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Effect of Maternal Nutrition and Micronutrient Supplementation on Neonatal Birth Weight and Health

Sanodia Afridi[1*], Sana Rehman Joya[2], Bela Inayat[3], Sara Mariyum[4], Ommia Kalsoom[5] and Hajra Imtiaz[6]

[1]Department of Obstetrics and Gynaecology, Health Net Hospital, Peshawar, Pakistan
[2]Department of Community Health Sciences, Peshawar Medical College, Peshawar, Pakistan
[3]Department of Biochemistry, Khyber Girls Medical College, Peshawar, Pakistan
[4]Department of Biochemistry, Swat Medical College, Swat, Pakistan
[5]Department of Physiology, Women Medical College, Abbottabad, Pakistan
[6]Department of Medical Education, Muhammad College of Medicine, Peshawar, Pakistan

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***Corresponding Author:**

Sanodia Afridi
Department of Obstetrics and Gynaecology, Health Net Hospital, Peshawar, Pakistan
sanodia.afridi@gmail.com

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ABSTRACT

Maternal nutrition significantly influences fetal growth, birth weight, and neonatal health. Deficiencies in iron, calcium, folic acid, and vitamin D increase the risks of preterm birth, low birth weight, and neonatal complications. **Objective:** To assess the impact of maternal micronutrient supplementation on neonatal birth weight and health outcomes. **Methods:** A quasi experimental study was conducted at Health Net Hospital, Peshawar. A total of 110 pregnant women were recruited (59 supplemented, 51 non-supplemented). Data on maternal dietary intake, weight gain, and micronutrient consumption were collected. Neonatal birth weight, gestational age, NICU admissions, and morbidity were recorded. Statistical analysis was performed using SPSS version 25.0, with independent t-tests and chi-square tests ($p<0.05$ considered significant). **Results:** Neonates in the supplemented group had significantly higher birth weights (3343.54 ± 407.90 g vs. 2825.63 ± 322.46 g, $p<0.001$). NICU admissions were lower in the supplemented group (6.8% vs. 43.1%, $p<0.001$). Neonatal morbidity, including infections, jaundice, and respiratory distress, was significantly lower in the supplemented group ($p<0.001$). **Conclusions:** Micronutrient supplementation during pregnancy improves neonatal birth weight and reduces neonatal morbidity. These findings highlight the need for targeted maternal nutrition strategies to improve neonatal outcomes, particularly in resource-limited settings.

INTRODUCTION

Maternal nutrition plays a crucial role in fetal growth and development, influencing pregnancy outcomes such as birth weight, preterm birth, and neonatal morbidity [1]. In many underdeveloped nations, low birth weight (LBW), small for gestational age (SGA) infants, and neonatal mortality remain significant public health concerns [2]. The prevalence of LBW varies between 6% and 30%, often attributed to intrauterine growth restriction (IUGR) [3,4]. Although full-term SGA infants may not face the same complications as preterm infants, they still have a higher risk of perinatal asphyxia, hypoglycemia, and increased neonatal mortality [5]. Nutrient deficiencies during pregnancy lead to placental dysfunction, restricted fetal growth, and increased medical complications [6]. Iron deficiency, the most common maternal nutritional deficit, affects nearly half of all pregnant women globally, contributing to maternal anemia, increased infection risks, and adverse pregnancy outcomes such as preterm birth and low birth weight. Calcium deficiency is associated with hypertensive disorders, fetal growth restriction, and

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preterm birth. Vitamin D is essential for fetal skeletal development and immune function, with deficiencies increasing the risk of neonatal respiratory issues and low birth weight. Folic acid is vital for neural tube development and fetal growth, improving birth outcomes [7]. Despite global initiatives, micronutrient deficiencies remain prevalent in resource-limited areas. Standard prenatal care typically includes iron-folic acid supplements, but research suggests that additional supplementation with calcium and vitamin D may further reduce complications. However, there is ongoing debate regarding the optimal combination and dosage of micronutrient supplements, with some studies suggesting diminishing returns when multiple nutrients are combined.

This study aimed to evaluate the effects of maternal supplementation with iron, calcium, folic acid, and vitamin D on neonatal birth weight and health outcomes, providing evidence to guide improved maternal nutrition strategies.

METHODS

This quasi experimental study was conducted at Health Net Hospital, Peshawar, from January, 2024, to January, 2025. It assessed the impact of maternal micronutrient supplementation on neonatal birth weight and health outcomes. A convenience sampling technique was used to recruit pregnant women from the hospital's antenatal clinic. The sample size was calculated using OpenEpi, based on National Nutrition Survey (NNS) 2018 data [8]. The sample size was calculated using a 95% confidence interval (Z = 1.96), a prevalence of iron deficiency anemia (p = 0.49) based on the National Nutrition Survey (NNS) 2018, and a margin of error (d = 0.10). The calculated minimum sample size was 100 participants, ensuring 80% power. A total of 110 pregnant women were recruited (59 supplemented, 51 non-supplemented). Ethical approval was obtained from the Hospital Ethics Review Committee (Reference: 3003/HNH/HR). Participants provided written informed consent. Group Assignment: Supplemented group: Women following a prescribed iron, folic acid, calcium, and vitamin D supplementation regimen. Non-supplemented group: Women with irregular or no supplementation. Assignment method: Based on self-reported intake, verified through medical records and antenatal follow-ups. Adherence was monitored using: Monthly follow-up interviews, Prescription record checks and Pill count method (for hospital-supplied supplements). Participants with <80% adherence were classified as non-adherent. Inclusion Criteria Pregnant women aged 18-40 years. Singleton pregnancies without congenital anomalies. Attending antenatal care at Health Net Hospital. Exclusion Criteria Chronic diseases (diabetes, hypertension). Fetal anomalies detected via ultrasound. Special medical diets affecting study variables.Multiple gestations (twins, triplets, etc.). Maternal characteristics: Age, education, socioeconomic status, occupation, antenatal visits. Dietary intake: 24-hour recall and Food Frequency Questionnaire (FFQ). Anthropometry: Pre-pregnancy BMI (self-reported), pregnancy weight gain (recorded at each visit). Blood samples were collected twice (1st and 3rd trimester) and analyzed for: Hemoglobin (Hb) (automated hematology analyzer), Serum ferritin (ELISA method), Serum calcium (colorimetric assay) and Vitamin D (chemiluminescence immunoassay). All analyses followed strict quality control protocols. Neonatal Outcome Assessment, Birth weight: Measured via calibrated electronic scale (within 1 hour of birth). Anthropometry: Length and head circumference measured using an infantometer and measuring tape. APGAR scores: Assessed at 1 and 5 minutes post-birth. Neonatal morbidity: Evaluated using clinical assessment + standardized diagnostic criteria, including Infections (lab-confirmed cultures). Jaundice (bilirubin levels, phototherapy need) and Respiratory distress (arterial blood gas tests). All collected data were entered and analyzed using SPSS version 25.0. Means, standard deviations, and frequencies were calculated. Comparisons: Independent t-tests for continuous variables: Maternal age, weight gain, dietary intake (calories, protein, carbohydrates, fats), micronutrient intake (iron, calcium, folic acid, vitamin D), and neonatal birth weight. Chi-square tests for categorical variables: Maternal education level, socioeconomic status, occupation, residence type, antenatal care visits, adherence to supplementation, food frequency score, birth weight category, gestational age category, NICU admission, neonatal morbidity (infections, jaundice, respiratory distress), APGAR score category, APGAR scores categorized as follows: Low (0-3) – Severe distress, Moderate (4-6) – Some distress requiring intervention and Good (7-10) – Normal neonatal adaptation mode of delivery, gestational diabetes, hypertension, and maternal smoking. To explore the relationship between maternal weight gain and neonatal birth weight, Pearson correlation analysis was performed. Additionally, multiple linear regression analysis was conducted to examine whether maternal weight gain and supplementation status independently predicted neonatal birth weight. The relationship between socioeconomic status, antenatal care visits, and supplementation adherence was assessed using Chi-square tests. Multiple Comparison Adjustment to reduce Type I errors, Bonferroni correction was applied where multiple comparisons were conducted. A p-value < 0.05 was considered statistically significant.

RESULTS

Maternal age was significantly lower in the supplemented group (27.15 ± 4.18 years vs. 32.13 ± 3.42 years, $p < 0.001$). Socioeconomic status also showed a significant association with supplementation ($p = 0.016$), with 49.0% of non-supplemented mothers belonging to the low-income group compared to 25.4% in the supplemented group. More urban mothers were in the supplemented group (76.3% vs. 56.9%, $p = 0.031$). Antenatal care visits were significantly higher in the supplemented group ($p = 0.001$), with 55.9% having 7-9 visits compared to 29.4% in the non-supplemented group. These findings suggest that socioeconomic status and antenatal visits influenced supplementation adherence.

Table 1: Demographic Variables and Antenatal Care Visits (n=110)

Variables	Category	Supplemented Group (Mean ± SD)/ Frequency (%)	Non-Supplemented Group (Mean ± SD)/ Frequency (%)	p-Value
Maternal Age (Years)	Age	27.15 ± 4.18	32.13 ± 3.42	<0.001
Maternal Education Level	No Formal	3 (5.1%)	1 (2.0%)	0.411
	Primary	17 (28.8%)	16 (31.4%)	
	Secondary	25 (42.4%)	27 (52.9%)	
	Higher	14 (23.7%)	7 (13.7%)	
Socioeconomic Status	Low	15 (25.4%)	25 (49.0%)	0.016
	Middle	33 (55.9%)	23 (45.1%)	
	High	11 (18.6%)	3 (5.9%)	
Occupation of Mother	Housewife	36 (61.0%)	26 (51.0%)	0.305
	Labourer	9 (15.3%)	7 (13.7%)	
	Office Worker	11 (18.6%)	10 (19.6%)	
	Other	3 (5.1%)	8 (15.7%)	
Residence Type	Urban	45 (76.3%)	29 (56.9%)	0.031
	Rural	14 (23.7%)	22 (43.1%)	
Antenatal Care Visits	1-3 visits	6 (10.2%)	9 (17.6%)	0.001
	4-6 visits	11 (18.6%)	25 (49.0%)	
	7-9 visits	33 (55.9%)	15 (29.4%)	
	10+ visits	9 (15.3%)	2 (3.9%)	

Supplemented mothers had higher weight gain (14.06 ± 2.12 kg vs. 9.26 ± 1.86 kg, $p < 0.001$) and greater caloric intake (2406.16 vs. 1770.55 kcal/day, $p < 0.001$). Protein, carbohydrate, fat, and micronutrient intake (iron, calcium, folic acid, vitamin D) were also significantly higher ($p < 0.001$). Adherence to supplementation was significantly better (84.7% vs. 52.9%, $p < 0.001$). Higher food frequency scores in the supplemented group ($p < 0.001$) reflected improved dietary diversity.

Table 2: Maternal Nutrition and Micronutrient Supplementation (n=110)

Variables	Supplemented Group (Mean ± SD)	Non-Supplemented Group (Mean ± SD)	p-Value
Maternal Weight Gain (Kg)	14.06 ± 2.12	9.26 ± 1.86	<0.001
Dietary Intake (Calories/Day)	2406.16 ± 167.73	1770.55 ± 188.24	<0.001
Protein Intake (g/Day)	84.60 ± 7.55	59.06 ± 8.46	<0.001
Carbohydrate Intake (g/Day)	347.82 ± 41.48	243.69 ± 44.01	<0.001
Fat Intake (g/Day)	78.15 ± 9.38	54.24 ± 8.49	<0.001
Iron Intake (mg/Day)	27.93 ± 3.60	12.41 ± 3.43	<0.001
Calcium Intake (mg/Day)	1380.64 ± 196.31	772.87 ± 139.53	<0.001
Folic Acid Intake (mcg/Day)	562.95 ± 90.64	251.68 ± 68.34	<0.001
Vitamin D Intake (IU/Day)	1209.05 ± 189.85	484.02 ± 112.15	<0.001
Adherence to Supplementation	9 (15.3%)	24 (47.1%)	<0.001
	50 (84.7%)	27 (52.9%)	
Food Frequency Score	6 (10.2%)	20 (39.2%)	<0.001
	22 (37.3%)	23 (45.1%)	
	31 (52.5%)	8 (15.7%)	

Multiple linear regression analysis examined maternal weight gain, neonatal birth weight, and supplementation status. The model was statistically significant ($F(2,107) = 78.443$, $p<0.001$), explaining 59.5% of the variance in maternal weight gain ($R^2 = 0.595$). Supplementation status was a significant predictor ($B = -4.996$, $p < 0.001$), indicating that supplemented mothers gained less weight than non-supplemented mothers. Neonatal birth weight was not an independent predictor of maternal weight gain ($B = 0.000$, $p = 0.480$).

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Table 3: Multiple Linear Regression Analysis for Predicting Maternal Weight Gain

Predictor Variables	B (Unstandardized Coefficient)	Standard Error	Beta	t	p-Value	95% Confidence Interval
Constant	20.290	2.099	-	9.665	<0.001	(16.129, 24.452)
Group (1=Supplemented, 0=Non -Supplemented)	-4.996	0.470	-0.800	-10.638	<0.001	(-5.927, -4.065)
Neonatal Birth Weight (g)	0.000	0.001	-0.053	-0.709	0.480	(-0.001, 0.001)

Neonates of supplemented mothers had significantly higher birth weights (3343.54 ± 407.90 g vs. 2825.63 ± 322.46 g, $p < 0.001$). However, birth weight categories (low birth weight, normal, macrosomia) did not show a significant difference ($p = 0.470$). Despite the higher mean birth weight in the supplemented group, the distribution across birth weight categories remained similar, likely due to a narrow range in birth weights among participants. NICU admissions were significantly lower in the supplemented group (6.8% vs. 43.1%, $p < 0.001$), and neonatal morbidity (infections, jaundice, respiratory distress) was significantly lower among supplemented neonates ($p < 0.001$). However, maternal health conditions and access to healthcare services may have influenced these findings, as hypertension was significantly higher in the non-supplemented group (21.6% vs. 6.8%, $p = 0.024$). APGAR scores did not show a significant difference ($p = 0.096$), possibly because the sample primarily included term neonates with generally stable health at birth.

Table 4: Neonatal Birth Outcomes (n=110)

Variables	Category	Supplemented Group (Mean ± SD)/ Frequency (%)	Non-Supplemented Group (Mean ± SD)/ Frequency (%)	p-Value
Neonatal Birth Weight (g)	Mean	3343.54 ± 407.90	2825.63 ± 322.46	<0.001
Birth Weight Category	Low (<2500g)	4 (6.8%)	7 (13.7%)	0.470
	Normal (2500-4000g)	52 (88.1%)	42 (82.4%)	
	Macrosomia (>4000g)	3 (5.1%)	2 (3.9%)	
Gestational Age Category	Preterm (<37 weeks)	5 (8.5%)	8 (15.7%)	0.397
	Term (37-42 weeks)	48 (81.4%)	40 (78.4%)	
	Post-term (>42 weeks)	6 (10.2%)	3 (5.9%)	
NICU Admission	No	55 (93.2%)	29 (56.9%)	<0.001
	Yes	4 (6.8%)	22 (43.1%)	
Neonatal Morbidity	Infections	3 (5.1%)	9 (17.6%)	<0.001
	Jaundice	8 (13.6%)	19 (37.3%)	
	Respiratory Distress	8 (13.6%)	11 (21.6%)	
	None	40 (67.8%)	12 (23.5%)	
APGAR Score Category	Low (0-3)	1 (1.7%)	5 (9.8%)	0.096
	Moderate (4-6)	10 (16.9%)	12 (23.5%)	
	Good (7-10)	48 (81.4%)	34 (66.7%)	

Fewer caesarean sections occurred in the supplemented group (25.4% vs. 52.9%, $p = 0.003$), while hypertension was significantly lower in supplemented mothers (6.8% vs. 21.6%, $p = 0.024$). Gestational diabetes and maternal smoking did not show significant differences between groups.

Table 5: Mode of Delivery and Other Confounders (n=110)

Variables	Category	Supplemented Group Frequency (%)	Non-Supplemented Group Frequency (%)	p-Value
Mode of Delivery	Vaginal	44 (74.6%)	24 (47.1%)	0.003
	Caesarean	15 (25.4%)	27 (52.9%)	
Gestational Diabetes	No	53 (89.8%)	42 (82.4%)	0.254
	Yes	6 (10.2%)	9 (17.6%)	
Hypertension in Pregnancy	No	55 (93.2%)	40 (78.4%)	0.024
	Yes	4 (6.8%)	11 (21.6%)	
Maternal Smoking	No	57 (96.6%)	50 (98.0%)	0.646
	Yes	2 (3.4%)	1 (2.0%)	

Figure 1 showed that vaginal deliveries were more common in the supplemented group, while caesarean sections and hypertension were higher in non-supplemented mothers. Gestational diabetes showed no major difference, and maternal smoking was rare in both groups. Nutritional intake was significantly better in the supplemented group, with higher calorie, protein, carbohydrate, fat, iron, calcium, folic acid, and vitamin D intake. This aligned with greater maternal weight gain in this group. Neonatal outcomes reflected these differences, with higher birth weights and fewer NICU admissions among newborns of supplemented mothers. Neonatal morbidity, including infections and jaundice, was more common in the non-supplemented group. The graphs reinforced the positive impact of maternal supplementation on pregnancy and newborn health.

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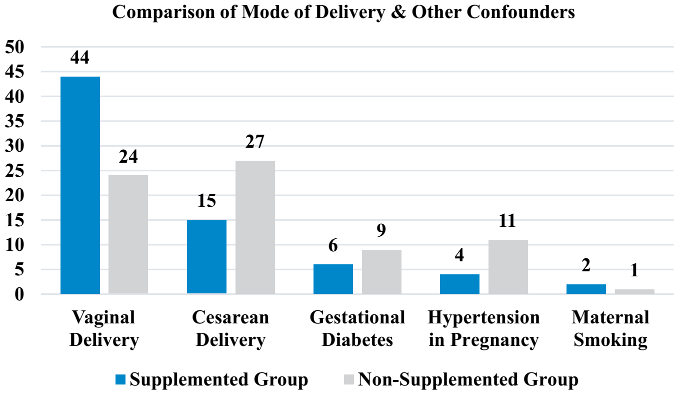

Figure 1: Comparison of Mode of Delivery and Other Confounders between Supplemented and Non-Supplemented Groups

DISCUSSION

This study examined the impact of maternal micronutrient supplementation on neonatal birth weight and health outcomes. Consistent with prior research, supplementation with iron, calcium, folic acid, and vitamin D was associated with higher birth weight, lower neonatal morbidity, and reduced NICU admissions [9,10]. The significant difference in maternal age (27.15 vs. 32.13 years, $p < 0.001$) between groups suggests a possible confounding effect. Younger mothers may have different dietary habits, metabolic responses, or healthcare access compared to older mothers. However, this study did not perform an age-stratified analysis, which remains a limitation. Extensive research supports the beneficial role of iron supplementation in preventing maternal anemia, preterm birth, and low birth weight. A systematic review by Cantor *et al.*, (2024) confirmed that iron supplementation during pregnancy significantly reduces anemia prevalence and improves birth weight outcomes [11]. This study aligned with these findings, as supplemented mothers had higher neonatal birth weights. Calcium supplementation has been shown to reduce hypertensive disorders during pregnancy, fetal growth restriction, and preterm birth [12,14]. Vitamin D plays a crucial role in fetal skeletal development and immune function [16,18]. Studies by Ilardi *et al.*, (2021) found that vitamin D supplementation led to increased birth weight and reduced NICU admissions [19].This study corroborated these findings, as neonates of supplemented mothers had higher birth weights and fewer NICU admissions. Folic acid supplementation is essential for neural tube development and fetal growth. Research by Alvestad *et al.*, and Caniglia *et al.*, indicated that folic acid intake before and during pregnancy reduces intrauterine growth restriction and improves neonatal outcomes [20, 21].This study found similar results, as mothers who received supplementation exhibited improved fetal growth outcomes. Although supplemented neonates had significantly higher mean birth weights ($p < 0.001$), the lack of a significant difference in birth weight categories ($p = 0.470$) suggests that supplementation may improve overall fetal growth but not necessarily shift neonates into different weight categories. This could be due to a relatively homogenous population in terms of gestational nutrition and healthcare access. NICU admissions were significantly lower in the supplemented group ($p < 0.001$). While supplementation likely contributed to this outcome, maternal health conditions such as hypertension, which was more prevalent in non-supplemented mothers ($p = 0.024$), could also be a confounding factor. Women with hypertension are at higher risk of preterm birth and fetal growth restriction, both of which increase NICU admissions [22,23]. APGAR scores showed no significant difference between groups ($p = 0.096$), indicating that maternal supplementation may not directly impact immediate neonatal adaptation post-delivery [24, 25]. Given that most neonates were full-term, they were likely to have stable postnatal transitions, reducing the likelihood of supplementation influencing APGAR scores. Clinically, these findings highlight the importance of micronutrient supplementation in pregnancy. This study was limited by its hospital-based design, which may affect generalizability to other populations. Additionally, maternal BMI was not analyzed, and while maternal weight gain correlated with neonatal birth weight ($r = 0.407$, $p < 0.001$), it was not an independent predictor in the regression model. Future research should incorporate BMI-adjusted models to further explore these relationships.

CONCLUSIONS

In conclusion, maternal micronutrient supplementation produces crucial effects that benefit both newborn weight and health outcomes. Supplementing pregnant mothers with iron and calcium, folic acid and vitamin D resulted in infants with increased birth weights along with decreased medical complications and reduced newborn for Intensive Care admission. The study findings confirm that proper maternal dietary care during pregnancy remains vital, especially in situations with widespread micronutrient deficiencies. The implementation of proper supplements minimizes the chances of negative birth results such as low birth weight, preterm birth and neonatal complications.

Authors Contribution

Conceptualization: SA
Methodology: HI
Formal analysis: SRJ
Writing, review and editing: SRJ, BI, SM, OK, HI

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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