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Research Article

Prenatal Nutrition's Effect on Neonatal Results: A Study on Maternal Dietary Patterns and Fetal Health

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Keywords

Prenatal nutrition, maternal diet, neonatal outcomes, birth weight, gestational age, anemia, Apgar scores, dietary patterns.

Abstract

Introduction: Fetal development and health are significantly influenced by maternal diet. Prenatal dietary practices are associated with neonatal outcomes such as birth weight, gestational age, and Apgar scores. This study assessed the effect of maternal dietary patterns on birth weight, gestational age, and maternal anemia.

Materials and Methods: This cross-sectional study included 144 pregnant women over a 12-month period at Pak International Medical College (PIMC), Hayatabad. Maternal eating patterns were assessed using a Food Frequency Questionnaire. Neonatal outcomes such as birth weight, gestational age, Apgar scores, and NICU admissions were recorded. Hemoglobin levels were used to evaluate maternal anemia. Data were analyzed using ANOVA, Chi-square tests, and independent t-tests.

Results: The mean age was 27.8 ± 4.9 years, with most participants from middle-income households. Dietary patterns showed 35.4% followed a balanced diet, 41.0% moderately imbalanced, and 23.6% highly imbalanced. Anemia was most prevalent in the highly imbalanced group (82.4%, $p < 0.001$). Neonatal outcomes showed a mean birth weight of 2.84 ± 0.52 kg, with 20.1% classified as low birth weight and 14.6% as preterm. Mothers with balanced diets had significantly higher birth weights, longer gestational ages, and better Apgar scores ($p < 0.001$). Maternal anemia was associated with higher rates of low birth weight (27.5% vs. 7.5%, $p = 0.003$) and preterm births (18.7% vs. 7.5%, $p = 0.048$).

Conclusion: Maternal dietary patterns significantly influence neonatal health. Public health interventions targeting maternal nutrition, especially in resource-limited settings, are essential to improve outcomes.

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Introduction

A crucial time, pregnancy is marked by significant physiological changes and increased dietary needs [1]. In order to support the fetus's growth, development, and overall health, maternal nutrition is crucial [2]. Adequate intake of essential nutrients not only supports the mother's well-being but also contributes significantly to placental function, fetal organogenesis, and the programming of long-term health in offspring [3]. Both macronutrient and micronutrient deficits during pregnancy have been repeatedly linked to negative consequences for the newborn, such as low birth weight, premature birth, intrauterine growth restriction (IUGR), and poor neurodevelopment [4].

Various dietary patterns have emerged as indicators of overall nutritional status in pregnancy. Rather than focusing solely on individual nutrients, examining maternal dietary patterns provides a more comprehensive picture of food consumption behaviors and nutrient synergies [5]. Patterns such as the Mediterranean diet that is rich in veggies, whole grains, fruits, and healthy fats have been linked to positive results for newborn [6]. Conversely, dietary habits in the West that emphasize consuming a lot of processed foods, saturated fats, and added sugars have been linked to adverse perinatal consequences [7].

Several biological mechanisms explain the link between maternal diet and fetal development. Hemoglobin synthesis, bone mineralization, brain development, and fetal neural tube closure all depend on nutrients like Vitamin B9, iron, calcium, and omega-3 fatty acids [8]. Moreover, poor maternal nutrition can contribute to placental dysfunction and increased oxidative stress, which further compromises fetal health [9]. In nations that have poor and moderate incomes, where food insecurity and limited maternal health literacy are common, these risks are magnified, making prenatal nutrition an urgent public health priority [10].

Despite the growing awareness of the importance of prenatal nutrition, there remains a lack of region-specific data assessing the link between maternal dietary habits and neonatal outcomes, particularly in developing countries. The complexity of cultural food practices, socioeconomic disparities, and limited antenatal nutritional counseling further complicates this issue. Although several studies have explored the role of specific nutrients in pregnancy, a notable research gap remains regarding the impact of overall maternal dietary patterns on neonatal outcomes in resource-limited settings. This study aims to address that gap by analyzing the association between prenatal dietary habits and key fetal health indicators.

Materials and Methods

Study Design: This cross-sectional observational study was conducted at the Department of Obstetrics and Gynecology, Pak International Medical College (PIMC), Hayatabad. The study period spanned 12 months, from January 2023 to December 2023. A total of 144 pregnant women were enrolled to examine the impact of maternal dietary patterns on neonatal outcomes.

Sample Size Calculation: Using OpenEpi software, the sample size was determined by considering a 95% confidence level, a 5 % inaccuracy limit, and an anticipated 20 % prevalence of unfavorable newborn outcomes because of inadequate maternal nutrition which was based on previous research.
A sample size of 132 was determined. A nonprobability sequential sampling strategy was used to choose a final sample size of 144 pregnant women to boost the power and account for possible dropouts or incomplete data.

Inclusion and Exclusion Criteria: The study population consisted of pregnant women enrolled in PIMC's antenatal clinics who were in their second trimester (14–28 weeks gestation).
Inclusion criteria were the women having singleton pregnancies between the ages of 18 and 40 who are not diagnosed with fatal conditions such diabetes, high blood pressure, or kidney problems. Women who were hesitant to engage, had pre-existing medical issues, or were pregnant with more than one child were not allowed to participate.

Data Collection: A standardized questionnaire given by the interviewer was used to gather data. The survey included socioeconomic status, lifestyle characteristics, obstetric history, and comprehensive demographic data. To assess maternal dietary

patterns, we employed a validated semi-quantitative Food Frequency Questionnaire (FFQ), which evaluated the frequency and quantity of consumption of various food groups over the preceding month. Based on their responses, participants were classified into three main dietary patterns: balanced, moderately imbalanced, and highly imbalanced. Nutritional status was further assessed through anthropometric maternal height, weight, and mid-upper arm circumference (MUAC), among other parameters. Hemoglobin levels were measured once during routine antenatal investigations in the second trimester using standard laboratory procedures to assess maternal anemia.

Neonatal Outcomes: After delivery, neonatal outcomes were assessed and recorded. Key indicators included birth weight, gestational age at birth, Apgar scores at 1 and 5 minutes, head circumference, and admission to the neonatal intensive care unit (NICU), if any. Preterm birth is regarded as birth before 37 weeks of gestation, while low birth weight was specified as less than 2.5 kg.

Data Analysis: SPSS version 26.0 was used to enter and analyze all of the data. The characteristics of the mother and the newborn were compiled using descriptive statistics (means, standard deviations, and frequencies). Independent sample t-tests and chi-square tests were used to evaluate relationships between continuous and categorical variables, respectively. Categorical variables such as dietary patterns (balanced, moderately imbalanced, highly imbalanced), anemia status (anemic: Hb <11 g/dL; non-anemic: Hb ≥11 g/dL), birth weight (low: <2.5 kg; normal: ≥2.5 kg), and gestational age (preterm: <37 weeks; term: ≥37 weeks) were grouped based on standard clinical thresholds and FFQ scoring criteria prior to statistical analysis. Additionally, neonatal outcomes from various maternal eating pattern groups were compared using One-Way ANOVA. A p-value of less than 0.05 was considered to be statistically significant. Multivariate analysis was not performed due to the study's observational design and limited sample size; findings represent unadjusted associations.

Ethical Considerations: The study was approved by the Institute's Institutional Review Board. All participants provided a signed statement guaranteeing anonymity and secrecy. Participants were informed that they might stop taking part at any time without facing any repercussions, and all the information was used only for research. The study adhered to ethical guidelines and aimed to minimize any potential harm to participants and their neonates.

Results

The final analysis comprised 144 pregnant women in total. The mean age of participants was 27.8 ± 4.9 years, with the largest proportion (41.0%, n=59) aged between 25 and 30 years. Additionally, 31.3% (n=45) were younger than 25 years, and 27.7% (n=40) were over 30. In terms of socioeconomic status, the majority of women (58.3%, n=84) belonged to middle-income households, followed by 25.0% (n=36) from low-income and 16.7% (n=24) from high-income backgrounds. Regarding educational attainment, 60.4% (n=87) had completed secondary education, 20.1% (n=29) held graduate or postgraduate degrees, and 19.4% (n=28) had received no formal education (figure 1).

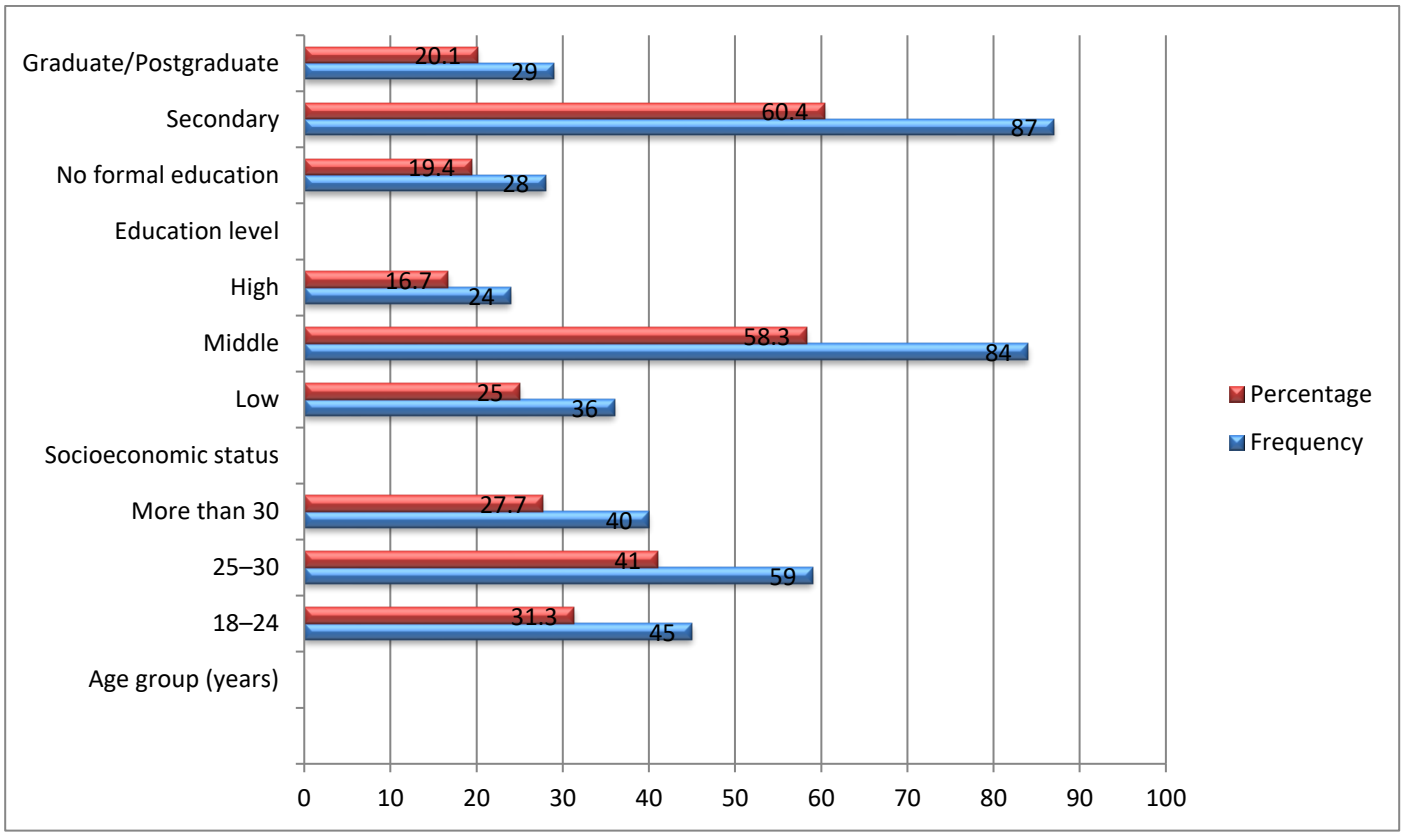

Figure 1: Baseline Characteristics of Study Participants

Based on the Food Frequency Questionnaire (FFQ), the study population was divided into three dietary pattern categories: balanced (35.4%, n=51), moderately imbalanced (41.0%, n=59), and highly imbalanced (23.6%, n=34). The mean mid-upper arm circumference (MUAC) for all participants was 25.6 ± 2.7 cm, with no statistically significant difference observed across the three dietary groups (p = 0.12). The mean hemoglobin level was 11.4 ± 0.9 g/dL in the balanced group, 10.6 ± 1.1 g/dL in the moderately imbalanced group, and 10.1 ± 1.0 g/dL in the highly imbalanced group, showing a statistically significant variation (p < 0.001). Furthermore, anemia, defined as hemoglobin <11 g/dL, was found in 45.1% of the balanced group, 66.1% of the moderately imbalanced group, and 82.4% of the highly imbalanced group, indicating a strong correlation between unhealthy eating habits and a higher incidence of anemia (p < 0.001), as shown in table 1.

Table 1: Maternal Nutrition and Anthropometric Data by Dietary Pattern (n=144). Anemia defined as hemoglobin <11 g/dL.

Parameter	Balanced (n=51)	Moderately Imbalanced (n=59)	Highly Imbalanced (n=34)	p-value
MUAC (cm, mean ± SD)	25.9 ± 2.6	25.4 ± 2.9	25.3 ± 2.4	0.12
Hemoglobin (g/dL, mean ± SD)	11.4 ± 0.9	10.6 ± 1.1	10.1 ± 1.0	<0.001
Anemia prevalence (%)	45.1%	66.1%	82.4%	<0.001

Neonatal outcomes revealed notable variations across the study population. The mean birth weight was 2.84 ± 0.52 kg, with 20.1% (n=29) of neonates classified as low birth weight (defined as <2.5 kg). The mean gestational age was 38.2 ± 1.5 weeks, and 14.6% (n=21) of the neonates were born preterm (before 37 weeks of gestation). Evaluation of neonatal vitality showed a mean Apgar score of 7.2 ± 1.1 at 1 minute and 8.5 ± 0.6 at 5 minutes, indicating overall good immediate postnatal adaptation in the

majority of cases. However, 11.8% (n=17) of newborns needed to be admitted to the Neonatal Intensive Care Unit (NICU). The primary reasons for NICU admission were prematurity, respiratory distress, and complications associated with low birth weight. These results highlight the significant impact of maternal health and nutrition on early neonatal wellbeing (Table 2).

Table 2: Neonatal Outcomes of the Study Population

Outcome	Mean ± SD / n (%)
Birth weight (kg)	2.84 ± 0.52
Low birth weight (<2.5 kg)	29 (20.1%)
Gestational age (weeks)	38.2 ± 1.5
Preterm births (<37 weeks)	21 (14.6%)
Apgar score (1 min)	7.2 ± 1.1
Apgar score (5 min)	8.5 ± 0.6
NICU admissions	17 (11.8%)

The analysis of neonatal outcomes based on maternal dietary patterns revealed significant differences across the three groups. Infants born to mothers following a balanced dietary pattern had the highest mean birth weight (3.05 ± 0.46 kg), followed by those with moderately imbalanced (2.81 ± 0.47 kg) and highly imbalanced diets (2.52 ± 0.44 kg), with the difference being statistically significant ($p < 0.001$). Similarly, gestational age was longest among the balanced group (38.9 ± 1.1 weeks) and shortest in the highly imbalanced group (37.2 ± 1.7 weeks), also reaching significance ($p < 0.001$). The prevalence of preterm births increased notably with worsening dietary quality: 7.8% in the balanced group, 13.6% in the moderately imbalanced group, and 29.4% in the highly imbalanced group ($p = 0.002$). Apgar scores at both 1 and 5 minutes were highest among neonates of mothers with balanced diets (7.7 ± 0.8 and 8.8 ± 0.5, respectively) and lowest in those with highly imbalanced diets (6.6 ± 1.3 and 8.1 ± 0.7), with both differences being statistically significant ($p < 0.001$). NICU admission rates were also lowest in the balanced group (3.9%) and highest in the highly imbalanced group (23.5%), showing a significant association with dietary pattern ($p = 0.012$). These findings highlight the impact of maternal nutrition on key neonatal outcomes (table 3).

Table 3: Neonatal Outcomes by Maternal Dietary Pattern

Neonatal Outcome	Balanced (n=51)	Moderately Imbalanced (n=59)	Highly Imbalanced (n=34)	p-value
Birth weight (kg)	3.05 ± 0.46	2.81 ± 0.47	2.52 ± 0.44	<0.001
Gestational age (weeks)	38.9 ± 1.1	38.0 ± 1.3	37.2 ± 1.7	<0.001
Preterm birth (%)	7.8% (n=4)	13.6% (n=8)	29.4% (n=10)	0.002
Apgar score (1 min)	7.7 ± 0.8	7.1 ± 1.0	6.6 ± 1.3	<0.001
Apgar score (5 min)	8.8 ± 0.5	8.4 ± 0.6	8.1 ± 0.7	<0.001
NICU admissions (%)	3.9% (n=2)	11.9% (n=7)	23.5% (n=8)	0.012

We further examined the link among newborn outcomes and mother anemia. Neonates born to anemic mothers had a significantly higher prevalence of low birth weight than those born to non-anemic mothers (27.5% vs. 7.5%, $p = 0.003$). Similarly, the rate of preterm birth was notably higher in the anemic group (18.7%) than in the non-anemic group (7.5%), reaching statistical significance ($p = 0.048$). Although a greater proportion of neonates born to anemic mothers required NICU admission (14.3% vs. 7.5%), there was no importance of this variation ($p = 0.202$), as illustrated in figure 2.

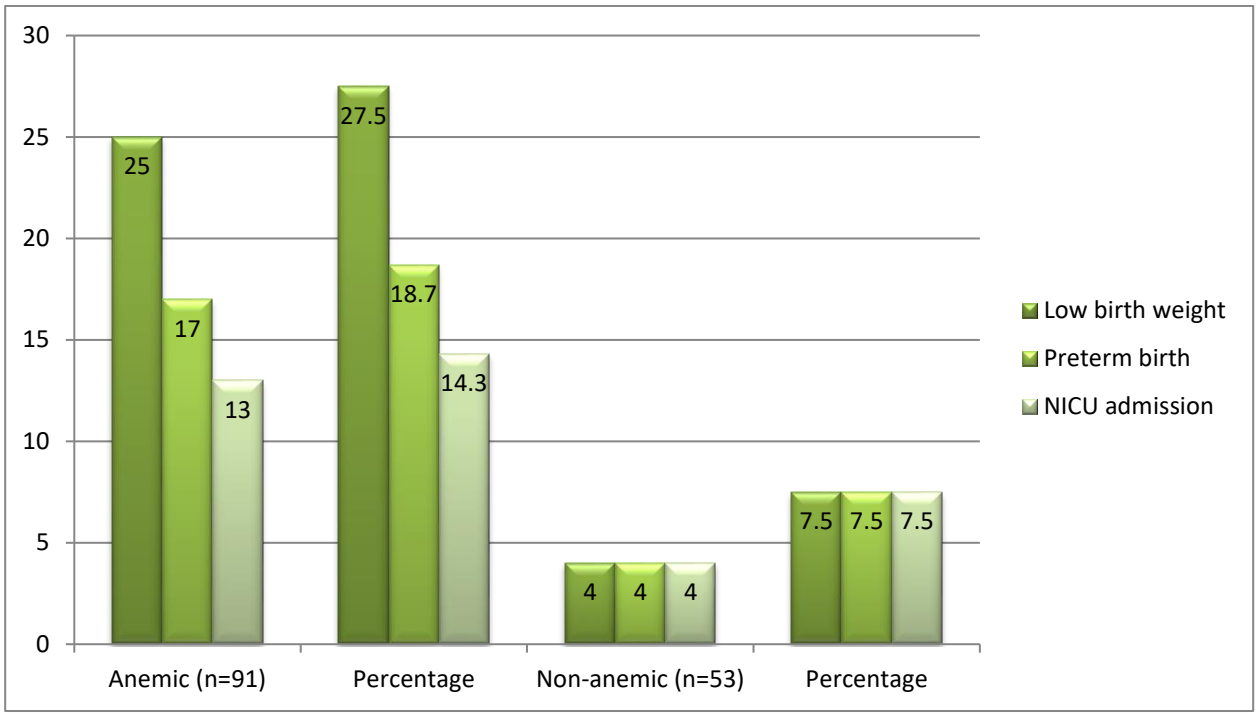

Figure 2: Association between Maternal Anemia and Neonatal Outcomes

Discussion

This study demonstrated a clear association between the nutritional habits of the mother during pregnancy and newborn results. Women who consumed a balanced diet had better nutritional status, lower anemia rates, and delivered neonates with significantly higher birth weights, better Apgar scores, longer gestational age, and fewer NICU admissions. Conversely, poor dietary intake and maternal anemia were linked with adverse neonatal outcomes such as low birth weight, preterm birth, and neonatal complications.

When compared with existing literature, these findings align closely with prior evidence showing that maternal nutrition is a critical determinant of fetal growth and perinatal health [11]. Previous studies consistently report that balanced intake of macronutrients and micronutrients during pregnancy leads to higher mean birth weights, reduced incidence of preterm labor, and overall improved neonatal vitality scores [12]. Likewise, anemia during pregnancy has long been established as a significant risk factor for intrauterine growth restriction and preterm birth, which mirrors the results observed in this study [13].

Multiple investigations conducted in low and middle-income countries have highlighted the role of socio-economic disparities, poor dietary diversity, and nutritional deficiencies in contributing to poor pregnancy outcomes [14]. The results of this study echo these findings, as the majority of women with highly imbalanced diets belonged to lower-income groups and had limited education. The direct effects of eating habits on Apgar scores and NICU admissions has also been corroborated by data from antenatal nutrition interventions, which show improvement in neonatal vitality with dietary counseling and supplementation [15].

In addition, this study reinforces growing evidence that gestational nutrition not only affects fetal growth but also modulates early neonatal adaptation, as reflected in Apgar scoring and the need for intensive care [16]. These associations emphasize the broader implications of maternal health on neonatal morbidity and healthcare resource utilization [17]. Improved maternal nutrition, particularly in the form of dietary supplementation and counseling, may reduce the burden on neonatal intensive care units, an important consideration for healthcare systems in both resource limited and high income settings [18].

Our findings also underline the importance of timely prenatal care and the surveillance of mother's fitness during pregnancy. The high rate of anemia in the study group emphasizes the necessity of efficient measures, particularly in population at a greater risk of inadequate nutrition, such as iron supplementation and nutritional education aimed at expectant mothers [19]. Enhanced prenatal care programs can mitigate the unfavorable outcomes due to inadequate maternal nutrition, highlighting the importance of timely prenatal care and monitoring maternal health during pregnancy.

Limitations and Future Suggestions

The single-center design of this study may limit the generalizability of the findings to other regions or populations. The use of self-reported dietary data through FFQs may have introduced recall bias. Moreover, the Food Frequency Questionnaire was not specifically adapted or validated for the local population, which may affect the accuracy of dietary pattern classification. In addition, biochemical markers beyond hemoglobin (e.g., ferritin, vitamin D, folate levels) were not measured due to resource constraints, which might have provided a more comprehensive nutritional profile. Future studies should include multicenter cohorts with larger sample sizes and incorporate longitudinal dietary monitoring along with detailed micronutrient analyses. Interventional studies evaluating the impact of nutritional counseling or supplementation programs on maternal and neonatal outcomes would also be beneficial in guiding public health policies, especially for populations at greater risk of nutritional deficiencies.

Conclusion

This study emphasizes the importance of balanced nutrition throughout pregnancy and the substantial influence that maternal dietary patterns have on neonatal health. Infants born to mothers with balanced diets had higher Apgar scores, longer gestational ages, and better birth weights compared to those whose mothers had imbalanced diets. Maternal anemia was also significantly associated with adverse neonatal outcomes, including low birth weight and preterm birth. These findings underscore the need for improved prenatal nutrition programs, particularly in resource-limited settings, to enhance maternal and neonatal health outcomes. Public health interventions such as routine nutritional screening, culturally appropriate dietary counseling, and targeted supplementation can play a critical role in improving both maternal and child health, and should be prioritized in national maternal health policies.

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