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ORIGINAL RESEARCH

Association Between Maternal Predictors and Neonatal Anthropometric Measurements

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ABSTRACT

Background: Maternal anthropometric factors - such as body mass index (BMI), weight, height, and mid-upper arm circumference (MUAC) - play a critical role in predicting neonatal health outcomes, particularly birth weight, length, and head circumference

Objectives: this study investigated the relationship between maternal anthropometric and sociodemographic factors and neonatal birth outcomes—specifically birth weight, length, and head circumference—among 50 women delivering at two hospitals in Sulaymaniyah, Iraq.

Methodology: Data collection involved direct maternal measurements, neonatal assessments immediately after birth, and a structured questionnaire capturing background variables. Key maternal predictors included gestational age, gravidity, weight, height, body mass index (BMI), weight gain, and hemoglobin concentration, as well as residence, educational level, and occupational status. Multiple linear regression analyses were employed to assess the simultaneous effects of all maternal predictors on each neonatal outcome. Additionally, Pearson product-moment correlation coefficients were calculated to evaluate bivariate associations between maternal and neonatal variables. Categorical predictors were numerically coded or dummy-encoded prior to inclusion in statistical models. Statistical significance was determined at a threshold of $p < 0.05$.

Results: showed that gestational age was the only statistically significant predictor of neonatal weight ($p = 0.0266$), while no other maternal or sociodemographic factor showed significant associations in the regression models for weight, length, or head circumference. Gravidity demonstrated a significant positive correlation with head circumference ($r = 0.311$, $p = 0.028$), and urban residence was significantly and negatively correlated with neonatal length ($r = –0.330$, $p = 0.019$). No significant associations were found for maternal BMI, weight gain, or hemoglobin concentration with any of the three neonatal measurements.

Conclusion: These findings suggest that gestational age remains a key determinant of neonatal birth weight, while gravidity and residential context may play modest roles in shaping head circumference and length, respectively. The lack of significant effects for BMI and hemoglobin may be due to sample size limitations or low variability in these measures. Further research with larger and more heterogeneous populations is recommended.

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INTRODUCTION

Maternal anthropometric factors - such as body mass index (BMI), weight, height, and mid-upper arm circumference (MUAC) - play a critical role in predicting neonatal health outcomes, particularly birth weight, length, and head circumference [1]. These indicators serve as accessible, cost-effective tools for identifying at-risk pregnancies, especially in low-resource settings [2]. Multiple studies have found significant correlations between maternal anthropometry and neonatal birth weight, with underweight mothers more likely to deliver low birth weight or small for gestational age infants [3, 4]. Higher maternal BMI is generally associated with increased neonatal birth weight and fat mass, though excessive weight gain may lead to complications such as macrosomia or cesarean delivery [5]. Additional anthropometric measures like MUAC are emerging as strong predictors of neonatal size and outcomes [6]. Likewise, inadequate maternal nutrition or anemia has been linked with decreased neonatal anthropometric measurements [7, 8]. Understanding these associations is critical for public health planning, as neonatal anthropometric outcomes are strong predictors of long-term health, including metabolic and cardiovascular diseases [9]. Extensive research underscores the significant association between maternal anthropometric status and neonatal outcomes, particularly birth weight and length [3]. Body Mass Index (BMI), maternal weight, and height are positively correlated with newborn anthropometric parameters across various populations [10]. Emerging evidence highlights gestational weight gain and body shape indices as predictors of macrosomia and extended hospital stay for mothers and neonates [11]. Advanced maternal age (AMA) has been associated with lower intake of key micronutrients, affecting neonatal head circumference and overall growth metric [8]. Nutritional deficiencies and anemia during pregnancy continue to influence neonatal anthropometry, particularly in urban, low-income populations [12]. Variations in birth outcomes are observed depending on maternal socioeconomic factors, such as education and income, alongside BMI and antenatal care visits [1]. However, prior studies often lack standardization in measuring anthropometric variables, and there is inconsistency in controlling for confounders like parity and diet [13]. There is limited evidence on longitudinal changes in maternal anthropometry and how they affect neonatal body composition beyond weight alone [5]. The important of this study is to show how maternal characteristics, including age, body mass index, and medical issues, impact the size and growth of newborns at birth. Comprehending these correlations aids in enhancing prenatal care, reducing the potential of low birth weight or stunted growth, and directing public health initiatives to improve the health of mothers and newborns.

AIMS OF THE STUDY

This study was design to investigated the relationship between maternal anthropometric and sociodemographic factors and neonatal birth outcomes—specifically birth weight, length, and head circumference—among pregnant women delivering at two hospitals in Sulaymaniyah, Iraq.

METHODOLOGY

Study Design and Setting

The research was conducted in Sulaymaniyah, Kurdistan Region of Iraq, specifically at Penjwen General and Shahid Hama Rash Hospitals—regional referral centers for maternal and child health. These institutions serve both urban and rural populations, enhancing the representativeness and generalizability of the findings. Both hospitals had standardized obstetric equipment and trained staff, ensuring uniform and reliable data collection in a naturalistic clinical environment. No interventions or experimental procedures were involved, as the study purely observed routine maternal care and childbirth processes.

Study Population and Eligibility Criteria

The study included pregnant women presenting for delivery at the two designated hospitals. Participants had diverse sociodemographic backgrounds and were assessed in the labor wards. Eligibility was restricted to term or near-term women with single, uncomplicated pregnancies to ensure consistency in neonatal outcomes and minimize confounding factors. Exclusion criteria involved chronic maternal conditions (e.g., diabetes, hypertension), multifetal pregnancies, and behavioral risks like tobacco or alcohol use. Enrollment continued consecutively until the target sample size was met. Informed consent was obtained from all participants. There were no restrictions regarding ethnicity, socioeconomic status, or parity, enhancing the representativeness of the sample.

Sample Size and Method of Sampling

The study enrolled 50 Pregnant women aged (20-44 years), a sample size determined by available time, resources, and the expected number of eligible participants during the study period. This number was deemed sufficient for the study's analytical aims and practical feasibility. A non-probabilistic, consecutive sampling method was used, enrolling all eligible women who delivered within the study window. No matching or stratification based on demographics was applied. Each participant contributed one complete maternal-neonatal dataset. Although the sampling did not aim for broad statistical representativeness, it provided enough variability for meaningful descriptive and inferential analysis within the study's cross-sectional design.

Data Collection Instruments and Procedures

Data collection involved both interviewer-administered questionnaires and direct physical measurements, carried out under clinical supervision in delivery wards. Sociodemographic data (age, residence, education, employment) and obstetric history (gravidity, gestational age) were gathered using a structured, pre-tested questionnaire through face-to-face interviews by trained health staff, minimizing response errors. Anthropometric measurements were taken using standardized procedures: maternal weight was measured with calibrated electronic scales under light clothing and without shoes, and height with a wall-mounted stadiometer. BMI was calculated as weight (kg) divided by height (m^2). Pregnancy weight gain was derived from the difference between pre-pregnancy and delivery weights.

Hemoglobin levels were obtained from routine third-trimester antenatal lab results, verified for accuracy and recency. Neonatal outcomes (weight, length, head circumference) were measured within the first hour post-delivery by attending nurses using standard tools (infant scale, infantometer, and flexible tape). All tools were pre-tested, and daily supervision ensured consistency and data accuracy. Data were anonymized and manually entered into a secure spreadsheet, with double-entry verification to avoid input errors. No electronic data collection tools were used. The standardized tools and rigorous protocol ensured high data reliability and consistency for statistical analysis.

Variables and Operational Definitions

Variables were classified as dependent (neonatal outcomes) or independent (maternal characteristics), each operationally defined for measurement clarity and consistency.

Dependent variables included:

- **Birth weight:** infant's mass in kg (to nearest 0.01 kg)
- **Length:** full body length in cm
- **Head circumference:** largest occipitofrontal diameter in cm.

These reflected neonatal growth at birth and were analyzed as continuous variables.

Independent variables included:

- **Gestational age** (weeks) and **gravidity** (number of pregnancies): both numeric
- **Residence:** urban/rural; **Education:** illiterate, primary, certificate or higher;

Occupation: employed/unemployed — all categorical Anthropometric data (maternal weight, height, BMI,

and weight gain) were continuous and measured quantitatively.

Hemoglobin (g/dL) was a continuous indicator of maternal nutritional status.

All variables were coded systematically for statistical analysis, aligned with international research standards. No complex transformations were used aside from BMI and weight gain calculations, ensuring clarity and consistency in analysis.

Ethical Considerations

Ethical approval was secured from institutional authorities before data collection, ensuring adherence to recognized standards for human research. Participants were informed of the study's purpose, procedures, and rights, including voluntary participation and withdrawal without consequences. Verbal informed consent was obtained and recorded before any data was collected. Confidentiality was maintained through anonymization and secure data storage, with access restricted to the research team. Use of medical records complied with institutional and national privacy regulations. The study involved no invasive procedures or physical risks, as it relied solely on clinical observations. Ethical safeguards were upheld throughout to protect participant rights and welfare.

Statistical Analysis

Data analysis was performed using IBM SPSS Statistics v26. Descriptive statistics summarized continuous and categorical variables (means, standard deviations, frequencies). Categorical variables were numerically coded for analysis. Pearson correlation tests assessed linear relationships between maternal variables and neonatal outcomes (birth weight, length, head circumference). Multiple linear regression models were developed for each outcome, including predictors such as gestational age, gravidity, residence, education, occupation, maternal weight, height, BMI, weight gain, and hemoglobin. Categorical variables were dummy-coded. Regression outputs included coefficients, standard errors, t-values, and p-values, with significance set at $p < 0.05$.

RESULTS

The multiple linear regression analysis in table 2 examined the collective influence of several maternal and sociodemographic factors on neonatal weight. The intercept of the model was not statistically significant, indicating that if all predictors were at their reference values, the predicted neonatal weight would not differ significantly from zero in this model context. Among the categorical predictors, urban residence was associated with a non-significant decrease in neonatal weight compared to rural residence. Similarly, being illiterate or having completed primary school did not significantly increase neonatal weight relative to the reference group (certificate and above). The occupational status of being un-employed also did not have a significant effect on neonatal weight.

Of the continuous variables, gestational age emerged as a statistically significant predictor, with each week increase in gestational age associated with a significant increase in neonatal weight. Gravidity, maternal weight, height, BMI, and hemoglobin did not show significant associations with neonatal weight in this model. Maternal weight gain approached but did not reach statistical significance as a negative predictor of neonatal weight, suggesting a marginal trend toward lower neonatal weight with higher maternal weight gain, though this result should be interpreted with caution due to its borderline significance. Overall, the results indicate that among the factors analyzed, only gestational age had a statistically significant effect on neonatal weight in this sample. None of the sociodemographic or other anthropometric variables demonstrated significant associations with neonatal weight after accounting for other predictors in the model.

The results of the multiple linear regression analysis in table 3 indicate that none of the included maternal or sociodemographic factors significantly

predicted neonatal length at the conventional significance level of p<0.05p<0.05. The intercept term, which represents the estimated neonatal length when all predictors are at their reference values, was close to statistical significance but did not reach it. None of the coefficients for residence, educational level, occupational status, gestational age, gravidity, maternal weight, height, BMI, weight gain, or hemoglobin were statistically significant. Urban residence showed a trend toward being associated with lower neonatal length compared to rural residence, but this trend was not statistically significant. Similarly, none of the other variables demonstrated a meaningful or statistically significant effect on neonatal length in this sample. The overall model suggests that, within the range of variables analyzed, none of the examined factors had a significant impact on neonatal length.

The multiple linear regression analysis in table 4 revealed that none of the included maternal or sociodemographic factors significantly predicted neonatal head circumference at the conventional significance level of $p < 0.05$, except for the intercept term, which was statistically significant. The intercept represents the estimated head circumference when all predictors are at their reference values, indicating a meaningful baseline prediction. None of the coefficients for residence, educational level, occupational status, gestational age, gravidity, maternal weight, height, BMI, weight gain, or hemoglobin were statistically significant. Gravidity showed a trend toward significance but did not reach the conventional threshold. The model included all specified predictors, but none showed robust or significant associations with neonatal head circumference in this sample. The overall results suggest that, within the range of variables analyzed, none of the examined factors had a significant impact on neonatal head circumference.

The Pearson correlation analysis in table 5 revealed that among all the variables examined, only gestational age demonstrated a statistically significant positive correlation with neonatal weight, with a correlation coefficient of 0.293 and a p-value of 0.039. This indicates that higher gestational age is associated with higher neonatal weight in this sample. None of the other variables, including gravidity, residence, educational level, occupational status, maternal weight, height, BMI, weight gain, or hemoglobin, showed a significant correlation with neonatal weight. The correlation coefficients for these variables were close to zero, and their p-values were above the threshold for statistical significance, suggesting that they do not have a meaningful linear relationship with neonatal weight in this dataset. The findings highlight gestational age as the primary factor among those analyzed that is significantly associated with neonatal weight.

The Pearson correlation analysis in table 6 revealed that among all the variables examined, only residence demonstrated a statistically significant negative correlation with neonatal height, with a correlation coefficient of -0.33 and a p-value of 0.019. This indicates that, when numerically encoded, urban residence is associated with lower neonatal height compared to rural residence in this sample. None of the other variables, including gestational age, gravidity, educational level, occupational status, maternal weight, height, BMI, weight gain, or hemoglobin, showed a significant correlation with neonatal height. The correlation coefficients for these variables were small, and their p-values were above the threshold for statistical significance, suggesting that they do not have a meaningful linear relationship with neonatal height in this dataset. The findings highlight residence as the primary factor among those analyzed that is significantly associated with neonatal height in this study.

The Pearson correlation analysis in table 7 demonstrated that gravidity had a statistically significant positive correlation with neonatal head circumference, with a correlation coefficient of 0.311 and a p-value of 0.028. This indicates that higher gravidity is associated with larger neonatal head

circumference in this sample. Gestational age showed a positive trend toward significance, with a correlation coefficient of 0.267 and a p-value of 0.061, which is close to but does not reach the conventional threshold for statistical significance. None of the other variables, including residence, educational level, maternal weight, height, BMI, weight gain, or hemoglobin, exhibited a significant correlation with neonatal head circumference. The correlation coefficients for these variables were small and their p-values were well above the threshold for statistical significance, indicating that they do not have a meaningful linear relationship with neonatal head circumference in this dataset. Occupational status was not included in the analysis due to insufficient variability. The findings highlight gravidity as the primary factor among those analyzed that is significantly associated with neonatal head circumference in this study.

DISCUSSION:

The present study aimed to evaluate the association between maternal and sociodemographic factors with neonatal birth weight using a multiple linear regression model. Among all variables examined, only gestational age demonstrated a statistically significant positive association with neonatal weight (coefficient = 0.1258, p = 0.0266), indicating that each additional week of gestation contributes to increased neonatal weight. Other maternal anthropometric measures such as weight, height, BMI, weight gain, and hemoglobin levels did not show statistically significant effects. Sociodemographic variables including residence, education, and occupational status also lacked significant predictive value. A marginal trend toward lower neonatal weight with increased maternal weight gain was observed, but this did not reach conventional statistical significance (p = 0.0564). The finding that gestational age significantly affects neonatal weight is consistent with a number of recent studies. For instance, a study by Qasim et al. (2024) confirmed that gestational age had a strong inverse association with low birth weight (OR = 0.776, p < 0.001), reinforcing the conclusion that extended gestation supports better fetal growth [14]. Similarly, Liu et al. (2022) identified an inverted U-shaped relationship between maternal hemoglobin levels and birth weight, with optimal outcomes observed at mid-range hemoglobin values and longer gestations [15]. However, the present study contrasts with other findings regarding maternal anthropometric and hematological factors. For example, Nurwati et al. (2024) found significant associations between maternal third-trimester weight gain and birth weight, contrary to the non-significant trend observed in the current study [16]. Likewise, Shah et al. (2020) observed that neonates born to anemic mothers had significantly lower birth weights, suggesting a more prominent role of hemoglobin in influencing birth outcomes than indicated in the current results [17]. Furthermore, Singh et al. (2024) demonstrated that maternal anemia was significantly associated with reduced neonatal weight, supporting the hypothesis that maternal hemoglobin concentration directly influences fetal growth metrics [18]. In contrast, the current study failed to find such an association, which may be due to the relatively narrow variation in hemoglobin values among participants or sample size limitations. A study by Javedi et al. (2022) also contradicts the present findings regarding hemoglobin, showing no significant association between maternal hemoglobin and neonatal birth weight but highlighting maternal weight and gestational age as stronger predictors [19]. This aligns partially with the current study in its emphasis on gestational age but diverges in the significance attributed to maternal weight. The divergence in findings regarding maternal hemoglobin and anthropometric variables across studies may reflect differences in sample characteristics, measurement methods, and contextual factors such as dietary intake, healthcare access, and ethnicity. The present study's null findings on BMI, weight, and hemoglobin

may be partly attributed to the homogeneous nature of the sample or limited statistical power due to the modest sample size. In contrast, larger multicenter studies have captured greater variability and statistical significance. In summary, the present study affirms the critical role of gestational age in influencing neonatal birth weight, while challenging commonly held associations with maternal anthropometric and hematologic factors observed in other studies. These discrepancies underscore the importance of contextual and methodological differences and highlight the need for larger, more diverse, and possibly longitudinal datasets to elucidate these relationships more robustly. In the present study, a multiple linear regression analysis was used to evaluate how maternal and sociodemographic factors affect neonatal length. None of the variables, including maternal hemoglobin, BMI, weight, height, gestational age, or sociodemographic status, showed statistically significant associations with neonatal length ($p > 0.05$ for all). Although the intercept was significant ($p = 0.050$), the main predictors did not reach significance, suggesting that, within this sample, neonatal length may not be strongly influenced by the studied maternal characteristics. However, gestational age ($p = 0.237$), hemoglobin ($p = 0.765$), and BMI ($p = 0.340$) showed trends that are worth exploring further in larger or stratified datasets. When comparing these findings to recent literature, there is significant evidence supporting associations between maternal hemoglobin and neonatal anthropometric outcomes. For example, a prospective study by Dhole et al. (2022) found that maternal anemia significantly affected neonatal length, among other anthropometric measures [20]. In the same way, Javed et al. (2023) documented that maternal anemia had strong links with weak neonate length and determination that showed the close connection between maternal hemoglobin and fetal growth [21]. This is compared to what is reported in the current study in which hemoglobin was not considered significant in influencing the neonatal length. More evidence is based on the study by Rahman et al. (2020), who confirmed the statistically significant association between the neonatal length and weight and the same in the third trimester of the pregnancy [22]. Similarly, Shah et al. (2020) reported that the lengths of those babies born by anemic mothers were significantly lower than their counterparts whose mothers were not anemic [17]. Nevertheless, not every recent research corroborates such correlations. In our case, the results correspond with the ones provided by Kaur et al. (2015), who have noticed that despite the positive relationship between hemoglobin levels in the mother and the outcomes of the newborn, the bivariate association was insignificant with regards to length and adjusted to the population characteristics [23]. Among possible reasons explaining the discrepancy between the present study and other findings, one can mention sample-specific reasons like a relatively small sample size, reduced variability related to maternal health indicators, or nutritional and healthcare dissimilarities of the population. In addition, the insignificance of this research could be a hindrance to the power of statistics or other confounding factors which were not controlled. It even may be that time of measurement of maternal parameters (e.g., hemoglobin late during the pregnancy, other earlier) may have affected the outcome. In conclusion, while the current study did not identify any statistically significant maternal predictors of neonatal length, recent literature strongly supports a role for maternal hemoglobin and nutritional status in shaping neonatal anthropometry. The lack of concordance suggests that future research should explore these relationships using larger, more diverse cohorts and standardized methodologies. In the present study, a multiple linear regression analysis was conducted to examine the relationship between maternal factors and neonatal head circumference. None of the variables, including gestational age, gravidity, maternal anthropometry (weight, height, BMI), hemoglobin, or

sociodemographic indicators (education, occupation, residence), reached statistical significance (all p-values > 0.05). However, gravidity (p = 0.085) and gestational age (p = 0.193) showed trends suggesting potential influence, though not reaching conventional levels of significance. The intercept was highly significant (p = 0.001), reflecting consistent baseline measurement across the cohort.

This lack of significant associations stands in partial contrast to several recent studies. For instance, Singh et al. (2024) found that maternal anemia was significantly associated with reduced neonatal head circumference, underscoring the influence of hemoglobin on fetal brain development [18]. Similarly, Shah et al. (2020) found that children born of anemic mothers had much smaller head circumference measurements, in line with the belief that smaller amounts of oxygen reaching the uterus during pregnancy can interfere with the development of the cranium [17]. When it comes to gestational age, its close relation to the circumference of the neonatal head is confirmed by the numerous studies. According to a study conducted by Javedi et al. (2022), the mother weight and the period of gestation were both positively correlated with the head circumference which is the natural growth of the fetus in extended period [19]. This is unlike the current study where the measure of gestational age did not achieve significance, which could be put on short span of gestational age of the sample or inadequate sample size.

Additional data favor the actions of anthropometric factors of mothers. According to Javed et al. (2023), maternal weight and BMI were found to be important factors of the head circumference of the newborn, implying that the appropriate diet of the mother is one of the determinants of the growth of the skull in the fetus [21]. In the same way, research by Liu et al. (2022) reported an inverted U-shaped connection between maternal hemoglobin and the anthropometry of the neonate (head circumference, etc.) indicative of the best results at the midpoint hemoglobin scale [15]. However, other studies also agree with the current findings. As an illustration, Rahman et al. (2020) discovered that, despite the fact that maternal hemoglobin was demonstrably associated with both birth weight and length, it was not meaningfully associated with head circumference, just like in the current research paper [22]. This is an indication that head circumference is not sensitive to variation of hemoglobin of the mother as compared to other anthropometric measures, or that other variables like genes and placental functions are more significant. These differences in the results could have been occasioned by the differences in the sample demographics, study designs and region maternal health profile. The insignificance of the findings in the present study can be associated with a somewhat homogeneous sample, an inadequate level of statistical power or possible confounding factors that were not measured. Subsequent studies with larger and broader samples may be able to shed further light upon these relations and possibly suggest possible threshold effects or non-linearities. To sum up, insignificant relationships between maternal predictors and neonatal head circumference were observed in the current research, whereas the available literature indicates that maternal hemoglobin, BMI and gestation age often have some effect. Such discrepancies promote the importance of a future study on different contexts.

CONCLUSIONS:

This study found that among the examined maternal and sociodemographic factors, gestational age was the most consistent and significant predictor of neonatal birth weight. Gravidity was positively associated with head circumference, and urban residence correlated negatively with neonatal length. Other variables, including maternal BMI, weight, height, weight gain, and hemoglobin levels, did not demonstrate significant effects on neonatal anthropometry. These results reinforce the critical

importance of gestational age in neonatal outcomes while suggesting that the effects of other maternal characteristics may be less pronounced or context-dependent. Future research with larger samples and broader geographic representation is needed to validate these findings and explore potential mediators and modifiers.

RECOMMENDATIONS:

Future research should focus on addressing these disparities through targeted interventions aimed at improving education, increasing access to healthcare in rural areas, and providing economic support to unemployed pregnant women.

Conflicts of Interest: No reflect of interest.

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TABLES & Figures:

Table (1): Part A: Continuous Data Summary Table

Variable	Count	Mean	Std. Dev.	Min	25%	50%	75%	Max
Gestational - age	50	38.44	1.62	32.0	38.0	38.0	40.0	41.0
Gravidity	50	2.24	1.13	1.0	1.0	2.0	3.0	4.0
Weight - kg_	50	78.52	12.50	58.0	69.38	77.1	87.63	112.0
Height - cm_	50	162.0	5.43	150.0	159.0	161.0	166.0	173.0
BMI	50	30.22	4.45	23.0	27.24	29.68	32.98	44.36
Weight - gain	50	12.57	8.16	-9.6	8.0	11.0	16.75	38.0
Hemoglobin	50	74.89	5.66	63.0	72.03	75.75	78.0	96.0
Weight - infant	50	3.38	0.57	2.67	2.90	3.25	3.59	5.55
Length - infant	50	49.31	2.95	39.0	48.0	49.0	50.6	57.0
Head - circumference	50	36.10	1.86	32.0	35.0	36.0	37.23	40.4

Table (1): Part B: Categorical Data Summary Table

Variable	Categories	Count	Frequency (Top Category)	% of Total
Residence	Urban, Rural	50	Urban (36)	72%
Educational - level	Illiterate, Primary school, Certificate & above	50	Primary school (26)	52%
Occupational-status	Un-employed, Employed	50	Un-employed (50)	100%

Table (2): Multiple Linear Regression Analysis of the Effect of Gestational Age, Gravidity, Residence, Educational Level, Occupational Status, Maternal Weight, Height, BMI, Weight Gain, and Hemoglobin on Neonatal Weight

Variable	Coefficient	Std. Error	t value	p value
Intercept	-1.7235	3.6615	-0.4707	0.6405
C(Residence) [T. Urban]	-0.1157	0.2068	-0.5598	0.5789
C(Educational - level) [T. Illiterate]	0.1753	0.5389	0.3253	0.7467
C(Educational - level) [T. Primary school]	0.2398	0.1904	1.2596	0.2155
C(Occupational - status) [T. Un-employed]	-0.0950	0.4582	-0.2074	0.8368
Gestational - age	0.1258	0.0545	2.3062	0.0266
Gravidity	-0.0772	0.0884	-0.8737	0.3878
Weight - kg_	0.0018	0.0092	0.2000	0.8425
Height - cm_	0.0031	0.0169	0.1820	0.8565
BMI	0.0078	0.0274	0.2866	0.7760
Weight - gain	-0.0222	0.0113	-1.9679	0.0564
Hemoglobin	-0.0018	0.0160	-0.1143	0.9096

Multiple linear regression was used to assess the effect of gestational age, gravidity, residence, educational level, occupational status, maternal weight, height, BMI, weight gain, and hemoglobin on neonatal weight. All categorical variables were included as factors (dummy variables). Statistical significance was considered at $p<0.05$.

Table (3): Multiple Linear Regression Analysis of the Effect of Gestational Age, Gravidity, Residence, Educational Level, Occupational Status, Maternal Weight, Height, BMI, Weight Gain, and Hemoglobin on Neonatal Length.

Variable	Coefficient	Std. Error	t value	p value
Intercept	37.857287	18.773412	2.016537	0.050851
C(Residence) [T. Urban]	-2.047208	1.060049	-1.931239	0.060938
C(Educational - level) [T. Illiterate]	1.710739	2.762901	0.619182	0.539491
C(Educational - level) [T. Primary school]	0.455167	0.976090	0.466316	0.643651
C(Occupational - status) [T. Un-employed]	1.875142	2.349273	0.798180	0.429726
Gestational age	0.335482	0.279634	1.199717	0.237676
Gravidity	0.181965	0.453025	0.401667	0.690179
Weight - kg_	-0.037259	0.047000	-0.792740	0.432851
Height - cm_	0.039538	0.086436	0.457430	0.649967
BMI	-0.135574	0.140340	-0.966038	0.340133
Weight - gain	0.001564	0.057964	0.026983	0.978615
Hemoglobin	-0.024647	0.082012	-0.300526	0.765414

Multiple linear regression analysis was used to assess the effect of gestational age, gravidity, residence, educational level, occupational status, maternal weight, height, BMI, weight gain, and hemoglobin on neonatal length. All categorical variables were included as factors (dummy variables). Statistical significance was considered at $p<0.05$.

Table (4): Multiple Linear Regression Analysis of the Effect of Gestational Age, Gravidity, Residence, Educational Level, Occupational Status, Maternal Weight, Height, BMI, Weight Gain, and Hemoglobin on Neonatal Head Circumference.

Variable	Coefficient	Std. Error	t value	p value
Intercept	40.136855	11.651759	3.444704	0.001408
C(Residence) [T. Urban]	-0.055928	0.657922	-0.08501	0.932702
C(Educational - level) [T. Illiterate]	1.477286	1.714801	0.861491	0.394371
C(Educational - level) [T. Primary school]	0.789571	0.605812	1.303326	0.200305
C(Occupational - status) [T. Un-employed]	0.765468	1.458082	0.524983	0.602645
Gestational - age	0.230072	0.173556	1.325638	0.192874
Gravidity	0.497280	0.281171	1.768602	0.084988
Weight - kg_	0.020946	0.029171	0.718037	0.477126
Height - cm_	-0.055284	0.053647	-1.03052	0.309279
BMI	-0.091745	0.087103	-1.05329	0.298858
Weight - gain	-0.007746	0.035976	-0.21530	0.830685
Hemoglobin	-0.067520	0.050901	-1.32650	0.192590

Multiple linear regression analysis was used to assess the effect of gestational age, gravidity, residence, educational level, occupational status, maternal weight, height, BMI, weight gain, and hemoglobin on neonatal head circumference. All categorical variables were included as factors (dummy variables). Statistical significance was considered at $p < 0.05$.

Table (5): Pearson Product-Moment Correlation Coefficient Analysis of the Relationship Between Gestational Age, Gravidity, Residence, Educational Level, Occupational Status, Maternal Weight, Height, BMI, Weight Gain, and Hemoglobin with Neonatal Weight.

Variable	Correlation Coefficient	p value
Gestational - age	0.293	0.039
Gravidity	-0.093	0.520
Residence	-0.176	0.222
Educational - level	0.208	0.147
Occupational - status	-0.017	0.905
Weight - kg_	-0.017	0.908
Height - cm_	0.004	0.978
BMI	0.001	0.997
Weight - gain	-0.204	0.155
Hemoglobin	-0.013	0.930

Pearson Product-Moment Correlation Coefficient Analysis was used to assess the correlation between gestational age, gravidity, residence, educational level, occupational status, maternal weight, height, BMI, weight gain, and hemoglobin with neonatal weight. Categorical variables (residence, educational level, occupational status) were numerically encoded for this analysis. Statistical significance was considered at $p<0.05$.

Table (6): Pearson Product-Moment Correlation Coefficient Analysis of the Relationship Between Gestational Age, Gravidity, Residence, Educational Level, Occupational Status, Maternal Weight, Height, BMI, Weight Gain, and Hemoglobin with Neonatal Length.

Variable	Correlation Coefficient	p value
Gestational - age	0.221	0.122
Gravidity	0.024	0.871
Residence	-0.330	0.019
Educational - level	0.145	0.316
Occupational - status	0.197	0.171
Weight - kg_	-0.166	0.248
Height - cm_	0.069	0.635
BMI	-0.175	0.225
Weight - gain	0.013	0.928
Hemoglobin	-0.125	0.388

Pearson Product-Moment Correlation Coefficient Analysis was used to assess the correlation between gestational age, gravidity, residence, educational level, occupational status, maternal weight, height, BMI, weight gain, and hemoglobin with neonatal height. Categorical variables (residence, educational level, occupational status) were numerically encoded for this analysis. Statistical significance was considered at $p < 0.05$.

Table (7): Pearson Product-Moment Correlation Coefficient Analysis of the Relationship Between Gestational Age, Gravidity, Residence, Educational Level, Occupational Status, Maternal Weight, Height, BMI, Weight Gain, and Hemoglobin with Neonatal Head Circumference

Variable	Correlation Coefficient	p value
Gestational - age	0.267	0.061
Gravidity	0.311	0.028
Residence	-0.039	0.789
Educational - level	-0.213	0.137
Occupational - status	—	—
Weight - kg_	0.057	0.696
Height - cm_	-0.105	0.469
BMI	-0.021	0.883
Weight - gain	0.045	0.756
Hemoglobin	-0.147	0.308

Pearson Product-Moment Correlation Coefficient Analysis was used to assess the correlation between gestational age, gravidity, residence, educational level, maternal weight, height, BMI, weight gain, and hemoglobin with neonatal head circumference. Categorical variables (residence, educational level) were numerically encoded for this analysis. Occupational status was excluded due to lack of variability in the sample. Statistical significance was considered at $p < 0.05$.