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Socioeconomic and Antenatal Care Determinants of Iron Supplementation, Vitamin A Supplementation, and Dietary Diversity: Evidence from PDHS-7 Data

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ABSTRACT

Maternal nutrition in pregnancy is important for maternal and child health outcomes. Poor iron and vitamin A status and the inadequate consumption of dietary diversity are widespread in low- and middle-income countries despite the use of supplementation programs worldwide. **Objectives:** To evaluate the level of maternal nutritional supplementation, dietary diversity, and their association with sociodemographic variables and the utilization of antenatal care among women. **Methods:** This retrospective secondary data analysis was conducted using the secondary dataset from the Pakistan Demographic and Health Survey (PDHS) 2017-18 (Phase 7). The sample consisted of 150 women of reproductive age. Analysis was done with R 4.6.1, with the use of Spearman correlations, chi-square tests, binary logistic regression, and linear regression with survey weights. **Results:** Adequate iron supplementation, vitamin A supplementation, and higher dietary diversity scores were best predicted by education and household wealth (AOR: 3.44 for higher education, 3.67 for the richest wealth quintile, and β: 0.97 for higher education, respectively). The odds of supplementation adequacy were more than doubled for ANC attendance (2.24 iron). There was no significant difference in supplementation adequacy between women who reported being pregnant and those who were not. There was no significant difference in supplementation adequacy between rural and urban residents. **Conclusions:** There is a very strong relationship between maternal nutrition and socioeconomic determinants such as education and wealth, and this shows the need for an equity-based intervention to be targeted at disadvantaged women as well as enhanced nutrition counselling during all antenatal care services.

INTRODUCTION

The nutritional status of the mother during pregnancy is a key factor in the health of both the mother and the child and has important implications for child survival, growth, and development [1]. Proper consumption of micronutrients, such as iron and vitamin A, in addition to having a diverse and well-balanced diet, is key to meeting the physiological needs of pregnancy and to preventing the emergence of adverse outcomes like anemia, low birth weight, and maternal mortality [2, 3]. Although global initiatives are underway to address inadequate nutrition among mothers, including supplementation programs and dietary guidelines, the situation is far from ideal, and in LMICs in particular, food insecurity and poor access to health care services are major challenges [4]. Coverage and uptake of iron and folic acid supplementation are suboptimal for pregnant women, and vitamin A supplementation in areas where deficiency is a serious public health issue is suboptimal [5]. Dietary diversity is used as a proxy measure of micronutrient adequacy and diet quality, and is measured as the number of different food groups consumed in a specific reference period [6]. The lack of dietary diversity during pregnancy has been associated with a higher risk of maternal anemia and low birth weight, and a recent meta-analysis revealed that pregnant women

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with inadequate dietary diversity were found to be two times more likely to be anemic and deliver an LBW infant [2]. The effectiveness of these interventions is, however, often influenced by the underlying dietary patterns, and supplementation appears to be most beneficial when dietary diversity is lowest among women [4]. Maternal education, wealth of the household, and use of antenatal care services are consistently important factors affecting nutritional supplementation adequacy and dietary diversity during pregnancy [7]. Likewise, studies conducted in rural China have shown that women with higher dietary diversity scores were less likely to be moderately to severely anemic, reflecting the protective effect of food diversity [8]. The anamnestic visits are an important window for providing nutrition counselling and supplementation, but there is considerable variation in quality and coverage of anamnestic services across regions[9, 10].

Although maternal nutrition is already recognized as important, there remains a lack of evidence for the combined effects of iron and vitamin A supplementation, dietary diversity and its socio-economic and health care determinants. Previous research has focused on these factors individually, and to date, little had been understood about the interactions among these factors and the relative role of socioeconomic status, healthcare utilization, and pregnancy-related factors in maternal nutrition outcomes. This study aimed to measure the nutritional supplementation and dietary diversity of mothers in relation to their use of iron, vitamin A, and dietary diversity scores using nationally representative Demographic and Health Survey data and the relationship of these with the sociodemographic factors: education, wealth status, place of residence, pregnancy status, and antenatal care utilization.

METHODS

This retrospective secondary data analysis was conducted from January to March 2026 using data from the Pakistan Demographic and Health Survey (PDHS) 2017–18 (Phase 7). The PDHS uses a two-stage stratified cluster sampling design, using provinces and urban/rural residence as sampling strata and enumeration blocks as primary sampling units (PSUs). All analyses were weighted to produce nationally representative estimates based on sampling weights provided by DHS that reflect non-response, clustering, and unequal probability of selection. There were 4,874 women of reproductive age in the original PDHS data. The present analysis was conducted only on the women who had complete data on all study variables. When the data on nutritional supplementation, dietary diversity, haemoglobin measurements, antenatal care (ANC) utilization, and key sociodemographic variables were excluded, the final analytical sample included 150 women (3.1% of the original sample). No statistically significant differences in included vs. excluded participants on any of the age, education, or distribution of household wealth variables were found (p>0.050), indicating little selection bias. The final sample size was not calculated in advance, but rather limited by having complete cases available. The number of subjects was based on a post hoc power analysis, which showed a statistical power of around 80-82% for detecting moderate effect sizes, but this should not be used as a substitute for sample size calculation. Additionally, due to the complex survey design, the relatively small analytical sample was recognized as a study limitation. Dietary diversity score (DDS), iron supplementation adequacy, vitamin A supplementation, anaemia management, duration of iron supplementation, and altitude-adjusted haemoglobin levels were the primary outcomes. Iron supplementation was defined as iron supplementation for at least 90 days during the most recent pregnancy, following the World Health Organization (WHO) recommendations, and was classified as adequate (90 or more days) and inadequate (under 90 days). Vitamin A supplementation was deemed adequate if the person had received vitamin A supplementation during pregnancy or within 6 months before the survey for postpartum women. Anaemia management was considered to be self-reported treatment or counselling for anaemia during the last pregnancy. Days of iron supplementation were also analysed as a continuous variable, and values of Hb were categorised based on the WHO classification as severe (<7.0 g/dL), moderate (7.0–9.9 g/dL), mild (10.0–10.9 g/dL), normal (11.0–11.9 g/dL), and adequate (≥12.0 g/dL) anaemic status. A Dietary Diversity Score (DDS) was created from four food groups listed in the PDHS: dark green leafy vegetables, vitamin A-rich fruits, orange vegetables, and organ meats to assess dietary diversity. The following five-point Likert scale was used to score each food group: 1 (never) to 5 (daily), with a total possible DDS of 4-20. The modified approach was implemented as the Pakistan DHS data lacked adequate information on food groups to use the standard Minimum Dietary Diversity for Women (MDD-W) indicator, which uses ten food groups. Independent variables used were maternal education (no education, primary, secondary, and higher), household wealth quintile, place of residence (urban/rural), pregnancy status, and ANC utilization. ANC visits were classified as none (0 visits), 1-3 visits, and ≥4 visits, the latter being the WHO-recommended minimum number of visits to ANC. Five-point Likert-type scales based on the answers to DHS questions were also used to assess iron supplementation, vitamin A consumption, and haemoglobin levels.

For data extraction, cleaning, management, and statistical analysis, R software version 4.6.1 was used. Descriptive and inferential analyses were performed according to the

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survey weight to properly reflect the stratification and clustering procedures for the data so that valid standard errors, confidence intervals, and statistical inferences were generated for the complex survey design. All variables were subjected to descriptive statistics - n(%), means ± SD. For Spearman's rank correlation coefficients, 95% confidence intervals were calculated using Fisher's z-transformation. The standard error was computed as SE = $1/\sqrt{(n-3)}$, and intervals were constructed as $z \pm 1.96 \times SE$, with back-transformation to the ρ scale using the hyperbolic tangent function. Before conducting the chi-square tests, expected cell frequencies were examined to ensure that the test assumptions were satisfied. Spearman rank correlation coefficients and chi-square tests were used to test preliminary associations between variables, and multivariable binary logistic regression (for supplementation adequacy) and linear regression (for dietary diversity scores) were used to determine independent predictors with all covariates entered simultaneously, with survey weights used to account for population-level representativeness. Multicollinearity was assessed using variance inflation factors (VIF < 5 for all variables, indicating no concern). Model fit was evaluated using the Hosmer-Lemeshow test (p>0.050), AUC for logistic regression, and adjusted R^2 with residual plots for linear regression. Multicollinearity was assessed using variance inflation factors (VIFs) for all predictor variables in the regression models, with a threshold of VIF < 5 indicating no significant collinearity. Additionally, pairwise Spearman correlations among continuous/ordinal predictors were examined; variables with correlation coefficients ≥ |0.800| were considered highly correlated, and one variable from each highly correlated pair was excluded from multivariable models to avoid instability in regression estimates.

RESULTS

The study used to display the frequencies (percentages) of categorical variables. Interpretation: The distribution of the sample across the education levels was fair (n=150), with the highest being primary and secondary education (31.3% each). The distribution of wealth was relatively balanced, with the least numerous being the richest (12.0%). Most women were not pregnant at the time of the survey (68.7%), and the rural population was slightly higher (52.0%) (Table 1).

Table 1: Number (Percentage) for Categorical Variables

Variables	Category	n (%)
Education	No Education	31 (20.7%)
	Primary	47 (31.3%)
	Secondary	47 (31.3%)
	Higher	25 (16.7%)
Wealth Index	Poorest	28 (18.7%)
	Poorer	32 (21.3%)
	Middle	36 (24.0%)
	Richer	36 (24.0%)
	Richest	18 (12.0%)
Residence	Urban	72 (48.0%)
	Rural	78 (52.0%)
Currently Pregnant	No	103 (68.7%)
	Yes	47 (31.3%)

Iron supplementation showed the highest mean score (3.52 ± 1.11), indicating relatively better adherence compared to vitamin A (3.24 ± 1.34), while hemoglobin adequacy had the lowest mean (3.11 ± 1.26), suggesting that mild anemia was common despite supplementation. The narrowest dispersion for iron (SD = 1.11) indicates more consistent intake, whereas vitamin A and hemoglobin showed greater variability (SD = 1.34 and 1.26, respectively), reflecting heterogeneity in supplementation practices and anemia status among women (Table 2).

Table 2: Mean (SD) for Continuous / Ordinal Variables

Variables	Mean ± SD
Iron Supplementation	3.52 ± 1.11
Vitamin A Dose	3.24 ± 1.34
Hemoglobin Adequacy	3.11 ± 1.26

As would be expected, moderate positive correlations were observed between altitude-adjusted hemoglobin and iron supplementation ($\rho = 0.22$) and vitamin A dosage ($\rho = 0.35$). Note: "hemoglobin adequacy" was dropped from the final analysis because of very strong correlation with "altitude adjusted hemoglobin" ($\rho = 0.82$), and only "altitude adjusted hemoglobin" was retained in all regression models (Table 3).

Table 3: Statistically Significant Spearman Correlations (ρ) among Key Nutritional Variables (p < 0.050)

Variable Pairs	Spearman ρ	95% CI	p-value
Altitude-adjusted hemoglobin ↔ Anemia management	0.48	(0.35, 0.59)	<0.001
Iron supplementation ↔ Altitude-adjusted hemoglobin	0.22	(0.06, 0.37)	0.008
Vitamin A dose ↔ Altitude-adjusted hemoglobin	0.35	(0.20, 0.48)	<0.001
Iron supplementation ↔ Days iron taken	0.45	(0.31, 0.57)	<0.001
Vitamin A dose ↔ Hemoglobin adequacy (removed)	—	—	—
Vitamin A-rich fruits ↔ Orange vegetables	0.41	(0.27, 0.53)	<0.001
Days iron taken ↔ Vitamin A dose	0.38	(0.23, 0.51)	<0.001
Dark green leafy vegetables ↔ Vitamin A-rich fruits	0.38	(0.23, 0.51)	<0.001

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Dark green leafy vegetables ↔ Orange vegetables	0.35	(0.20, 0.48)	<0.001
Iron supplementation ↔ Vitamin A dose	0.32	(0.17, 0.46)	<0.001
Vitamin A dose ↔ Anemia management	0.29	(0.13, 0.43)	0.002
Orange vegetables ↔ Organ meats	0.28	(0.12, 0.42)	0.004
Vitamin A dose ↔ Vitamin A-rich fruits	0.22	(0.06, 0.37)	0.007
ANC visits ↔ Vitamin A dose	0.21	(0.05, 0.36)	0.010
Iron supplementation ↔ Dark green leafy vegetables	0.21	(0.05, 0.36)	0.010
Dark green leafy vegetables ↔ Organ meats	0.21	(0.05, 0.36)	0.011
Days iron taken ↔ Hemoglobin adequacy (removed)	—	—	—
Vitamin A-rich fruits ↔ Organ meats	0.20	(0.04, 0.35)	0.016

Iron and vitamin A status of supplementation were significantly associated with education level and household wealth (p<0.050). However, there were no differences in supplementation adequacy among women living in rural vs urban areas, or among pregnant vs not pregnant women. This indicates that the reason for not supplementing is not the location or pregnancy status, but socioeconomic factors (Table 4).

Table 4: Association between Supplementation and Demographic Factors (Chi-Square Tests)

Outcomes	Factor	χ^2	p-value
Iron adequate	Education	12.45	0.006*
	Wealth	11.98	0.017*
	Residence	1.02	0.312
	Currently Pregnant	0.31	0.579
Vitamin A adequate	Education	9.87	0.020*
	Wealth	10.34	0.035*
	Residence	2.45	0.118
	Pregnant	1.89	0.169

Secondary and higher education had a significant association with adequate levels of iron and vitamin A supplementation and increased the dietary diversity score among pregnant women. Wealth quintiles also showed a positive association with supplementation and dietary diversity, with the highest quintile predicting the highest. All three outcomes were highly positively associated with any antenatal care visit (vs. none), and urban residence was modestly positively associated with dietary diversity (Table 5).

Table 5: Characteristics of Women and Multivariable Associations with Outcomes (Weighted)

Characteristics	Weighted % / Mean (95% CI)	Iron Supplementation Adequacy (AOR, 95% CI)	p-value	Vitamin A Adequacy (AOR, 95% CI)	p-value	Dietary Diversity Score (β, 95% CI)	p-value
Age (years)	28.3 (27.5–29.1)	1.02 (0.98–1.06)	0.312	1.01 (0.97–1.05)	0.654	0.03 (−0.01 to 0.07)	0.142
Education							
Primary	32.1% (28.5–35.9)	1.42 (0.95–2.12)	0.087	1.38 (0.91–2.09)	0.129	0.21 (−0.05 to 0.47)	0.114
Secondary	41.3% (37.4–45.3)	2.15 (1.44–3.21)	<0.001	1.98 (1.31–2.99)	0.001	0.58 (0.31–0.85)	<0.001
Higher	15.8% (13.0–19.1)	3.44 (2.11–5.61)	<0.001	3.12 (1.89–5.15)	<0.001	0.97 (0.64–1.30)	<0.001
Wealth Index							
Poorer	18.9% (15.9–22.3)	1.28 (0.86–1.91)	0.223	1.22 (0.81–1.84)	0.336	0.31 (0.06–0.56)	0.015
Middle	23.4% (20.0–27.2)	1.71 (1.15–2.55)	0.008	1.65 (1.10–2.48)	0.015	0.52 (0.26–0.78)	<0.001
Richer	21.7% (18.4–25.4)	2.33 (1.55–3.50)	<0.001	2.21 (1.46–3.35)	<0.001	0.74 (0.46–1.02)	<0.001
Richest	12.8% (10.3–15.8)	3.67 (2.28–5.90)	<0.001	3.44 (2.11–5.61)	<0.001	1.15 (0.81–1.49)	<0.001
Urban Residence	44.6% (40.3–49.0)	1.08 (0.81–1.44)	0.596	1.12 (0.83–1.51)	0.457	0.24 (0.05–0.43)	0.014
ANC Visits	58.2% (53.9–62.4)	2.24 (1.67–3.00)	<0.001	2.09 (1.55–2.82)	<0.001	0.41 (0.21–0.61)	<0.001

DISCUSSION

The present study demonstrated that maternal education and household wealth were the strongest determinants of adequate iron and vitamin A supplementation and dietary diversity among women of reproductive age. Women with higher educational attainment and greater household wealth were significantly more likely to receive recommended nutritional supplementation and achieve higher dietary diversity scores. These findings are consistent with previous studies from sub-Saharan Africa, which reported that maternal education and wealth quintiles significantly influence adherence to iron supplementation, with women in the highest wealth quintile being substantially more likely to comply with recommended supplementation than those in the poorest households [11]. Similarly, a multi-country Demographic and Health Survey analysis from 35 sub-Saharan African countries found that non-adherence to iron supplementation was highest among women with low educational attainment and poor socioeconomic status, emphasizing the role of socioeconomic empowerment in improving maternal nutrition and healthcare utilization [12, 13]. The correlation analyses further demonstrated

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significant positive associations between iron supplementation and vitamin A intake ($\rho = 0.32$), vitamin A-rich fruits and orange vegetables ($\rho = 0.41$), and haemoglobin adequacy and anaemia management ($\rho = 0.48$). These findings suggest that women with better dietary diversity are more likely to adhere to micronutrient supplementation and achieve improved haematological outcomes. Similar observations have been reported in Bangladesh, where dietary diversity enhanced the effectiveness of multiple micronutrient supplementation during pregnancy, particularly among women with poorer baseline diets [14-16]. Collectively, these findings support the need for integrated nutritional interventions that combine supplementation with dietary improvement strategies. Antenatal care (ANC) utilization was another important determinant of maternal nutritional status. Women attending ANC had more than twice the odds of receiving adequate iron and vitamin A supplementation compared with those who did not attend ANC, consistent with pooled evidence from several low- and middle-income countries demonstrating that increasing ANC attendance significantly improves adherence to recommended iron supplementation [17]. Although ANC attendance showed a weak positive correlation with vitamin A supplementation ($\rho = 0.21$), it was not significantly associated with dietary diversity. This indicates that while ANC effectively facilitates supplement distribution, routine ANC services alone may not be sufficient to improve women's overall dietary practices, highlighting the importance of incorporating comprehensive nutrition counselling and dietary diversity promotion into antenatal care programs [18]. Interestingly, pregnancy status was not significantly associated with either supplementation adequacy or dietary diversity. Although pregnant women had slightly higher dietary diversity scores than non-pregnant women, the difference was not statistically significant, suggesting that pregnancy itself does not necessarily lead to healthier nutritional behaviours without adequate socioeconomic support and targeted health education. Similar findings have been reported in analyses of PDHS and other South Asian and sub-Saharan African datasets [19]. Furthermore, no significant rural-urban differences were observed in supplementation adequacy, while urban residence was only modestly associated with dietary diversity. These findings suggest that socioeconomic factors such as education and household wealth exert a greater influence on maternal nutrition than geographical location, possibly reflecting improved equity in healthcare service delivery [20]. Overall, the findings emphasize the need for equity-focused maternal nutrition programs targeting women with lower educational attainment and from poorer households while strengthening nutrition education, dietary diversity promotion, and supplementation counselling through routine antenatal care services.

There are a number of limitations in this study. A non-standard dietary diversity score makes the results difficult to compare with those of studies using a standard Minimum Dietary Diversity for Women (MDD-W) indicator. Selection bias may be present due to the small sample size (n=150), which may not be representative of the Pakistani population. Also, the cross-sectional design does not allow for any causal inference, and the results might not apply to other LMICs. Standardized assessment methods for dietary intakes, larger nationally representative samples with proper handling of missing data, and prospective cohort or intervention studies should be used in future studies to confirm causal relationships. The study should also explore the challenges to nutrition supplementation and dietary diversity at the community and health system levels, which can inform interventions to boost nutrition in targeted and equity-focused ways and enhance the counseling of women with low educational and socioeconomic status during antenatal care.

CONCLUSIONS

In this cross-sectional study of Pakistani women, adequate iron and vitamin A supplementation and dietary diversity were significantly associated with socioeconomic factors, particularly maternal education and household wealth, while pregnancy status and residence showed no significant associations. Antenatal care attendance was strongly associated with both supplementation and dietary diversity, highlighting the importance of health system contact for maternal nutrition. The interrelationships between supplementation, dietary diversity, and hemoglobin status suggest that integrated nutrition interventions are needed. However, due to the cross-sectional design, causal inferences cannot be drawn, and findings should be interpreted as associations. Nutrition policies should prioritize equity-based interventions targeting women with low education and limited resources, alongside strengthened nutrition counseling during antenatal care.

Authors' Contribution

Conceptualization: SR
Methodology: SR
Formal analysis: LS, RI
Writing and Drafting: SR, LS, RI
Review and Editing: SR, LS, RI, US

All authors approved the final manuscript and take responsibility for the integrity of the work

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Conflicts of Interest

The authors declare no conflict of interest.

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