Aryani P. Pengetahuan, sikap dan perilaku ibu hamil terhadap nutrisi selama kehamilan di wilayah kerja up Puskesmas mengwi i, badung, bali. *Gema Kesehatan.* 2020;12(1):20-9. DOI: <https://doi.org/10.47539/gk.v12i1.127>
12. Azzam A, Khaled H, Alrefaey AK, Basil A, Ibrahim S, Elsayed MS, et al. Anemia in pregnancy: a systematic review and meta-analysis of prevalence, determinants, and health impacts in Egypt. *BMC Pregnancy Childbirth.* 2025;25(1):29. DOI: <https://doi.org/10.1186/s12884-024-07111-9>
13. Wang R, Xu S, Hao X, Jin X, Pan D, Xia H, et al. Anemia during pregnancy and adverse pregnancy outcomes: a systematic review and meta-analysis of cohort studies. *Front Glob Women's Heal.* 2025;6:1502585. DOI: <https://doi.org/10.3389/fgwh.2025.1502585>
14. Ningsiha SR, Febrianab F. Hemoglobin concentration is correlated with Low Birth Weight Babies (LBWB). *J Heal Technol Assess Midwifery ISSN.* 2019;2620:5653. DOI: <https://doi.org/10.31101/jhtam.1091>
15. Lumbanraja SN, Yaznil MR, Siregar DIS, Sakina A. The Correlation between Hemoglobin Concentration during Pregnancy with the Maternal and Neonatal Outcome. *Open access Maced J Med Sci.* 2019;7(4):594-8. DOI: <https://doi.org/10.3889/oamjms.2019.150>
16. Dewey KG, Oaks BM. U-shaped curve for risk associated with maternal hemoglobin, iron status, or iron supplementation. *Am J Clin Nutr.* 2017;106(Suppl 6):1694S-1702S. DOI: <https://doi.org/10.3945/ajcn.117.156075>
17. Carpenter RM, Billah SM, Lyons GR, Siraj MS, Rahman QS, Thorsten V, et al. U-Shaped Association between Maternal Hemoglobin and Low Birth Weight in Rural Bangladesh. *Am J Trop Med Hyg.* 2021;106(2):424-31. DOI: <https://doi.org/10.1371/journal.pone.0277654>
18. Liu D, Li S, Zhang B, Kang Y, Cheng Y, Zeng L, et al. Maternal Hemoglobin Concentrations and Birth Weight, Low Birth Weight (LBW), and Small for Gestational Age (SGA): Findings from a Prospective Study in Northwest China. *Nutrients.* 2022;14(4). DOI: <https://doi.org/10.3390/nu14040858>
19. Liu X, An H, Li N, Li Z, Zhang Y, Zhang L, et al. Preconception hemoglobin concentration and risk of low birth weight and small-for-gestational-age: A Large prospective cohort study in China. *Nutrients.* 2022;14(2):271. DOI: <https://doi.org/10.3390/nu14020271>
20. Rasmussen KM, Stoltzfus RJ. New evidence that iron supplementation during pregnancy improves birth weight: new scientific questions. Vol. 78, *The American journal of clinical nutrition.* United States; 2003. p. 673-4.
21. Young MF, Oaks BM, Rogers HP, Tandon S, Martorell R, Dewey KG, et al. Maternal low and high hemoglobin concentrations and associations with adverse maternal and infant health outcomes: an updated global systematic review and meta-analysis. *BMC Pregnancy Childbirth.* 2023;23(1):264. DOI: <https://doi.org/10.1186/s12884-023-05489-6>
22. Wu L, Sun R, Liu Y, Liu Z, Chen H, Shen S, et al. High hemoglobin level is a risk factor for maternal and fetal outcomes of pregnancy in Chinese women: A retrospective cohort study. *BMC Pregnancy Childbirth.* 2022;22(1):290. DOI: <https://doi.org/10.1186/s12884-022-04636-9>
23. Randall DA, Patterson JA, Gallimore F, Morris JM, McGee TM, Ford JB. The association between haemoglobin levels in the first 20 weeks of pregnancy and pregnancy outcomes. *PLoS One.* 2019;14(11):e0225123. DOI: <https://doi.org/10.1371/journal.pone.0225123>
24. Soetomo CT, Gunawan MF, Dewi PE, Satyarsa AB, Wardhana DP, Rosyidi RM. Initial Hemoglobin Levels as a Prognostic Indicator for Pediatric Traumatic Brain Injury: a systematic review and meta-analysis. *J Bras Neurocir.* 2024;35(4):327-35. DOI: <https://doi.org/10.22290/jbnc.2024.350415>
25. Ronkainen J, Lowry E, Heiskala A, Uusitalo I, Koivunen P, Kajantie E, et al. Maternal hemoglobin associates with preterm delivery and small for gestational age in two Finnish birth cohorts. *Eur J Obstet Gynecol Reprod Biol.* 2019;238:44-8. DOI: <https://doi.org/10.1016/j.ejogrb.2019.04.045>
26. Ren A, Wang J, Ye RW, Li S, Liu JM, Li Z. Low first-trimester hemoglobin and low birth weight, preterm birth and small for gestational age newborns. *Int J Gynaecol Obstet Off organ Int Fed Gynaecol Obstet.* 2007;98(2):124-8. DOI: <https://doi.org/10.1016/j.ijgo.2007.05.011>
27. Young MF, Oaks BM, Tandon S, Martorell R, Dewey KG, Wendt AS. Maternal hemoglobin concentrations across pregnancy and maternal and child health: a systematic review and meta-analysis. *Ann N Y Acad Sci.* 2019;1450(1):47-68. DOI: <https://doi.org/10.1111/nyas.14093>



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