Section: Community Medicine

Original Research Article

ASSOCIATION OF MATERNAL HAEMOGLOBIN CONCENTRATION AND GESTATIONAL WEIGHT PARAMETERS WITH NEONATAL LENGTH AMONG ANAEMIC MOTHERS: A CROSS-SECTIONAL STUDY FROM NORTH KARNATAKA

Shiv Kumar[1], Roopakala N[2], Raghavendra D[3], Tewe U Kapfo[4]

[1]Assistant Professor, Department of Community Medicine, Navodaya Medical College Hospital & Research Centre, Navodaya Nagar, Raichur, Karnataka, India.
[2]Associate Professor, Department of Community Medicine, Navodaya Medical College Hospital & Research Centre, Navodaya Nagar, Raichur, Karnataka, India.
[3]Assistant Professor, Department of Community Medicine, Sri Chamundeshwari Medical College, Hospital & Research Institute, Channapatna, Bengaluru South, Karnataka, India.
[4]Assistant Professor, Department of Community Medicine, Nagaland Institute of Medical Sciences & Research, Phrieba, Kohima, Nagaland, India.

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Corresponding Author:
Dr. Raghavendra D,
Assistant Professor, Department of Community Medicine, Sri Chamundeshwari Medical College, Hospital & Research Institute, Channapatna, Bengaluru South, Karnataka, India.
Email: raghavendra060690@gmail.com

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ABSTRACT

Background: Maternal anaemia is a major public health problem that adversely affects fetal growth. While its association with low birth weight is well established, evidence linking trimester-specific maternal haemoglobin, maternal weight, and gestational weight gain with neonatal length remains limited, particularly in India. This study therefore assessed the association of maternal haemoglobin concentration, maternal weight parameters, and gestational weight gain with neonatal length among anaemic mothers to identify determinants of fetal linear growth and inform antenatal nutritional interventions.

Materials and Methods: A hospital-based cross-sectional study was conducted over one year at KIMS, Hubballi, among 360 anaemic antenatal women selected by consecutive sampling. Maternal haemoglobin levels, trimester-specific weight, gestational weight gain, and neonatal anthropometry were recorded using standardized methods. Data were analysed using IBM SPSS Statistics version 25, with Pearson's correlation assessing associations between maternal haemoglobin, weight parameters, gestational weight gain, and neonatal length; $p < 0.05$ was considered statistically significant.

Results: Among 360 anaemic antenatal women, mean maternal haemoglobin declined from 10.09 ± 0.99 g/dL in the first trimester to 9.53 ± 1.20 g/dL in the third trimester, while 98.9% of newborns had a birth length ≥45.7 cm. Maternal haemoglobin showed significant positive correlations with neonatal length in the second ($r = 0.155$, $p = 0.003$) and third trimesters ($r = 0.162$, $p = 0.002$), but not in the first. Maternal weight ($r = 0.308–0.347$; $p < 0.001$) and gestational weight gain ($r = 0.174$, $p = 0.001$) were also significantly associated with greater neonatal length.

Conclusion: Maternal haemoglobin concentration during the second and third trimesters, maternal weight throughout pregnancy, and gestational weight gain were all significantly and positively associated with neonatal length, indicating that improved maternal nutritional and haematological status contributes to better neonatal growth.

Keywords: Iron-Deficiency Anemia, Maternal Nutritional Status, Weight Gain, Neonatal Length, Fetal Growth.

INTRODUCTION

Maternal anaemia remains one of the most common nutritional disorders affecting pregnant women worldwide and continues to be a major public health concern, particularly in low- and middle-income countries.[1,2] Iron deficiency accounts for most cases of maternal anaemia and adversely affects maternal health, placental function, and fetal growth.[1-3] While low birth weight has traditionally been considered the principal adverse neonatal outcome, impaired linear growth at birth, reflected by reduced neonatal length, has emerged as an important indicator of intrauterine growth and fetal nutritional status.[4-6] Neonatal length is a sensitive marker of skeletal growth and has been associated with subsequent childhood growth, neurodevelopment, and long-term metabolic health.[5,7]

Adequate maternal haemoglobin concentration throughout pregnancy is essential for optimal oxygen delivery and nutrient transport to the developing fetus.[1,2] Maternal anaemia, particularly during the second and third trimesters, has been associated with impaired fetal skeletal growth, leading to reduced neonatal length and other anthropometric measures at birth.[3,8] In addition, maternal nutritional status, including maternal weight during pregnancy and gestational weight gain, plays a crucial role in fetal linear growth by ensuring adequate nutrient availability during critical stages of development.[9-11] However, the relative contributions of trimester-specific maternal haemoglobin levels, maternal weight at different stages of pregnancy, and gestational weight gain to neonatal length remain inconsistently reported.[10,12]

Although numerous studies have investigated the association between maternal anaemia and birth weight, comparatively few have evaluated neonatal length as the primary outcome among anaemic mothers.[3,8] Evidence regarding the relationship of trimester-specific maternal haemoglobin concentrations, maternal weight parameters, and gestational weight gain with neonatal length remains limited, particularly in the Indian population, and data from North Karnataka are scarce despite the high prevalence of maternal anaemia in the region.[1,2]

A better understanding of these maternal factors may facilitate the early identification of pregnancies at risk for impaired fetal growth and support targeted antenatal nutritional interventions. Therefore, the present study was undertaken to assess the association between maternal haemoglobin concentration during pregnancy and neonatal length among anaemic mothers, and to evaluate the correlations of trimester-specific maternal haemoglobin concentrations, maternal weight during pregnancy, and gestational weight gain with neonatal length.

MATERIALS AND METHODS

This hospital-based cross-sectional study was conducted over a period of one year in the Department of Community Medicine in coordination with Obstetrics and Gynaecology, Karnataka Institute of Medical Sciences (KIMS), Hubballi, after obtaining approval from the Institutional Ethics Committee. The study aimed to evaluate the association between maternal haemoglobin concentration during pregnancy and neonatal length among anaemic antenatal women. Based on the reported prevalence of maternal anaemia of 64.7% from a previous study by Kumar KJ et al,[12] the minimum required sample size was calculated to be 351 using the single population proportion formula with 5% absolute precision. The sample size was rounded off to 360, and eligible participants were enrolled consecutively by convenient sampling.

Anaemic antenatal women admitted for delivery, irrespective of gestational age, were included in the study after obtaining informed consent. Women with diabetes mellitus, pregnancy-induced hypertension, TORCH infections, renal or cardiac disorders, haemoglobinopathies, multiple gestation, HIV, hepatitis B surface antigen positivity, syphilis, thyroid disorders, malaria, urinary tract infection, helminthic infestations, addictions, or incomplete antenatal records were excluded to minimise potential confounding factors.

A pre-tested semi-structured questionnaire was used to obtain information regarding socio-demographic characteristics, obstetric history, antenatal care, and previous medical history. Clinical examination included assessment of general physical and systemic findings. Maternal haemoglobin concentrations during the first, second, and third trimesters were obtained from antenatal records, while haemoglobin at admission was estimated using Sahli's acid haematin method. Information regarding maternal weight during pregnancy, gestational weight gain, iron and folic acid supplementation, intravenous iron sucrose therapy, blood transfusion, and other antenatal interventions was also documented. Neonatal details including birth length, birth weight, gestational age at delivery, sex, and Apgar score were recorded immediately after delivery using standard hospital protocols. Maternal anaemia was classified according to the severity recorded during each trimester, while neonatal length was measured in centimetres using standard anthropometric techniques immediately after birth.

The collected data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 25. Continuous variables were expressed as mean with standard deviation, while categorical variables were presented as frequencies and percentages. Pearson's correlation coefficient was used to determine the relationship between

trimester-specific maternal haemoglobin concentrations, maternal weight parameters, gestational weight gain, and neonatal length. A two-sided p-value of less than 0.05 was considered statistically significant after satisfying the assumptions of the respective statistical tests.

RESULTS

Most participants were aged 20–24 years (60.8%), followed by 25–29 years (30.6%). Nearly three-fifths resided in rural areas (59.4%), and 77.2% were literate. Regarding socioeconomic status, the largest proportion belonged to the lower middle class (36.4%), followed by the middle class (33.9%). Only 3.3% belonged to the upper socioeconomic class. [Table 1]

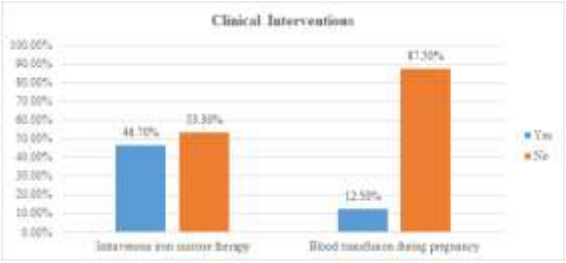

Figure 1: Clinical interventions administered during the study period (N = 360)

Table 1: Sociodemographic characteristics of the study participants (N = 360)

Characteristic	Category / Statistic	n (%) / Mean ± SD
Maternal age (years)	15–19	12 (3.3)
	20–24	219 (60.8)
	25–29	110 (30.6)
	≥30	19 (5.3)
Residence	Rural	214 (59.4)
	Urban	146 (40.6)
Educational status	Illiterate	82 (22.8)
	Literate	278 (77.2)
Socioeconomic status*	Upper	12 (3.3)
	Upper middle	74 (20.6)
	Middle	122 (33.9)
	Lower middle	131 (36.4)
	Lower	21 (5.8)

Socioeconomic status classified according to the Modified B.G. Prasad classification.

First-order births were most common (41.1%), followed by second-order births (39.2%). A birth interval of ≥2 years was reported in 43.1% of participants, while 40.3% were primigravidae. Most women delivered at term (92.8%). Intravenous iron sucrose therapy was administered to 46.7% of participants, whereas 12.5% underwent blood transfusion during pregnancy. [Table 2, Figure 1]

Table 2: Obstetric characteristics of the study participants (N = 360)

Characteristic	Category / Statistic	n (%) / Mean ± SD
Birth order	1	148 (41.1)
	2	141 (39.2)
	3	52 (14.4)
	>3	19 (5.3)
Birth interval	<2 years	60 (16.7)
	≥2 years	155 (43.1)
	Primigravida	145 (40.3)
Gestational age at delivery	Preterm	26 (7.2)
	Term	334 (92.8)

Table 3: Maternal haemoglobin concentrations and neonatal birth length among the study participants (N = 360)

Characteristic	Category / Statistic	n (%) / Mean ± SD
Maternal haemoglobin (g/dL)	First trimester	10.09 ± 0.99
	Second trimester	9.56 ± 0.99
	Third trimester	9.53 ± 1.20
Neonatal birth length (cm)	<45.7	4 (1.1)
	≥45.7	356 (98.9)

The mean maternal haemoglobin concentration declined from 10.09 ± 0.99 g/dL in the first trimester to 9.56 ± 0.99 g/dL in the second trimester and 9.53 ± 1.20 g/dL in the third trimester. Nearly all newborns had a birth length of ≥45.7 cm (98.9%), while only 1.1% had a birth length below 45.7 cm. [Table 3]

Table 4: Correlation between trimester-specific maternal haemoglobin concentrations and neonatal length (N = 360)

Maternal haemoglobin concentration	Correlation coefficient (r)	p-value#
First trimester	0.059	0.264
Second trimester	0.155	0.003*
Third trimester	0.162	0.002*

 # Pearson's correlation analysis; * Statistically significant (p < 0.05)

Among the 360 anaemic antenatal women, maternal haemoglobin concentration demonstrated a progressively stronger positive correlation with neonatal length as pregnancy advanced. No significant correlation was observed between first-trimester haemoglobin concentration and neonatal length (r = 0.059, p = 0.264). In contrast, significant positive correlations were observed during the second trimester (r = 0.155, p = 0.003) and third trimester (r = 0.162, p = 0.002), indicating that higher maternal haemoglobin concentrations during mid- and late pregnancy were associated with greater neonatal length. [Table 4]

Table 5: Correlation between maternal weight parameters during pregnancy and neonatal length (N = 360)

Maternal weight parameter	Correlation coefficient (r)	p-value#
First trimester maternal weight	0.308	<0.001*
Second trimester maternal weight	0.308	<0.001*
Third trimester maternal weight	0.347	<0.001*
Gestational weight gain	0.174	0.001*

 # Pearson's correlation analysis; * Statistically significant (p < 0.05)

Maternal weight parameters demonstrated significant positive correlations with neonatal length. The strength of the correlation increased progressively across pregnancy, with first-trimester weight showing a moderate positive correlation (r = 0.308, p < 0.001), followed by second-trimester weight (r = 0.308, p < 0.001) and the strongest correlation for third-trimester weight (r = 0.347, p < 0.001). Gestational weight gain also showed a significant, though comparatively weaker, positive correlation with neonatal length (r = 0.174, p = 0.001), suggesting that greater maternal weight and adequate gestational weight gain were associated with increased neonatal length. [Table 5]

DISCUSSION

Maternal anaemia remains a major public health concern and may adversely affect fetal growth; however, evidence linking trimester-specific haemoglobin levels and gestational weight parameters with neonatal length is limited. Therefore, a one-year hospital-based cross-sectional study was conducted at KIMS, Hubballi, after ethics approval. Based on an anaemia prevalence of 64.7%, 360 anaemic antenatal women admitted for delivery were consecutively enrolled after informed consent. Women with major medical disorders, multiple gestation, infections, haemoglobinopathies, addictions, or incomplete records were excluded. Data were collected using a pre-tested questionnaire, antenatal records, and clinical examination, including trimester-wise haemoglobin, maternal weight, gestational weight gain, antenatal interventions, and neonatal anthropometry.

In the present study, 60.8% of anaemic women were aged 20–24 years, 30.6% were 25–29 years, 3.3% were teenagers, and 5.3% were aged ≥30 years. Apoorva MS et al,[13] (2018), Saini S et al,[14] (2016), and Sumana M et al,[15] (2016) reported higher LBW among teenage or older mothers, whereas Dayanithi M et al,[16] (2018) found no significant age-related difference (32.6% vs. 31.0%; p=0.371). Rural participants comprised 59.4%; Nair M et al,[17] (2016) reported 85.3–90.5% rural residence, while Apoorva MS et al,[13] (2018) found no significant residence association (p>0.05). Literacy was 77.2%; lower education was associated with LBW in Apoorva MS et al,[13] (33.7% vs. 18.5%) and Sumana M et al,[15] (29.1% vs. 10%). Most participants belonged to lower-middle (36.4%) or middle class (33.9%); Apoorva MS et al,[13] Dayanithi M et al,[16] Sumana M et al,[15] Saini S et al,[14] and Nair M et al,[17] consistently linked socioeconomic disadvantage with adverse fetal growth.

In the present study, first-order births constituted 41.1%, second-order 39.2%, third-order 14.4%, and birth order >3 accounted for 5.3%; 40.3% were primigravidae. Dayanithi M et al,[16] (2018) reported 41.4% primigravidae, with higher LBW (35.4% vs. 28.5%) and prematurity (33.9% vs. 18.2%; p=0.004) among primiparous women. Nair M et al,[17] (2016) found that 90.5% of severely anaemic women were multiparous, while Sumana M et al,[15] (2016) reported non-significantly higher LBW among parity ≥2 (18% vs. 14%; p>0.05). Birth spacing ≥2 years occurred in 43.1%, whereas 16.7% had <2 years; Apoorva MS et al,[13] (2018) and Sumana M et al,[15] (2016) linked short spacing with higher LBW, though Dayanithi M et al.16 (2018) found no association (p=0.574). Term delivery occurred in 92.8%; preterm delivery was 7.2%, lower than Apoorva MS et al,[13] (32.8%) and Dayanithi M et al,[16] (25.6%).

Mean maternal haemoglobin progressively declined in the present study from 10.09 ± 0.99 g/dL in the first trimester to 9.56 ± 0.99 g/dL in the second trimester and 9.53 ± 1.20 g/dL in the third trimester. Kumar KJ et al,[12] (2013) observed a physiological mid-trimester decline among non-anaemic women, with mean haemoglobin decreasing from 12.23 g/dL in the first trimester to 11.78 g/dL in the second trimester before increasing to 12.10 g/dL in the third trimester. In contrast, their anaemic group demonstrated progressive improvement from 9.38 g/dL in the first trimester to 9.81 g/dL in the second and 10.13 g/dL in the third trimester, attributed to antenatal iron supplementation and clinical management. Therefore, although haemodilution

may produce a physiological mid-pregnancy decline, haemoglobin trends among anaemic women depend substantially on the timing, dose, and adherence to iron therapy.

The present study demonstrated no significant correlation between first-trimester maternal haemoglobin and neonatal length (r=0.059, p=0.264), whereas significant positive correlations were observed during the second (r=0.155, p=0.003) and third trimesters (r=0.162, p=0.002). Kumar KJ et al,[12] (2013) similarly found that only third-trimester anaemia significantly increased LBW by 6.5% (p=0.001), with no significant effect in the first (p=1.0) or second trimester (p=0.23). Apoorva MS et al,[13] (2018) reported higher LBW among mothers with haemoglobin <11 g/dL than ≥11 g/dL (34.3% vs. 18%; p<0.01). Sumana M et al,[15] (2016) observed a significant association (p<0.001), while Nair M et al,[17] (2016) reported severe anaemia (<7 g/dL) increased the odds of LBW (aOR=6.19) and SGA (aOR=8.72). These findings emphasize the importance of maintaining adequate maternal haemoglobin during late pregnancy for optimal fetal growth.

Maternal weight showed significant positive correlations with neonatal length in the first (r=0.308, p<0.001), second (r=0.308, p<0.001), and third trimesters (r=0.347, p<0.001), while gestational weight gain was also positively associated (r=0.174, p=0.001). Dayanithi M et al,[16] (2018) reported significantly higher LBW among mothers weighing ≤40 kg than >40.1 kg (45.5% vs. 29.4%; p=0.035). Apoorva MS et al,[13] (2018) observed LBW in 70% of mothers with height <140 cm versus 23.7% among those ≥140 cm (p<0.01). Sumana M et al,[15] (2016) similarly found a significant association (p<0.001), whereas Dayanithi M et al,[16] (2018) reported no significant association between maternal weight and birth weight (38.5% vs. 30.8%; p=0.821). Overall, adequate maternal weight and gestational weight gain are important determinants of optimal fetal growth and neonatal length.

Strengths and limitations

The study's strengths include a relatively large sample size (360 anaemic mothers), trimester-specific assessment of maternal haemoglobin, comprehensive evaluation of maternal weight parameters and gestational weight gain, and standardized neonatal anthropometric measurements after excluding major confounding maternal conditions, enhancing internal validity. However, its cross-sectional, single-centre design, consecutive sampling, and inclusion of only anaemic mothers limit causal inference and the generalizability of the findings to the broader obstetric population.

CONCLUSION

Among 360 anaemic antenatal women, maternal haemoglobin concentration demonstrated an increasingly positive association with neonatal length as pregnancy progressed, with significant correlations observed during the second and third trimesters but not in the first trimester. Maternal weight throughout pregnancy and gestational weight gain also showed significant positive correlations with neonatal length, with the strongest association observed for third-trimester maternal weight. These findings indicate that maintaining adequate maternal haemoglobin levels during mid- and late pregnancy, along with optimal maternal weight and gestational weight gain, is associated with improved neonatal length.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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