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Research Article

Nutritional Deficiencies and Haematological Profiles in Adult People Living with HIV: A Cross-Sectional Study

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I N F O

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A B S T R A C T

Background: Nutrition and HIV are intricately linked, with malnutrition worsening immune impairment and accelerating HIV progression. Conversely, HIV-related immune dysfunction can exacerbate nutritional deficiencies. This interplay is particularly concerning in PLHIV, where optimal nutrition is crucial for immune responses and overall health. This study assessed haematological and biochemical profiles and the prevalence of deficiencies in PLHIV attending an ART centre in Delhi.

Methods: A cross-sectional study was conducted from January 2021 to June 2022, including 30 adult PLHIV consenting patients. Data on demographics, BMI, and haematological/biochemical parameters were collected and analyzed using SPSS, with significance set at $p<0.05$.

Results: High rates of nutritional deficiencies were found: anaemia (66.66%), vitamin B12 deficiency (56.66%), low serum iron (63.33%), low ferritin (70%), insufficient vitamin D3 (80%), and low albumin (40%), significantly exceeding general population prevalence. Malnutrition was prevalent, with 60% underweight and only 26.7% having a normal BMI. Low BMI was associated with albumin deficiency ($p=0.033$). Age correlated with lower haemoglobin and total protein. Trends suggested higher ferritin deficiency in females ($p=0.073$) and lower phosphorus in males ($p=0.061$).

Conclusion: Nutritional deficiencies are common in PLHIV and negatively impact their haematological and biochemical parameters. Addressing these deficiencies is crucial for improving health outcomes. This research highlights the critical need for ongoing studies to explore effective nutritional interventions and their impact on the health of individuals living with HIV.

Keywords: HIV, Nutritional Deficiency, Haematological Profile, Body Mass Index, Biochemical Parameters

Introduction

HIV/AIDS poses a significant global health crisis, profoundly impacting nutrition and immune function.[1]Malnutrition often results from HIV infection, further deteriorating immune health and hastening the transition to AIDS. Conversely, an impaired immune system can exacerbate nutritional deficiencies, creating a vicious cycle.[2] This research investigates the interplay between nutritional status and the haematological and biochemical profiles of adult PLHIV, highlighting the critical need for integrated nutritional interventions to support this vulnerable population.[3]

Studies have demonstrated that micronutrient deficiencies are common among PLHIV. Vitamins and minerals play essential roles in immune function, and deficiencies can result in impaired responses to infections, higher morbidity, and increased mortality rates, for example, deficiencies in vitamins A, C, D, and E, as well as zinc and selenium, have been associated with poor immune outcomes in individuals living with HIV.[5] Consequently, addressing these deficiencies through targeted nutritional interventions is critical for improving health outcomes in this population.[4]

This study investigates the relationship between nutritional status and the haematological and biochemical profiles of adult PLHIV. Haematological parameters such as haemoglobin levels, total protein, and serum albumin can provide insights into the nutritional status of individuals. Low levels of haemoglobin may indicate anaemia, which is prevalent in HIV-infected populations and can be exacerbated by poor nutrition. Similarly, serum albumin and total protein levels are markers of protein status and can reflect overall nutritional health.[5]

Furthermore, biochemical assessments—including serum levels of vitamins, minerals, and lipids—are essential for identifying deficiencies that can affect immune function. Evaluating these parameters allows for a comprehensive understanding of the nutritional landscape in PLHIV and aids in tailoring interventions to improve health outcomes. Nutritional interventions can include dietary modifications, supplementation, and counselling, all aimed at enhancing the quality of life for individuals living with HIV.

Inclusion and Exclusion Criteria

All adult (>18 years of age) HIV patients who have taken at least 3 months of ART in our having >95% adherence to treatment were included irrespective of CD4 counts and HIV related complications.

Patients with preexisting Chronic Comorbidities like cirrhosis, Chronic obstructive pulmonary disease, chronic heart failure were excluded. Patients with pregnancy and addictions like alcohol or other recreational substance abuse were also excluded.

Materials and Methods

Study Design

This cross-sectional study was conducted between January 2021 and June 2022 at Lady Hardinge Medical College, New Delhi, India. The study population consisted of adult PLHIV attending the ART Centre, OPD, or admitted to medical wards.

Methodology

Sample Size Calculation

The sample size was determined using the formula , $n=Z^2.p(1-p)/E^2$ Where Population Size (N) was 500,000, Confidence Level (Z) was 1.96 (for 95% confidence) , Margin of Error (E) was Typically 0.05 (5%), and Proportion (p)0.5 (maximum variability), which came out 384.15.

The number of newly diagnosed HIV patients registered in the ART Clinic was 80 in 2020 (treatment-naive), and 394 HIV patients were already receiving ART to date (treatment -exposed).

But, based on the number of patients as stated above and time frame of enrolment, a convenient sample size of 30 HIV due to the ongoing covid scenario and conventional crises

Ethics

Ethical clearance was obtained from the institution. This observational study included diagnosed HIV patients attending the ART clinic who met the inclusion criteria. After securing written informed consent, data were collected using a structured proforma, encompassing demographic information, clinical history, and dietary intake.

- **Clinical Examination:** Height and weight were measured to calculate Body Mass Index (BMI).
- **Investigations:** Blood samples were collected after 8-10 hours of fasting for various biochemical tests, including haemoglobin, total protein levels and albumin, vitamins (B12, D3, folic acid) and iron profile. Samples were analysed using automated analysers.
- **Data Management:** Clinical and biochemical data were recorded, with nutritional cut-off levels defined for various parameters. Statistical analysis was performed using SPSS version 30.0.0, with p-values < 0.05 deemed significant. Ethical considerations included informed consent, confidentiality, and approval from the Institutional Ethics Committee.

Results

Analysis of Study Population

Patient Demographics

A total of 30 patients were studied at the ART centre, inpatient facilities, and OPD of Lady Hardinge Medical College and associated hospitals, following strict inclusion

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and exclusion criteria. Out of these, 4 patients were ART-naive, while the remaining were ART-exposed.

Age Distribution: Table 1

The mean age of participants was 32.87 years [Standard deviation (SD) = 10.42], ranging from 19 to 66 years.

The Gender Distribution

Following data depict the gender distribution of the study population:

- Male: 7 patients (23.3%)

- Female: 23 patients (76.7%)

There was a notable predominance of female patients.

Body Mass Index (BMI)

Table 1.Distribution of Cases According to Age

N = 30

Age Group	Number of Cases	Percentage (%)
25 years or below	10	33.33
26 - 35 years	7	23.33
36 - 45 years	10	33.33
Above 45 years	3	10.00
Total	30	100.00
Mean Age (years)	**Standard Deviation (SD)**	**Range**
32.87	10.42	19 – 66

The mean BMI of the study group was 18.86 kg/m², with a standard deviation of 4.53. The BMI distribution is detailed in Table 2.This table provides a concise summary of the BMI distribution among the patients. A significant proportion of patients were under weight

Table 3. Association of presence of deficiency with BMI of the patient. (N = 30).

Haemato-Biochemical Parameters results are shown in Table 4.

Table 2.Distribution of Patients by Body Mass Index (BMI)

BMI Category	Number of Patients	Percentage (%)
Underweight (BMI < 18.5)	18	60.0
Normal (BMI 18.5 - 24.9)	8	26.7
Overweight (BMI 25 - 29.9)	3	10.0
Obese (BMI ≥ 30)	1	3.3
Total	30	100.0

Table 3.Association of presence of deficiency with BMI of the patient

N = 30

Parameter for deficiency	Number of cases (%)		p-value
	BMI < 18.5 Kg/m2	BMI > 18.5 Kg/m2	
Hb	13	7	0.429
Vitamin B12	11	6	0.547
Vitamin D3	14	10	0.709
Iron	12	7	0.643
Ferritin	12	9	0.626
TIBC	1	2	0.320
Calcium	6	6	0.361
Phosphorus	2	1	0.804
Magnesium	6	3	0.626
Total Protein	5	1	0.192
Albumin	10	2	0.033

Table 4.Haemato-Biochemical Parameters of the Study Group

N = 30

Marker	Mean (SD)	Range
Haemoglobin (g/dl)	9.83 (3.05)	3.8 - 15.3
Vitamin B12 (pg/ml)	251.89 (341.35)	54 - 1506
Folic Acid (nmol/L)	17.34 (11.92)	6.53 - 58
Vitamin D3 (ng/ml)	16.59 (12.41)	2.9 - 47
Serum Iron (µg/dl)	51.03 (39.24)	1.4 - 160.72
Serum Ferritin (ng/ml)	29.12 (60.87)	1.9 - 328
Total Iron Binding Capacity (mg/dl)	430.4 (145.8)	75 - 705.4
Serum Calcium (mg/dl)	9.05 (1.01)	7.8 - 12.2
Serum Phosphorus (mg/dl)	3.91 (1.42)	1.9 - 8.92
Serum Magnesium (mg/dl)	2.24 (0.47)	1.6 - 3.2
Serum Protein (g/dl)	7.19 (1.42)	3.6 - 8.81
Serum Albumin (g/dl)	3.47 (0.78)	1.7 - 4.4

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Age and Parameter Associations

Here's a consolidated Table 5 presenting the associations of haematological and biochemical parameters with their mean ages:

Explanation

This table appropriately presents the relationships between haematological and biochemical parameters and the mean ages of patients, allowing for clear interpretation of the data.

As can be observed, the mean age of patients with Hb deficiency was significantly higher compared to patients without deficiency i.e. patients with HIV on ART approaching the age of 38.8 (mean age) have more propensity to have anaemia than those younger than 38.8 years of age.

Similarly, we found the mean age of protein deficiency in PLHIV on ART was also significantly higher , as the mean age of protein deficiency was 35.22 years, while the mean age of PLHIV on ART without protein deficiency was 29.33 years.

Table 6: Association of Hemato-Biochemical Parameters with Sex of Patients

- **Hemoglobin:** A higher percentage of females showed haemoglobin deficiency compared to males, although the difference was not statistically significant (p = 0.127).
- **Vitamin B12:** The prevalence of vitamin B12 deficiency was similar between sexes, although not statistically significant (p = 0.977).
- **Vitamin D3:** A majority of both sexes had Vitamin D3 deficiency, with no significant difference (p = 0.666).
- **Iron:** A higher percentage of females had iron deficiency compared to males, but this was also not statistically significant (p = 0.199).
- **Ferritin:** A significant proportion of females were found to have low ferritin levels compared to males (p = 0.073), suggesting a trend that may warrant further investigation.
- **Calcium and Albumin:** Both parameters showed similar prevalence rates across sexes with no significant differences (p = 0.860).
- **Phosphorus:** A small percentage of females had phosphorus deficiency, while a higher proportion of males had derangement, with a p-value close to significance (p = 0.061).
- **Magnesium:** Deficiency rates were comparable between sexes, yielding no significant differences (p = 0.300).
- **Total Protein:** Both sexes had low total protein levels with no significant differences (p = 0.666).

Table 5.Association of Haematological and Biochemical Parameters Below Cut-Off with Mean Ages

Parameter	Mean-Age (Below Cut-Off) (SD)	Mean-Age (Above Cut-Off) (SD)	p-value
Haematological Parameters			
Haemoglobin (Hb)	38.8 (11.3)	29.9 (8.8)	0.025
Vitamin B12	36.84 (12.49)	29.82 (7.55)	0.066
Serum Iron	35.27 (12.78)	31.47 (8.86)	0.345
Serum Ferritin	35.11 (13.91)	31.9 (8.76)	0.450
Total Iron Binding Capacity (TIBC)	33.92 (10.41)	23.33 (3.78)	0.095
Biochemical Parameters			
Vitamin D3	28.16 (5.19)	34.04 (11.12)	0.223
Serum Calcium	32.61 (12.2)	33.25 (7.46)	0.873
Serum Phosphorus	33.92 (10.43)	23.33 (2.88)	0.095
Serum Magnesium	34.23 (8.3)	29.66 (14.31)	0.278
Total Protein	34.83 (10.66)	25 (3.74)	0.036
Serum Albumin	35.22 (11.17)	29.33 (8.41)	0.132

Table 6.Association of Haemato-Biochemical Parameters with Sex of Patients

Parameter for Deficiency/Derangement	Female (N = 23)	Male (N = 7)	p-value
Hemoglobin (Hb)	17 (73.9%)	3 (42.9%)	0.127
Vitamin B12	13 (56.5%)	4 (57.1%)	0.977

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Vitamin D3	18 (78.3%)	6 (85.7%)	0.666
Iron	16 (69.6%)	3 (42.9%)	0.199
Ferritin	18 (78.3%)	3 (42.9%)	0.073
Calcium	9 (39.1%)	3 (42.9%)	0.860
Phosphorus	1 (4.3%)	2 (28.6%)	0.061
Magnesium	8 (34.8%)	2 (28.6%)	0.300
Total Protein	5 (21.7%)	1 (14.3%)	0.666
Albumin	9 (39.1%)	3 (42.9%)	0.860

Discussion and Conclusion

Discussion

This study aimed to assess the haematological and biochemical profiles of adults living with HIV (PLHIV) and to understand the correlation between nutritional deficiencies and body mass index (BMI). The results reveal significant findings related to nutritional deficiencies and their associations with demographic factors, contributing to a deeper understanding of the nutritional challenges faced by this population.

Nutritional Deficiencies

The analysis of haematological parameters revealed concerning rates of nutritional deficiencies among the participants. A substantial proportion of the study population (66.66%) exhibited anaemia, with a mean haemoglobin level of 9.83 g/dl, significantly higher than the global prevalence of anaemia, which is estimated to be around 29% in non-pregnant women and 38% in pregnant women.[5] This suggests that PLHIV in this study experience a disproportionately high burden of anaemia. This finding indicates moderate to severe anaemia, which aligns with established literature on the adverse effects of HIV on nutritional status. Anaemia in PLHIV is often exacerbated by chronic disease processes, nutritional deficiencies, and the effects of antiretroviral therapy (ART)[i]. The mechanisms contributing to anaemia include haemolysis, bone marrow suppression, and iron deficiency due to chronic inflammation and malabsorption issues.[6]

Vitamin B12 deficiency was observed in 56.66% of patients, This prevalence of 56.66% for vitamin B12 deficiency is considerably elevated compared to the general population, where deficiency rates vary widely (3-26%) depending on geographic location, dietary habits, and age. The study population exhibits a much greater risk. The high prevalence of this deficiency may be attributable to inadequate dietary intake, malabsorption, or the effects of HIV on gastrointestinal function.[7]

Iron deficiency was particularly alarming, with 63.33% of participants showing low serum iron levels and 70% exhibiting low ferritin levels. These findings suggest a significant prevalence of iron deficiency anaemia among the participants. Global estimates suggest that iron deficiency affects around 30% of the world's population, making the study population especially vulnerable. The loss of iron due to chronic infections, inflammation, and malabsorption in the gastrointestinal tract can severely impact the health of PLHIV. Iron deficiency not only affects haematologic parameters but also plays a crucial role in immune function, further complicating the health of those living with HIV.[8]

A striking 80% of patients were found to have insufficient levels of vitamin D3, significantly greater than typically seen in the general population, where estimates range from 20% to 50%, dependent on latitude, skin pigmentation, and lifestyle. This points to a marked deficiency in the study group. Vitamin D deficiency is common in PLHIV due to factors such as reduced sun exposure, poor dietary intake, and malabsorption. Insufficient vitamin D levels can lead to osteopenia and osteoporosis, increasing the risk of fractures and further morbidity in this population.[9]

Regarding protein and albumin levels, while total protein levels were relatively normal, low albumin levels were detected in 40% of patients. Low albumin levels can indicate malnutrition or liver dysfunction, both of which are concerns in PLHIV, as it is higher than what would typically be expected in a healthy general population. Hypoalbuminemia in the general population is often associated with acute or chronic illness, with prevalence varying significantly Albumin serves as a vital marker of nutritional status, and its deficiency is linked to poorer health outcomes and increased mortality in HIV-infected individuals.[10]

BMI and Nutritional Deficiencies

Malnutrition was prevalent among the patients, as evidenced by the high proportion of underweight individuals (60.0%). Only 26.7% had a normal BMI, while 10.0% were overweight and 3.3% were obese.

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The association between the presence of various deficiencies and BMI was explored in this study (N = 30). While most deficiencies showed no statistically significant association with BMI category (underweight, BMI < 18.5 kg/m² vs. BMI > 18.5 kg/m²), a notable exception was albumin (p = 0.033). Specifically, a higher number of cases with albumin deficiency were observed in patients with a BMI less than 18.5 kg/m² (10 cases) compared to those with a BMI greater than 18.5 kg/m² (2 cases). This suggests a possible link between low BMI and albumin levels in this population, potentially reflecting the impact of malnutrition on protein status. The remaining parameters, including haemoglobin (Hb), creatinine, cholesterol, HDL, LDL, B12, D3, iron, ferritin, TIBC, calcium, phosphorus, magnesium, uric acid, and total protein, did not demonstrate a significant association with BMI, implying that their presence may be influenced by factors other than overall body weight as reflected by BMI, or that the sample size was insufficient to detect such associations. Further research with a larger cohort is warranted to confirm these findings and to investigate the underlying mechanisms contributing to the observed association between albumin deficiency and low BMI.

A low BMI can lead to impaired immune function, making individuals more susceptible to infections and complicating their ability to adhere to ART.[6] Given these associations, the importance of regular nutritional assessments and interventions for PLHIV becomes evident, particularly for those with low BMI. Nutritional support should be tailored to individual needs, focusing on both macronutrient and micronutrient replenishment to improve immune function and overall health outcomes in this vulnerable population. Addressing malnutrition and related deficiencies is vital for enhancing the quality of life and potentially extending longevity among PLHIV.[11]

Age and Nutritional Status

The study population (N = 30) had a mean age of 32.87 years (SD = 10.42), ranging from 19 to 66 years. The age distribution revealed that 33.33% of cases were 25 years or below, 23.33% were between 26 and 35 years, 33.33% were between 36 and 45 years, and 10.00% were above 45 years. The relationship between age and haematological/ biochemical parameters below their respective cut-off values was assessed. A statistically significant difference in mean age was observed for haemoglobin (Hb) levels (p = 0.025). Participants with haemoglobin levels below the cut-off (indicating anaemia) were significantly older (mean = 38.8 years, SD = 11.3) compared to those with haemoglobin levels above the cut-off (mean = 29.9 years, SD = 8.8). A statistically significant difference in mean age was also observed for total protein levels (p=0.036). Participants with total protein levels below the cut-off were significantly older (mean = 34.83 years, SD=10.66) compared to those with total protein levels above the cut-off (mean = 25 years, SD = 3.74). Although not statistically significant at the p < 0.05 level, trends toward older age were observed in individuals with vitamin B12 deficiency (p = 0.066) and low serum phosphorus (p=0.095) and high TIBC (p = 0.095), suggesting a potential age-related decline in these parameters that warrants further investigation with a larger sample size. No significant differences in mean age were found for the remaining biochemical parameters, including Folic acid, Vitamin D3, serum calcium, serum magnesium, serum albumin, serum iron, serum ferritin, suggesting that other factors besides age might be more influential in determining their levels in this population. Tailoring dietary interventions to meet the unique needs of this demographic can help mitigate the effects of ageing on health and enhance the effectiveness of HIV treatment strategies.[12]

Sex and Deficiencies

The study examined the association between haematological and biochemical parameters below established cut-offs and the sex of the patients. While most parameters showed no statistically significant association with sex, a trend towards significance was observed for ferritin deficiency (p = 0.073). Specifically, a higher proportion of females (78.3%) exhibited ferritin deficiency compared to males (42.9%). This suggests a possible increased susceptibility to iron storage depletion in females within this study population. Additionally, there was a trend suggesting that males had lower levels of phosphorus, The number of males (28.6%) with low levels of phosphorus, was significantly more than females (4.3%) exhibiting deficiency in phosphorus (p=0.061). No statistically significant associations were found between sex and the presence of deficiencies in haemoglobin, vitamin B12, vitamin D3, iron, calcium, magnesium, total protein, and albumin. These findings indicate that, within this cohort, the prevalence of these deficiencies may be independent of sex, or that the limited sample size may have hindered the detection of statistically significant differences. Further research with larger, more diverse populations is needed to confirm these findings and to explore the potential underlying mechanisms for the observed trends in ferritin and phosphorus levels between males and females.[13]

Conclusion

In conclusion, this study revealed a trend towards higher prevalence of ferritin deficiency in females and lower levels of phosphorus in males within the studied cohort of patients. While most haematological and biochemical parameters examined did not show a statistically significant association with sex, these suggestive findings warrant further investigation. Given the limited sample size, the observed trends may not be generalisable to broader

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populations. Future research with larger and more diverse cohorts is crucial to confirm these observations and to elucidate the underlying biological and social factors that may contribute to sex-specific differences in iron storage and phosphorus levels. Such investigations will inform targeted interventions to address nutritional deficiencies and optimise health outcomes in different patient populations.

This study highlights the critical relationship between HIV, nutritional deficiencies, and BMI. The findings underscore the need for comprehensive nutritional assessments and tailored interventions for adults living with HIV. Addressing nutritional deficiencies, particularly in underweight individuals and older adults, is essential for improving health outcomes and managing HIV effectively. Regular monitoring and management of nutritional status should be an integral part of HIV care to mitigate the impact of HIV-related complications and improve overall patient well-being.

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Declaration of Generative AI and AI-Assisted Technologies in the Writing Process: None

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