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Prevalence of anemia and comparison of perinatal outcomes among anemic and nonanemic mothers

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Abstract:

BACKGROUND: The prevalence of anemia is a significant public health challenge. Approximately half of all pregnant women in India experience anemia during pregnancy. This study aims to determine the prevalence of anemia and perinatal outcomes among anemic and nonanemic pregnant mothers.

MATERIALS AND METHODS: The quantitative research approach was adopted using a descriptive comparative design. The study was conducted in the Obstetrics and Gynecology and Pediatric departments of a tertiary care hospital. Hemoglobin (Hb) was recorded using antenatal records of pregnant mothers in their III trimester. Based on their Hb level, subjects were divided into two groups, anemic and nonanemic as per World Health Organization criteria. The subjects were followed up until the first week after birth.

RESULTS: The prevalence of anemia was 48% [N = 410]; 70.6% had mild, 13.7% had moderate, and 15.7% had severe. The anemic group had a significantly higher incidence of low birthweight (30.9% vs 10.3%, $P = 0.001$) and preterm births (24.2% vs 3.2%, $P = 0.001$) compared to the nonanemic group. Additionally, there were significant differences in various quantitative perinatal parameters such as weight ($P = 0.001$), length ($P = 0.001$), head circumference ($P = 0.001$), chest circumference ($P = 0.034$), APGAR score at one minute ($P = 0.022$), and APGAR score at five minutes ($P = 0.001$) between the anemic and nonanemic.

CONCLUSION: The maternal anemia is associated with increased risk of unfavorable perinatal outcomes. Identifying and managing anemia among pregnant women is critical to minimize adverse outcomes. Adequate antenatal care can play a significant role in preventing avoidable complications associated with anemia during the third trimester.

Keywords:

Anemia, pregnant mothers, perinatal outcomes

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Introduction

The prevalence of anemia is a significant public health challenge. Maternal anemia affects 25-50% of the global population, which is estimated to be around half of all pregnant women.[1] During pregnancy, a natural decrease in hemoglobin (Hb) levels occurs due to increased plasma volume. The estimated prevalence of anemia in pregnancy was 52.7% for Indian women and 51.7% for women in Punjab.[2]

Evidence indicates that anemia is associated with mortality of mothers and infants and has other negative consequences among both.[3] One of the most common health problems during pregnancy is anemia. The prevalence and etiology of anemia during pregnancy vary by geographical region.[4] Maternal anemia related to pregnancy increases the risk of adverse outcomes for both the mother and the fetus.[5] The consequences of anemia during pregnancy include inadequate weight gain, problems during delivery, premature birth, maternal mortality and morbidity.[6]

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The maternal anemia is associated with low birth weight (LBW), preterm (PT) delivery, and neurobehavioral and cognitive deficiencies in newborns, including impaired recognition memory, motor deficits, and lower global developmental scores.[7] Additionally, it is associated with premature birth, small birthweight, intrauterine deaths (IUD), poor APGAR scores at five minutes, and intrauterine growth restriction (IUGR) in developing countries.[8-10] The extent to which maternal hemoglobin (Hb) levels affect baby weight and fetal outcomes remains unclear. A significant association was reported between low Hb levels in pregnancy and negative outcomes.[11]

Despite the underlying cause, pregnancy anemia is closely linked to maternal and neonatal fatalities.[12,13] Thus, this research is aimed to examine the prevalence of anemia among pregnant women and it is crucial to compare the perinatal outcomes of anemic and nonanemic mothers. It not only raises much awareness about the widespread issue of maternal anemia but also highlights the potential negative impact on both mothers and their newborns. By emphasizing early detection and timely intervention, this research can contribute to better health outcomes for both mother and child and inform public health strategies and policies to reduce maternal and neonatal complications. In the end, this aligns with the overarching goals of worldwide maternal and child health improvement.

Materials and Methods

Study design and setting

The quantitative research approach was adopted using a descriptive comparative design. The study was conducted in the Obstetrics and Gynecology and Pediatric departments of a tertiary care hospital in Amritsar, Punjab.

Study participants and sampling

The sample size was calculated based on pilot study; the prevalence of anemia was reported among pregnant mothers = 36%, permissible error = 5% and assumed drop rate = 15%.

$$n = \frac{\left(Z_{1-\alpha/2}\right)^2 (p)(q)}{d^2}$$

The sample size was determined to be 410. The study subjects were selected using the nonprobability purposive sampling technique. The researcher enrolled 410 pregnant women in their third trimester (28 weeks). Based on their Hb level, pregnant women were divided into two groups; 197 subjects were anemic (Hb <11gm/dl) and 213 subjects were non-anemic women (Hb ≥11gm/dl) [Figure 1]. According to WHO criteria, anemia was further classified as mild, moderate, and severe.

Data collection tool and technique

The proforma was developed to collect maternal demographics, obstetrical, clinical information and perinatal outcomes. The informed written consent was obtained. Data were collected using interview methods, clinical records, and biophysical methods. The mothers were followed up till first week after birth. The attrition rate was 10.98% within the first week following birth. Therefore, a final analysis was performed among 365 pregnant women (180 Group I and 185 Group II).

Statistical analysis

The data were analyzed using SPSS version 26 for Windows (IBM Corp., Armonk, NY). The normality of data was checked using the Kolmogorov–Smirnov and Shapiro–Wilk tests. Descriptive statistics were used for further analysis, including frequency, percentage, mean, standard deviation, and median. For inferential statistics, the Chi-square and Fisher's exact tests were applied for categorical data, while the Mann–Whitney test was used for quantitative perinatal parameters.

Ethical consideration

The institutional ethics committee approval was obtained prior to the study initiation [letter No. 52/2020, date: 07/02/2020]. Subsequently, permission was sought from the Director Principal and Medical Superintendent of the SGRD hospital, Sri Amritsar, India.

Results

Out of 410 pregnant mothers, the prevalence of anemia was 48% [Table 1]; 70.6% of mothers had mild, 13.7% had moderate, and 15.7% had severe anemia [Table 2]. The median age of the anemic and nonanemic groups was 28 (6) and 28 (5). In the both groups, the median age of marriage was 21 (3) [Table 3].The majority of the women in both groups were multigravida, and the distribution of parity and gravida was similar. Both groups had a similar percentage of women with

Table 1: Prevalence of anemia among pregnant mothers in III trimester (28 weeks) (*n*=410)

Anemia Status	*n* (%)	Mean±SD	Median (IQR)
Anemic (Hb <11 gm/dl)	197 (48.0)	9.36±1.46	10 (2.70)
Nonanemic (Hb ≥11 gm/dl)	213 (52.0)	11.93±0.69	11.80 (1.00)

Table 2: Level of anemia in III trimesters (28 weeks) (*n*=197)

Level of Anemia	*n* (%)	Mean±SD	Median (IQR)
Mild	139 (70.6)	10.27±0.40	10.30 (0.60)
Moderate	27 (13.7)	7.58±0.36	7.70 (0.80)
Severe	31 (15.7)	6.86±0.07	6.90 (0.10)

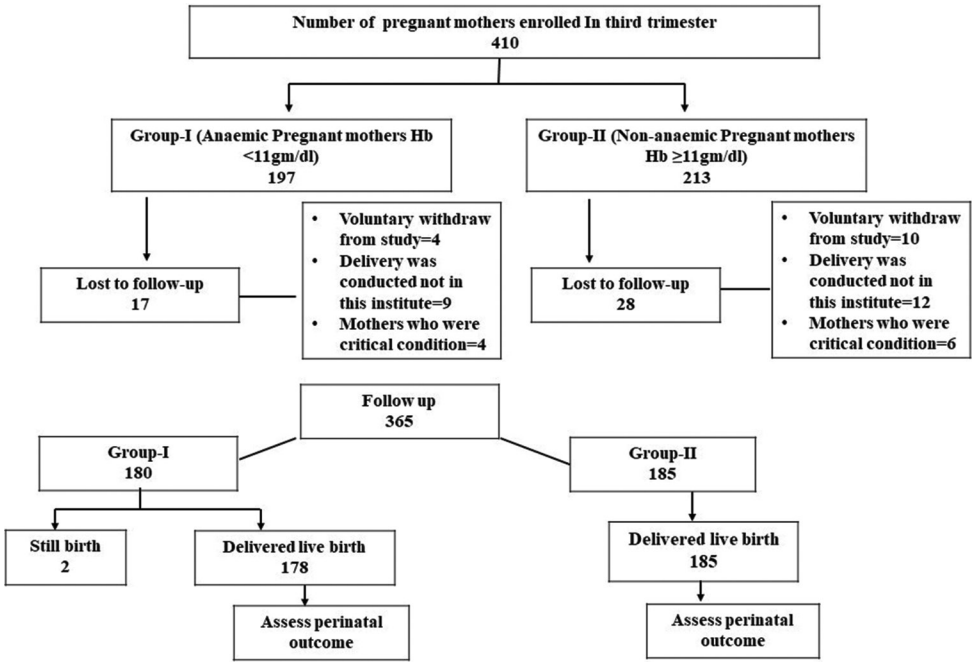

Figure 1: Flowchart of the study

Table 3: Socio-demographic profile of anemic and nonanemic pregnant mothers (*n*=410)

Variables	Anemic mothers (*n*=197) *n* (%)	Nonanemic mothers (*n*=213) *n* (%)
Age (years)		
≤25	56 (28.4)	52 (24.4)
26-30	88 (44.7)	101 (47.4)
31-35	44 (22.3)	42 (19.7)
≥35	9 (4.6)	18 (8.5)
Median (IQR)	28 (6)	28 (5)
Marriage age (years)		
<21	59 (29.9)	68 (31.9)
21-25	128 (65.0)	133 (62.4)
26-30	10 (5.1)	12 (5.6)
Median (IQR)	21 (3)	21 (3)
Habitat		
Rural	144 (73.1)	157 (73.7)
Urban	53 (26.9)	56 (26.3)
Educational status of mother		
No formal education	15 (7.6)	12 (5.6)
up to 10th	93 (47.2)	81 (38.0)
12th	26 (13.2)	52 (24.4)
Graduation and above	63 (32.0)	68 (31.9)
Dietary habit		
Vegetarian	159 (80.7)	116 (54.5)
Nonvegetarian	38 (19.3)	97 (45.5)

history of abortion. However, Group II had a higher percentage of women with fewer than four antenatal visits. Group II also had a higher percentage of women who consumed iron–folic acid tablets, while Group I had a higher percentage of women with a history of parasite infestation [Table 4].

In the anemic group, 74.7% of mothers had hypothyroidism, 8.4% had tuberculosis, 7.2% had other disorders, 4.8% had cardiac diseases, and 4.8% had diabetes mellitus. On the other hand, in the nonanemic group, 25% of mothers had hypothyroidism, 25% had cardiac diseases, 25% had other disorders, 15% had diabetes mellitus, and 10% had tuberculosis. There was a significant difference (P = 0.001) in disease conditions in anemic and nonanemic pregnant mothers [Table 5].

In the anemic group, 28% had pregnancy-induced hypertension, 28% had other complications, 24% had gestational diabetes mellitus, and 20% had placental abnormality. Whereas in the nonanemic group, 57.6% of mothers had gestational diabetes mellitus, 27.3% had pregnancy-induced hypertension, 10.6% had other complications and only 4.5% had placental abnormality. The antenatal complications are statistically significant (P = 0.004) between groups I and II [Table 6].

In a study examining perinatal outcomes, low birthweight (LBW) and preterm births were significantly more prevalent in anemic mothers compared to nonanemic mothers (30.9% vs 10.3%, P = 0.001; 24.2% vs 3.2%, P = 0.001). Jaundice was more common in the nonanemic group (31.4% vs 6.2%, P = 0.001). Neonates born to anemic mothers had a higher NICU admission rate (44.4% vs 27.6%, P = 0.001) and increased incidence of respiratory distress syndrome (66.7% vs 30.8%, P = 0.001). CPAP use was significantly higher in newborns among nonanemic mothers (51.9% vs 45.7%, P = 0.014). Surfactant use, sepsis incidence, and congenital anomaly rates were not significantly different between groups (P = 0.087,

Table 4: Obstetrical and clinical profile of group I and group II pregnant mothers (*n*=365)

Variables	Group I (*n*=180) *n* (%)	Group II (*n*=185) *n* (%)
Parity		
Primigravida	75 (41.7)	79 (42.7)
Multigravida	105 (58.3)	106 (57.3)
Gravida		
One	75 (41.7)	79 (42.7)
Two	51 (28.3)	71 (38.4)
Three and above	54 (30.0)	35 (18.9)
Live (*n*=177)		
One	59 (64.1)	75 (88.2)
Two	29 (31.5)	8 (9.4)
Three	4 (4.3)	2 (2.4)
Birth interval (*n*=177)		
≤24 months	31 (33.7)	36 (42.4)
>24 months	61 (66.3)	49 (57.6)
Abortion		
Yes	40 (22.2)	43 (23.2)
No	140 (77.8)	142 (76.8)
Antenatal visit		
<4	73 (40.6)	122 (65.9)
≥4	107 (59.4)	63 (34.1)
IFA Tablet		
Yes	127 (70.6)	164 (88.6)
No	53 (29.4)	21 (11.4)
Parasite infestation		
Yes	8 (4.4)	5 (2.7)
No	172 (95.6)	180 (97.3)
HIV status		
Yes	3 (1.7)	1 (0.5)
No	177 (98.3)	184 (99.5)
Hepatitis C virus		
Yes	7 (3.9)	3 (1.6)
No	173 (96.1)	182 (98.4)
Smoking habit		
No	180 (100.0)	180 (100.0)
Alcohol consumes		
No	180 (100.0)	180 (100.0)

IFA=Iron Folic Acid

Table 5: Disease conditions among group I and group II mothers (*n*=365)

Disease condition	Group I (*n*=180) *n* (%)	Group II (*n*=185) *n* (%)	$\chi 2$	*P*
Hypothyroidism	62 9 (74.7)	10 (25)	31.115	0.001**,†
TB	7 (8.4)	4 (10)		
Cardiac disease	4 (4.8)	10 (25)		
DM	4 (4.8)	6 (15)		
Others	6 (7.2)	10 (25)		

**Significant at 0.01 level, †=Fisher exact test TB=tuberculosis, DM=diabetes mellitus

P = 0.565, and *P* = 0.734, respectively). However, asphyxia rates were significantly higher in newborns among anemic mothers (29.2% vs 18.4%, *P* = 0.015). Hence, anemic mothers are at higher risk of adverse perinatal outcomes [Table 7].

As a result revealed that weight (*P* = 0.001), length (*P* = 0.001), head circumference (*P* = 0.001), chest circumference (*P* = 0.034), APGAR score in one minute (*P* = 0.022), APGAR score in five minutes (*P* = 0.001) had significant difference between group I and group II perinatal outcomes [Table 8].

Discussion

The prevalence of anemia in this study was 48% among pregnant women, which is consistent with the findings of several other studies, including Anwar R *et al*.,[14] H.K. Cheema *et al*.,[15] and Haider BA *et al*.,[16] which reported rates ranging from 46% to 69.9%. However, Stephen G *et al*.[17] reported a lower prevalence of 18%. In contrast, Bansal R *et al*.,[18] Osborn *et al*.,[19] Kumari *et al*.,[6] and Locks *et al*.[20] found higher rates ranging from 64.5% to 79%.

The current study found that 13.7% had moderate and 15.7% had severe anemia. These results are supported by the findings of H.K. Cheema *et al*.[15] who reported 60% mild, 30.4% moderate, and 9.6% severe anemia. In contrast, Stephen G *et al*.[17] found that 18% of participants had mild anemia and 2% had severe anemia. The current study also reported an average Hb level of 9.36 ± 1.46 gm/dL, while Mahmood T *et al*.[21] reported a lower Hb level of 7.2 ± 1.3 gm/dL.

The current study found that anemia significantly impacted perinatal outcomes, with 16.9% of newborns having LBW, 24.2% being born prematurely, and a mean APGAR score rank of 171.76 at one minute and 133.63 at five minutes. Previous studies have also reported an association between anemia and LBW and PT birth.[22-24] Anwar R *et al*.[14] reported that LBW was present in 36.2% of anemic cases and 14.6% of nonanemic cases, while Stephen G *et al*.[17] found lower rates of 3.02% for LBW and 3.37% for premature birth.

Maternal anemia has been consistently associated with negative perinatal outcomes, including LBW, PT birth, and low APGAR scores. This association has been demonstrated in studies by Anwar R. *et al*.,[14] Bizuneh Ayano BA,[25] Heydarpour F *et al*.,[26] and Kumari S *et al*.[6] Furthermore, Sehgal R. *et al*.[27] have also demonstrated this association. Other studies have also found a relationship between maternal anemia and LBW and PT delivery and an increased risk of adverse neonatal outcomes, such as low APGAR scores, in developing countries.[5,28-30]

The current study indicated maternal anemia was significantly associated with adverse perinatal outcomes, such as low Hb levels in newborns, stillbirth, and asphyxia. The study also found a higher NICU admission rate in newborns from anemic mothers. These findings

are consistent with earlier studies that have linked anemia with negative newborn outcomes, including stillbirth, infant mortality, asphyxia, and NICU admission.[31-34]

Strength

Firstly, it took a prospective and comparative approach to data collection, which involved multiple clinical and obstetrical variables collected at various time points throughout pregnancy, from the third trimester to one week after birth. This approach allowed for a thorough description of the study population and perinatal outcomes. Additionally, the study's lack of time, language, or outcome restrictions enabled a comprehensive assessment of perinatal outcomes attributed to maternal anemia and the ability to draw reasonable conclusions. The comprehensive data analysis included appropriate statistical tests, such as tests for normality, which allowed for accurate estimates. Overall, these strengths enhance the credibility of the study's findings.

Limitations

Despite the consistency of results that may generate hypotheses for further investigation. One significant limitation is the inability to determine the causality of observed relationships due to the study design. Additionally, this research was performed at a single tertiary hospital, which may not be representative of the entire country, and therefore, the generalizability of the findings may be limited. Finally, the small number of women who were lost to follow-up between enrolment and delivery did not give birth in the study setting. This may have had an impact on the incidence of birth outcomes and further limited the generalizability of the findings.

Conclusion

The maternal anemia exacerbates unfavorable perinatal outcomes. It is crucial to identify at-risk women and ensure they get treatment promptly. Proper antenatal care will minimize avoidable poor outcomes, such as anemia in the third trimester. The statement highlights the significance of addressing maternal anemia as it directly impacts the well-being of both the mother and the developing fetus. Identifying women who are

Table 6: Antenatal complications among group I and group II mothers (*n*=365)

Antenatal complications	Group I (*n*=180) *n* (%)	Group II (*n*=185) *n* (%)	χ^2	*P*
GDM	6 (24)	38 (57.6)	12.723	0.004**,†
PIH	7 (28)	18 (27.3)		
Placental abnormality	5 (20)	3 (4.5)		
Others	7 (28)	7 (10.6)		

**=Significant at 0.01 level, †=Fisher exact test, GDM=Gestational diabetes mellitus, PIH=Pregnancy-induced hypertension

Table 7: Perinatal outcomes among group I and group II mothers

Outcomes Parameters	Group I		Group II		χ^2	*P*
	Yes *n* (%)	No *n* (%)	Yes *n* (%)	No *n* (%)		
LBW (*n*=363)	55 (30.9)	123 (69.1)	19 (10.3)	166 (89.7)	23.785	0.001**
Preterm (*n*=363)	43 (24.2)	135 (75.8)	6 (3.2)	179 (96.8)	33.982	0.001**
Jaundice (*n*=363)	11 (6.2)	167 (93.8)	58 (31.4)	127 (68.6)	37.33	0.001**
NICU Admission (*n*=363)	79 (44.4)	99 (55.6)	51 (27.6)	134 (72.4)	11.15	0.001**
RDS (*n*=133)	54 (66.7)	27 (33.3)	16 (30.8)	36 (69.2)	16.36	0.001**
CPAP/ventilator (*n*=133)	59 (72.8)	22 (27.2)	27 (51.9)	25 (48.1)	6.06	0.014*
Surfactant (*n*=133)	37 (45.7)	44 (54.3)	16 (30.8)	36 (69.2)	2.93	0.087^{NS}
Sepsis (*n*=363)	42 (23.6)	136 (76.4)	39 (21.1)	146 (78.9)	0.33	0.565^{NS}
Asphyxia (*n*=363)	52 (29.2)	126 (70.8)	34 (18.4)	151 (81.6)	5.89	0.015*
Congenital anomalies (*n*=363)	8 (4.5)	170 (95.5)	7 (3.8)	178 (96.2)	0.12	0.734^{NS}

NS=Non-significant, *=Significant at 0.05 level, **=Significant at 0.01 level, NICU=Neonatal intensive care unit, RDS=Respiratory distress syndrome, CAPA=Continue positive pressure support

Table 8: Perinatal outcomes among group I and group II mothers (*n*=363)

Perinatal outcomes	Group I (*n*=178)		Group II (*n*=185)		*U*	*Z*	*P*
	Median (IQR)	Mean ranks	Median (IQR)	Mean ranks			
Weight (gm)	2550 (807)	121.03	2750 (550)	243.30	5495	11.184	0.001**
Length (cm)	46 (3)	144.40	48 (3)	220.56	9702	6.974	0.001**
HC (cm)	35 (1)	194.14	35 (1)	172.16	14645	2.126	0.034*
CC (cm)	31.50 (2)	136.62	32 (1)	228.12	8302	8.443	0.001**
APGAR score (1 min)	8 (1)	168.33	8 (0)	197.27	14010	3.186	0.001**
APGAR score (5 min)	9 (2)	171.76	9 (1)	193.93	14627	2.292	0.022*
Hb (gm/dl)	18.60 (5.80)	133.63	20 (3.10)	231.04	7762	8.846	0.001*

*Significant level at 0.05. **=Significant level at 0.01, HC=Head circumference, CC=Chest circumference, Hb=Hemoglobin, APGAR=Appearance, Pulse, Grimace, Activity, and Respiration

susceptible to anemia allows healthcare professionals to intervene early and administer appropriate treatments. This proactive approach aims to prevent the escalation of anemia, which can lead to complications during pregnancy, and perinatal outcomes.

Moreover, emphasizing the importance of proper antenatal care underscores the role of regular check-ups, screenings, and interventions throughout pregnancy. Such care provides an opportunity to closely monitor the mother's health, detect anemia or other potential complications, and take necessary actions promptly. These measures can significantly reduce the occurrence of avoidable negative outcomes, thereby enhancing the overall health and well-being of pregnant women and their infants.

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Conflicts of interest

There are no conflicts of interest.

References

1. Ahankari A, Leonardi-Bee J. Maternal hemoglobin and birth weight: Systematic review and meta-analysis. Int J Med Sci Public Health. 2015 Apr 1;4:435-5.
2. National Family Health Survey - 5.India Fact Sheet 2019-21. Available from: http://rchiips.org/nfhs/factsheet_NFHS-5.shtml. [Last accessed on 2023 May 03].
3. Daru J, Zamora J, Fernández-Félix BM, Vogel J, Oladapo OT, Morisaki N, *et al*. Risk of maternal mortality in women with severe anaemia during pregnancy and post partum: A multilevel analysis. Lancet Global Health 2018;6:e548-54.
4. Bakacak M, Avci F, Ercan O, Köstü B, Serin S, Kiran G, *et al*. The effect of maternal hemoglobin concentration on fetal birth weight according to trimesters. J Maternal Fetal Neonatal Med 2015;28:2106-10.
5. Smith C, Teng F, Branch E, Chu S, Joseph KS. Maternal and perinatal morbidity and mortality associated with anemia in pregnancy. Obstet Gynecol 2019;134:1234-44.
6. Kumari S, Garg N, Kumar A, Guru PK, Ansari S, Anwar S, *et al*. Maternal and severe anaemia in delivering women is associated with risk of preterm and low birth weight: A cross sectional study from Jharkhand, India. One Health 2019;8:100098. doi: 10.1016/j.onehlt.2019.100098.
7. German KR, Juul SE. Iron and neurodevelopment in preterm infants: A narrative review. Nutrients 2021;13:3737. doi: 10.3390/nu13113737.
8. Symington EA, Baumgartner J, Malan L, Wise AJ, Ricci C, Zandberg L, *et al*. Maternal iron-deficiency is associated with premature birth and higher birth weight despite routine antenatal iron supplementation in an urban South African setting: The NuPED prospective study. PloS One 2019;14:e0221299. doi: 10.1371/journal.pone. 0221299.
9. Savaliya K, Sharma N, Surani R, Dhakar V, Gupta A, Savaliya KA. Multigravida women with moderate to severe anaemia in third trimester: Fetomaternal outcomes. Cureus 2021;13. doi: 10.7759/cureus. 20493.
10. Rahmati S, Azami M, Badfar G, Parizad N, Sayehmiri K. The relationship between maternal anemia during pregnancy with preterm birth: A systematic review and meta-analysis. J Maternal Fetal Neonatal Med 2020;33:2679-89.
11. Jung J, Rahman MM, Rahman MS, Swe KT, Islam MR, Rahman MO, *et al*. Effects of hemoglobin levels during pregnancy on adverse maternal and infant outcomes: A systematic review and meta-analysis. Ann N Y Acad Sci 2019;1450:69-82.
12. Parks S, Hoffman MK, Goudar SS, Patel A, Saleem S, Ali SA, *et al*. Maternal anaemia and maternal, fetal, and neonatal outcomes in a prospective cohort study in India and Pakistan. BJOG 2019;126:737-43.
13. 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.
14. Anwar R, Razzaq K, Noor N. Impact of maternal anemia on perinatal outcome. Pak Armed Forces Med J 2019;69:397-402.
15. Cheema HK, Bajwa BS, Kaur K, Joshi H. Prevalence and possible risk factors of anaemia in different trimesters of pregnancy. IJCMR 2016;3:1194-7.
16. Haider BA, Olofin I, Wang M, Spiegelman D, Ezzati M, Fawzi WW. Anaemia, prenatal iron use, and risk of adverse pregnancy outcomes: Systematic review and meta-analysis. BMJ 2013;346:f3443. doi: 10.1136/bmj.f3443.
17. Stephen G, Mgongo 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: 10.1155/2018/1846280.
18. Bansal R, Bedi M, Kaur J, Kaur K, Shergill HK, Khaira HK, Suri V. Prevalence and factors associated with anemia among pregnant women attending antenatal clinic. Adesh Univ J Med Sci Res2020;2:42-8.
19. Osborn AJ, Muhammad GM, Ravishankar SL, Mathew AC. Prevalence and correlates of anemia among women in the reproductive age (15–49 years) in a rural area of Tamil Nadu: An exploratory study. J Educ Health Promot 2021;10:1-7. doi: 10.4103/jehp.jehp_1526_20.
20. Locks LM, Patel A, Katz E, Simmons E, Hibberd P. Seasonal trends and maternal characteristics as predictors of maternal undernutrition and low birthweight in Eastern Maharashtra, India. Matern Child Nutr 2021;17:e13087. doi: 10.1111/mcn. 13087.
21. Mahmood T, Rehman AU, Tserenpil G, Siddiqui F, Ahmed M, Siraj F, *et al*. The association between iron-deficiency anemia and adverse pregnancy outcomes: A retrospective report from Pakistan. Cureus 2019;11. doi: 10.7759/cureus. 5854.
22. Jwa SC, Fujiwara T, Yamanobe Y, Kozuka K, Sago H. Changes in maternal hemoglobin during pregnancy and birth outcomes. BMC Pregnancy Childbirth 2015;15:1-10. doi: 10.1186/s12884-015-0516-1.
23. Menon KC, Ferguson EL, Thomson CD, Gray AR, Zodpey S, Saraf A, *et al*. Effects of anemia at different stages of gestation on infant outcomes. Nutrition 2016;32:61-5.
24. Aziz Ali S, Abbasi Z, Feroz A, Hambidge KM, Krebs NF, Westcott JE, *et al*. Factors associated with anemia among women of the reproductive age group in Thatta district: Study protocol. Reprod Health 2019;16:1-9. doi: 10.1186/s12978-019-0688-7.

25. Bizuneh Ayano BA. Assessment of prevalence and risk factors for anemia among pregnant mothers attending ANC clinic at Adama Hospital Medical College, Adama, Ethiopia. Am J Gynecol Obstet 2017;6:31-9.
26. Heydarpour F, Soltani M, Najafi F, Tabatabaee HR, Etemad K, Hajipour M, *et al*. Maternal anemia in various trimesters and related pregnancy outcomes: Results from a large cohort study in Iran. Iran J Pediatr 2019;29. doi: 10.5812/ijp.69741.
27. Sehgal R, Kriplani A, Vanamail P, Maiti L, Kandpal S, Kumar N. Assessment and comparison of pregnancy outcome among anaemic and non anaemic primigravida mothers. Indian J Public Health 2016;60:188. doi: 10.4103/0019-557x.189011.
28. Rahman MA, Khan MN, Rahman MM. Maternal anaemia and risk of adverse obstetric and neonatal outcomes in South Asian countries: A systematic review and meta-analysis. Public Health Pract 2020;1:100021. doi: 10.1016/j.puhip. 2020.100021.
29. Kabir MA, Rahman MM, Khan MN. Maternal anemia and risk of adverse maternal health and birth outcomes in Bangladesh: A nationwide population-based survey. Plos One 2022;17:e0277654. doi: 10.1371/journal.pone.0277654.
30. Majella MG, Sarveswaran G, Krishnamoorthy Y, Sivaranjini K, Arikrishnan K, Kumar SG. A longitudinal study on high risk pregnancy and its outcome among antenatal women attending rural primary health centre in Puducherry, South India. J Educ Health Promot 2019;8.1-8. doi: 10.4103/jehp.jehp_144_18.
31. Berhe AK, Ilesanmi AO, Aimakhu CO, Mulugeta A. Effect of pregnancy induced hypertension on adverse perinatal outcomes in Tigray regional state, Ethiopia: A prospective cohort study. BMC Pregnancy Childbirth 2020;20:1-1. doi: 10.1186/s12884-019-2708-6.
32. Shi H, Chen L, Wang Y, Sun M, Guo Y, Ma S, *et al*. Severity of anemia during pregnancy and adverse maternal and fetal outcomes. JAMA Network Open 2022;5:e2147046. doi: 10.1001/jamanetworkopen.2021.47046.
33. Baravkar PN, Baravkar TP. Study of fetomaternal outcome in pregnant women with severe anemia at a tertiary hospital. Eur J Mol Clin Med 2022;9:604-9.
34. Raisanen S, Kancherla V, Gissler M, Kramer MR, Heinonen S. Adverse perinatal outcomes associated with moderate or severe maternal anaemia based on parity in Finland during 2006–10. Paediatr Perinat Epidemiol 2014;28:372-80.