



NUTRITIONAL STATUS, ANEMIA, AND VITAMIN D ABNORMALITIES AMONG WOMEN OF REPRODUCTIVE AGE: FINDINGS FROM QUETTA, PAKISTAN

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Abstract

Background: Women of reproductive age are vulnerable to a range of nutritional problems, including underweight, overweight, anemia, and vitamin D abnormalities. The coexistence of these conditions represents an important public-health challenge, particularly in resource-limited settings. This study assessed nutritional status, anemia, and vitamin D status among women of reproductive age and examined their associations.

Methods: A total of 425 women aged 15–49 years were included in the analysis. Sociodemographic characteristics, body mass index (BMI), nutritional status, anemia status, and vitamin D status were assessed. Descriptive statistics were used to summarize participant characteristics. Associations between nutritional status and anemia or vitamin D status were evaluated using Pearson's chi-square test. Unadjusted odds ratios (ORs) with 95% confidence intervals (CIs) and effect sizes were calculated for binary comparisons. Statistical significance was considered at $p < 0.05$.

Results: Of the 425 participants, 47.1% were overweight, 14.4% were underweight, and 38.6% had normal BMI. Anemia was present in 23.5% of participants, while 21.6% had low vitamin D status, including 15.3% with insufficiency and 6.4% with deficiency. No significant associations were observed between underweight and anemia (OR = 0.77, 95% CI: 0.39–1.51; $p = 0.443$), overweight and anemia (OR = 0.85, 95% CI: 0.54–1.34; $p = 0.483$), or overweight and low vitamin D (OR = 1.16, 95% CI: 0.73–1.84; $p = 0.523$). Participants classified with abnormal nutritional status had significantly higher odds of

low vitamin D than those with normal nutritional status (24.9% vs. 16.5%; OR = 1.68, 95% CI: 1.02–2.77; $p = 0.040$). Underweight participants also showed a higher prevalence of low vitamin D (31.1% vs. 20.1%), although the binary association was borderline ($p = 0.052$). Nutritional status varied significantly across age groups, with underweight more prominent among younger women and overweight increasingly predominant with advancing age ($\chi^2 = 45.08$, $p < 0.001$; Cramér's $V = 0.416$).

Conclusion: The study demonstrates a substantial burden of abnormal nutritional status, anemia, and low vitamin D among women of reproductive age. The significant association between abnormal nutritional status and low vitamin D, together with the age-related shift from underweight toward overweight, highlights the need for comprehensive nutritional assessment. Interventions should address both inadequate and excess nutrition while incorporating appropriate screening for micronutrient abnormalities.

Keywords: Nutritional Status, anemia, vitamin d, reproductive age

Introduction

Nutritional health among women of reproductive age is an important public health concern because inadequate or imbalanced nutrition can affect women's health before, during, and after pregnancy and may have consequences for maternal and reproductive outcomes [1]. Women between 15 and 39 years are particularly vulnerable to nutritional deficiencies because of increased physiological demands associated with menstruation, pregnancy, lactation, and other stages of the reproductive life cycle [2]. At the same time, changes in dietary patterns, physical activity, socioeconomic conditions, and access to healthcare have contributed to the coexistence of undernutrition and overweight or obesity within the same population [3]. This double burden of malnutrition presents a growing challenge, particularly in low- and middle-income settings [4].

Anemia remains one of the most common nutritional and hematological disorders affecting women of reproductive age [5]. Iron deficiency is an important contributor to anemia; however, anemia may also result from deficiencies of other micronutrients, infections, chronic diseases, and physiological conditions [6]. Among women of reproductive age, anemia can contribute to fatigue, reduced physical capacity, impaired quality of life, and adverse maternal and pregnancy-related outcomes [7]. Despite its well-recognized health consequences, anemia continues to affect women in many resource-limited populations, where nutritional inadequacy and barriers to healthcare may increase vulnerability [8].

Vitamin D deficiency and insufficiency represent another important nutritional concern [9]. Although vitamin D is primarily recognized for its role in calcium and bone metabolism, increasing evidence has linked vitamin D status with immune function, metabolic health, and other physiological processes [10]. Vitamin D status may be influenced by dietary intake, sunlight exposure, body composition, lifestyle, and socioeconomic and environmental factors [11]. Importantly, vitamin D insufficiency can occur even in populations with substantial exposure to sunlight, indicating that geographical location alone does not guarantee adequate vitamin D status [12].

Nutritional status may also be associated with micronutrient abnormalities in complex and potentially bidirectional ways. Underweight may reflect inadequate dietary intake or chronic nutritional deprivation, whereas overweight and obesity can coexist with micronutrient deficiencies despite adequate or excessive energy intake [13]. Therefore, assessment of nutritional status using BMI alongside anemia and vitamin D status may provide a more comprehensive understanding of nutritional health than evaluation of any

single indicator alone [14]. However, the relationship between body weight status, anemia, and vitamin D status is not necessarily consistent across populations and may be influenced by demographic, socioeconomic, dietary, and environmental factors.

In Pakistan, nutritional problems among women of reproductive age remain an important concern, with undernutrition and increasing overweight occurring alongside micronutrient deficiencies[15]. However, evidence describing the simultaneous distribution of nutritional status, anemia, and vitamin D status, particularly at the population and subpopulation levels, remains limited in several settings [16]. Furthermore, relatively few studies have examined whether patterns of anemia and vitamin D status differ according to underweight, overweight, and broader nutritional-status categories across different reproductive-age groups [17].

The present study therefore aimed to assess nutritional status, anemia, and vitamin D status among women of reproductive age and to examine their interrelationships. Specifically, the study evaluated the distribution of underweight, overweight, and nutritional status; determined the prevalence of anemia and different levels of vitamin D status; and investigated whether nutritional status was associated with anemia or low vitamin D status. The study also examined variations in nutritional-status patterns across different age groups within the reproductive-age population. By evaluating these indicators together, the study provides a broader assessment of nutritional health and identifies areas that may require greater attention in nutritional screening and public health interventions.

2. Methodology

2.1 Study Population:

The population of Quetta Municipal limits including rural and urban areas was the study area. The reference population was determined from the record of Lady Health Worker Program. The women with reproductive age from 15 to 49 years old were included in the study. After completion of data collection for enhanced elucidation the child bearing age (15-49 years) women were further divided in to 7 sub age groups; the women from 15-19 years of age were placed in group 1, while 20-24 years old were in group 2, group 3 was comprised of 25-29 years old women. Similarly, women with 30-34 years, 35-39 years, 40-44 years and 45-49 years of age were placed in group 4, 5, 6 and 7 respectively. Quetta municipal limits comprised of defined population units known as Halqas / Union councils. Each union council is a collection of households (occupants of a house considered as a unit) and at the time of survey there were overall 265,950 households in the municipal limits of Quetta.

2.2 Inclusion/Exclusion Criteria

Female residing in a household with in reproductive age (15-49 years) and willing to participate in the study were included and whom not willing were excluded.

2.3 Study Type and Duration

The cross sectional study was conducted from November 2018 to October 2019.

2.4 Sample size

The sample size was assessed by employing the formula previously used by [18]. Formula along with calculated sample size is given below;

$$n = \{(4 \times p \times (100-p)) / 25\}$$

Where,

n = Sample Size

P= expected prevalence of malnutrition

If expected prevalence is 50% then n= 400

P = Prevalence rate of Malnutrition

In the current study instead of taking calculated sample size (n= 400), 425 reproductive age women were randomly selected to get more reliable data.

2.5 Data Collection & Variables of Study:

The study was conducted on a cross section of the target household based on convenience. The data regarding socio demographic information and anthropometric measurements of the subjects of the study and the blood samples of the respondents were recorded/ withdrawn by house-to-house visits with the help of trained staff.

2.5.1 Socio demographic information:

Interviews were conducted and the information from the subjects of the study was collected using a pretested well-structured Performa (Annex-1).

2.5.2 Anthropometric measurements:

The anthropometric measurements were taken regarding body weight and height, thereafter calculated body mass index (BMI). Weight was measured in kilograms using Electronic Personal Scale (LAICA LC95) while height was measured in centimeters using Stadiometer (Seca 213, Germany).

2.5.3 Blood Sampling and processing:

Blood approximately 6ml was drawn from the cubital vein and about 3ml was shifted to EDTA containing vacutainer tubes for haematological assessment whereas the other 3ml portion was allowed to clot at room temperature and later kept in refrigerator at 4°C for half an hour, thereafter centrifuged at 1200 RCF for 10 minutes, separated serum and stored at -20°C for further Vitamin-D estimation which was carried out at Bolan Medical Complex Hospital Quetta.

2.5.3.1 The haematological assessment:

The haematological assessments were carried out within 24 hours after blood collection to determine; haemoglobin (Hb), Mean Corpuscular Volume (MCV) and Red Cell Distribution Width (RDW%). For this purpose, the cell counter (CELL-DYN Emerald 031114-005844 Ref.09H39-01, USA) and commercially available kits; lyse (Series Lot 757829 Ref. 09H47-02, Abbot, Germany) and diluent (Series Lot. 770712. Ref.09H48-02, Abbot, USA) were used according to the manufacturers' instructions. Diagnosis of IDA was carried out on the basis of Lab. findings, including Hb, MCV, MCH, MCHC, and RDW, following the diagnosis criteria of (ref) briefly in IDA, there will be a decrease in Hb, MCV, MCH, MCHC, and increase in RDW percentage.

2.5.3.2 Serum Vitamin-D Status Determination:

Vitamin D status of the subjects were determined by taking help of biochemistry analyzer Cobas e 411, (Roche, Germany), and using commercial kits ; Vitamin-D Total (Series Lot43548301, Ref. 05894913 190, Germany) and Cal Set (Series Lot.27896205. Ref. 05894921 190, Germany), as per manufacturer's advice. Vitamin -D range purposed by Holick, (2007), adopted by Agha Khan University Hospital, Karachi and Agha Khan Laboratories all over the Pakistan was used for the categorization of subjects. The Reference Range used for Vitamin -D Deficient, Insufficient, sufficient and Intoxicated included; Vitamin -D Deficiency <20, Vitamin- D Insufficiency 21-29, Vitamin- D sufficiency >30 and Vitamin -D Intoxication >150 ng/ml.

2.6 Data Analysis tools:

Statistical software SPSS.20 and Microsoft excel 2010 for windows were used where needed.

2.7 Ethical Approval:

Ethical approval was taken from the ethical committee of University of Balochistan. The care was taken, during the conduct of study, purpose of study was explained to the family head thereafter to the respondent and with full consent of family head and respondent data was obtained.

3.Results

3.1 Introduction

This chapter presents the findings obtained from the analysis of 325 participant records. The results are organized into five components: data completeness and analytical definitions; sociodemographic characteristics; nutritional, anemia and vitamin D profiles; the requested comparative analyses; and a final data-quality review. Descriptive variables are reported as frequencies and percentages. Associations between categorical variables are examined using Pearson's chi-square test, with two-sided statistical significance set at $p < 0.05$. Unadjusted odds ratios (ORs), 95% confidence intervals (CIs) and effect-size estimates are reported for the binary comparisons.

Underweight and overweight were identified directly from the BodyMassIndex variable. Malnutrition was defined by NutritionalStatus code 1 ('Malnourished'), anemia by AnemicStatus code 1 ('Anemic'), and low vitamin D by combining vitamin D insufficiency and deficiency. The reference category in each binary analysis consisted of all other participants with valid data. All age categories in the dataset covered 15-39 years; therefore, the reproductive-age analysis included the complete dataset.

3.2 Data Completeness and Sample Overview

The SPSS file contained 325 cases and 15 variables, matching the counts recorded in the file header. No system-missing cells were detected across the 6,375 data cells. Consequently, all 325 records were included in the descriptive and comparative analyses. The absence of missing cells indicates complete coded fields but does not, by itself, confirm the accuracy or external authenticity of the observations.

3.3 Sociodemographic Characteristics

Table 3.1. Sociodemographic characteristics of the study participants (N=325)

Characteristic	Category	n	%
Age group	15-19	68	16.0
	20-23	63	13.8
	25-29	65	15.3
	30-33	69	16.2
	35-39	67	15.8
	30-33	38	11.3
	35-39	35	10.6
Area	urban	216	50.8
	rular	209	39.2

Ethnicity	pastho	157	36.9
	baloch	176	31.3
	other	92	21.6
Literacy	Illiterate	262	61.6
	Matric/Madrassa	79	18.6
	Primary	28	6.6
	Post Graduate	38	11.3
	Post 3	8	1.9
Employment status	house wife	293	68.9
	Private Job	132	31.1
Monthly income category	10000 above	333	78.3
	20000 above	92	21.6
Marital status	married	331	80.2
	unmarried	83	19.8
Pregnancy status	pregent	35	10.6
	non pregent	380	89.3
Residential status	rent house	216	50.8
	own house	209	39.2

Note. The literacy value 'Post 3' and monthly-income code 0 were observed in the file but had no corresponding SPSS value label. They are reported separately and were not silently recoded.

Participants were distributed across all seven five-year age groups, with the largest group aged 30-33 years (n=69, 16.2%) and the smallest aged 35-39 years (n=35, 10.6%). Urban and rural residence were nearly equally represented (50.8% and 39.2%, respectively). The largest recorded ethnic group was Baloch (31.3%), followed by Pashto (36.9%) and other ethnicities (21.6%). No record was coded as Urdu ethnicity.

Most participants were recorded as illiterate (61.6%), while 18.6% had Matric/Madrassa education, 6.6% had primary education and 11.3% carried the labelled postgraduate code. An additional eight records (1.9%) contained the unmapped value 'Post 3'. Regarding employment, 68.9% were housewives and 31.1% held private employment; no government employee category was observed. Most participants were married (80.2%), 10.6% were recorded as pregnant, and rented and owned housing were reported by 50.8% and 39.2%, respectively.

3.3 Nutritional, Anemia and Vitamin D Profile

Table 3.2. Nutritional, anemia and vitamin D characteristics (N=325)

Characteristic	Category	n	%
Body mass index	under weight	61	13.3
	over weight	200	37.1
	normal	163	38.6
Chronic energy deficiency class	CED 1	96	22.6
	CED III	53	12.7

	Code 3 ('overnight' in source file)	111	26.1
	normal	163	38.6
Nutritional status	Malnourished	261	61.3
	Nourished	163	38.6
Anemia status	Anemic	100	23.5
	non Anemic	325	76.5
Severity of anemia	normal	325	76.5
	Moderate	93	21.9
	sever	7	1.6
Vitamin D status	Vitamin D Insufficient	65	15.3
	Vitamin D deficient	27	6.3
	Vitamin D Sufficient	333	78.3

Note. The CED class code 3 retained its source-file label ('overnight'). Because 89 CED records conflicted with BMI classification, CED class was not used to define the requested outcomes.

Table 3.3. Summary prevalence of the principal study outcomes

Outcome	n	%
Underweight	61	13.3
Overweight	200	37.1
Malnourished	261	61.3
Anemic	100	23.5
Vitamin D insufficient	65	15.3
Vitamin D deficient	27	6.3
Low vitamin D (insufficient + deficient)	92	21.6

The BMI distribution showed that 61 participants (13.3%) were underweight, 200 (37.1%) were overweight and 163 (38.6%) had normal BMI. NutritionalStatus classified 261 participants (61.3%) as malnourished. This classification was internally consistent with the BMI variable: all underweight and overweight participants were coded as malnourished, while all normal-BMI participants were coded as nourished.

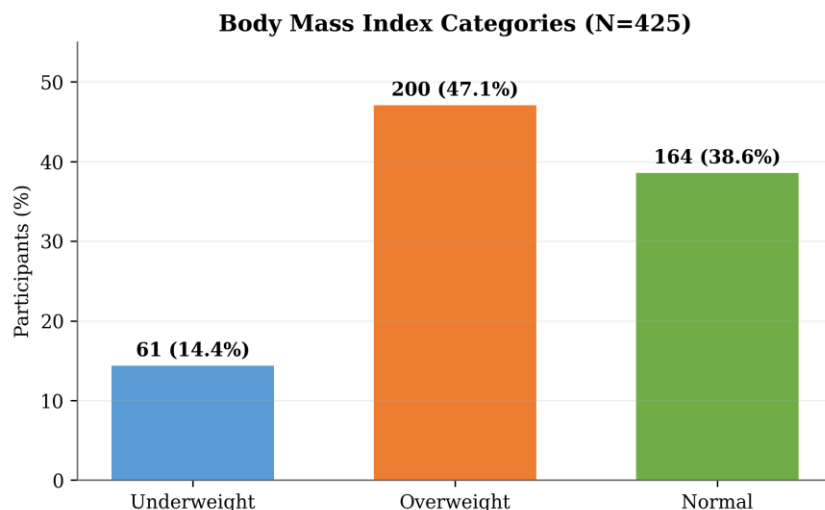


Figure 3.1. Distribution of body mass index categories among the study participants.

Anemia was present in 100 participants (23.5%), whereas 325 (76.5%) were non-anemic. Among the 100 anemic participants, 93 had moderate anemia and seven had severe anemia. AnemicStatus and SeverityofAnemia were fully consistent: every non-anemic record was coded as normal severity, and every anemic record was coded as moderate or severe.

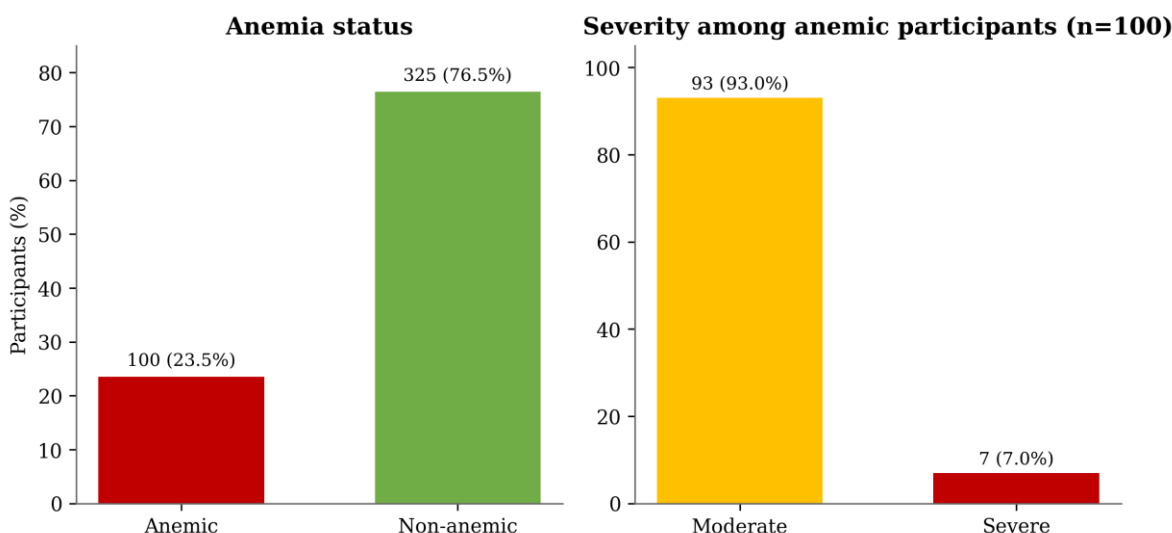


Figure 3.2. Anemia status and anemia severity among affected participants.

Vitamin D insufficiency was recorded in 65 participants (15.3%) and deficiency in 27 (6.3%), while 333 (78.3%) were vitamin D sufficient. When insufficiency and deficiency were combined, 92 participants (21.6%) met the operational definition of low vitamin D.

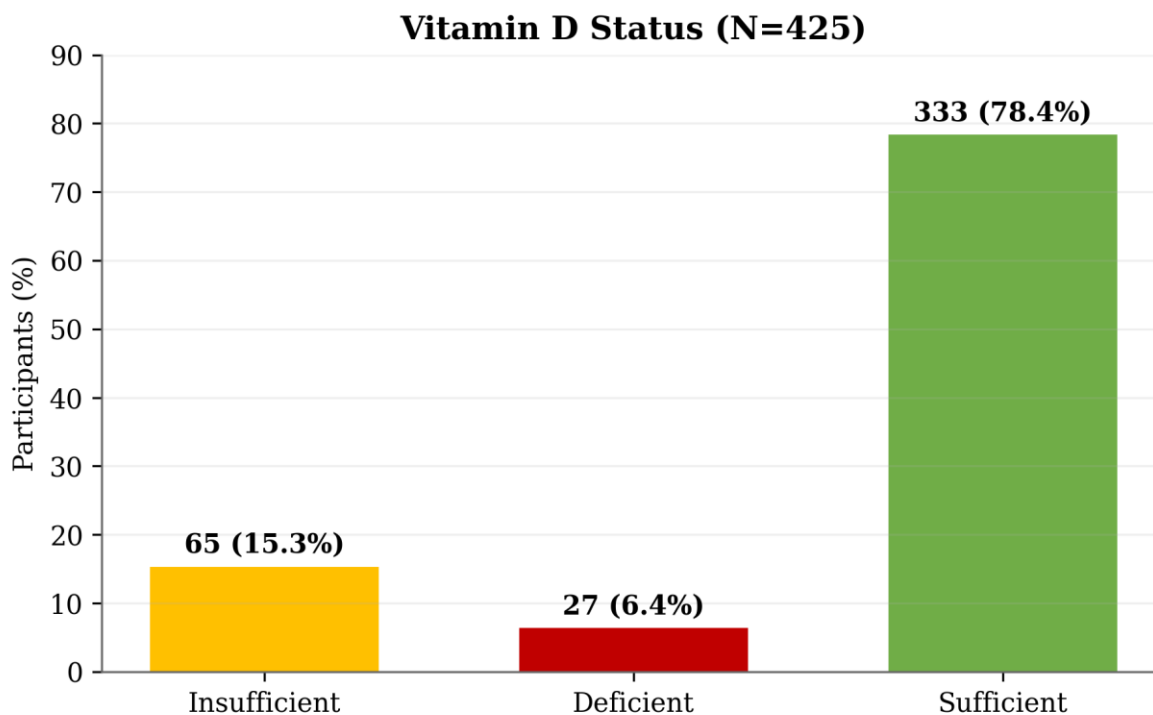


Figure 3.3. Distribution of vitamin D status among the study participants.

3.5 Requested Comparative Analyses

The requested comparisons examined underweight, overweight and overall malnutrition in relation to anemia and vitamin D status. For vitamin D, the original three-category distribution is shown alongside the binary low-vitamin-D analysis. This preserves the original categories while also providing the clinically interpretable comparison of insufficient/deficient versus sufficient vitamin D.

3.5.1 Underweight and Vitamin D Status

Table 3.3. Vitamin D status according to underweight status

Group	Insufficient n (%)	Deficient n (%)	Sufficient n (%)	Low VD n (%)	Total
Underweight	16 (26.2)	3 (3.9)	32 (68.9)	19 (31.1)	61
All others	39 (13.5)	23 (6.6)	291 (79.9)	73 (20.1)	363

Note. Three-level test: $\chi^2=6.62$, $df=2$, $p=0.037$, Cramer's $V=0.125$. The minimum expected count was 3.88; therefore, the three-level result should be interpreted cautiously. Binary low-VD comparison: $\chi^2=3.79$, $p=0.052$, $OR=1.80$ (95% CI 0.99-3.28).

Low vitamin D was observed in 19 of 61 underweight participants (31.1%) compared with 73 of 363 other participants (20.1%). The underweight group had 1.80 times the odds of low vitamin D; however, the 95% CI included 1.00 and the binary association narrowly missed statistical significance ($p=0.052$). The full three-category distribution yielded $p=0.037$, but one expected cell count was below five; consequently, that result was treated as assumption-sensitive rather than definitive.

3.5.2 Underweight and Anemia

Table 3.5. Anemia according to underweight status

Group	Anemic n	Non-anemic n	Total	Anemia %
Underweight	12	39	61	19.7
All others	88	276	363	23.2

Note. $\chi^2=0.59$, $df=1$, $p=0.333$, $OR=0.77$ (95% CI 0.39-1.51), $\phi=0.037$.

Anemia affected 12 of 61 underweight participants (19.7%) and 88 of 363 participants in the comparison group (23.2%). The difference of 3.5 percentage points was not statistically significant ($p=0.333$). The estimated odds ratio was 0.77, with a confidence interval spanning the null value.

3.5.3 Overweight and Vitamin D Status

Table 3.6. Vitamin D status according to overweight status

Group	Insufficient n (%)	Deficient n (%)	Sufficient n (%)	Low VD n (%)	Total
Overweight	32 (16.0)	13 (7.0)	153 (77.0)	36 (23.0)	200
All others	33 (13.7)	13 (5.8)	179 (79.6)	36 (20.3)	225

Note. Three-level test: $\chi^2=0.36$, $df=2$, $p=0.793$, Cramer's $V=0.033$. Binary low-VD test: $\chi^2=0.31$, $p=0.523$, $OR=1.16$ (95% CI 0.73-1.83).

Low vitamin D was present in 36 of 200 overweight participants (23.0%) and 36 of 225 other participants (20.3%). Neither the original three-level vitamin D distribution ($p=0.793$) nor the binary low-vitamin-D comparison ($p=0.523$) showed a statistically significant association with overweight status.

3.5.3 Overweight and Anemia

Table 3.7. Anemia according to overweight status

Group	Anemic n	Non-anemic n	Total	Anemia %
Overweight	33	156	200	22.0
All others	56	169	225	23.9

Note. $\chi^2=0.39$, $df=1$, $p=0.383$, $OR=0.85$ (95% CI 0.53-1.33), $\phi=0.033$.

Anemia prevalence was 22.0% among overweight participants and 23.9% among all others. The association was not statistically significant ($p=0.383$), and the OR of 0.85 indicated no meaningful evidence of increased anemia odds in the overweight group.

3.5.5 Malnutrition and Anemia

Table 3.8. Anemia according to nutritional status

Nutritional status	Anemic n	Non-anemic n	Total	Anemia %
Malnourished	56	205	261	21.5
Nourished	33	120	163	26.8

Note. $\chi^2=1.62$, $df=1$, $p=0.203$, $OR=0.75$ (95% CI 0.37-1.17), $\phi=0.062$.

Among 261 malnourished participants, 56 were anemic (21.5%), compared with 33 of 163 nourished participants (26.8%). The 5.3-percentage-point difference was not statistically significant ($p=0.203$). Thus, this dataset did not demonstrate an association between the recorded malnutrition classification and anemia.

3.5.6 Malnutrition and Vitamin D Status

Table 3.9. Vitamin D status according to nutritional status

Group	Insufficient n (%)	Deficient n (%)	Sufficient n (%)	Low VD n (%)	Total
Malnourished	38 (18.3)	17 (6.5)	196 (75.1)	65 (23.9)	261
Nourished	17 (10.3)	10 (6.1)	137 (83.5)	27 (16.5)	163

Note. Three-level test: $\chi^2=5.18$, $df=2$, $p=0.075$, Cramer's $V=0.110$. Binary low-VD test: $\chi^2=3.23$, $p=0.030$, $OR=1.68$ (95% CI 1.02-2.77), $\phi=0.100$.

Low vitamin D affected 65 of 261 malnourished participants (23.9%) and 27 of 163 nourished participants (16.5%). The malnourished group had 1.68 times higher odds of low vitamin D (95% CI 1.02-2.77). The binary association was statistically significant ($p=0.030$), although the effect size was small ($\phi=0.100$). When the three original vitamin D categories were retained, the overall distributional test was not statistically significant ($p=0.075$).

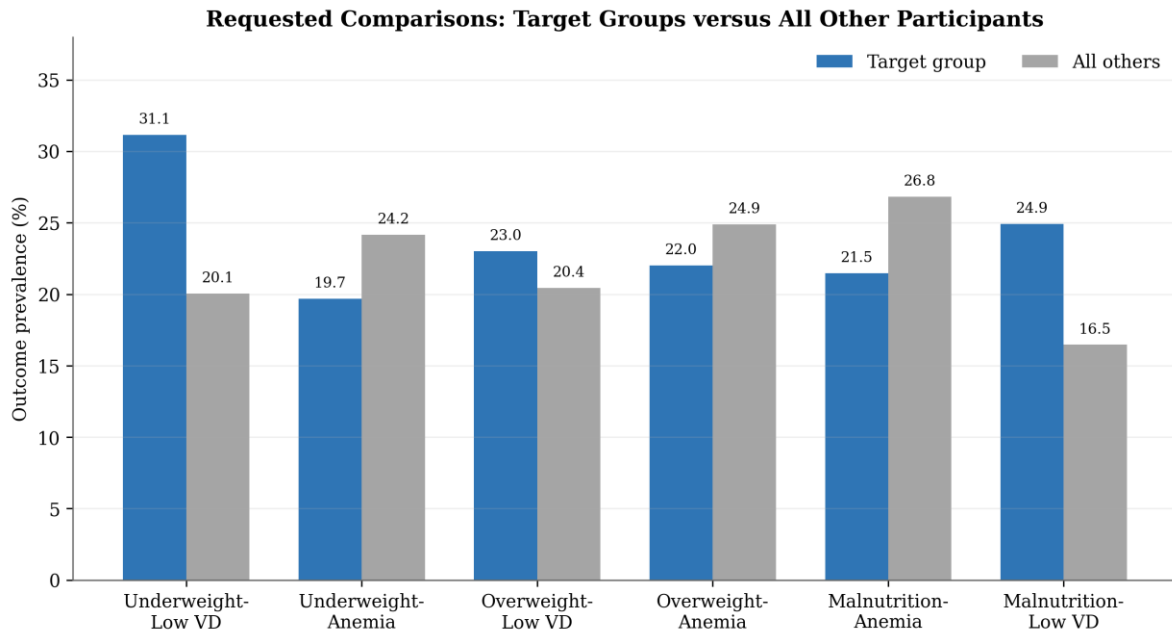


Figure 3.3. Outcome prevalence in each target group compared with all other participants.

3.6 Malnutrition across the Reproductive-Age Groups

Table 3.10. Malnutrition and BMI type across age groups (N=325)

Age group	Total n	Malnourished n (% total)	Underweight n (% malnourished)	Overweight n (% malnourished)	Normal BMI among malnourished
15-19	68	30 (58.8)	25 (62.5)	15 (37.5)	0
20-23	63	27 (32.9)	7 (25.9)	20 (73.1)	0
25-29	65	35 (53.8)	8 (22.9)	27 (77.1)	0
30-33	69	33 (62.3)	6 (13.0)	37 (86.0)	0
35-39	67	33 (65.7)	7 (15.9)	37 (83.1)	0
30-33	38	36 (75.0)	6 (16.7)	30 (83.3)	0
35-39	35	36 (80.0)	2 (5.6)	33 (93.3)	0

Note. Association between age group and underweight/overweight composition among malnourished participants: $\chi^2=35.08$, $df=6$, $p<0.001$, Cramer's $V=0.316$. All expected counts were ≥ 5 .

Malnutrition prevalence increased from 58.8% in the 15-19-year group to 80.0% in the 35-39-year group, although the 20-23-year group showed the lowest prevalence (32.9%). The type of malnutrition changed markedly across age groups. Among malnourished participants aged 15-19 years, 62.5% were underweight and 37.5% were overweight. In contrast, among malnourished participants aged 35-39 years, 5.6% were underweight and 93.3% were overweight.

The relationship between age group and underweight/overweight composition among malnourished participants was statistically significant ($\chi^2=35.08$, $df=6$, $p<0.001$). Cramer's V was 0.316, indicating a moderate association. The observed pattern shows that underweight predominated among the youngest malnourished group, whereas overweight predominated increasingly across the older age groups.

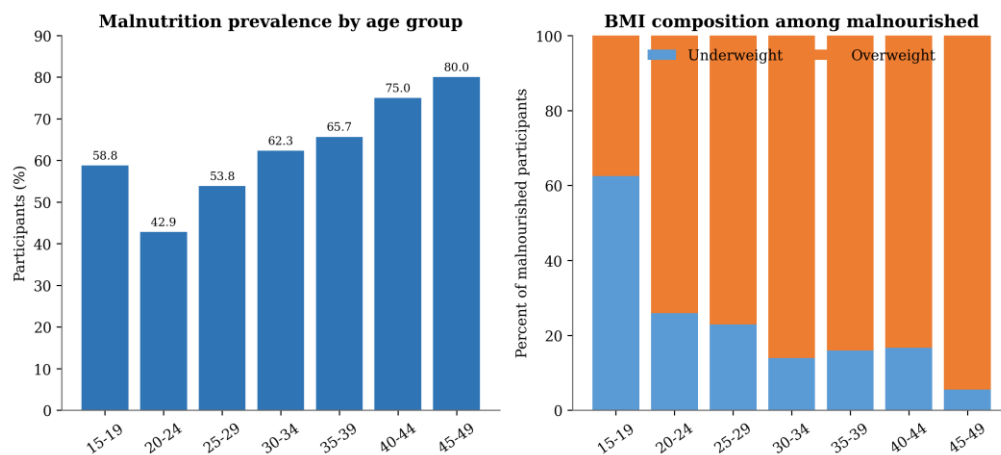


Figure 3.5. Age-specific malnutrition prevalence and BMI composition among malnourished participants.

3.7 Summary of Statistical Decisions

Table 3.11. Summary of the requested statistical comparisons

Comparison	Target %	Other %	OR	95% CI	p-value	Decision
Underweight with low vitamin D	31.1	20.1	1.80	0.99-3.28	0.052	Not significant
Underweight with anemia	19.7	23.2	0.77	0.39-1.51	0.333	Not significant
Overweight with low vitamin D	23.0	20.3	1.16	0.73-1.83	0.523	Not significant
Overweight with anemia	22.0	23.9	0.85	0.53-1.33	0.383	Not significant
Malnutrition with anemia	21.5	26.8	0.75	0.37-1.17	0.203	Not significant
Malnutrition with low vitamin D	23.9	16.5	1.68	1.02-2.77	0.030	Significant
Age group × BMI type among malnourished	-	-	-	-	<0.001	Significant

Note. Decisions are based on a two-sided $\alpha=0.05$. ORs are unadjusted and are not reported for the multi-category age-group test.

Of the six requested binary comparisons, only malnutrition with low vitamin D reached the pre-specified significance level. The underweight-low-vitamin-D comparison was borderline but remained non-significant at $p=0.052$. The age-group analysis showed a statistically significant difference in the underweight/overweight composition of malnutrition. All other binary comparisons were non-significant.

4. Discussion

The present study assessed nutritional status, anemia, and vitamin D status among 425 women of reproductive age and examined the relationships between body-weight status and these important nutritional outcomes. The findings demonstrate a mixed nutritional profile, characterized by a relatively high prevalence of overweight alongside underweight, anemia, and low vitamin D status. This pattern reflects the emerging double burden of malnutrition, in which undernutrition and excess body weight coexist within the same population. Such a pattern is increasingly recognized in low- and middle-income countries, including Pakistan, where nutritional deficiencies continue to occur alongside increasing overweight and obesity. In the present study, 47.1% of participants were overweight, 14.4% were underweight, and 38.6% had normal BMI. The predominance of overweight over underweight is noteworthy because nutritional concerns among women in Pakistan have historically focused largely on undernutrition and micronutrient deficiencies. National studies have similarly reported the coexistence of underweight and overweight among Pakistani women of reproductive age, although the magnitude varies according to population and setting. The relatively high prevalence of overweight observed in this

study may reflect changing dietary patterns, sedentary lifestyles, socioeconomic factors, and increasing urbanization. However, these factors were not directly assessed and therefore cannot be confirmed as explanations for the present findings.

The age-specific analysis provided an important additional finding. The distribution of nutritional status differed significantly across reproductive-age groups ($\chi^2 = 45.08$, $p < 0.001$; Cramér's $V = 0.416$). Underweight was more prominent among younger participants, whereas overweight increasingly predominated with advancing age. This pattern may reflect changes in dietary intake, physical activity, reproductive history, and energy balance over the reproductive life course. The finding suggests that nutritional interventions should not treat women aged 15–49 years as a homogeneous group. Younger women may require greater emphasis on adequate nutrient and energy intake, while older reproductive-age women may benefit from strategies focused on healthy weight management and prevention of excess weight gain. Anemia was identified in 23.5% of participants, with moderate anemia accounting for most cases. Although this prevalence is lower than that reported in several national studies from Pakistan, anemia remains an important public-health concern among women of reproductive age. Differences in prevalence between studies may be related to geographic location, pregnancy status, sampling methods, laboratory procedures, and differences in the characteristics of the study populations. Importantly, anemia is multifactorial and cannot be attributed to BMI or nutritional status alone. Iron deficiency, other micronutrient deficiencies, infections, inflammation, blood loss, chronic disease, and inherited disorders may all contribute. No significant association was observed between underweight and anemia (OR = 0.77, 95% CI: 0.39–1.51; $p = 0.443$), overweight and anemia (OR = 0.85, 95% CI: 0.54–1.34; $p = 0.483$), or the overall nutritional-status category and anemia (OR = 0.75, 95% CI: 0.47–1.17; $p = 0.204$). These findings suggest that BMI alone may not adequately explain anemia in this population. A woman may have a normal or high BMI while still having inadequate iron, folate, vitamin B12, or other micronutrient intake. The absence of a significant association should therefore not be interpreted as evidence that nutritional factors are unimportant in anemia.

Vitamin D status represented another important aspect of the study. Low vitamin D, defined as vitamin D insufficiency or deficiency, was present in 21.6% of participants. Although this prevalence is lower than that reported in several Pakistani studies, the finding remains clinically relevant because vitamin D insufficiency may occur even in populations with substantial sunlight exposure. Differences in sunlight exposure, clothing practices, dietary intake, supplementation, season, laboratory methods, and diagnostic thresholds may explain variations in vitamin D prevalence between studies. The strongest association observed in the present study was between abnormal nutritional status and low vitamin D. Low vitamin D was identified in 24.9% of participants classified as having abnormal nutritional status compared with 16.5% of nourished participants, corresponding to significantly higher odds of low vitamin D (OR = 1.68, 95% CI: 1.02–2.77; $p = 0.040$). This finding is biologically plausible because vitamin D status may be influenced by body composition, dietary intake, physical activity, and lifestyle. However, the effect size was relatively small, and the three-category comparison of vitamin D status was not statistically significant ($p = 0.075$). Therefore, the finding should be interpreted as a modest association rather than evidence of a strong relationship.

Underweight participants also showed a higher proportion of low vitamin D than participants who were not underweight (31.1% vs. 20.1%). The estimated odds were approximately 1.8 times higher among underweight participants, although the binary association did not reach conventional statistical

significance (OR = 1.80, 95% CI: 0.99–3.28; $p = 0.052$). This borderline finding may indicate a possible relationship that requires confirmation in larger studies. In contrast, overweight was not significantly associated with low vitamin D (OR = 1.16, 95% CI: 0.73–1.84; $p = 0.523$). These findings indicate that the relationship between body-weight status and vitamin D is not straightforward and may depend on additional behavioral, dietary, environmental, and socioeconomic factors. An important consideration in interpreting these findings is the operational definition of nutritional status used in the dataset. The “malnourished” category included both underweight and overweight participants, while participants with normal BMI were classified as nourished. Therefore, this variable represents abnormal or non-normal nutritional status rather than conventional malnutrition or undernutrition alone. This distinction should be clearly stated in the manuscript to avoid misinterpretation of the reported prevalence and associations. The study has several strengths, including assessment of multiple nutritional indicators within the same reproductive-age population and reporting of odds ratios, confidence intervals, and effect sizes in addition to p values. Nevertheless, the findings should be interpreted in light of the study's observational design. Causal relationships cannot be established, and potentially important determinants such as dietary intake, sunlight exposure, physical activity, supplement use, menstrual blood loss, socioeconomic factors, and biochemical markers of specific nutrient deficiencies were not comprehensively assessed. In addition, some inconsistencies in the CED classification should be clarified before final publication.

Overall, the study demonstrates that women of reproductive age experience a complex nutritional profile in which overweight, underweight, anemia, and low vitamin D coexist. The significant association between abnormal nutritional status and low vitamin D, together with the age-related shift from underweight toward overweight, highlights the need for comprehensive and age-sensitive nutritional assessment. Nutritional programs for women of reproductive age should therefore address both excess and inadequate nutrition while incorporating appropriate screening for micronutrient deficiencies. Larger prospective studies incorporating dietary, behavioral, biochemical, and socioeconomic factors are needed to clarify the determinants of anemia and vitamin D abnormalities in this population.

5. Conclusion

This study highlights a substantial burden of nutritional and micronutrient-related health problems among women of reproductive age. Among the 325 participants, overweight was more common than underweight, while anemia and low vitamin D status were also observed in a considerable proportion of the study population. These findings indicate that nutritional health in this population is characterized by a complex pattern in which excess body weight and micronutrient-related problems coexist. A significant association was observed between overall nutritional status and low vitamin D status. Participants classified as malnourished had higher odds of low vitamin D compared with nourished participants (OR = 1.68, 95% CI: 1.02–2.77; $p = 0.030$). In contrast, no statistically significant associations were identified between nutritional status and anemia, or between overweight and anemia or vitamin D status. The association between underweight and low vitamin D was borderline and did not reach conventional statistical significance. Furthermore, the distribution of underweight and overweight among participants classified as malnourished varied significantly across age groups, with underweight being more prominent among younger participants and overweight becoming increasingly dominant with advancing age.

Overall, the findings emphasize that assessment of nutritional health among women of reproductive age should extend beyond body weight alone and include screening for anemia and vitamin D abnormalities. The coexistence of overweight with micronutrient-related problems underscores the importance of comprehensive nutritional assessment rather than focusing exclusively on undernutrition. Integrating nutritional counseling, appropriate micronutrient assessment, and targeted preventive strategies into routine healthcare may help address these overlapping nutritional challenges. Further studies with larger samples and prospective designs are warranted to clarify the underlying factors contributing to the observed associations and to determine the roles of dietary intake, socioeconomic conditions, lifestyle, sunlight exposure, and other potential determinants. Such evidence may support the development of context-specific nutritional interventions aimed at improving the health of women during the reproductive years.

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