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Dietary Patterns in Blood Donors With Borderline-Eligible Haemoglobin Levels: A Cross-Sectional Observational Study

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Abstract

Purpose

Blood donors with borderline-eligible haemoglobin concentrations represent a group in whom dietary factors may be relevant for understanding their haemoglobin status. So this study assessed the association between dietary practices and haemoglobin concentration among blood donors with borderline-eligible haemoglobin levels of 12.5-13.4 g/dL.

Methods and materials

In this study, 116 donors with borderline haemoglobin levels of 12.5-13.4 g/dl were surveyed from June to August 2026. Donors' dietary habits were measured using a questionnaire and analysed for regression with blood haemoglobin levels.

Results

A total of 116 eligible blood donors with borderline haemoglobin concentrations were included in the final analysis, representing 3.92% of all donors during the study period. Their mean age was 33.04±7.44 years, mean weight was 77.96±13.39 kg, and mean Hb concentration was 12.94±0.34 g/dL. There were 96 (82.8%) male and 20 (17.2%) female donors; as regards food preferences, 59 (50.9%) consumed non-vegetarian food, 48 (41.4%) vegetarian food, and nine (7.8%) preferred lacto-ovo-vegetarian diet. Fifty-five (47.4%) were first-time donors and 61 (52.6%) had donated blood at least once before. On multivariable analysis, a vegetarian dietary pattern was independently associated with lower Hb compared with a non-vegetarian (β=-0.292 g/dL; 95% confidence interval (CI) -0.530 to -0.055; P=0.016). Male donors showed higher Hb concentrations, while repeat-donor status showed a negative association with Hb. Consumption of tea, coffee, and dairy products with meals showed minimal inverse associations, whereas vitamin C-rich food intake showed a positive but non-significant association with Hb.

Conclusion

Blood donors with borderline haemoglobin levels have a higher risk of iron deficiency anaemia and dietary reinforcement can be considered for these donors.

Categories: Nutrition, Hematology, Public Health
Keywords: anaemia, blood donation, borderline haemoglobin, diet, dietary pattern, haemoglobin, iron deficiency, iron deficiency anaemia

Introduction

The World Health Organisation defines iron-deficiency anaemia (IDA) as a condition in which the number of red blood cells or the haemoglobin concentration is lower than normal in humans [1]. It is the most common blood disorder in the world, affecting over two billion people [2]. Globally, it is estimated that 40% of all children aged 6-59 months, 37% of pregnant women and 30% of women 15-49 years of age are affected by anaemia [3].

The Government of India has defined 12.5 g/dl as the normal haemoglobin level and only those having haemoglobin above this level may become blood donors [4]. The WHO defines normal haemoglobin at 12 g/dl for non-pregnant adult women and 13 g/dl for adult men [5].

Iron deficiency is an important nutritional and clinical concern among blood donors because blood donation causes loss of haemoglobin and body iron. Haemoglobin screening is routinely used to determine donor eligibility; however, haemoglobin concentration may remain within the acceptable range despite early depletion of iron stores. Dietary intake and the bioavailability of dietary iron may therefore be particularly relevant in donors with borderline haemoglobin concentrations, especially among those who donate

repeatedly.

Dietary iron is present mainly as haem and non-haem iron. Haem iron, obtained primarily from animal-source foods, is generally more readily absorbed, whereas non-haem iron absorption is influenced by meal composition [6]. Phytates and polyphenols can reduce non-haem iron absorption, while ascorbic acid enhances it by promoting non-haem iron uptake [6,7]. Thus, the amount of iron consumed does not necessarily correspond to the amount available for physiological use.

Vegetarian dietary patterns are of particular interest because they provide predominantly non-haem iron and exclude meat, an important source of haem iron. However, a well-planned vegetarian diet can provide adequate iron, and vegetarian status alone should not be considered synonymous with iron deficiency [8]. A systematic review and meta-analysis of 27 cross-sectional and three interventional studies reported significantly lower serum ferritin concentrations among adult vegetarians compared with non-vegetarian controls, with a pooled difference of -29.71 μg/L [9]. Similarly, a review of vegetarian adults found considerable variation in iron status, with low ferritin and inadequate haemoglobin reported in a proportion of vegetarian populations [10].

The foods and beverages consumed with meals can also influence non-haem iron absorption. Ascorbic acid enhances iron absorption, whereas polyphenol-containing beverages such as tea and coffee may inhibit it [6,7]. In young Indian women, tea reduced iron absorption from a rice-based meal, whereas ascorbic acid enhanced absorption [11]. Calcium has also been reported to inhibit iron absorption under certain experimental conditions, although the magnitude of this effect varies with the calcium dose and meal composition and may be reduced in the presence of ascorbic acid [12].

These dietary factors may be particularly relevant to blood donors with borderline haemoglobin concentrations. However, the frequency of consuming food does not necessarily reflect total nutrient intake, portion size, iron bioavailability, or the body's iron stores.

The present study therefore evaluated dietary patterns among blood donors with borderline-eligible haemoglobin concentrations using a multivariable linear regression and examined their associations with selected dietary practices, including consumption of green leafy vegetables, pulses, vitamin C-rich foods, meat, eggs, tea/coffee, and dairy products, in relation to haemoglobin concentration.

Materials And Methods

Study design and setting

This exploratory, prospective observational study was conducted from June to August 2026 among in-house blood donors at the Department of Transfusion Medicine of a tertiary care hospital in New Delhi. The study was conducted over a predefined period of three months, with recruitment restricted to this period. We obtained written informed consent from all participants and maintained participant confidentiality and privacy throughout the study. No personally identifiable information was included in the study dataset or manuscript.

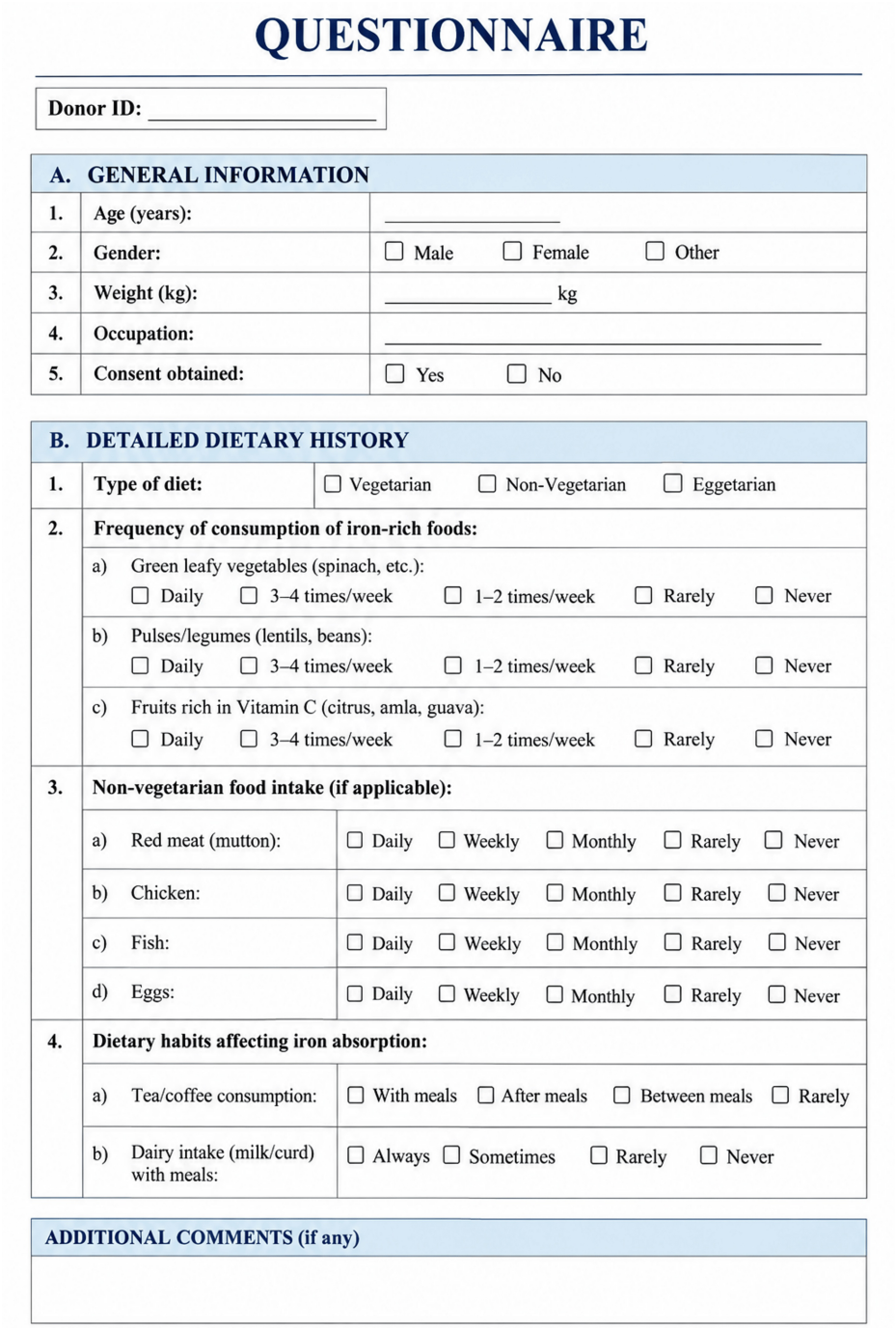
Study population

We included blood donors with haemoglobin (Hb) concentrations in the borderline-eligible range of 12.5-13.4 g/dL. While 12.5 g/dL is considered the lower limit due to the national eligibility criteria for blood donation, only those with higher haemoglobin levels would be donating blood [4]. The upper limit of 13.4 g/dL was considered due to the risk of iron store depletion [13]. We initially measured Hb using a HemoCue® Hb 301 system (HemoCue AB, Ängelholm, Sweden) and subsequently confirmed it using a Mindray BC-6000 (Shenzhen Mindray Bio-Medical Electronics Co., Ltd., Shenzhen, China) automated haematology analyser. We excluded donors with Hb <12.5 g/dL or >13.4 g/dL.

A total of 116 donors constituted the final analytical population. The participants included both first-time and repeat blood donors. This was a time-bound exploratory pilot study, and we did not conduct a formal a priori sample-size calculation. We included all eligible donors who consented to participate during the predefined three-month study period.

Data collection and dietary assessment

We collected data using a structured questionnaire administered to eligible donors (Figure *1*).



QUESTIONNAIRE

Donor ID: _____

A. GENERAL INFORMATION		
1.	Age (years):	_____
2.	Gender:	☐ Male ☐ Female ☐ Other
3.	Weight (kg):	_____ kg
4.	Occupation:	_____
5.	Consent obtained:	☐ Yes ☐ No

B. DETAILED DIETARY HISTORY		
1.	Type of diet:	☐ Vegetarian ☐ Non-Vegetarian ☐ Eggetarian
2.	Frequency of consumption of iron-rich foods:	
	a) Green leafy vegetables (spinach, etc.):	☐ Daily ☐ 3–4 times/week ☐ 1–2 times/week ☐ Rarely ☐ Never
	b) Pulses/legumes (lentils, beans):	☐ Daily ☐ 3–4 times/week ☐ 1–2 times/week ☐ Rarely ☐ Never
	c) Fruits rich in Vitamin C (citrus, amla, guava):	☐ Daily ☐ 3–4 times/week ☐ 1–2 times/week ☐ Rarely ☐ Never
3.	Non-vegetarian food intake (if applicable):	
	a) Red meat (mutton):	☐ Daily ☐ Weekly ☐ Monthly ☐ Rarely ☐ Never
	b) Chicken:	☐ Daily ☐ Weekly ☐ Monthly ☐ Rarely ☐ Never
	c) Fish:	☐ Daily ☐ Weekly ☐ Monthly ☐ Rarely ☐ Never
	d) Eggs:	☐ Daily ☐ Weekly ☐ Monthly ☐ Rarely ☐ Never
4.	Dietary habits affecting iron absorption:	
	a) Tea/coffee consumption:	☐ With meals ☐ After meals ☐ Between meals ☐ Rarely
	b) Dairy intake (milk/curd) with meals:	☐ Always ☐ Sometimes ☐ Rarely ☐ Never

ADDITIONAL COMMENTS (if any)

FIGURE 1: Dietary questionnaire used to assess the frequency and meal-related consumption of selected dietary factors among blood donors with borderline-eligible haemoglobin concentrations.

Questionnaire Development and Validation

The questionnaire was developed in accordance with the study objectives and validated by two experts: one from Laboratory Medicine and one from Transfusion Medicine. Both experts reviewed the questionnaire for relevance, clarity, and appropriateness, and their suggestions were incorporated into the final version.

The questionnaire was subsequently pilot-tested among 10 blood donors to assess its clarity, comprehensibility and feasibility of administration. Necessary modifications were incorporated before its use in the main study.

The questionnaire recorded demographic and donor-related characteristics, including age, sex, body weight and previous donation status. Dietary information included dietary pattern (vegetarian, lacto-ovo vegetarian (eggetarian) or non-vegetarian), frequency of consumption of selected iron-rich foods, intake of vitamin C-rich foods and consumption of foods or beverages that may influence dietary iron absorption.

The questionnaire recorded the frequency of consumption of green leafy vegetables (GLVs), pulses, vitamin C-rich foods, red meat, chicken and eggs. We also collected information on the timing of tea/coffee consumption relative to meals and the frequency of dairy consumption with meals. The questionnaire assessed frequency rather than portion size or quantitative nutrient intake.

The possibility of repeat enrolment was minimised by the prescribed minimum inter-donation intervals for whole-blood donation in India, which are three months for male donors and four months for female donors [14]. Given the three-month study period, these intervals substantially restricted the opportunity for repeat participation.

Statistical analysis

We entered the data into Microsoft Excel Version 16.x (Microsoft, Redmond, WA) and analysed them statistically. We summarised continuous variables as mean±standard deviation (SD) and categorical variables as frequencies and percentages.

We performed multivariable linear regression with Hb concentration as the continuous dependent variable. Independent variables included dietary pattern, vitamin C-rich food intake, red meat consumption, chicken consumption, egg consumption, tea/coffee consumption around meals, and dairy consumption with meals.

Regression coefficients (β) with 95% confidence intervals (CIs) and P values were reported. We considered a two-sided P value <0.05 as statistically significant. We assessed model fit using the coefficient of determination (R^2) and adjusted R^2.

Results

In this study, 116 eligible blood donors were included in the final analysis. This constituted 3.92% of the total donors who donated blood at the time of data collection. Their mean age was 33.04±7.44 years, mean weight was 77.96±13.39 kg, and mean haemoglobin (Hb) concentration was 12.94±0.34 g/dL. There were 96 (82.8%) male and 20 (17.2%) female donors. As regards food consumption, 59 (50.9%) donors consumed non-vegetarian diet, 48 (41.4%) a vegetarian diet, and nine (7.8%) preferred a lacto-ovo vegetarian diet. Fifty-five (47.4%) were first-time donors and 61 (52.6%) were repeat donors (Table *1*).

Characteristic	Value
Age, years, mean±SD	33.04±7.44
Weight, kg, mean±SD	77.96±13.39
Haemoglobin, g/dL, mean±SD	12.94±0.34
Gender, n (%)	
Male	96 (82.8)
Female	20 (17.2)
Dietary pattern, n (%)	
Non-vegetarian	59 (50.9)
Vegetarian	48 (41.4)
Eggetarian	9 (7.8)
Donation history, n (%)	
First-time donor	55 (47.4)
Repeat donor	61 (52.6)

TABLE 1: Baseline characteristics of study participants (N=116)

Dietary patterns

GLVs were consumed at least one to two times per week by 114 (98.3%) donors, with 66 (56.9%) consuming them three to four times per week. All 116 (100%) donors consumed pulses at least one to two times per week; 15 (12.9%) reported daily consumption, 37 (31.9%) consumed pulses three to four times per week, and 64 (55.2%) consumed them one to two times per week.

Vitamin C-rich foods were consumed at least one to two times per week by 79 (68.1%) donors, while 37 (31.9%) reported rare consumption. Red meat consumption was infrequent, with 111 (95.7%) donors consuming it monthly or less frequently, including 64 (55.2%) who reported never consuming red meat. Chicken was consumed monthly or less frequently by 82 (70.7%) donors, while eggs were consumed monthly or less frequently by 63 (54.3%) donors.

Regarding tea/coffee intake in relation to meals, 27 (23.3%) donors consumed it with meals, 17 (14.7%) between meals and 25 (21.6%) after meals, whereas 47 (40.5%) reported rare consumption. Dairy products were consumed with meals always by 77 (66.4%) donors, sometimes by 30 (25.9%), rarely by seven (6.0%), and never by two (1.7%) donors (Table *2*).

Dietary parameter	Frequency	n (%)
Green leafy vegetables	Daily	14 (12.1)
	3-4 times/week	66 (56.9)
	1-2 times/week	34 (29.3)
	Rarely	2 (1.7)
Pulses	Daily	15 (12.9)
	3-4 times/week	37 (31.9)
	1-2 times/week	64 (55.2)
Vitamin C-rich foods	Daily	13 (11.2)
	3-4 times/week	4 (3.4)
	1-2 times/week	62 (53.4)
	Rarely	37 (31.9)
Red meat	Weekly	5 (4.3)
	Monthly	40 (34.5)
	Rarely	7 (6.0)
	Never	64 (55.2)
Chicken	Daily	1 (0.9)
	Weekly	33 (28.4)
	Monthly	22 (19.0)
	Rarely	2 (1.7)
	Never	58 (50.0)
Eggs	Daily	13 (11.2)
	Weekly	40 (34.5)
	Monthly	4 (3.4)
	Rarely	5 (4.3)
	Never	54 (46.6)
Tea/coffee in relation to meals	With meals	27 (23.3)
	Between meals	17 (14.7)
	After meals	25 (21.6)
	Rarely	47 (40.5)
Dairy with meals	Always	77 (66.4)
	Sometimes	30 (25.9)
	Rarely	7 (6.0)
	Never	2 (1.7)

TABLE 2: Frequency of dietary practices among study participants (N=116)

Association with haemoglobin

We performed multivariable linear regression with Hb concentration as the dependent variable. Figure *2* presents the adjusted associations as regression coefficients with 95% confidence intervals.

A vegetarian dietary pattern was independently associated with lower Hb concentration compared with a non-vegetarian dietary pattern (β=-0.292 g/dL; 95% CI, -0.530 to -0.055; P=0.016). A lacto-ovo vegetarian dietary pattern showed a similar inverse association, although it did not reach statistical significance (β=-0.249 g/dL; 95% CI, -0.532 to 0.033; P=0.084).

Vitamin C-rich food intake showed a positive association with Hb. Donors consuming vitamin C-rich foods at least one to two times per week had an adjusted Hb that was 0.088 g/dL higher than those with less frequent intake (β=+0.088 g/dL; 95% CI, -0.056 to 0.231; P=0.232). This association was not statistically significant.

Repeat-donor status also showed a negative direction of association with Hb (β=-0.097 g/dL; 95% CI, -0.224 to 0.029; P=0.132). Male sex showed a positive direction of association (β=+0.146 g/dL; 95% CI, -0.038 to 0.329; P=0.120). Tea/coffee consumption with meals showed a minimal inverse association with haemoglobin concentration (β=-0.010 g/dL; 95% CI, -0.139 to 0.118; P=0.874). Similarly, consuming dairy products always with meals showed a modest inverse association with haemoglobin (β=-0.101 g/dL; 95% CI, -0.245 to 0.044; P=0.171); neither association reached statistical significance.

We observed no statistically significant independent associations between Hb and age, red-meat consumption, chicken consumption, egg consumption, tea/coffee timing, or dairy consumption (Figure 2).

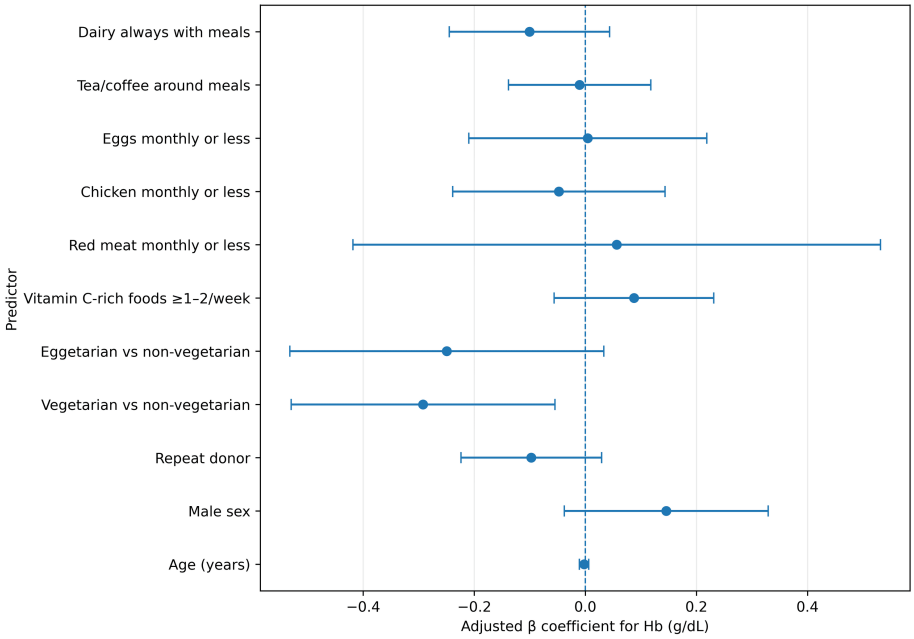


FIGURE 2: Multivariable linear regression analysis of factors associated with haemoglobin concentration among blood donors with borderline-eligible haemoglobin levels (N=116).

β, adjusted regression coefficient; CI, confidence interval.

Points show adjusted β values and bars show 95% CIs. The vertical line indicates β=0.

Discussion

The present study included 116 blood donors with borderline-eligible haemoglobin concentrations and examined the relationship between dietary practices and Hb. A vegetarian dietary pattern was independently associated with lower Hb compared with a non-vegetarian pattern (β=-0.292 g/dL; 95% CI, -0.530 to -0.055; P=0.016). Vitamin C-rich food intake showed a positive association, whereas tea/coffee and dairy consumption with meals showed small inverse associations; however, these associations were not statistically significant.

The lower Hb among donors following a vegetarian dietary pattern may reflect the predominance of non-haem iron in such diets. Unlike haem iron, non-haem iron absorption is strongly influenced by other components of the meal. Phytates and polyphenols reduce absorption, whereas ascorbic acid enhances it [6,7]. A systematic review and meta-analysis by Haider et al. found significantly lower serum ferritin among adult vegetarians than non-vegetarians, with a pooled difference of -29.71 µg/L [9]. Another review

also reported low ferritin and inadequate Hb in some vegetarian populations [10]. We did not measure ferritin or other iron-status markers. Therefore, the lower Hb in vegetarian donors cannot be taken as evidence of iron deficiency. A vegetarian dietary pattern was associated with a lower haemoglobin concentration in this study; however, the underlying explanation for this association cannot be established from the available data, as biochemical iron status and quantitative dietary iron intake were not assessed.

Vitamin C-rich food intake showed a small positive association with Hb. Donors consuming these foods at least one to two times per week had an adjusted Hb 0.088 g/dL higher than those with less frequent intake (β=+0.088 g/dL; 95% CI, -0.056 to 0.231; P=0.232). This finding is consistent with the known role of ascorbic acid in enhancing non-haem iron absorption [7]. Thankachan et al. similarly found increased iron absorption with ascorbic acid and reduced absorption with tea in young Indian women [11]. However, the present association was not statistically significant.

Tea/coffee consumption in relation to meals showed almost no association with Hb (β=-0.010 g/dL; 95% CI, -0.139 to 0.118; P=0.874). Although tea polyphenols can inhibit non-haem iron absorption [6,11], our questionnaire assessed timing rather than quantity, strength or total daily intake. An effect on iron absorption at individual meals may therefore not be reflected in Hb, particularly in donors with a narrow Hb range.

Dairy consumption with meals also showed a small inverse association with Hb (β=-0.101 g/dL; 95% CI, -0.245 to 0.044; P=0.171). Calcium can reduce iron absorption under some experimental conditions, although the effect depends on the amount consumed and the meal's composition [12].

Almost all donors consumed green leafy vegetables and pulses at least one to two times per week, while red-meat intake was relatively infrequent. These frequencies suggest an important contribution from plant-based foods, but they do not indicate total iron intake or bioavailability. We did not assess portion sizes, total dietary iron, haem versus non-haem iron, phytate content, or food preparation.

The lack of significant associations for most dietary factors may also reflect the restricted Hb range in this study. In addition, Hb is not a sensitive marker of early iron depletion and changes in iron stores may occur before Hb falls. This may be relevant because previous studies have reported more consistent differences in ferritin than Hb between vegetarian and non-vegetarian populations [9,10].

Similarly, studies in blood donors have shown that repeated blood donation can progressively deplete iron stores despite relatively stable haemoglobin concentrations, with low ferritin associated with an increased risk of subsequent low-haemoglobin deferral [15]. Strategies such as dietary advice, iron supplementation and extending the inter-donation interval have therefore been proposed to reduce donation-related iron depletion [16,17]. This may be relevant because previous studies have reported more consistent differences in ferritin than Hb between vegetarian and non-vegetarian populations [9,10].

The study has the advantage of prospective dietary data and donor-level information, allowing adjustment for demographic characteristics, donation history and dietary factors. However, the single-centre design, relatively small sample size and narrow Hb range limit the generalisability of the findings. Dietary intake was recorded by frequency rather than quantity, and biochemical measures of iron status were not available. It was only measured whether or not blood had been donated before but not the number of times blood has been donated previously. The findings therefore show associations with Hb and cannot establish iron deficiency or causality.

A vegetarian dietary pattern was independently associated with lower Hb in this group of 116 blood donors with borderline-eligible Hb. Vitamin C-rich food intake showed a positive but non-significant association, while tea/coffee and dairy consumption showed small, non-significant inverse associations. Further studies using quantitative dietary assessment and biochemical measures of iron status are needed to determine whether these findings reflect differences in iron intake, absorption or body iron stores. Further studies are also recommended to use a larger sample size, evaluate the amounts of food type in the diet and also take data from a larger Hb range.

Conclusions

Among blood donors with borderline-eligible haemoglobin concentrations of 12.5-13.4 g/dL, a vegetarian dietary pattern was independently associated with a lower haemoglobin concentration than a non-vegetarian dietary pattern. These findings are restricted to the selected study population and do not establish causality or iron deficiency, which was not assessed biochemically. Further studies incorporating biochemical assessment of iron status are needed to clarify the relationship between dietary patterns and haemoglobin concentration in this population.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Kavin Chaudhary, Neha Jha, Rasika D. Setia

Acquisition, analysis, or interpretation of data: Kavin Chaudhary, Neha Jha

Drafting of the manuscript: Kavin Chaudhary

Critical review of the manuscript for important intellectual content: Neha Jha, Rasika D. Setia

Supervision: Rasika D. Setia

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Dr. B.L. Kapur Memorial Hospital Ethics Committee issued approval BLK/AARCE/PROTOCOL/JUNE/2026/22 dated June 8, 2026. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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