Vitamin B12 Deficiency and Gender Dynamics: Insights From A Tertiary Care Hospital Experience.

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ABSTRACT:

Objective: To assess the clinical manifestations associated with vitamin B12 deficiency and to investigate the variations in clinical presentation between different genders.

Methodology: This descriptive cross-sectional study was conducted at Department of Medicine, Dow University Hospital, Ojha Campus, Karachi from February 2025 to July 2025. A total of 134 adults presenting with clinical symptoms suggestive of vitamin B12 deficiency were consecutively enrolled from the outpatient department. Patients were evaluated about their medical history and lifestyle habits. Patients were also enquired about their present symptoms and clinically examined. Vitamin B12 deficiency level was confirmed on serum vitamin B12 levels. SPSS version 26 with a p-value of 0.05 was used for statistical analysis.

Results: Vitamin B12 deficiency was confirmed in 66 (49.3%) patients. Of which 80.3% were male and 19.7% were female (p = 0.043). The most common clinical symptom was easy fatigability (87.9%), followed by pallor (86.4%), palpitations (62.1%), glossitis (50.0%), and shortness of breath grade ≥1 (50.0%).

Conclusion: This study concludes that vitamin B12 deficiency presents with a wide spectrum of clinical manifestations, most commonly fatigue, pallor, palpitations, glossitis, and neurological complaints, emphasizing its significant impact on overall health.

Keywords: Fatigue, glossitis, pallor, palpitations, vitamin B12 deficiency.

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Introduction:

Vitamin B12 is one of the most common and essential members of the B complex vitamins, which play a vital role in cellular proliferation because of its significant role in deoxyribonucleic acid (DNA) metabolic processes, methylation, and mitochondrial metabolism within the body.[1] This water-soluble vitamin is predominantly found in foods sourced from animals, including fish, meat, and dairy products, in addition to being available in fortified cereals and a range of dietary supplements.[1,2] It is essential for the nervous system to function effectively.and to facilitate the production of red blood cells, and DNA, acting as a coenzyme in three biochemical pathways. It is absorbed in the terminal ileum in conjunction with a protein known as intrinsic factor after being processed by gastric acid.[3] The condition is defined as a collection of symptoms resulting from low concentrations of vitamin B12 in the plasma and tissues. Some signs of mild deficiency involve fatigue, anemia, sore tongue, ulcers in the mouth and gums, easy breathlessness, dizziness, tachycardia, pallor, alopecia, impaired cognitive dysfunction, paresthesia-associated pain, and the occurrence of neurological abnormalities. Some of the severe manifestation include; impaired memory, loss of vision, irritability, ataxia, lethargy, depression, anxiety and psychosis. Temporary sexual sterility that can be treated may be realized, and if deficiency remains untreated, it leads to growth deficiency, developmental delay, and impaired movement in exclusively breastfed infants of vegan mothers.[4,5] There are three cutoff points for vitamin B12 status: 1) deficiency if the level is below 200 pg/mL; 2) insufficiency is when the level ranges between 200-350 pg/mL; 3) sufficiency is determined if the level is 350 pg/mL or above.[6] Studies have shown a statistically significant variation in mean serum vitamin B12 levels among men and women, with men generally showing higher deficiency rates and a stronger association with severe deficiencies as compared to women.[7] Age and sex influence the prevalence of vitamin B12 deficiency. Overall, a substantial proportion of patients present with clinical symptoms such as fatigue, memory loss, weakness, depression, aches and pains, and shortness of breath.[8] Additionally, anemia along with vitamin B12 and folate deficiencies remains a remarkable public health concern, particularly among women in their reproductive years in Pakistan.[9] Elevated plasma homocysteine levels, which are linked to vitamin B12 deficiency, can results in serious health conditions such as stroke, atherosclerosis, Alzheimer's disease, myocardial infarction, cognitive decline in the elderly, birth defects in pregnant women, and increased mortality rates.[10]

Objective: The primary objective of the current study is to determine the signs and symptoms associated with vitamin

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B12 deficiency and investigate the gender-specific expressions of this deficiency in Pakistan. This research project aims at contributing towards the finding of clinical indications, manifestations, and possibly difficulties which may be faced when managing patients who are affected with B12 deficiency.

Methodology:

A descriptive cross-sectional study was conducted on patients presenting with clinical symptoms suggestive of vitamin B12 deficiency at Department of Medicine, Dow University Hospital, Ojha Campus, Dow University of Health Sciences (DUHS), Karachi from February 2025 to July 2025. The sample size for this research was calculated using the Open Epi software for sample size calculation. A previous researcher, Aamir et al., reported that numbness was found in 90.4% of patients diagnosed with vitamin B12 deficiency and was used as a reference with a confidence level of 95% and a margin of error of 5%. The final calculated sample size was 134.

The study includes: (1) adult patients of both genders, (2) individuals aged 18-65 years, (3) patients exhibiting clinical symptoms such as easy fatigability, palpitations, and shortness of breath, and (4) patients presenting for the first time to the outpatient department.

The study excludes: (1) patients who declined to participate in the study, (2) individuals with a medical history of illness or prior use of medications or nutritional supplements, (3) preexisting hematological disorders or malignancies, as documented in medical records, (4) a history of blood transfusions within the past two weeks, (5) pregnant or lactating women, and (6) individuals who have been taking metformin, proton pump inhibitors (PPIs), H2 receptor antagonists, colchicine, or chloramphenicol for a minimum duration of three months.

The study received approval prior to commencement from the Institutional Review Board (IRB) of DUHS, Karachi (Letter No. IRB-3714/DUHS/Approval/2024/36, dated 28-01-2025). Written informed consent was obtained from patients who strictly fulfil the inclusion criteria of the study. Patients were enquired about demographics and lifestyle habits. Patients were also questioned about their current symptoms, including palpitations, shortness of breath, easy fatigability, and numbness in the hands and feet. A comprehensive clinical examination was performed for finding pallor, glossitis, and stomatitis symptoms in addition to vital indicators like pulse rate. Information about medical history including diabetes mellitus, hypertension, hypothyroidism, acid peptic disease, chronic kidney disease, malabsorption syndromes, autoimmune diseases, previous intestinal surgeries, and family histories of vitamin B12 deficiency was also obtained from patient. Enquiry about lifestyle habits of patients include smoking, alcohol consumption, and dietary practices. Blood samples were collected in a sterile environment and subsequently analyzed in the laboratory for vitamin B12 levels, along with other hematological parameters, including hemoglobin levels and mean corpuscular volume (MCV) percentage. Serum levels <200 pg/mL is commonly used for confirming diagnosis of vitamin B12 deficiency.

The analysis of data was conducted utilizing statistical package for social sciences (SPSS), version 26. Continuous variables were reported as means accompanied by standard deviations. Categorical variables were reported as frequency accompanied by percentages. The chi-square test was employed to determine the p-value. Results were displayed in tables and graphs, with a statistical significance determined at a p-value of 0.05.

Results:

Of the 134 patients with suspected vitamin B12 deficiency, 49.3% (n=66) were vitamin B12 deficient, whereas 50.7% (n=68) had normal vitamin B12 levels [Figure 1].

Overall, male patients were the majority (72.4%, n=97) compared to female patients (27.6%, n=37). Male patients were also significantly more likely to have vitamin B12 deficiency compared to female patients (80.3% vs. 19.7%, p = 0.043). Overall, the mean age was 45.69 ± 12.90 years, and it was significantly elevated in patients diagnosed with low levels of vitamin B12 in contrast to those with normal levels [48.65 ± 12.25 vs. 42.82 ± 12.95, p=0.008]. Similarly, current smokers (43.9% vs. 26.5%, p=0.034), and vegetarians (54.5% vs. 36.8%, p=0.039) were more likely to have low levels of vitamin B12 in contrast to those with normal levels [Table 1].

A comparison of medical history indicates that diabetes mellitus (24.2% vs. 14.7%, p=0.163), hypothyroidism (21.2% vs. 10.3%, p=0.082), chronic kidney disease (21.2% vs. 16.2%, p=0.454), malabsorption (27.3% vs. 14.7%, p=0.074), autoimmune disease (12.1% vs. 8.8%, p=0.533), and a family history of vitamin B12 deficiency (6.1% vs. 2.9%, p=0.383) were non-significantly higher in patients with low levels of vitamin B12 in contrast to those with normal levels, whereas hypertension was non-significantly higher in patients with normal vitamin B12 levels than in vitamin B12-deficient patients (12.1% vs. 23.5%, p=0.085) [Table 1].

A comparison of clinical characteristics indicates that easy fatigability (87.9% vs. 50.0%, p<0.001), shortness of breath grade ≥2 (36.3% vs. 0.0%, p<0.001), palpitations (62.1% vs. 38.2%, p=0.006), numbness of hand and feet (36.4% vs. 17.6%, p=0.015), mean pulse rate (115.33 ± 10.85 vs. 94.12 ± 9.46, p<0.001), pallor p<0.001), glossitis (50.0% vs. 0.0%, p<0.001), and stomatitis (22.7% vs. 5.9%, p<0.001) were significantly elevated in patients with low levels of vitamin B12 in contrast to those with normal levels [Table 2].

A comparison of laboratory findings also indicates that the mean values of hemoglobin (6.35 ± 2.44 vs. 12.04 ± 2.40, p<0.001), leukocyte count (4.31 ± 1.56 vs. 5.69 ± 1.22, p<0.001), platelets count (78.61 ± 59.13 vs. 247.32 ± 64.03, p<0.001), and serum Vitamin B12 level (117.14 ± 39.82 vs. 266.69 ± 42.55, p<0.001) were significantly lower in patients with low levels of vitamin B12 in contrast to those with normal levels, whereas mean corpuscular volume was significantly higher in patients with normal vitamin B12 levels than in vitamin B12-deficient patients (113.96 ± 8.98 vs. 90.03 ± 7.33, p<0.001) [Table 3].

Similarly, comparisons between male and female patients indicate significant and non-significant differences in demographics, lifestyle habits, medical history [Table 4], and clinical characteristics [Table 45, whereas laboratory findings showed only non-significant differences [Table 6]. Specifically, differences were observed in occupation (p<0.001), smoking (p=0.003), dietary habit (p=0.015), diabetes mellitus (p=0.005), easy fatigability (p=0.022), shortness of breath (p=0.024), numbness of hand and feet (p=0.006), and glossitis (p=0.005).

Figure 1: Vitamin B12 Status.

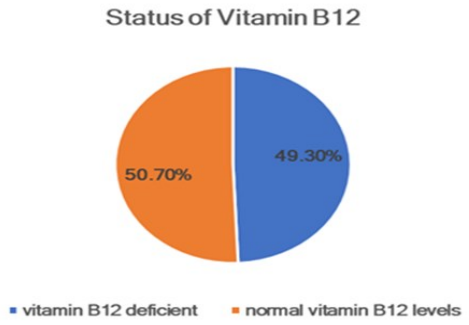

Table No 1: Patients Demographics, Lifestyle Habits and Medical History Distribution According to their Vitamin B12 Status.

	Deficient (n=66)	Normal (n=68)	Total (n=134)	p-Value
Gender				
Male	53 (80.3%)	44 (64.7%)	97 (72.4%)	0.043
Female	13 (19.7%)	24 (35.3%)	37 (27.6%)	
Age				
Mean ± SD	48.65 ± 12.25	42.82 ± 12.95	45.69 ± 12.90	0.008
18-34	8 (12.1%)	16 (23.5%)	24 (17.9%)	0.029
35-49	18 (27.3%)	26 (38.2%)	44 (32.8%)	
50-65	40 (60.6%)	26 (38.2%)	66 (49.3%)	
Occupation				
Student	11 (16.7%)	9 (13.2%)	20 (14.9%)	0.628
Housewife	11 (16.7%)	17 (25.0%)	28 (20.9%)	
Employed	44 (66.7%)	42 (61.8%)	86 (64.2%)	
Smoking				
Non-Smoker	37 (56.1%)	50 (73.5%)	87 (64.9%)	0.034
Current Smoker	29 (43.9%)	18 (26.5%)	47 (35.1%)	
Dietary Habit				
Vegetarian	36 (54.5%)	25 (36.8%)	61 (45.5%)	0.039
Non-Vegetarian	30 (45.5%)	43 (63.2%)	73 (54.5%)	
Medical History				
DM	16 (24.2%)	10 (14.7%)	26 (19.4%)	0.163
HTN	8 (12.1%)	16 (23.5%)	24 (17.9%)	0.085
Hypothyroidism	14 (21.2%)	7 (10.3%)	21 (15.7%)	0.082
CKD	14 (21.2%)	11 (16.2%)	25 (18.7%)	0.454
Malabsorption	18 (27.3%)	10 (14.7%)	28 (20.9%)	0.074
Autoimmune Disease	8 (12.1%)	6 (8.8%)	14 (10.4%)	0.533
Family History of B12 Deficiency	4 (6.1%)	2 (2.9%)	6 (4.5%)	0.383

DM: Diabetes Mellitus; HTN: Hypertension; CKD: Chronic Kidney Disease

Table 2: Patients Clinical Characteristics According to their Vitamin B12 Status.

	Deficient (n=66)	Normal (n=68)	Total (n=134)	p value
Clinical Features				
Easy Fatigability	58 (87.9%)	34 (50.0%)	92 (68.7%)	<0.001
Shortness of Breath				
Grade 0	33 (50.0%)	34 (50.0%)	67 (50.0%)	<0.001
Grade 1	9 (13.6%)	34 (50.0%)	43 (32.1%)	
Grade 2	16 (24.2%)	0 (0.0%)	16 (11.9%)	
Grade 3	8 (12.1%)	0 (0.0%)	8 (6.0%)	
Palpitations	41 (62.1%)	26 (38.2%)	67 (50.0%)	0.006
Numbness of Hand and Feet	24 (36.4%)	12 (17.6%)	36 (26.9%)	0.015
Clinical Examination Findings				
Pulse Rate (Mean ± SD)	115.33 ± 10.85	94.12 ± 9.46	104.57 ± 14.70	<0.001
Pallor	57 (86.4%)	22 (32.4%)	79 (59.0%)	<0.001
Glossitis	33 (50.0%)	0 (0.0%)	33 (24.6%)	<0.001
Stomatitis	15 (22.7%)	4 (5.9%)	19 (14.2%)	0.005

Table 3: Patients Laboratory Characteristics According to their Vitamin B12 Status.

Variables	Deficient (n=66)	Normal (n=68)	Total (n=134)	p value
Hb	6.35 ± 2.44	12.04 ± 2.40	9.24 ± 3.74	<0.001
MCV	113.96 ± 8.98	90.03 ± 7.33	101.81 ± 14.51	<0.001
Leukocyte	4.31 ± 1.56	5.69 ± 1.22	5.01 ± 1.56	<0.001
Platelets	78.61 ± 59.13	247.32 ± 64.03	164.22 ± 104.61	<0.001
Vitamin B12	117.14 ± 39.82	266.69 ± 42.55	193.03 ± 85.56	<0.001

Hb: Hemoglobin; MCV: Mean Corpuscular Volume

Discussion:

Vitamin B12 deficiency remains a significant yet often overlooked clinical issue, particularly among patients presenting with nonspecific symptoms or risk factors. Although the classic neurological and haematological features are well established, many patients suspected of having vitamin B12 deficiency present with a wide spectrum of symptoms and laboratory abnormalities before the diagnosis is confirmed. Early identification and timely management of vitamin B12 deficiency are crucial to prevent neurological complications and enhance patient outcomes.[11, 12]

Therefore, this study aimed to assess the clinical manifestations associated with vitamin B12 deficiency and to investigate the variations in clinical presentation between different genders. In this study, a total of 134 patients with suspected vitamin B12 deficiency were evaluated, of whom 49.3% (n = 66) were vitamin B12 deficient, whereas 50.7%

(n = 68) had normal vitamin B12 levels. Similar higher burden was also reported from Pakistani studies, such as Aamir et al. also highlighted a substantial burden, reporting deficiency in 56.1% of their study population.[8]

Table No 4: Patients Demographics, Lifestyle Habits and Medical History Distribution According to Gender in Vitamin B12 Deficiency.

Variables		Male (n=53)	Female (n=13)	p value
Age	Mean ± SD	48.76 ± 12.11	48.23 ± 13.28	0.891
	18-34	6 (11.3%)	2 (15.4%)	0.883
	35-49	15 (28.3%)	3 (23.1%)	
	50-65	32 (60.4%)	8 (61.5%)	
Occupation	Student	9 (17.0%)	2 (15.4%)	<0.001
	Housewife	0 (0.0%)	11 (84.6%)	
	Employed	44 (83.0%)	0 (0.0%)	
Smoking	Non-Smok-	25 (47.2%)	12 (92.3%)	0.003
	Current Smok-	28 (52.8%)	1 (7.7%)	
Dietary Habit	Vegetarian	25 (47.2%)	11 (84.6%)	0.015
	Non-Vege-	28 (52.8%)	2 (15.4%)	
Medical History	DM	9 (17.0%)	7 (53.8%)	0.005
	HTN	8 (15.1%)	0 (0.0%)	0.135
	Hypothyroid	10 (18.9%)	4 (30.8%)	0.347
	CKD	11 (20.8%)	3 (23.1%)	0.854
	Malabsor	16 (30.2%)	2 (15.4%)	0.283
	Autoimmune Dis-	7 (13.2%)	1 (7.7%)	0.585
	Family History of B12 Deficiency	3 (5.7%)	1 (7.7%)	0.783

DM: Diabetes Mellitus; HTN: Hypertension; CKD: Chronic Kidney Disease

Another study from Pakistan by Ijaz et al. reported vitamin B12 deficiency in 33.5% of clinically diagnosed depressive patients.[13] Similarly, Iqbal et al. found a much higher prevalence of 78.5% among patients with megaloblastic anemia.[14] In contrast, a large cross-sectional study conducted by Margalit et al. among apparently healthy adults showed a lower prevalence of 23.4%.[7] The increased prevalence of vitamin B12 deficiency reported in Pakistani studies is mainly linked to hospital-based recruitment of clinically suspected patients, which raises the likelihood of confirmed deficiency. Other contributing factors include smoking, dietary habits, and a higher burden of comorbidities.

Table No 5: Gender wise Clinical Features of Vitamin B12 Deficiency.

Variables		Male (n=53)	Female (n=13)	p value
Clinical Features	Easy Fatigability	49 (92.5%)	9 (69.2%)	0.022
	Shortness of Breath			
	Grade 0	29 (54.7%)	4 (30.8%)	0.024
	Grade 1	9 (17.0%)	0 (0.0%)	
	Grade 2	9 (17.0%)	7 (53.8%)	
	Grade 3	6 (11.3%)	2 (15.4%)	
	Palpitations	33 (62.3%)	8 (61.5%)	0.961
	Numbness of Hand and Feet	15 (28.3%)	9 (69.2%)	0.006
Clinical Examination Findings	Pulse Rate (Mean ± SD)	115.17 ± 11.47	116.00 ± 8.22	0.807
	Pallor	48 (90.6%)	9 (69.2%)	0.045
	Glossitis	22 (41.5%)	11 (84.6%)	0.005
	Stomatitis	12 (22.6%)	3 (23.1%)	0.973

Table No 6: Laboratory Characteristics of male & female patients having deficiency of Vitamin B12.

Variables	Male (n=53)	Female (n=13)	p value
Hb	6.43 ± 2.54	6.03 ± 1.99	0.604
MCV	114.21 ± 9.45	112.92 ± 6.97	0.648
Leukocyte	4.43 ± 1.70	3.83 ± 0.66	0.217
Platelets	79.47 ± 63.34	75.08 ±39.15	0.812
Vitamin B12	116.94 ± 41.25	117.92 ±34.85	0.937

Hb: Hemoglobin; MCV: Mean Corpuscular Volume

In this study, male patients were more likely to have vitamin B12 deficiency compared to female patients (80.3% vs. 19.7%). Similar higher male burden was also reported from other studies, such as Margalit et al. reports the vitamin B12 deficiency in 74.8% male patients and 21.6% female patients,[7] while Aamir et al. reports the vitamin B12 deficiency in 71.4% male patients and 51.0% female patients.[8] Iqbal et al. reports that there was no significant difference of gender in vitamin B12 deficiency patients.[14] The increased prevalence of vitamin B12 deficiency in male patients reported in studies is mainly linked to lifestyle factors such as smoking, dietary habits, and a higher burden of comorbidities.

In this study, the mean age was significantly elevated in patients diagnosed with low levels of vitamin B12 in contrast to those with normal levels [48.65 ± 12.25 vs. 42.82 ± 12.95, p = 0.008]. The age group of 50-65 years comprised the majority of vitamin B12 deficient patients (n=66, 60.6%), followed by those aged 35-49 years (n=18, 27.3%) and 18-34 years (n=8, 12.1%). Ijaz et al. reported that 73.1% of vitamin B12 deficient patients were in the age group of 30-60 years, while 26.9% were in the 15-30 years group.[8] Similarly, Abu-Shanab et al. identified older age as

a significant risk factor for vitamin B12 deficiency.[16] In contrast, some other studies did not observe any significant association between age and vitamin B12 deficiency.[7, 8, 17] Our study along with some previous studies found that older age is significantly associated with a higher risk of vitamin B12 deficiency, and the risk increases with advancing age. However, since other studies found no such association, the role of age in vitamin B12 deficiency remains unclear and may vary across different populations.

In this study, life style habits of patients also significantly increased the risk of vitamin B12 deficiency, such as current smokers (43.9% vs. 26.5%, p=0.034), and vegetarians (54.5% vs. 36.8%, p=0.039) were more likely to have low levels of vitamin B12 in contrast to those with normal levels. Similar to our findings, multiple studies have also shown that both smokers and vegetarians are at higher risk of vitamin B12 deficiency such as a study Kothari et al. evaluated the association between vitamin B12 levels, nutritional status, and smoking, and reported a negative impact of smoking and dietary habits on vitamin B12 levels.[18] Similarly, Shekoohi et al. examined the effect of smoking on vitamin B12 status and found lower levels in smokers.[19] Other studies assessing the association between vitamin B12 levels and dietary patterns also reported significantly lower vitamin B12 levels in vegetarians compared to non-vegetarians.[20, 21] These results indicate that two significant risk factors for decreased vitamin B12 levels are smoking and vegetarian diets. The decreased dietary intake of vegetarians and the negative metabolic effects of smoking on vitamin absorption and utilisation are probably the main causes of the deficiency.

In this study, the most common clinical characteristic of patients with vitamin B12 deficiency was easy fatigability 87.9% (n=58) followed by pallor 86.4% (n=57), palpitations 62.1% (n=41), glossitis 50.0% (n=33), shortness of breath grade ≥1 50.0% (n=33). numbness of hand and feet 36.4% (n=24) and stomatitis 22.7% (n=15). In the comparison between male and female patients, significant differences were observed in easy fatigability (p=0.022), shortness of breath (p=0.024), numbness of hands and feet (p=0.006), and glossitis (p=0.005). Similar to our findings, multiple studies have also documented a wide range of clinical manifestations in patients with vitamin B12 deficiency.

Aamir R et al. reports various clinical symptoms associated with this deficiency, including memory impairment (93.5%), numbness (90.4%), fatigue (83.6%), shortness of breath (85%), weakness (62.9%), depression (68%), aches and pains (57.7%)[8] Similarly, Agrawal et al. reported the fatigue (66.7%) as most common symptom followed by numbness/tingling (54.4%), light-headedness (45.6%) and gastrointestinal symptoms (26.7%) in vitamin B12 deficiency patients.[12] Singh et al. reported the paresthesia (98.18%) as most common symptom followed by head heaviness/ache (95%), anxiety (83.63%), fatigue (81.82%), impaired vibratory sense (73.63%), irritability (51.36%), pale skin (38.18%), and glossitis (35.45%).[22] Lashari et al. reported the numbness (65.2%) as most common symptom followed by motor weakness (24.1%), myelopathy (20.5%) and ataxia (18.2%).[23] These studies help to conclude that fatigue, pallor, glossitis, and neurological symptoms were the most common clinical manifestations of vitamin B12 deficiency, underscoring the broad and variable clinical spectrum of this condition.

This study has certain limitations that should be acknowledged. Being cross-sectional in design, it cannot establish causal relationships between vitamin B12 deficiency and clinical manifestations. The relatively small sample size and single-center setting may restrict the generalizability of the findings to wider populations. In addition, the short study duration limited the ability to fully assess long-term dietary influences on vitamin B12 status. Larger, multi-center longitudinal studies are recommended to validate and expand upon these results.

Conclusion: This study concludes that vitamin B12 deficiency presents with a wide spectrum of clinical manifestations, most commonly fatigue, pallor, palpitations, glossitis, and neurological complaints, emphasizing its significant impact on overall health. A significant gender differences were found in easy fatigability, shortness of breath, numbness of hands and feet, and glossitis.

Ethical permission: Dow University of Health Sciences ERC (Letter No. IRB-3714/DUHS/Approval/2024/36, dated 28-01-2025)

Conflict of Interest: There is no conflict of interest.

References:

1. Vasavada A, Patel P, Sanghavi DK. Cyanocobalamin. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan. Available from: https://www.ncbi.nlm.nih.gov/books/NBK555964/.
2. Zhou Y, Wang A, Yeung LF, Qi YP, Pfeiffer CM, Crider KS. Folate and vitamin B12 usual intake and biomarker status by intake source in United States adults aged ≥19 y: NHANES 2007-2018. Am J Clin Nutr. 2023;118 (1):241-54. Available from: https://doi.org/10.1016/j.ajcnut.2023.05.017
3. Wolffenbuttel BH, Owen PJ, Ward M, Green R. Vitamin B12. BMJ. 2023;383:e071725. Available from: https://doi.org/10.1136/bmj-2022-071725.
4. Obeid R, Andrès E, Češka R, Hooshmand B, Guéant-Rodriguez RM, Prada GI, et al. Diagnosis, treatment and long-term management of vitamin B12 deficiency in adults: a Delphi expert consensus. J Clin Med. 2024;13(8):2176. Available from: https://doi.org/10.3390/jcm13082176.
5. Hasbaoui BE, Mebrouk N, Saghir S, Yajouri AE, Abilkassem R, Agadr A. Vitamin B12 deficiency: case report and review of literature. Pan Afr Med J. 2021;38:237. Available from: https://doi.org/10.11604/pamj.2021.38.237.27542.
6. Baltaci D, Deler MH, Turker Y, Ermis F, Iliev D, Velioglu U. Evaluation of serum vitamin B12 level and related nutritional status among apparently healthy obese female individuals. Niger J Clin Pract. 2017;20 (1):99-105. Available from: https://doi.org/10.4103/1119-3077.181394.
7. Margalit I, Cohen E, Goldberg E, Krause I. Vitamin B12 deficiency and the role of gender: a cross-sectional study of a large cohort. Ann Nutr Metab. 2018;72 (4):265-71. Available from: https://doi.org/10.1159/000488067.
8. Aamir R, Virk ST, Zahra T, Virk KA, Virk ST. Vitamin B12 deficiency and its clinical correlation. Rawal Med J. 2018;43(4):615-8.
9. Soofi S, Khan GN, Sadiq K, Ariff S, Habib A, Kureishy S, et al. Prevalence and possible factors associated with anaemia, and vitamin B12 and folate deficiencies in women of reproductive age in Pakistan: analysis of national-level secondary survey data. BMJ Open. 2017;7(12):e018007. Available from: https://doi.org/10.1136/bmjopen-2017-018007.
10. Sahu P, Thippeswamy H, Chaturvedi SK. Neuropsychi-

atric manifestations in vitamin B12 deficiency. Vitam Horm. 2022;119:457-70. Available from: https://doi.org/10.1016/bs.vh.2022.03.021
11. Papakitsou I, Papazachariou A, Filippatos T. Prevalence, associated factors, and impact of vitamin B12 deficiency in older medical inpatients. Eur Geriatr Med. 2025;16(1):337-46. Available from: https://doi.org/10.1007/s41999-024-00975-1.
12. Agrawal AR, Mair N, Mehta RS, Chakrapani AS, Gupta K, Srivastav Y, et al. Clinical and hematological characteristics of vitamin B12 deficiency and evaluation of the therapeutic response to vitamin B12 supplementation. Cureus. 2024;16(12):e76468. Available from: https://doi.org/10.7759/cureus.76468.
13. Ijaz S, Rauf S, Zubair UB, Iqbal F, Iqbal W, Nasir Z. Vitamin B12 deficiency among depressive patients presenting in tertiary care hospital of Karachi. Pak Armed Forces Med J. 2025;75(1):99.
14. Iqbal SP, Kakepoto GN, Iqbal SP. Vitamin B12 deficiency: a major cause of megaloblastic anaemia in patients attending a tertiary care hospital. J Ayub Med Coll Abbottabad. 2009;21(3):92-4.
15. Yakub M, Iqbal MP, Kakepoto GN, Rafique G, Memon Y, Azam I, et al. High prevalence of mild hyperhomocysteinemia and folate, B12 and B6 deficiencies in an urban population in Karachi, Pakistan. Pak J Med Sci. 2010;26(4):923-9.
16. Abu-Shanab A, Zihlif M, Rbeihat MN, Shkoukani ZW, Khamis A, Isleem U, et al. Vitamin B12 deficiency among the healthy Jordanian adult population: diagnostic levels, symptomology and risk factors. Endocr Metab Immune Disord Drug Targets. 2021;21(6):1107-14. Available from: https://doi.org/10.2174/1871530320666200617103837.
17. Patel SV, Makwana AB, Gandhi AU, Tarani G, Patel J, Bhavsar V. Factors associated with vitamin B12 deficiency in adults attending tertiary care hospital in Vadodara: a case-control study. Egypt J Intern Med. 2022;34(1):11. Available from: https://doi.org/10.1186/s43162-022-00133-5.
18. Kothari V, Leelavathi L, Jayaraman S. Association of nutritional status and vitamin B12 levels among smokers and non-smokers. J Pioneer Med Sci. 2024;13(7):135-40.
19. Shekoohi N, Javanbakht MH, Sohrabi M, Zarei M, Mohammadi H, Djalali M. Smoking discriminately changes the serum active and non-active forms of vitamin B12. Acta Med Iran. 2017;55(6):389-94.
20. Kapoor A, Baig M, Tunio SA, Memon AS, Karmani H. Neuropsychiatric and neurological problems among vitamin B12 deficient young vegetarians. Neurosciences (Riyadh). 2017;22(3):228-32. Available from: https://doi.org/10.17712/nsj.2017.3.20170027.
21. Singh G, Patel MK, Bharati P, Singh S, Singh P. Prevalence of vitamin B12 deficiency in the northern Indian vegetarian population: a clinical study. Saudi J Med. 2019;4(2):219-21.
22. Singh J, Dinkar A, Gupta P, Atam V. Vitamin B12 deficiency in northern India tertiary care: prevalence, risk factors and clinical characteristics. J Family Med Prim Care. 2022;11(6):2381-8. Available from: https://doi.org/10.4103/jfmpc.jfmpc_2062_21.
23. Lashari I, Khanzada BA, Larik AB, Siyal NN, Abro MA. Clinical determinants and neurological manifestation among adult patients with vitamin B deficiency. Pak J Neurol Surg. 2025;29(1):45-52.

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Sindhoo	Contributions to conception and design, acquisition of data, analysis, and interpretation of data.
Darshan Kumar	is droughting the article and sharing its expert opinion and experience in finalizing the manuscript. Final proofreading, review of literature, sequencing of the material, as well as grammatical review
Afshan Siddique	Contributed to conception and interpretation of data and gave expert view
Salma Salman	Collection and acquisition of data and help in analysis and review of manuscript.
Shayan Ali	Contributed to conception and interpretation of data
Qutab Uddin	Final proofreading, review of literature, sequencing of the material, as well as grammatical review.