

# Factors associated with anemia among female adult vegetarians in Malaysia

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**BACKGROUND/OBJECTIVES:** A large number of studies on anemia have focused mostly on pregnant women or children. The vegetarian population, which is another potential risk group for anemia, remains largely unexplored. Therefore, this cross-sectional study examined the associations of the sociodemographic, lifestyle, nutritional, and psychological factors with the anemia status among female adult vegetarians.

**SUBJECTS/METHODS:** A total of 177 female vegetarians were recruited from a Buddhist and Hindu organization in Selangor, Malaysia. The participants completed a self-administered questionnaire, which analyzed their sociodemographic characteristics, physical activity level, sleep quality, depression, anxiety, and stress. The body weight, height, waist circumference, and body fat percentage of the participants were also measured. A 3-day dietary recall was conducted to assess their dietary intake. Blood samples (3 ml) were withdrawn by a nurse from each participant to determine the hemoglobin (Hb) level.

**RESULTS:** The findings revealed 28.2% of the participants to be anemic. The age group (AOR = 2.46, 95% CI = 1.19-5.05), marital status (AOR = 2.69, 95% CI = 1.27-5.71), and percentage of energy from protein (AOR = 5.52, 95% CI = 1.41-21.65) were the significant predictors of anemia.

**CONCLUSIONS:** Anemia is a public health problem among female vegetarians in this study. Health promotion programs that target female adult vegetarians should be conducted to manage and prevent anemia, particularly among those who are married, aged 50 and below, and with an inadequate protein intake.

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## INTRODUCTION

Tracing back to ancient Greece, vegetarianism has often been related to either ethics or health but has a checkered history among different religious doctrines, such as Buddhism, Hinduism, and Seventh Day Adventists [1]. On the other hand, it was only until the 19<sup>th</sup> century that scientists began to assess the health advantages of a plant-based diet [2]. To date, several studies on the prevalence of vegetarians have revealed varying results. For example, the prevalence of vegetarianism was found to be much higher in India (36%) [3] than in other countries, such as the United Kingdom (UK; 5%) [4]. In light of the global epidemic of chronic diseases, the idea of an 'ideal diet', which also includes a vegetarian diet, has been pursued desperately with the aim of resolving the problem once and for all [5].

The vegetarian diet may have some health advantages but it does not necessarily equal an adequate balanced nutrient intake. Some debate still exists as to whether vegetarians, especially vegans, can derive an optimal amount of vital

nutrients, such as vitamins B<sub>12</sub> and D, iron, calcium, and long-chain n-3 fatty acids [6]. In terms of bioavailability, the non-heme iron that can be obtained from grains, cereals, nuts, legumes, and vegetables in plant-based diets is inferior to heme iron in animal products because the human body can absorb heme iron more easily than non-heme iron [7]. Therefore, the iron status of vegetarians is a matter of concern considering that anemia is one of the commonest micronutrient deficiencies in the world [8].

The results from earlier studies have shown that more females adopt a vegetarian lifestyle than males [9, 10]. One possible explanation for this might be the greater health-consciousness and adherence towards less risk-taking behaviors and social life among women [11]. Nevertheless, females appear to be a high-risk group of individuals who are often diagnosed with anemia compared to males because of their physiological function in nature, particularly concerning their experience in iron losses during menstruation and pregnancy [12]. Furthermore, hormone testosterone is responsible for raising the red

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blood cell count, which stimulates erythropoietin (EPO) that helps boost the hemoglobin concentrations in adult men [13]. Therefore, females tend to be more vulnerable to anemia biologically.

Globally, half of anemia cases have been attributed to iron deficiency (ID) [8]. Moreover, the most affected group is non-pregnant reproductive women (estimated 468 million) [8]. Anemia is still growing and has been posed as a health threat even in developed countries, such as the United States (US) with a prevalence ranging from 4.0% to 7.0% between 2003-2004 and 2011-2012 [14]. In Malaysia, the National Health and Morbidity Survey (NHMS) 2015 reported that the prevalence of anemia among Malaysians was 24.6%, which can be divided into 35.5% and 14.3% of females and males, respectively [15]. Existing research recognizes a high prevalence of anemia among the vegetarian population. For example, a cross-sectional study was conducted among women aged 15 to 49 years in an urban slum from Mumbai, India who had been taking a mixed diet (47.4%), and the results showed that they were less anemic than those who were vegetarians (64.4%) [16]. Another cross-sectional study in Rajasthan, India showed that all of the female vegetarians were anemic [17].

The major health consequences of anemia, which include declined immunity, elevated morbidity, and impaired cognitive performance, are still regarded as a significant burden to the worldwide population [18]. In addition, the interactions between various potential etiologies have also made anemia mitigation extremely challenging. Anemia is not merely a medical condition, but also an important social issue because it commonly leads to decreased work performance and insufficient earning. Recent evidence indicates several factors associated with anemia among women, which include the demographic factors (age and marital status [19]), nutritional status (overweight/obesity [20]), lifestyle factors (physical activity [21] and sleep quality [22]), and psychological factors (depression [23]). On the other hand, previous research examining the factors associated with anemia focused more on the non-vegetarian population. Little is known about anemia in vegetarians. Therefore, it is important to understand the anemia status of Malaysian vegetarians and its associated factors due to the increasing interest in vegetarianism among Southeast Asians. In response to this matter, the present study examined the factors associated with anemia among female vegetarians in Malaysia.

## SUBJECTS AND METHODS

### *Study population and design*

This cross-sectional study was conducted at a Buddhist and Hindu organization located in Selangor, Malaysia. Buddhists and Hindus were selected as the participants of this study because they are the main groups of vegetarians in Malaysia [24]. A convenience sampling method was used to recruit the participants by placing an advertisement on notice boards at these organizations. The exclusion criteria were pregnant or lactating women as well as those with chronic illnesses (such as diabetes mellitus, heart disease, kidney disease, and liver disease) or undergoing medical treatment.

Ethical clearance was granted from the Ethics Committee for

Research Involving Human Subjects of University Putra Malaysia (Reference No.: FPSK (FR16) P023). Permission to conduct this study at the Buddhist and Hindu organizations was also obtained, while written informed consent was obtained from all the participants prior to the process of data collection.

### *Sociodemographic, lifestyle, and psychological characteristics*

A self-administered questionnaire was distributed to the participants to obtain information on their sociodemographic background, lifestyle, and psychological condition. Information on the participants, such as age, ethnicity, marital status, education level, household size, and household income, was included as the sociodemographic details.

The WHO Global Physical Activity Questionnaire (GPAQ) [25] was administered to determine the level of physical activity of the participants. A total of 16 questions regarding physical activity (PA) were asked in the questionnaire. The first six items (i.e. Q1-Q6) measured the activity at work, whereas the next nine items (i.e. Q7-Q15) measured the physical activity that were related to leisure and recreation. Finally, the last item (Q16) measured the sedentary behavior, or in other words referred to sitting/reclining without the incorporation of sleep time. The participants were divided into different PA levels, which are represented as low (< 600 MET-min/week), moderate (at least 600-2,999 MET-min/week), or high (3,000+ MET-min/week).

The Depression Anxiety Stress Scale (DASS-21) [26] was used to measure the symptoms of the three emotional states, namely depression, anxiety, and stress. In particular, each of these three emotions in DASS-21 contained a total of seven items that were rated on a 4-point Likert scale from zero ("did not apply to me at all") to three ("applied to me most of the time"). The subscale scores were then added. No reverse-scored item was used. The participants were categorized into different severity rating indices, which included normal, mild, moderate, severe, and extremely severe [26]. This scale revealed a good internal consistency reliability in the present study (Cronbach's  $\alpha = 0.89$  for DASS-21 total score, 0.78 for DASS-Depression, 0.65 for DASS-Anxiety, and 0.82 for DASS-Stress subscales score).

The Pittsburgh Sleep Quality Index (PSQI) [27] was also used in the current research to measure the sleep quality over a one-month time interval. The seven subscales of the PSQI ranged from zero to three (no difficulty to severe difficulty). The sum of the seven subscale scores provided the overall PSQI score ranging from zero to 21. A higher score represented poorer sleep quality, in which poor sleep quality was indicated with a score of five or more. The index demonstrated a good internal consistency reliability (Cronbach's  $\alpha = 0.75$ ) in the current study.

### *Anthropometric measurements*

The body weight, height, waist circumference (WC), and body fat percentage (BF%) of the participants were measured using a TANITA Digital Weighing Scale HD319 (TANITA Corp., Tokyo, Japan), a SECA Portable Stadiometer 213 (SECA, Hamburg, Germany), a Lufkin Executive Diameter steel tape W606PM (Cooper Hand Tools, Raleigh, North Carolina, USA), and an Omron Body Fat Monitor HBF-306 (Omron Healthcare Co. Ltd., Kyoto, Japan), respectively. The body mass index (BMI) was

calculated as the weight (kg) divided by the height (m) squared; the classification of the BMI from the World Health Organization (WHO) [28] was used. A WC  $\geq$  80 cm for Asian adult women [29] was categorized as abdominal obesity. The BF% was ranked based on four groups as follows: too low ( $\leq$  8%); acceptable, lower end (9-23%); acceptable, higher end (24-31%); and too high ( $\geq$  32%) [30].

#### Dietary intake assessment

A face-to-face interview on a three-day dietary recall (two weekdays and one weekend) was conducted to assess the dietary intake of the participants. Household measurement cups and spoons were used to estimate the portion size and quantities of food consumed. The dietary intake data were analyzed using Nutritionist Pro™ Nutrition Analysis Software version 3.2.0 (First Data Bank, USA, 2011). The Malaysian Food Composition Table [31] was used to analyze the diet data. Dietary adequacy was evaluated by comparing the mean values for energy and nutrient intake with the Recommended Nutrient Intake (RNI) for Malaysians [32]. For adults, it is recommended that 50%-65% of the total daily energy intake be derived from carbohydrates, 10%-20% from protein, and 25%-30% from fat [32]. For micronutrient intake (vitamins A, B<sub>12</sub>, C, calcium, folate, iron, and zinc), participants who met or exceeded 100% of the RNI for micronutrients were considered to have an adequate micronutrient intake.

#### Determination of anemia status

A nurse was assigned to withdraw 3 mL of venous blood from the participants for Hb analysis. The Hb level of the participants was measured using an automated hematology analyzer, Sysmex Analyzer. A hemoglobin level  $<$  11.9 g/dL indicates that a woman is anemic and can be further categorized into three groups: mild (10.0-11.9 g/dL), moderate (7.0-9.9 g/dL), and severe ( $<$  7.0 g/dL) [33].

#### Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics 24 (IBM Corp., Armonk, NY, USA). Descriptive statistics, which are also known as the absolute (n) and relative (%) frequencies are presented for the categorical variables, whereas the means and standard deviations (SD) are reported for the continuous variables. Logistic regression analysis was used to determine the association between the various potential risk factors with the anemia status among vegetarians. The crude odds ratios (ORs) with 95% confidence interval (CIs) were calculated from simple logistic regression analysis. All variables with a *P*-value of  $<$  0.25 in simple logistic regression analysis were analyzed further in the final multiple logistic regression analysis model. Finally, a stepwise method was adopted to determine the adjusted odds ratios for the variables in the final model, while the level of statistical significance was set to *P*  $<$  0.05.

## RESULTS

#### Sociodemographic, nutritional, lifestyle, and psychological characteristics according to anemia status

A total of 177 participants out of the initial total of 225 female

**Table 1.** General characteristics of the participants according to their anemia status (n = 177)

Characteristics	Mean $\pm$ SD / n (%)		
	Normal (n = 127)	Anemic (n = 50)	Total (n = 177)
<b>Sociodemographic Factors</b>			
Age (yrs)	48.8 $\pm$ 12.4	47.1 $\pm$ 12.0	48.4 $\pm$ 12.3
$\leq$ 30	15 (11.8)	4 (8.0)	19 (10.7)
31-40	13 (10.3)	6 (12.0)	19 (10.7)
41-50	31 (24.4)	24 (48.0)	55 (31.1)
$>$ 50	68 (53.5)	16 (32.0)	84 (47.5)
Ethnicity			
Chinese	80 (63.0)	28 (56.0)	108 (61.0)
Indian	47 (37.0)	22 (44.0)	69 (39.0)
Marital status			
Single	37 (29.1)	10 (20.0)	47 (26.6)
Divorced	13 (10.2)	1 (2.0)	14 (7.9)
Widowed	11 (8.7)	2 (4.0)	13 (7.3)
Married	66 (52.0)	37 (74.0)	103 (58.2)
Education level			
No formal education	2 (1.6)	1 (2.0)	3 (1.7)
Primary	18 (14.2)	3 (6.0)	21 (11.9)
Secondary	69 (54.3)	34 (68.0)	103 (58.2)
Tertiary	38 (29.9)	12 (24.0)	50 (28.3)
Occupation			
Managers	16 (12.6)	7 (14.0)	23 (13.0)
Professionals	29 (22.8)	14 (28.0)	43 (24.3)
Technician and other workers	25 (19.7)	13 (26.0)	38 (21.5)
Housewives/unemployed	51 (40.2)	15 (30.0)	66 (37.3)
Students	6 (4.7)	1 (2.0)	7 (4.0)
Household members			
$\leq$ 2	30 (25.4)	9 (19.1)	39 (22.0)
3-4	40 (33.9)	20 (42.6)	60 (33.9)
5-6	35 (29.7)	16 (34.0)	51 (28.8)
$>$ 6	13 (11.0)	2 (4.3)	15 (8.5)
Monthly household income (USD) <sup>1)</sup>			
Low ( $<$ 553)	41 (32.8)	21 (42.0)	62 (35.0)
Middle (553-1345)	46 (36.8)	17 (34.0)	63 (35.6)
High ( $\geq$ 1346)	38 (30.4)	12 (24.0)	50 (28.2)
Vegetarian category			
Lacto-ovo	66 (52.0)	21 (42.0)	87 (49.1)
Ovo	6 (4.7)	3 (6.0)	9 (5.1)
Lacto	32 (25.2)	17 (34.0)	49 (27.7)
Vegan	23 (18.1)	9 (18.0)	32 (18.1)
Total yrs of being vegetarian	15.6 $\pm$ 11.9	14.3 $\pm$ 8.4	13.9 $\pm$ 9.9
$<$ 5	23 (18.1)	8 (16.0)	31 (17.5)
$\geq$ 5	104 (81.9)	42 (84.0)	146 (82.5)
Lifestyle Factors			
Sleep quality	5.32 $\pm$ 2.74	4.66 $\pm$ 1.80	5.14 $\pm$ 2.52
Good	43 (33.9)	24 (48.0)	67 (37.9)
Poor	84 (66.1)	26 (52.0)	110 (62.1)
Physical activity level			
Low	71 (55.9)	21 (42.0)	92 (52.0)
Moderate	38 (29.9)	18 (36.0)	56 (31.6)
High	18 (14.2)	11 (22.0)	29 (16.4)

**Table 1.** continued

Characteristics	Mean±SD / n (%)		
	Normal (n = 127)	Anemic (n = 50)	Total (n = 177)
<b>Psychological Factors</b>			
Depression	4.03 ± 5.27	4.12 ± 5.69	4.06 ± 5.38
Normal	107 (84.3)	41 (82.0)	148 (83.6)
Mild	15 (11.8)	6 (12.0)	21 (11.9)
Moderate	3 (2.3)	2 (4.0)	5 (2.8)
Extreme	2 (1.6)	1 (2.0)	3 (1.7)
Anxiety	6.44 ± 5.70	6.68 ± 5.86	6.51 ± 5.73
Normal	81 (63.8)	30 (60.0)	111 (62.7)
Mild	10 (7.9)	4 (8.0)	14 (7.9)
Moderate	26 (20.5)	11 (22.0)	37 (20.9)
Severe	6 (4.8)	3 (6.0)	9 (5.1)
Extreme	4 (3.1)	2 (4.0)	6 (3.4)
Stress	9.09 ± 7.49	9.20 ± 7.59	9.12 ± 7.50
Normal	105 (82.7)	41 (82.0)	146 (82.5)
Mild	13 (10.2)	6 (12.0)	19 (10.7)
Moderate	3 (2.4)	1 (2.0)	4 (2.3)
Severe	4 (3.1)	1 (2.0)	4 (2.3)
Extreme	2 (1.6)	1 (2.0)	3 (1.7)

n, number; SD, standard deviation

<sup>1)</sup>United States Dollar (USD) = 4.15 Malaysian Ringgit (MYR)

vegetarians who registered to participate in this study consented and fulfilled the recruitment criteria, producing a response rate of 78.7%. The mean Hb level of the participants was 12.6 ± 1.2 g/dL (range 8.7-15.4 g/dL). More importantly, the prevalence of anemia among the vegetarians was 28.2%, where 46 of them were regarded as mild anemic (26.0%) and four as moderate anemic (2.3%). As shown in Table 1, the mean age of the participants was 48.4 ± 12.3 years. The majority of the participants were Chinese (61.0%), less than 50 years old (52.5%), and married (58.2%). Moreover, most of the vegetarians had

**Table 2.** Nutritional status of the participants according to their anemia status (n = 177)

Characteristics	Mean±SD / n (%)		
	Normal (n = 127)	Anemic (n = 50)	Total (n = 177)
Body mass index (BMI; kg/m <sup>2</sup> )	22.9 ± 3.9	23.2 ± 3.9	23.1 ± 3.9
Underweight (< 18.5)	12 (9.4)	8 (16.0)	20 (11.3)
Normal weight (18.5-24.9)	74 (58.3)	26 (52.0)	100 (56.5)
Overweight (25.0-29.9)	34 (32.3)	13 (26.0)	47 (26.6)
Obesity (≥ 30.0)	7 (5.5)	3 (6.0)	10 (5.6)
Waist circumference (WC; cm)	81.8 ± 12.1	75.9 ± 9.4	80.2 ± 11.7
No risk (< 80)	76 (59.8)	23 (46.0)	99 (56.0)
Abdominal obesity (≥ 80)	51 (40.2)	27 (54.0)	78 (44.0)
Body fat percentage (BF%)	35.3 ± 6.5	30.9 ± 5.4	34.1 ± 6.5
Unhealthy, too low (≤ 8)	1 (0.8)	0 (0)	1 (0.6)
Acceptable, lower end (9-23)	2 (1.6)	5 (10.0)	7 (4.0)
Acceptable, higher end (24-31)	20 (15.7)	22 (44.0)	42 (23.7)
Unhealthy, too high (≥ 32)	104 (81.9)	23 (46.0)	127 (71.8)

n, number; SD, standard deviation

completed secondary (58.2%) and tertiary education (28.3%). In terms of the vegetarian category, 49.1% were lacto-ovo vegetarians, 27.7% were lacto-vegetarians, 18.1% were vegans, and 5.1% were ovo-vegetarians. More than half of the participants reported a poor sleep quality (62.1%) and low PA level (52.0%). Moreover, the prevalence of depression, anxiety and stress were 16.4%, 37.3%, and 17.5%, respectively.

As shown in Table 2, approximately one third of participants were overweight (26.6%) and obese (5.6%). Almost half of the participants were abdominally obese (44.0%). More than two thirds of them had a body fat percentage that was not within the healthy range (71.8%). In terms of dietary intake, more than half of the participants did not have an adequate intake of energy (59.3%), protein (56.5%), fiber (88.1%), vitamin B<sub>12</sub> (99.4%), calcium (89.3%), folate (90.4%), and zinc (52.0%), as listed in Table 3.

**Table 3.** Dietary intake of the participants according to their anemia status (n = 177)

Characteristics	Mean±SD / n (%)		
	Normal (n = 127)	Anemic (n = 50)	Total (n = 177)
Energy (kcal)	1,747.84 ± 772.84	1,862.78 ± 766.31	1,780.31 ± 770.57
≥ RNI <sup>1)</sup>	52 (40.9)	20 (40.0)	72 (40.7)
< RNI	75 (59.1)	30 (60.0)	105 (59.3)
Protein (g)	57.84 ± 27.91	57.48 ± 26.08	57.74 ± 27.34
≥ RNI	54 (42.5)	23 (46.0)	77 (43.5)
< RNI	73 (57.5)	27 (54.0)	100 (56.5)
Percentage of energy from protein (%)	13.16 ± 2.96	12.58 ± 2.48	12.99 ± 2.84
< 10%	9 (7.5)	10 (21.7)	19 (11.4)
10-20%	109 (90.8)	35 (76.1)	144 (6.7)
> 20%	2 (1.7)	1 (2.2)	3 (1.8)
Carbohydrate (g)	277.46 ± 122.92	284.29 ± 129.56	279.39 ± 124.49
Percentage of energy from carbohydrate (%)	63.62 ± 9.15	63.34 ± 8.64	63.54 ± 8.98
< 50%	14 (11.7)	3 (6.5)	17 (10.2)
50-65%	48 (40.0)	28 (60.9)	76 (45.8)
> 65%	58 (48.3)	15 (32.6)	73 (44.0)
Total fat (g)	46.46 ± 25.30	48.28 ± 30.99	46.97 ± 26.95

**Table 3.** continued

Characteristics	Mean±SD / n (%)		
	Normal (n = 127)	Anemic (n = 50)	Total (n = 177)
Percentage of energy from fat (%)	23.20 ± 8.43	24.02 ± 8.33	23.43 ± 8.39
< 25%	73 (60.8)	21 (45.7)	94 (56.6)
25-30%	24 (20.0)	15 (32.6)	39 (23.5)
> 30%	23 (19.2)	10 (21.7)	33 (19.9)
Total fiber (g)	8.26 ± 6.59	15.83 ± 8.02	10.40 ± 7.79
< 20	114 (89.8)	42 (84.0)	156 (88.1)
20-30	11 (8.7)	7 (14.0)	18 (10.2)
> 30	2 (1.6)	1 (2.0)	3 (1.7)
Vitamin A (RE)	956.32 ± 598.94	1084.95 ± 736.366	992.66 ± 688.17
≥ RNI	76 (59.8)	32 (64.0)	108 (61.0)
< RNI	51 (40.2)	18 (36.0)	69 (39.0)
Vitamin B <sub>12</sub> (µg)	0.49 ± 0.57	0.57 ± 0.88	0.51 ± 0.67
≥ RNI	0 (0.0)	1 (2.0)	1 (0.6)
< RNI	127 (100.0)	49 (98.0)	176 (99.4)
Vitamin C (mg)	181.04 ± 127.15	215.55 ± 206.68	190.79 ± 153.98
≥ RNI	91 (71.7)	27 (54.0)	118 (66.7)
< RNI	36 (28.3)	23 (46.0)	59 (33.3)
Calcium (mg)	781.92 ± 997.51	652.09 ± 408.36	745.25 ± 873.04
≥ RNI	12 (9.4)	7 (14.0)	19 (10.7)
< RNI	115 (90.6)	43 (86.0)	158 (89.3)
Folate (µg)	192.22 ± 127.15	194.73 ± 122.04	192.93 ± 140.88
≥ RNI	11 (8.7)	6 (12.0)	17 (9.6)
< RNI	116 (91.3)	44 (88.0)	160 (90.4)
Iron (mg)	18.99 ± 12.12	20.76 ± 11.74	19.49 ± 12.01
≥ RNI	95 (74.8)	35 (70.0)	130 (73.4)
< RNI	32 (25.2)	15 (30.0)	47 (26.6)
Zinc (mg)	5.22 ± 3.62	4.68 ± 2.94	5.07 ± 3.44
≥ RNI	31 (24.4)	38 (76.0)	69 (39.0)
< RNI	96 (75.6)	12 (24.0)	108 (61.0)

n, number; SD, standard deviation

<sup>1)</sup>RNI, Recommended Nutrient Intake [32]**Table 4.** Factors associated with anemia status in vegetarians in simple logistic regression analysis (n = 177)

Characteristics	Simple logistic regression	
	Crude OR (95% CI)	P-value
Age groups (yrs)		
> 50	1.00	
≤ 50	2.45 (1.23, 4.88)	0.011
Ethnicity		
Chinese	1.00	
Indian	1.34 (0.69, 2.59)	0.391
Marital status		
Single/divorced/widowed	1.00	
Married	2.63 (1.28, 5.41)	0.009
Education level		
No formal education/primary education	1.00	
Secondary education	2.46 (0.78, 7.78)	0.124
Tertiary education	1.58 (0.45, 5.53)	0.475
Occupation		
Managers	1.00	
Professionals	1.10 (0.37, 3.29)	0.860

**Table 4.** continued

Characteristics	Simple logistic regression	
	Crude OR (95% CI)	P-value
Technicians and other workers	1.19 (0.39, 3.62)	0.761
Housewives/unemployed	0.67 (0.23, 1.94)	0.462
Students	0.38 (0.04, 3.78)	0.410
Household members		
≤ 2	1.00	
3-4	1.67 (0.67, 4.17)	0.276
5-6	1.52 (0.59, 3.94)	0.385
> 6	0.51 (0.97, 2.71)	0.432
Monthly household income		
Low	1.00	
Medium	0.72 (0.34, 1.55)	0.403
High	0.62 (0.27, 1.42)	0.256
Vegetarian category		
Lacto-ovo	1.00	
Ovo	1.57 (0.36, 6.84)	0.547
Lacto	1.67 (0.78, 3.59)	0.190
Vegan	1.23 (0.49, 3.07)	0.657

Table 4. continued

Characteristics	Simple logistic regression	
	Crude OR (95% CI)	P-value
Total yrs of vegetarianism		
≤ 5	1.00	
> 5	1.16 (0.48, 2.80)	0.740
Body mass index (BMI)		
Underweight	1.00	
Normal weight	0.53 (0.19, 1.43)	0.209
Overweight	0.57 (0.19, 1.72)	0.322
Obese	0.64 (0.12, 3.25)	0.593
Waist circumference (WC)		
No risk	1.00	
Abdominal obesity	1.75 (0.90, 3.38)	0.097
Body fat percentage (BF%)		
Acceptable	1.00	
Unhealthy, too high	1.07 (0.55, 2.07)	0.841
Energy		
≥ RNI	1.00	
< RNI	1.04 (0.53, 2.03)	0.908
Protein (g)		
≥ RNI	1.00	
< RNI	0.87 (0.45, 1.68)	0.674
Percentage of energy from protein (%)		
> 20%	1.00	
10-20%	2.18 (0.78, 6.09)	0.138
< 10%	6.22 (1.68, 23.06)	0.006
Percentage of energy from fat (%)		
< 25%	1.00	
25-30%	2.17 (0.97, 4.87)	0.060
> 30%	1.51 (0.62, 3.67)	0.361
Percentage of energy from carbohydrate (%)		
< 50%	1.00	
50-65%	2.72 (0.72, 10.31)	0.140
> 65%	1.21 (0.31, 4.75)	0.788
Iron (mg)		
≥ RNI	1.00	
< RNI	1.27 (0.62, 2.63)	0.515
Total fiber (g)		
< 20	1.00	
20-30	1.73 (0.63, 4.75)	0.290
> 30	1.36 (0.12, 15.36)	0.805
Vitamin A (RE)		
≥ RNI	1.00	
< RNI	0.84 (0.43, 1.65)	0.610
Vitamin C (mg)		
≥ RNI	1.00	
< RNI	2.15 (1.09, 4.24)	0.026
Folate (µg)		
≥ RNI	1.00	
< RNI	0.70 (0.24, 1.99)	0.499
Calcium (mg)		
≥ RNI	1.00	
< RNI	0.64 (0.24, 1.74)	0.381

Table 4. continued

Characteristics	Simple logistic regression	
	Crude OR (95% CI)	P-value
Zinc (mg)		
≥ RNI	1.00	
< RNI	1.12 (0.45, 0.22)	0.735
Sleep quality		
Good	1.00	
Poor	1.46 (0.66, 3.24)	0.350
Physical activity level		
Low	1.00	
Moderate	1.60 (0.76, 3.37)	0.214
High	2.07 (0.85, 5.05)	0.112
Depression		
Normal	1.00	
Mild	1.04 (0.38, 2.87)	0.934
Moderate/severe	1.57 (0.36, 6.85)	0.552
Anxiety		
Normal	1.00	
Mild	1.41 (0.61, 3.28)	0.419
Moderate/severe	0.97 (0.41, 2.32)	0.949
Stress		
Normal	1.00	
Mild	1.18 (0.42, 3.32)	0.751
Moderate/severe	0.85 (0.22, 3.31)	0.819

OR, Odd Ratio; CI, Confidence Interval; RNI, Recommended Nutrient Intake

Table 5. Factors associated with anemia status in vegetarians in multiple logistic regression analysis (n = 177)

Characteristics	Multiple logistic regression	
	Adjusted OR (95% CI)	P-value
Age groups (yrs)		
> 50	1.00	
≤ 50	2.46 (1.19, 5.05)	0.014*
Marital status		
Single/divorced/widowed	1.00	
Married	2.69 (1.27, 5.71)	0.010*
Percentage of energy from protein (%)		
> 20%	1.00	
10-20%	2.00 (0.69, 5.80)	0.200
< 10%	5.52 (1.41, 21.65)	0.014*

OR, Odd Ratio; CI, Confidence Interval

$\chi^2 = 21.519$ ,  $P < 0.001$ ; Cox & Snell  $R^2 = 0.112$ ; Nagelkerke  $R^2 = 0.161$

\* Statistically significant at  $P < 0.05$

#### Factors associated with anemia status

The variables with  $P < 0.25$  in Table 4 (age, marital status, WC, percentages of energy from protein (%), vitamin C intake, and PA level) were included in the multiple logistic regression model. As shown in Table 5, the association of anemia status in vegetarians was most evident among females aged 50 years and below (AOR = 2.46, 95% CI = 1.19-5.05), married (AOR = 2.69, 95% CI = 1.27-5.71), and with an inadequate intake of percentage of energy derived from protein (AOR = 5.52, 95% CI = 1.41-21.65). Furthermore, the Nagelkerke R-square for the model was 0.161, which further indicates that 16.1% of the

variance in the anemia status of female vegetarians in this study could be explained by these three factors.

## DISCUSSION

The findings of the present study revealed a 28.2% prevalence of anemia among female vegetarians, which further indicates that anemia is a moderate public health problem [33]. This result is consistent with the WHO report, which stated that 30% of adult women in Malaysia were anemic [34]. Furthermore, participants aged 50 years and younger were more likely to have anemia than those aged more than 50 years old. Menstruation is among the factors that could be associated with anemia due to periodic blood loss [12], which explains the rationale of the classification of age groups in this study, provided that the average year of menopause among Malaysian women is 50 years old [12]. On the other hand, a study in India reported that women from the age group below 25 years old tended to be more affected by anemia [16]. A possible explanation for the variation might be the common occurrence of teenage pregnancy in India considering that half of them usually fall pregnant with a maternal age below 20 years old, while more than one fourth fall pregnant before 18 years old [35].

The marital status was found to be positively associated with anemia in the present study. Recent evidence regarding the association between marriage and anemia has been two sided. Entry into high-quality marriage could help encourage healthy behaviors and promote longevity [36]. Nevertheless, married life has also been identified as a risk factor that leads to a poor nutritional status. In many cases, the husband or wife may no longer be concerned with their body image, resulting in an increase in fast food consumption, excessive television watching, and prolonged sedentary habits [37]. In addition, married women play the roles as both mothers and wives. Hence, they are always required to carry their responsibility in taking care of the needs of the household, which sometimes causes them to neglect their own needs, resulting in a poor nutritional status [38].

A high prevalence of overweight and obesity (32.2%) was reported among female vegetarians in this study, suggesting that overweight and obesity is a public health problem among female vegetarians. Anemic participants showed a higher mean BMI than their counterparts, which is in line with the obesity-anemia mechanism, in which pro-inflammatory cytokines induced by adipose tissue can inhibit iron absorption and retain iron in the bone marrow macrophages [20]. On the other hand, none of the anthropometric indices in the present study, which included the BMI, WC, and BF%, had an association with anemia. Data from previous studies showed conflicting results whereby a meta-analysis [39] reported that obesity is emerging risk factor for anemia. In contrast, in the studies conducted in China [40] and Bangladesh [38], anemia was found to be more prevalent among underweight women. Consistent with the present finding, BMI had no association with anemia in US adults based on the findings reported in the third National Health and Nutrition Examination Survey (NHANES III) [41]. Limited studies were conducted to examine the associations of WC and BF% with the anemia status, particularly among vegetarians.

The findings of this study showed that vegetarians with inadequate energy intake from protein were 5.52 times more likely to develop anemia compared to those who had adequate energy intake from protein. Similar studies in US [42] and Saudi Arabia [43] support this finding. Of the three macronutrients, protein has the greatest influence on the iron metabolism. The effects of protein on the anemia status have been discussed in many studies in terms of the protein food source. For example, soy is high in iron and ferritin, and it contains fiber, polyunsaturated fat, and phytoestrogens, which all can lower the levels of inflammatory markers and reduce the metabolic causes of anemia [44]. In addition, egg white protein was also shown to have power in anemia recovery because of the negative carboxylate sites (-CO<sub>2</sub><sup>-</sup>) on the molecule surface of ovalbumin, which have a strong binding effect of iron [45]. In contrast, egg yolk protein reduces the iron bioavailability when the resistant protein, phosvitin, combines with dietary iron and forms an insoluble iron complex in the small intestine [46]. Vegetarians have a high intake of these food sources, which might explain the significant association between the percentage of energy intake from protein and anemia. Further studies will be needed to confirm this finding.

Surprisingly, vitamin C and iron intake of the anemic participants were higher than the non-anemic participants, but no association between these nutrients with anemia status was reported. This might be because some anemic vegetarians might realize their symptoms of anemia and increase their dietary intake of vitamin C and iron. On the other hand, the recovery of symptoms took a certain period and could be delayed due to other factors, such as inflammation. Hence, more studies will be needed to confirm this finding.

Physical activity had no association with the anemia status in this study. Exercise-induced anemia is more common in endurance sports, which further explains the non-significant relationship between anemia and physical activity in non-athletic persons. The present study also failed to detect any significant relationship between anemia and psychological factors. Psychological factors might be more prominent and convincing among elderly if their anemia status is more severe [47]. All vegetarian participants in the current study were either Buddhists or Hindus, in which high religiosity could be a protective factor against poor mental health. The influence of sleep quality in adults with anemia is complex. A previous study positively correlated the sleep quality with the Hb level among dialysis patients [48]. Nevertheless, sleep quality was found to have no association with anemia among vegetarians in the present study.

This study had several limitations. First, the results were limited to being a cross-sectional study. Thus, a determination of a possible temporal relationship between anemia and the risk factors will require further prospective cohort studies. Second, this study employed a convenience sample of female adult vegetarians, in which the findings cannot be generalized to all vegetarians. Furthermore, the current research was limited by the inability to differentiate the specific types of anemia because other biochemical indicators, such as vitamin B<sub>12</sub>, folate, ferritin, and iron, were not included. Moreover, this study did not involve a non-vegetarian group; hence, a comparison

between vegetarian and non-vegetarian groups could not be made. Another limitation of this study refers to the fact that the menstruation status, which may be one of the factors associated with anemia in females, was not investigated in the present study.

In conclusion, anemia appears to be a public health issue that is regarded as a critical concern among female adult vegetarians in Malaysia. More importantly, age, marital status, and percentage of energy derived from protein intake were found to be significant predictors of anemia. Therefore, nutrition education and intervention programs on anemia among vegetarians should be carried out by targeting married individuals aged 50 and below. In addition, these programs should focus on educating vegetarians on the importance of having an adequate energy intake from protein to prevent anemia. Anemia is a disease that is readily preventable and treatable. Therefore, more studies will be needed to confirm these findings.

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## CONFLICT OF INTEREST

The authors declare no potential conflicts of interests.

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