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Research Article

DIETARY DETERMINANTS OF HEMOGLOBIN LEVELS AMONG YOUNG ADULTS: EVIDENCE FROM A CROSS-SECTIONAL STUDY

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ABSTRACT

Objectives: Nutrition plays a crucial role throughout all stages of life, but young adulthood is particularly significant for establishing healthy eating habits that can persist into the future. Globally, iron-deficiency anemia stands as the most prevalent cause of anemia, highlighting the importance of adequate iron intake during this formative period. This study aimed to (i) assess hemoglobin levels in male and female young adults and (ii) examine their association with dietary patterns.

Methods: A cross-sectional study was conducted among adults (n=200). Data collection involved a structured questionnaire assessing dietary patterns, anthropometric measurements, and laboratory evaluation of hemoglobin levels.

Results: A significant difference in the prevalence of overweight, obesity, and anemia was observed between the sexes. Among men, 88.9% were classified as overweight or obese (Class I), with 11.1% having mild anemia. In contrast, 66.7% of women were overweight, and 11.1% had severe anemia. Moreover, only 35% of women had normal hemoglobin levels, compared to 86% of men. The dietary analysis revealed an association between the intake of protein-rich foods – such as legumes, eggs, fish, and other animal sources – and the maintenance of healthy hemoglobin levels. The gender, food adequacy, and food diversity showed positive association through Kendall's tau-b and Gamma test (0.522, 0.605, 0.437 and 0.849, 0.892, and 0.707, respectively) with $p<0.001$. Conversely, a significant negative association (−0.423, −0.365, −0.637, and −0.511, respectively) was observed between hemoglobin levels and factors such as body mass index and a family history of iron deficiency anemia across both genders.

Conclusion: These findings underscore the critical need for robust electronic data collection systems within nutrition programs that are sensitive to gender-specific needs, thereby enabling the development of targeted and effective public health strategies to combat anemia and malnutrition in Pakistan.

Keywords: Anemia, Body mass index, Hemoglobin, Iron deficiency, Nutrition.

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INTRODUCTION

Nutrition is always found to be important for humans throughout the stages of life. It merely not just helps in growth but also supports survival, mental and physical development, and our work performance, as well as overall health [1]. A healthy diet is important as it supports our immune system, reduces the chances of the development of complications for women during pregnancy and childbirth, and reduces the risk of chronic disorders such as diabetes and heart disease and will help us to live longer as well [2-5]. The importance of micronutrients cannot be denied, as they are dietary components that our body cannot produce. A diet that lacks essential micronutrients such as calcium and iron can cause serious health issues [6]. Iron deficiency can be identified using several biochemical and hematological markers such as ferritin, serum iron, total iron-binding capacity (TIBC), transferrin, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and hemoglobin level. A low serum ferritin level is a key early indicator, reflecting depleted iron stores. Serum iron concentrations typically decrease, while TIBC increases and transferrin saturation declines, indicating reduced iron availability in the blood. Hematological parameters such as MCV and MCH also drop, signifying the presence of small, pale red blood cells (microcytic and hypochromic cells). Interestingly, hemoglobin, the oxygen-carrying protein in red blood cells, relies on iron for its structure and function. Since iron is an essential component of hemoglobin, iron deficiency directly impairs its synthesis, often resulting in a reduced hemoglobin concentration – leading to anemia [7,8].

Anemia, defined as a low hemoglobin level, is a widespread public health concern, with iron deficiency being its most common cause. When hemoglobin levels are insufficient, the blood's oxygen-carrying capacity declines, manifesting as fatigue, weakness, breathlessness, and cognitive impairment. Iron deficiency anemia (IDA) is thus strongly linked to poor iron status and remains one of the most prevalent nutritional disorders globally, affecting nearly one-third of the world's population. The World Health Organization (WHO) estimates that nearly 2 billion individuals, or 25% of the global population, are anemic, with approximately half of this group affected by IDA [9-11]. There was an estimate in 2016 that indicated that anemia affected 40% of women of reproductive age and 42% of children under 5 years old globally [12]. Traditional beliefs, gender disparities, and economic status are social determinants that limit access to nutrient-rich food, particularly for women, especially in rural and conflict-affected regions [13-15]. In Pakistan, nutrition is often regarded as a low-priority topic, despite the existence of established guidelines known as the Pakistan Dietary Guidelines for Better Nutrition. These guidelines reported adults aged 19–60 have significant health issues related to body mass index (BMI) profile [16]. Furthermore, research on eating habits in Pakistan is limited, with existing studies frequently relying on small, unrepresentative samples and concentrating on specific diseases. The knowledge gap remains regarding the characteristics and variations of dietary habits in Pakistan [17].

Moreover, nutrition-related studies are mostly conducted on women of reproductive age, school-going children, or elderly adults. However, there are no studies in young adults including both men and women. The gap group that received the least attention is 20–30 years old, as this age is critical for the development of those dietary habits. Moreover, male gender is usually not given equal importance in research such as iron deficiency, and females receive low priority with respect to nutrient-dense food. Our study (i) investigated (i) hemoglobin levels among both males and females and (ii) investigated the association between the hemoglobin levels and dietary patterns. This filled a major gap in the lack of literature related to the crucial age group of 20–30. Hence, this study will help to provide awareness about current nutritional health issues, which could be helpful for future researchers, health policymakers, and health sectors.

METHODS

Study design

The cross-sectional study was performed by convenient sampling from five different towns. A total of n=200 were included in the study with equal distribution of gender: n=100 males and n=100 females. The inclusion criteria of the study were that participants between the ages of 20 and 30 were selected, while exclusion criteria were any participants who had health issues including hypertension, diabetes, heart diseases, polycystic ovary syndrome (PCOS) (in females), or any other health issues. The pregnant and breast-feeding females were also excluded from the study. Moreover, any participants taking any medication or taking any health supplement were excluded from the study.

Data collection tools

Data collection and questionnaire design

Data were collected through brief interviews to ensure that participants met the inclusion and exclusion criteria before receiving the questionnaire. Participation was entirely voluntary, and they may choose to withdraw from the study at any point without any penalty or loss of benefits. All the participants filled out the consent form before the study. A structured questionnaire was developed to obtain comprehensive and relevant information. It comprised both open- and closed-ended questions, using simple English to enhance participant understanding and avoid medical jargon. The questionnaire was divided into five sections: Section I: Personal History, Section II: Medical, Section III: Awareness of IDA, Section IV: General Dietary History, and Section V: Detailed Dietary Intake – Focused on the frequency of consumption across five food groups: Fruits, vegetables, legumes, grains, and dairy/meat/proteins. The dietary intake was categorized into five frequency levels: Daily, 4–6 times/week, 2–3 times/week, once/week, and rarely. A key was provided to standardize responses and ensure consistency. Based on data from Section V, two indices were computed: (i) Food Adequacy – Participants were categorized as having either adequate or inadequate diets. (ii) Dietary Diversity – Participants consuming four or more food groups daily were considered to have a diversified diet, while those consuming fewer than four were classified as having a monotonous diet.

Weight and height measurement

The height and weight of each participant were measured using a Megmedius (BW-2200 PU). While comprehensive guidelines and rules were followed to make sure to get the accurate measurement, such as lightweight clothes followed by barefoot while keeping view at the Frankfort plane with neck and back straight. Moreover, a person was supervised to make sure to assist each individual and to achieve correct measurements.

BMI

For nutritional status screening, BMI was calculated for all of the participants using the formula:

$$BMI = \frac{\text{Weight in kg}}{\text{Height in m}^2}$$

The WHO has proposed specific BMI cutoff points for Asian adults, considering the higher tendency of South Asians to accumulate visceral fat [18]. According to these criteria, individuals with a BMI below 18.5 are classified as underweight or malnourished, increasing their vulnerability to nutritional deficiencies and related diseases. A BMI between 18.5 and 22.9 is considered healthy, indicating a lower risk of developing health complications. A BMI above 23 signifies the onset of overweight status, associated with an increased risk of chronic conditions. Specifically, a BMI between 23.0 and 24.9 is categorized as an “at-risk” stage, with a higher likelihood of comorbidities. A BMI between 25.0 and 29.9 corresponds to Obesity Stage I, representing a moderate health risk, while a BMI ≥30.0 indicates Obesity Stage II, where the risk of severe comorbidities is significantly elevated.

Hemoglobin test

Hemoglobin assessment is a reliable indicator for anemia screening [19]. This test was used to measure the levels of hemoglobin in the blood using complete blood count analyzer (Backman Coulter, Inc US). Normal hemoglobin levels among adults are males (13.5–17.51 g/dL) and females (non-pregnant) (12.0–16.0 g/dL), while hemoglobin below the normal range is considered IDA. It is categorized in three stages: Mild (10–11 g/dL), moderate (7–9.9 g/dL), and severe (<7 g/dL) [20].

Data analysis

Data were analyzed using the Statistical Package for the Social Sciences (IBM Corp., NY, USA) version 29.0. Gamma correlation was employed to assess the strength and direction of associations between ordinal variables, serving as a complement to Kendall’s tau-b analysis. Statistical significance was determined using p-values; it was highly significant if $p \leq 0.001$.

Exclusion

Iron deficiency is detected through serum ferritin level, TIBC, MCV, and MCH along with hemoglobin. However, due to limited resources, research was limited to hemoglobin only and in five towns within Lahore, and no other age groups (elders) were included in the study.

Inclusion

The study was delimited to both males and females aged 20–30 years and five major towns within Lahore to ensure equal distribution.

RESULTS AND DISCUSSION

Participant health and dietary profile

All participants reported no history of chronic health conditions such as hypertension, diabetes, or cardiovascular diseases. In addition, none of the female participants reported being diagnosed with PCOS. In terms of food allergies, 81% of participants reported no known allergies. However, 9% identified nut allergies (manifesting as skin rash and nausea), and 10% were uncertain but noted discomfort after consuming specific foods. Only 19% had previously undergone hemoglobin testing during routine checkups, while the majority (81%) had never been tested. Regarding family history, 38.5% reported a known history of IDA in either their mother or siblings. In contrast, 42.5% had no such history, while 19% were unsure. Awareness assessment revealed that 87% had good knowledge of IDA, while 13% had limited or no understanding. While asked about symptoms, 78% correctly identified all options (pale skin, fatigue, and lack of concentration), while others selected only one.

Dietary patterns

The food frequency questionnaire revealed detailed insights into the participant’s dietary habits: Fruit Intake: Only 0.5% consumed fruits daily, 21% consumed them 4–6 times per week, 5% reported 2–3 times weekly, 32% consumed them once weekly, and 41.5% rarely consumed fruits. Vegetable Intake: About 10% consumed vegetables daily, 18.5% consumed them 4–6 times weekly, 32.5% consumed them 2–3 times weekly, and 38.5% consumed vegetables once per week. Legume Intake: A high intake was noted, with 44.5% consuming legumes daily, 42.5% 4–6 times weekly, 8.5% 2–3 times weekly, and 4.5% once weekly. Whole Wheat Products: Common items included roti, paratha, bread, pasta, biscuits, and crackers. Daily consumption was reported by 39%, while 56.5% consumed them 4–6 times weekly, 2% consumed them 2–3 times weekly, and 2.5% consumed them once a week. Refined Wheat Products: These included naan, puri, cakes, pastries, and pizza. Daily intake was reported by 26.5%; 44.5% consumed them 4–6 times weekly, 27.5% 2–3 times weekly, and 1.5% once weekly. Rice: About 27% consumed rice daily, 45.5% 4–6 times weekly, and 27.5% 2–3 times weekly. Dairy Product Consumption: Milk (including plain milk, shakes, and milk tea): 42% consumed daily, 29% 4–6 times weekly, 11% 2–3 times weekly, 7.5% once weekly, and 10.5% rarely. Yogurt (including plain, fruit, and frozen): 37% consumed daily, 34% 4–6 times weekly, 12.5% 2–3 times weekly, 14% once weekly, and 2.5% rarely. Cheese: Only 3% consumed cheese daily, while 44% reported 4–6 times weekly, 30% 2–3 times weekly, 17% once weekly, and 6% rarely. Animal Protein Consumption: Eggs: Daily consumption was reported by 7%; 35.5% consumed eggs 4–6 times weekly, 20.5% 2–3 times weekly, 23.5% once weekly, and 14% rarely. Chicken: 6.5% consumed chicken daily, 55% 4–6 times weekly, 12% 2–3 times weekly, 15% once weekly, and 11.5% rarely. Mutton: Consumption was less frequent, with 37% consuming it 2–3 times weekly, 32.5% once weekly, and 30.5% rarely. Beef: 40% consumed beef 4–6 times weekly, 16.5% 2–3 times weekly, 27.5% once weekly, and 16% rarely. Fish: As a seasonal food, fish was less commonly consumed. Only 3% consumed it daily, 32.5% 4–6 times weekly, 19.5% 2–3 times weekly, 30% once weekly, and 15% rarely. These dietary intake patterns (Fig. 1) provide valuable insights into the food habits of young Pakistani adults, with implications for addressing iron status and nutritional adequacy.

BMI analysis

BMI-related breakdown among males indicates that across all categories – normal, overweight, Obesity Class I, and Obesity Class II – the vast majority were non-anemic. Specifically, 96.8% of overweight males and over 88% of those in obesity categories were non-anemic, with only a small proportion exhibiting mild anemia and none showing moderate or severe anemia. Among normal-weight males, 69.4% were non-anemic and 30.6% mildly anemic. In females, a different pattern emerged. Underweight females showed no non-anemia; instead, anemia was distributed across mild (55.6%), moderate (35.6%), and severe (8.9%) categories. Among normal-weight females, only 27% were non-anemic, with higher rates of mild (56.8%) and some moderate (13.5%) and severe anemia (2.7%). Interestingly, overweight females had the highest non-anemic rate among female BMI groups (66.7%), suggesting better hemoglobin status compared to underweight and normal-weight peers (Table 1).

Hemoglobin analysis

The data highlight the distribution of anemia among n=200, classified as non-anemic, mildly anemic, moderately anemic, or severely anemic. Overall, 60.5% of the participants were non-anemic, 24.5% were mildly anemic, 11.5% were moderately anemic, and 3.5% were severely anemic. Among males, the majority (86%) were non-anemic, and 14% were mildly anemic; no male participants were found to be moderately or severely anemic. In contrast, females showed a higher anemia burden, with only 35% non-anemic, 35% mildly anemic, 23% moderately anemic, and 7% severely anemic, as shown in Table 1.

Association tests for hemoglobin and dietary intake

Hemoglobin and gender

The statistical analysis highlighted a significant positive association between hemoglobin level and gender ($p<0.001$, Table 2). Findings showed that gender significantly influenced hemoglobin levels. Males had a high proportion of non-anemic individuals (86%), while 14% mild anemia was observed. Whereas, females provided a clear picture of how gender is affecting hemoglobin levels, as females exhibited a wide range of hemoglobin levels, as 35% were non-anemic, 35% mildly anemic, 23% moderately anemic, and 7% severely anemic.

Hemoglobin and BMI

The analysis had provided a significant negative association between BMI and hemoglobin levels ($p<0.001$, Table 2). As underweight participants showed the highest rates of mild anemia (26.7%), moderate anemia (35.6%), and severe anemia (6.7%), 31.1% of participants with underweight were non-anemic. Participants with normal BMI showed 49.3% non-anemic, 42.7% mildly anemic, 6.7% moderately anemic, and 1.3% severely anemic. Overweight individuals were 85.1% non-anemic, 4.3% mildly anemic, 4.3% moderately anemic, and 6.4% severely anemic. Obesity-I individuals showed 88.9% non-anemic and 11.1% mild anemia, whereas Obesity-II participants had 93.3% non-anemic and 6.7% mild anemia.

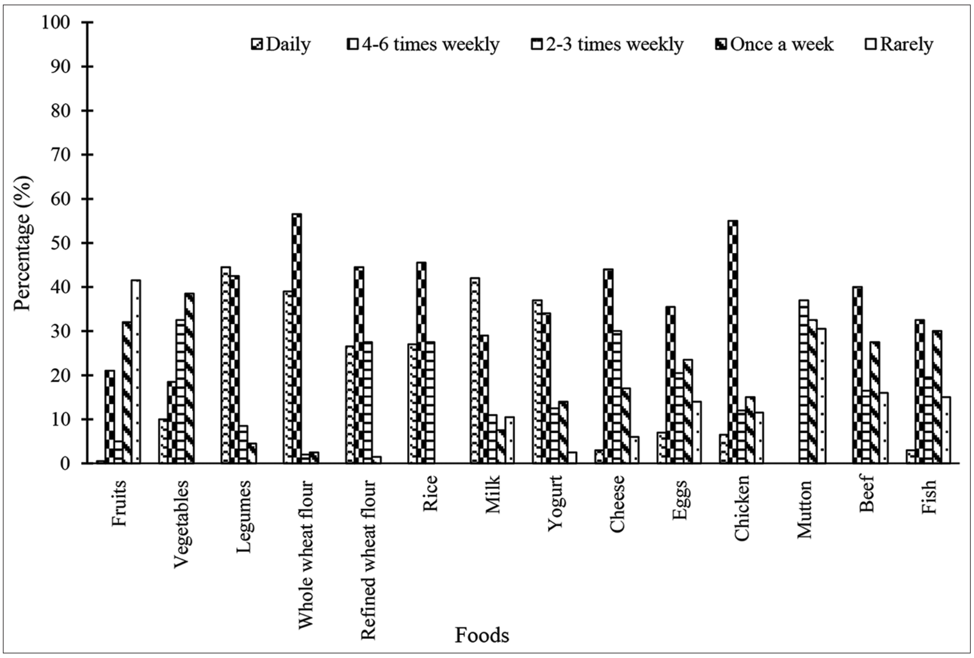

Fig. 1: Dietary intake based on food frequency of different foods

Table 1: The hemoglobin and BMI parameters in male and female participants

Parameters	Category	Non-anemic		Mild anemic		Moderate anemic		Severe anemic	
		Total	Frequency%	Total	Frequency %	Total	Frequency %	Total	Frequency%
All participants		121	60.5	49	24.5	23	11.5	7	3.5
Gender	Males (n=100)	86	86.0	14	14.0	0	0.0	0	0.0
	Females (n=100)	35	35.0	35	35.0	23	23.0	7	7.0
BMI - males	Normal	25	69.4	11	30.6	0	0.0	0	0.0
	Overweight	30	96.8	1	3.2	0	0.0	0	0.0
	Obesity-I	16	88.9	2	11.1	0	0.0	0	0.0
	Obesity-II	14	93.3	1	6.7	0	0.0	0	0.0
BMI - females	Underweight	0	0.0	25	55.6	16	35.6	4	8.9
	Normal	10	27.0	21	56.8	5	13.5	1	2.7
	Overweight	12	66.7	2	11.1	2	11.1	2	11.1

*Normal hemoglobin levels for adult males: (13.5–17.51) g/dL and for adult females (non-pregnant) 12.0–16.0 g/dL, whereas anemia: Mild (10–11 g/dL), moderate (7–9.9 g/dL), and severe (<7 g/dL) [20]. The standard error is<1 or±<0.63. BMI: Body mass index

Table 2: Association test for hemoglobin and study parameters

Parameters	Kendall's tau-b	Gamma Test value	p-value
Gender	0.522	0.849	<0.001
BMI	−0.423	−0.637	<0.001
Family history of iron deficiency anemia	−0.365	−0.511	<0.001
Food adequacy	0.605	0.892	<0.001
Food diversity	0.437	0.707	<0.001

Kendall's tau-b and Gamma test association ranges between−1 and+1. However, p values are highly significant. If p≤0.001

Hemoglobin and family history of IDA

The findings revealed a highly significant negative association between hemoglobin levels and family history of IDA (p<0.001, Table 2). Participants who had a family history of IDA exhibited interesting findings, as among them 53.2% had mild, 14.3% moderate, and 9.1% had severe anemia, while only 23.4% were found non-anemic. Whereas participants with no family history of IDA, among whom 94.1% were non-anemic, had 3.5% cases of mild anemia and only 2.4% cases of moderate anemia observed in them. Finally, participants who were uncertain about family history, among whom 60.5% were non-anemic, 13.2% mildly anemic, and 26.3% moderately anemic.

Hemoglobin and food adequacy

The findings of the analysis revealed a significant positive association between food adequacy and hemoglobin levels (p<0.001, Table 2). Participants who took adequate food were likely to be 90.5% non-anemic, 7.6% mildly anemic, 0% moderately anemic, and 1.9% severely anemic. Whereas, those who took in an inadequate diet were 27.4% non-anemic, 43.2% mildly anemic, 24.2% moderately anemic, and 5.3% severely anemic.

Hemoglobin and food diversity

The findings of the analysis revealed a significant positive association between hemoglobin and food diversity (p<0.001, Table 2). Participants who took a diversified diet had 81.7% non-anemic, 11% mild, 6.4% moderate, and 0.9% severe anemia. Whereas, participants who had monotonous diet patterns were likely to have higher levels of anemia; among them, only 32.5% were non-anemic, while 40.7% were mildly anemic, 17.6% were moderately anemic, and 6.6% were severely anemic.

Association between hemoglobin and food

Fruits and vegetables

No significant association was observed between fruit intake and hemoglobin levels (p=0.070, Table 3). However, participants with frequent fruit consumption (4–6 times weekly) showed a higher proportion of non-anemic cases and fewer moderate-to-severe anemia cases. In contrast, those who rarely consumed fruits had higher anemia prevalence, with only 50.6% non-anemic and 21% presenting moderate-to-severe anemia. Interestingly, vegetable intake demonstrated a significant but negative association with hemoglobin levels (p=0.009). All participants with daily vegetable consumption were non-anemic. However, those consuming vegetables 4–6 times weekly exhibited the highest rates of anemia. Similarly, among 2–3 times weekly consumers, 55.4% were non-anemic, while the remainder was anemic at varying levels. Those consuming vegetables once a week had 76.6% non-anemic prevalence. These findings suggest that increased vegetable intake did not consistently correspond with improved hemoglobin status.

Table 3: Foods association test with hemoglobin

Parameters	Kendall's tau-b	Gamma test value	p-value
Fruits	0.111	0.179	0.070
Vegetables	−0.158	−0.236	0.009
Legumes	0.270	0.428	<0.001
Whole wheat flour	0.118	0.216	0.067
Refined wheat flour	−0.070	−0.115	0.276
Rice	−0.046	−0.077	0.475
Milk	−0.040	−0.061	0.527
Yogurt	0.087	0.129	0.187
Cheese	0.043	0.067	0.507
Eggs	0.452	0.617	<0.001
Chicken	0.610	0.842	<0.001
Mutton	0.674	0.902	<0.001
Beef	0.700	0.892	<0.001
Fish	0.532	0.737	<0.001

Kendall's tau-b and Gamma test association ranges between−1 and+1. However, p values are highly significant. if p≤0.001

Legumes

Legume consumption showed a strong positive and statistically significant association with hemoglobin levels (p<0.001). Among daily consumers, 77.5% were non-anemic. As frequency declined, anemia prevalence increased. For example, only 22.2% of participants who consumed legumes once weekly were non-anemic, while 77.8% exhibited varying degrees of anemia.

Whole/refined wheat and rice

Whole wheat intake was not significantly associated with hemoglobin levels (p=0.067). Daily consumers had a majority non-anemic, whereas those consuming wheat 2–3 times weekly showed 75% mild anemia prevalence. Similarly, no significant association was found between refined wheat intake and hemoglobin levels (p=0.070). However, daily and weekly refined wheat consumers generally exhibited higher non-anemic rates. Rice intake also showed no significant association (p=0.475). Hemoglobin status among daily and weekly rice consumers remained similar, with over 57% non-anemic in all groups, and a modest percentage presenting with mild-to-severe anemia.

Dairy products

Milk intake showed no significant association with hemoglobin levels (p=0.061). Daily consumers had 69% non-anemic prevalence, which decreased among less frequent consumers. Interestingly, all participants who rarely consumed milk were found non-anemic. Yogurt intake was also not significantly associated (p=0.187). Daily consumers had the highest non-anemic proportion (78.4%), while less frequent consumers showed increased anemia prevalence. Rare yogurt consumers were all non-anemic. Cheese intake showed no significant correlation with hemoglobin levels (p=0.507). While 69.3% of 4–6 times weekly consumers were non-anemic, those consuming cheese 2–3 times weekly had higher mild and moderate anemia rates. All rare cheese consumers were non-anemic.

Animal protein sources

Significant positive associations were found between hemoglobin levels and animal protein sources, including eggs, chicken, mutton, beef, and fish (all p<0.001, Table 3): Eggs: 100% of daily egg consumers were non-anemic. Anemia prevalence increased substantially with reduced frequency. Chicken: Like eggs, daily and 4–6 times weekly chicken consumers were mostly non-anemic, whereas rare consumers showed high rates of moderate-to-severe anemia. Mutton: 95.9% of 2–3 times weekly mutton consumers were non-anemic. Anemia increased drastically among those who rarely consumed mutton. Beef: All 4–6 times weekly beef consumers were non-anemic. Infrequent consumption was associated with higher anemia levels. Fish: Daily and 4–6 times weekly fish consumers showed 100% non-anemic status. In contrast, rare consumers had elevated rates of moderate (43.3%) and severe (13.3%) anemia.

This nutritional status evaluation primarily focused on the dietary habits, BMI, and biochemical markers of healthy young adults (aged 20–30) in Lahore, Pakistan. We observed significant gender disparities in the following areas: 64% of men were overweight or obese, 45% of women were underweight, and none of the men were underweight. An examination of hemoglobin levels showed that 86% of men were not anemic, 35% of women were, with 35% suffering from mild anemia, 23% from moderate, and 7% from severe anemia. Negligible, moderate, or severe anemia occurred among the men, whereas just 14% experienced mild anemia. The impact of food sources on iron status was demonstrated by a robust positive correlation between the consumption of animal protein (e.g., chicken, beef, mutton, fish, and eggs) and hemoglobin levels (p<0.001). The hemoglobin levels were also substantially correlated with family history, dietary adequacy, and diversification. The majority of participants were aware of IDA: 87% were familiar with the term, and 78% could accurately identify the symptoms of IDA. Findings from Lahore [21] and Saudi Arabia [22] are at odds with these results, whereas those from Sialkot and the Philippines are in agreement [23,24]. Similarly, another study noticed a knowledge-practice gap, although poor nutritional outcomes continued despite this understanding. Gender differences were also shown by anthropometric testing, which found that women were more likely to be underweight and men were more likely to be overweight or obese [25]. Although other studies found greater prevalence of obesity in females [26], these patterns are consistent with those from South Korea [27], Kerala [28], and Bangladesh [29]. There can be underlying differences due to cultural and societal factors. Cultural pressures and gendered food standards influence how Pakistani women eat [30,31].

Gender and IDA were shown to have significant relationships according to hemoglobin analysis (p<0.001). In contrast to the majority of men, nearly two-thirds of the women who took part in the study were anemic. The Lancet [32] estimated a global prevalence of anemia of 31.2% in women and 17.5% in males, with iron deficiency being the main cause. These findings are in line with those data which were more likely to experience moderate-to-severe anemia, while those who were overweight seemed to be protected against this condition, suggesting a strong negative relationship between BMI and hemoglobin levels (p<0.001). The findings of some studies [33,34] were consistent with one another. Furthermore, low hemoglobin levels were significantly linked to a family history of IDA (p<0.001), lending credence to the results of a study [35] that shared genetics and environment. There was a strong relationship between hemoglobin status and dietary adequacy and diversification (p<0.001). In contrast to 27.4% of individuals whose diets were poor, 90.5% of those whose diets were acceptable had normal hemoglobin levels. A similar favorable correlation between dietary variety and iron status was observed: 81.7% of those whose diets were diversified were not anemic, compared to only 35.2% whose diets were monotonous. The results agree with some other investigations conducted [36,37]. Heme iron is absorbed up to 35% [38,39] with animal-based (heme) proteins (p<0.001). In addition, legumes demonstrated a strong positive correlation, indicating that iron can be supplemented through plant-based sources, particularly when cooked in a way that maximizes bioavailability [40]. On the other hand, there was no statistically significant correlation between hemoglobin and fruits (p=0.070), and a weak negative correlation between hemoglobin and vegetables (p=0.009) could be due to reporting bias or the presence of iron inhibitors. Studies like [41,42] have also shown similar tendencies.

It is probable that the relationship between hemoglobin and cereal-based staples like wheat and rice is related to the absorption-impairing phytates and cooking losses [43,44]. Legumes, unprocessed rice, and whole grains contain phytates, which can lower the absorption of non-heme iron by 51–82%. Similarly, there was no statistically significant relationship between hemoglobin levels and dairy products. Despite its importance for bone health, dairy products, particularly when eaten with meals that are high in iron, may reduce the absorption of iron due to their calcium content [44,45]. The finding on interaction between gender, socioeconomic status, cultural customs, and dietary types, the intricacy of iron nutrition becomes clear. The socioeconomic norms and restrictions on food distribution may contribute to gender variations in eating habits. Nutrient deficiencies are more common among Pakistani women since they are frequently not given priority when it comes to distributing food in the home [46-48].

CONCLUSION AND FUTURE RECOMMENDATION

This study highlights key nutritional challenges faced by young adults in Pakistan, including iron deficiency, gender disparities, and limited engagement in preventive health behaviors. Despite adequate nutritional knowledge, many participants failed to translate awareness into healthy practices, indicating a critical knowledge–practice gap. Future research should explore this disconnect through qualitative methods such as interviews or focus groups to uncover barriers to behavior change. Intervention and pilot studies targeting young adults with poor dietary habits could evaluate the impact of increased animal protein intake or more diverse diets on hemoglobin levels. In addition, examining how traditional Pakistani dietary patterns influence nutritional adequacy can guide culturally appropriate strategies to improve nutrient intake. Addressing these issues during young adulthood is essential to prevent nutrition-related chronic diseases and promote long-term health. The findings of this study provide a foundation for future interventions and public health strategies tailored to the cultural context of Pakistani youth.

CONFLICTS OF INTEREST

No conflicts of interest.

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ETHICS APPROVAL

Informed written consent was obtained from all participants. The study was conducted in full accordance with the ethical principles outlined in the Declaration of Helsinki.

CONSENT FOR PUBLICATION

All authors have consent for publication.

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