



# OPEN Knowledge and attitudes on anemia and menstrual health among Malaysian female university students

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Anemia is a significant public health concern, particularly among young female adults due to its potential impact on reproductive health. This study investigated the association between anemia-related knowledge, attitudes, menstrual health, and anemia status among Malaysian university students. This was a cross-sectional study named “SCARF” - Study to Combat Anemia - Research for Female Students, involving 674 university students in Malaysia. Anemia status was determined based on haemoglobin level, while knowledge, attitude and menstrual health were measured using validated questionnaires. The mean menarche age of students in this study was  $12.1 \pm 1.21$  years. Students who were anemic had significantly longer menstrual cycle duration ( $P = 0.034$ ) and more days with heavy flow ( $P = 0.038$ ). Most students had poor knowledge (44.5%) and attitudes (84.1%) towards anemia. Students with good knowledge were 1.1 times more likely to have better anemia status compared to those with poor knowledge (95% CI: 1.0–1.2,  $P = 0.049$ ). This study highlighted a lack of practical application of the knowledge to dietary habits. Collaborative efforts between educators and healthcare providers are crucial in developing a comprehensive strategy, such as interventions to prioritise educational initiatives and practical support to enhance overall menstrual health among female students.

**Keywords** Anemia, Knowledge, Attitude, Menstrual health, Preventive health, Women’s health

Anemia is characterised by a low red blood cell count which may impact one’s quality of life and can lead to significant clinical symptoms if left untreated. Women of reproductive age (WRA) and often require attention for their anemia status. However, a lack of concern is given to young female adults owing to the fact they are healthy and are not on the priority front when it comes to health. One of the most affected regions in the world with a high prevalence of anemia is Southeast Asia. Almost 30% of WRA (i.e., 15–49 years old) were anemic<sup>1</sup>, which accounted for more than 500 million women affected worldwide. Owing to these statistics, reducing anemia prevalence is now included as one of the six World Health Assembly Global Nutrition Targets and the United Nations 2030 Agenda for Sustainable Development. Meanwhile, in Malaysia, approximately 4.6 million people, constituting 21.3% of Malaysians, were reported to be dealing with anemia<sup>2</sup>. Among females, 3 out of 10 who were from the reproductive age group surveyed were anemic<sup>2</sup>.

Educational interventions significantly improve knowledge, attitudes, and practices regarding iron deficiency anemia among females, leading to better prevention and management of the condition<sup>3–5</sup>. However, knowledge alone is insufficient for behavioural modifications, as attitude also plays a significant role in mediating health risk behaviours<sup>6</sup>. A previous study found that with education to promote awareness of the prevention of anemia, more females would have a positive attitude<sup>7</sup>. Low levels of knowledge and unfavourable attitudes towards anemia prevention have been associated with increased anemia risk. This highlights the importance of implementing knowledge transfer and attitude change strategies specifically targeting young females to address this gap early on<sup>8</sup>.

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A rising prevalence of anemia among WRA is a growing concern as this leads to higher rates of anemia during pregnancy and may lead to adverse pregnancy outcomes such as gestational diabetes mellitus, polyhydramnios, preterm birth, low birth weight, and neonatal complications<sup>9–12</sup>. Therefore, research efforts focusing on young female adults in the reproductive age group are imperative to activate preventive measures. Amidst the academic challenges and stressors faced by university students, this population may inadvertently face risks associated with anemia due to poor nutritional habits, often exacerbated by tight schedules and limited access to nutritious foods<sup>12</sup>. Low dietary diversity leads to micronutrient deficiencies in essential nutrients like iron, contributing to anemia<sup>12</sup>. Additionally, the stress of university life can disrupt the regularity of menstrual cycles in young women, which is one of the common causes of iron deficiency anemia<sup>13</sup>. The prevalence of females experiencing irregular menstrual cycle features such as irregular periods and heavy bleeding range from 20 to 37% varying by country and age: 20.7% in Uganda<sup>14</sup>, 29.1% in India<sup>15</sup>, 32.6% in Ethiopia<sup>16</sup> and 37.2% in Malaysia<sup>17</sup>. Existing literature on anemia has predominantly focused on identifying the associated risk factors. Nevertheless, there is a notable scarcity of primary studies looking into female university students' understanding and perceptions of anemia, which remains a noteworthy gap among this population in Malaysia. Addressing anemia among female university students is crucial not only for their immediate health but also for safeguarding their reproductive capacities and future pregnancy outcomes. Therefore, the objective of this study was to explore the knowledge and attitudes of Malaysian female university students about anemia, how these variables are associated with their anemia status, and to examine the differences in menstrual health between those with and without anemia.

## Methodology

### Study settings and subjects

This cross-sectional study named “SCARF” (Study to Combat Anemia - Research for Female Students) was conducted from May 2023 to November 2023 in three universities located in Kuala Lumpur and Selangor state of Malaysia, namely UCSI University, Universiti Teknologi MARA (UiTM) Puncak Alam and Sunway University. The subjects were recruited using a convenience sampling method, where the subjects were recruited via a booth set up at student activity centers of each university to ensure accessibility and maximise student engagement. Written informed consent was obtained from all subjects before their involvement in the study, ensuring they were fully informed of the study objectives and the data collection procedures. Self-reported data were collected through printed questionnaires, in which the subjects were required to complete the questionnaire on-site. Malaysian female university students aged 18 to 25 who could understand English were included in the study. As the questionnaires were designed in English, including non-English-speaking participants could have led to misinterpretations, affecting the reliability and validity of their responses. Students who were pregnant or lactating, had chronic diseases such as diabetes, hypertension, and congenital diseases, or were fasting during the data collection period were excluded from participation to avoid confounding factors that could affect the study outcomes. These factors can significantly alter the nutritional and physiological status of the students, which might influence haemoglobin levels and other health parameters. Excluding these students helped to ensure data reliability and allowed for a clearer interpretation of the study's findings.

### Sample size determination

The sample size for this study was determined using the single proportion formula<sup>18</sup> to estimate prevalence:  $n = \frac{z^2 p(1-p)}{e^2}$ , where

$n$  = Requires sample size.

$p$  = Proportion of anemic WRA in Kuala Lumpur, Malaysia based on NHMS 2019<sup>2</sup> = 0.252.

$e$  = Desired level of precision = 0.05.

$z$  = Desired level of confidence = 1.96 (95%).

With a desired precision of 0.05 and a confidence level of 95%, the initial calculated sample size was 290. To account for a potential non-response rate of 30%, the adjusted sample size was increased to 377 participants, ensuring adequate power and representativeness for the study.

### Ethical approval

The ethical approval of this study was approved by UCSI Institutional Ethics Committees (Ref. No. IEC-2023-FAS-0001) and Sunway University Research Ethics Committee (Ref. No. SUREC 2023/063). Written informed consent was obtained from all participants prior to the commencement in this study. The study was performed in accordance with the Declaration of Helsinki.

### Data collection

Data were collected using a self-administered questionnaire which consisted of socio-demographic characteristics, menstrual health, knowledge, and attitude toward anemia. The duration for the subjects to complete the questionnaire was approximately 15–20 minutes. After completing the questionnaire, the haemoglobin levels of the subjects were assessed to identify the anemia status of the subjects. Every subject was briefed on the blood sampling procedure before the blood sample collection for the haemoglobin level test. Appropriate nutritional counselling and guidance to improve their anemia status were provided to students who were identified with low haemoglobin levels to ensure their health and well-being were prioritised throughout the study.

### Socio-demographic characteristics

Socio-demographic data of the subjects, such as age, date of birth, ethnicity, current study programme, monthly household income, monthly allowance or personal income. The weight and height of the subjects were also measured and recorded in this section to calculate the body mass index (BMI).

## Menstrual health

In this section, the subjects were required to report data related to their menstrual health including the age of menarche, average length of menstruation (in days), and menstrual blood loss. Heavy menstrual is defined as excessive menstrual blood loss that affects a woman's physical, emotional, social, or quality of life<sup>19</sup>. These descriptive data were reported in frequencies.

## Knowledge and attitude of anemia

The questionnaire to assess knowledge and attitude toward anemia was adapted from previous studies<sup>20,21</sup>. The first section consisted of 22 items, such as the definition of anemia, symptoms of anemia, causes of anemia, the importance of iron supplements, and iron-rich food sources. Subjects were asked to choose one answer (yes, no or I don't know). One (1) point was given to every correct response, while zero (0) was given to incorrect or unsure responses, except for one question (item K3e) with reverse scoring, namely the use of contraceptives as the cause of anemia. The minimum and maximum scores for this section were 0 and 22 respectively. A higher knowledge score indicated better knowledge of anemia.

The second section of this questionnaire consisted of six questions to assess the subjects' attitudes towards anemia, which included perceived susceptibility and severity of anemia, perceived benefits, barriers, and self-confidence in preparing meals with iron-rich foods. Subjects were asked to express their levels of agreement on these questions. One (1) point was given to each positive response (likely, serious, good, not difficult, confident, or like), while zero (0) was given to each negative response (not likely, not serious, not good, difficult, not confident, maybe, not sure). The minimum and maximum scores for this section were 0 and 6 respectively. A higher attitude score indicated a better attitude towards anemia. The total scores for knowledge and attitude were calculated in percentage and also categorised into 3 levels based on Bloom's cut-off: high level (80–100%), moderate level (60–79.9%), and poor level (<60%).

## Haemoglobin level assessment

To assess the anemia status of the subjects, the haemoglobin (Hb) level test was performed using the HemoCue haemoglobinometer (HemoCue® Hb 201 + System, Angelholm, Sweden) by point-of-care testing on capillary blood samples. A drop of blood was drawn and filled in the HemoCue microcuvette, and the result was shown within 10 min. Anemia status and the severity level of the female university students were determined according to the age and gender-specific haemoglobin cut-off points, where the subjects were classified as anemic when they had Hb levels lower than 12.0 g/dL. The Hb ranges for mild, moderate, and severe anemia for non-pregnant women aged 15 years and above were 11.0–11.9 g/dL, 8.0–10.9 g/dL, and <8.0 g/dL, respectively<sup>22</sup>.

## Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics version 23.0. Descriptive data were reported by mean and standard deviation for continuous variables and percentages and frequencies for categorical variables. The normality test was conducted for the continuous variables through the Shapiro-Wilk analysis (Table 1). Consequently, knowledge and attitude scores were categorized based on predefined total score ranges, allowing for a more meaningful interpretation of the data. To assess differences between groups for menstrual duration and heavy menstrual days, the Mann-Whitney U test was employed as the data does not meet the assumptions of normality. Pearson chi-square test was used to examine the associations between knowledge and attitude categories with anemia status. Generalised Estimating Equation (GEE) analysis was used to assess the effect of knowledge on anemia status of female university students, considering the potential cluster effect of the university location. The covariates adjusted for the GEE regression model were identified by conducting univariate logistic regression analysis for all sociodemographic variables with anemia prevalence. The variables with  $P < 0.25$  were included into the model<sup>23</sup>. The significance level for all analyses was set at two-tailed  $P < 0.05$ .

## Results

Of 674 students in this study, the mean haemoglobin level was  $11.6 \pm 1.3$  g/dL. In this study, most students were anemic (59.4%), of which 30% of them had mild anemia and 29.4% of them had moderate anemia. The mean age of the subjects was  $21.2 \pm 1.5$  years old. Most of the subjects were Chinese (48.8%), and the median monthly household income was RM 2500.00, with an interquartile range of RM 6565.00. Majority of the subjects were pursuing an undergraduate programme (87.9%). The socio-demographic data based on anemia status is shown in Table 2. The distribution of anemia varies notably among the ethnic groups, where half of the anemic group were Malay students (50.0%), indicating a higher prevalence of anemia compared to the other ethnic groups. The analysis reveals a statistically significant association between ethnic background and anemia status ( $\chi^2 = 17.1$ ,  $P < 0.001$ ). Among those who were classified as anemic, most were from low monthly households (46.0%). A

Variables	Shapiro-Wilk			Distribution
	Statistics	df	P	
Knowledge	0.985	660	<0.001	Not normally distributed
Attitude	0.937	660	<0.001	Not normally distributed
Menstrual duration	0.579	660	<0.001	Not normally distributed
Days of heavy menstrual	0.548	660	<0.001	Not normally distributed

**Table 1.** Output of normality test.

Variables	n (%)			$\chi^2$	P
	Total (n = 674)	Non-Anemic (n = 274)	Anemic (n = 400)		
<b>Age Group (years)</b>				0.2	0.634
18–21	401 (59.5)	166 (60.6)	235 (58.8)		
22–25	273 (40.5)	108 (39.4)	165 (41.3)		
<b>Ethnicity</b>				17.1	<0.001
Malay	299 (44.4)	99 (36.1)	200 (50.0)		
Chinese	329 (48.8)	154 (56.2)	175 (43.8)		
Indian	23 (3.4)	14 (5.1)	9 (2.3)		
Bumiputera	23 (3.4)	7 (2.6)	16 (4.0)		
<b>Academic Level</b>				1.7	0.432
Pre-university /Diploma	71 (10.6)	34 (12.5)	37 (9.3)		
Undergraduate	589 (87.9)	235 (86.1)	354 (89.2)		
Postgraduate	10 (1.5)	4 (1.5)	6 (1.5)		
<b>Programme Type</b>				2.5	0.111
Health science	205 (30.4)	74 (27.0)	131 (32.8)		
Non-health science	469 (69.6)	200 (73.0)	269 (67.3)		
<b>Monthly Household Income Classification+</b>				9.3	0.010
Low	338 (50.1)	154 (56.2)	184 (46.0)		
Middle	176 (26.1)	70 (25.5)	106 (26.5)		
High	160 (23.7)	50 (18.2)	110 (27.5)		
<b>Personal Allowance (n = 416)</b>				0.2	0.644
Below MYR 600	237 (57.0)	98 (58.3)	139 (56.0)		
MYR 600 and above	179 (43.0)	70 (41.7)	109 (44.0)		
<b>BMI Classification</b>				4.9	0.178
Underweight	139 (20.6)	67 (24.5)	72 (18.0)		
Normal	321 (47.6)	120 (43.8)	201 (50.2)		
Overweight	87 (12.9)	37 (13.5)	50 (12.5)		
Obese	127 (18.8)	50 (18.2)	77 (19.3)		

**Table 2.** Sociodemographic characteristics and anemia status of Malaysian female university students ( $N = 674$ ). Data reported based on Chi-square analysis. + Household income classification based on data from the Department of Statistics Malaysia (DOSM) 2019, with income range for low (B40) with below MYR 4,850, middle (M40) with MYR 4,850 – MYR10,970, and high (T20) with MYR 10,971 and above. Note: USD 1 = MYR 4.72 (as of 18th June 2024).

Variables	Median (IQR)			Z	P
	Total	Non-Anemic	Anemic		
<b>Menstrual duration (days)</b>	6.5 (2.0)	6.0 (2.0)	7.0 (2.0)	-2.1	0.034
<b>Heavy menstrual (days)</b>	1.0 (1.0)	0	1.0 (0)	-2.1	0.038

**Table 3.** Descriptive of the menstrual pattern of female university students ( $N = 674$ ). Data reported based on Mann-Whitney U test.

significant relationship between monthly household income and anemia status was found, where lower income levels are associated with anemia ( $\chi^2 = 9.3$ ,  $P = 0.01$ ).

Meanwhile, the mean age of menarche for the students in this study was  $12.1 \pm 1.2$  years. Majority of the subjects (75.5%) reported having a regular menstrual cycle, followed by irregular for a few months (14.1%) and never regular (10.4%). Results from Table 3 showed that the median number of heavy menstrual flow days for the whole group was 1 day, with an IQR of 0–2 days. In comparison, students who were anemic had significantly longer menstrual duration and days with heavy flow, as compared to their non-counterparts, indicating a potential link between more frequent heavy menstrual flow and anemia. This finding highlights the influence of menstrual patterns on anemia risk among participants.

The study analysed the knowledge and attitudes of Malaysian female university students regarding anemia, examining symptoms, causes, the importance of iron supplements, and examples of iron-rich food sources. Most students defined anemia as iron deficiency (80.3%) and low haemoglobin level (86.1%). More than half of them were able to identify the symptoms of anemia, such as exceptional shortness of breath (54.0%), fatigue (83.1%), and general weakness (86.1%). The majority of the students reported poor nutrition (78.2%) as the cause of

anemia, while they also reported that iron supplements are important for women's health (83.4%), anemia prevention (86.1%), and baby's health (61.3%). More than half were able to identify that red meat (84.3%), liver (78%), vegetables (64.2%) legumes (51.8%), and chicken (51.3%) are iron-rich food sources.

Most students (44.5%) in this study had poor knowledge of anemia (Fig. 1). A significant association was found between knowledge and anemia status among this population, where students who were anemic (22.5%) were more likely to have significantly lower knowledge than those who were non-anemic (14.2%) ( $P=0.023$ ). Students from health-related majors had significantly higher knowledge scores compared to their counterparts in non-health-related disciplines ( $\chi^2 = 50.1, P < 0.01$ ), as shown in Fig. 2.

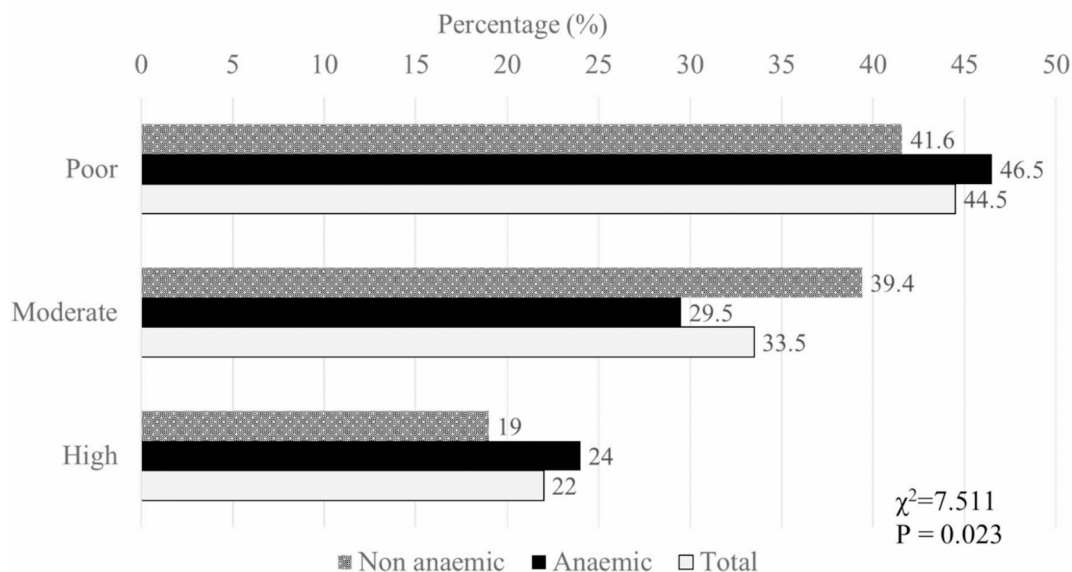
Figure 3 displays the descriptive data for the responses on the attitude towards anemia among students. Majority of them had poor attitude towards anemia (84.1%), followed by moderate (10.5%) and good (5.3%). However, no significant association was found between the attitude and the students' anemia status ( $\chi^2 = 0.9, P = 0.627$ ).

Table 4 presents the effect of knowledge on the anemia status. As the attitude towards anemia was not significantly associated with students' anemia status at Chi-square level, the variable was not included in the GEE model. Several covariates were included in the analysis model, namely the study location, ethnicity, age, monthly household income, personal allowances, and menstrual health-related data (menstrual length and days of heavy menstrual). The GEE analysis yielded significant associations between knowledge with anemia status, as indicated by Wald chi-square tests ( $\chi^2 = 6.9$ ). Female university students with good knowledge were 1.1 times more likely to have better anemia status based on their haemoglobin level (95% CI: 1.0–1.2,  $P = 0.049$ ) as compared to those with poor knowledge.

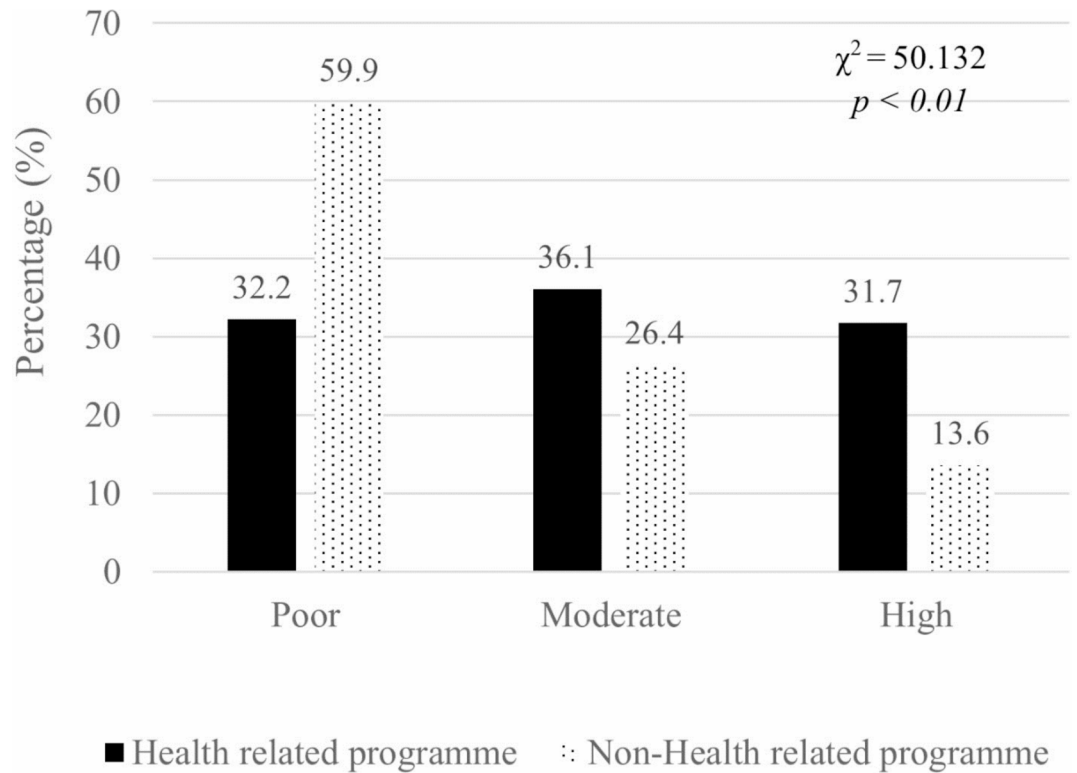
## Discussion

In general, women of reproductive age (WRA) are significantly more prone to be anemic than men<sup>4</sup>, primarily due to menstrual blood loss, insufficient nutrient intake, or parasitic infections<sup>24</sup>. This study discovered an alarming public health issue where over half of the Malaysian female university students (59.4%) were anemic. Those with mild and moderate anemia were 30.0% and 29.4% respectively. The prevalence of anemic non-pregnant females in this study was almost double the data from the previous National Health and Morbidity Survey (NHMS) year 2015 and 2019, which were 34.8%<sup>25</sup> and 29.9%<sup>2</sup> respectively. Meanwhile, the prevalence of anemic young females in this study was higher than in China<sup>26</sup> (16.4%), Indonesia<sup>27</sup> (48.9%), and India<sup>7</sup> (57.0%); but lower than the data reported in Bangladesh<sup>28</sup> (63.3%) and Saudi Arabia<sup>24</sup> (64.0%). These findings highlight the need for targeted interventions by healthcare providers, including early screening and nutrition education to manage and reduce the prevalence of anemia. With that, the nutritional health and overall health outcomes of WRA, especially among female students can be improved.

In this study, anemic students were found to experience longer menstrual durations and heavier menstrual flows compared to their non-anemic counterparts. Heavy menstrual bleeding is a common medical condition



**Fig. 1.** Female university students' knowledge of anemia based on anemia status. **(A)** Percentage of students with poor knowledge about anemia. The anemic group had a higher percentage (46.5%) compared to the non-anemic group (41.6%), with the total percentage being 44.5%. **(B)** Percentage of students with moderate knowledge about anemia. The anemic group had a lower percentage (29.5%) compared to the non-anemic group (39.4%), with the total percentage being 33.5%. **(C)** Percentage of students with high knowledge about anemia. The anemic group had a higher percentage (24%) compared to the non-anemic group (19%), with the total percentage being 22%. The chi-square test indicated a significant difference in knowledge levels between anemic and non-anemic students ( $\chi^2 = 7.5, P = 0.023$ ).



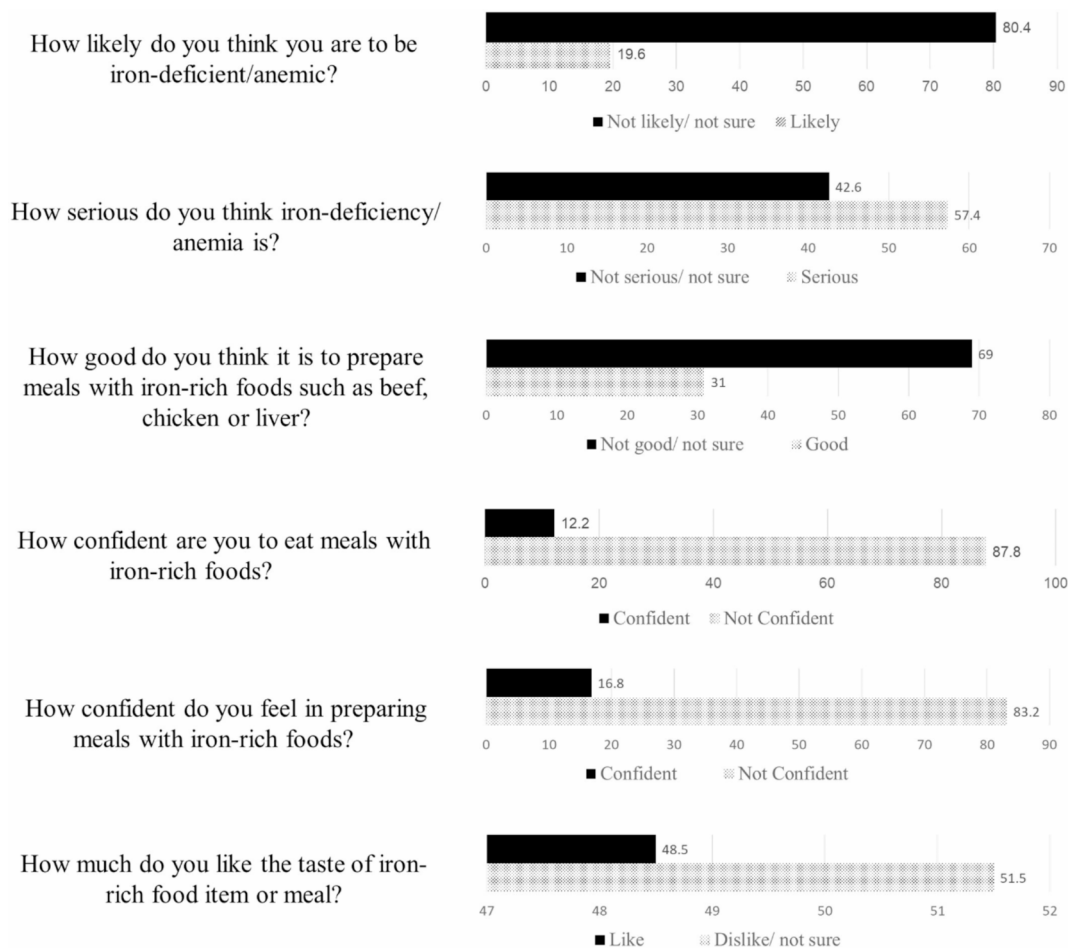
**Fig. 2.** Types of study programme and their association with knowledge of anemia. (A) Students from non-health-related programmes exhibited a significantly higher percentage (59.9%) of poor knowledge compared to those from health-related programmes (32.2%). (B) A higher proportion of students from health-related programmes demonstrated high knowledge of anemia (31.7%) compared to their non-health-related counterparts (13.6%).

that affects up to 25% of women globally<sup>29</sup>. Due to the body's inability to maintain adequate haemoglobin levels and exacerbate menstrual flow, this creates a vicious menstrual cycle with heavy bleeding and leads to abnormality in terms of menstrual frequency, volume, regularity, and duration, which may contribute to higher anemia risk<sup>30</sup>. Chronic iron deficiency may disrupt normal menstrual cycle regulation, leading to extended periods. Consistent with previous literature, prolonged menstrual duration can be both a cause and an effect of anemia, coupled with other wide-ranging symptoms such as hair loss, fatigue, dizziness, and overall poor health, further impacting their quality of life<sup>31</sup>. Therefore, a proper diagnosis and regular treatment of iron deficiency anemia are crucial to breaking this cycle and restoring normal menstrual function.

Although the subjects of this study were pursuing tertiary education, most of them had poor knowledge about anemia, as shown in Fig. 1. This finding is inconsistent with previous studies<sup>32–34</sup>, as higher education is often assumed to correlate with better access to household resources, health knowledge, and practices, but it was not observed in this study. While the significant difference lies in the proportion of students with poor and high knowledge levels between the anemic and non-anemic groups, it is notable that even among students with high knowledge, a substantial proportion were still anemic (24%). Several factors that may affect anemia status were not assessed as they were not within the scope of this study, such as environmental factors, dietary practices, and access to healthcare services. To fully understand and effectively combat anemia, future research should explore these factors and their interactions, as they may play a crucial role in influencing anemia status among young females. Thus, while knowledge is vital, policymakers and health professionals must consider these additional factors when developing comprehensive strategies to address anemia in this population. A multifaceted approach to address anemia, going beyond knowledge enhancement is warranted.

Besides that, female students enrolled in health-related majors had significantly higher knowledge scores compared to those in non-health-related disciplines, which is consistent with findings from past studies<sup>12,35</sup>. These results highlight the importance of targeted educational interventions for non-health-related students, as they may lack adequate exposure to health information. University curricula for non-health majors could benefit from integrating essential health education topics, including anemia awareness and prevention strategies<sup>3,12</sup>. By fostering greater awareness among students across all disciplines, universities can contribute to reducing the prevalence of anemia among young women, ultimately improving overall health outcomes.

Students from this study had inadequate knowledge about the causes of anemia and were unsure about the examples of iron-rich foods, such as fish, eggs, and fruits. This deficiency in knowledge suggests that current educational efforts among Malaysian female university students might be insufficient. Students in this study may underestimate their risk and severity of anemia, believing it to be predominantly affecting older populations.



\*Data reported in percentages (%)

**Fig. 3.** Descriptive data of female university students’ attitude towards anemia. **(A)** Likelihood of being iron-deficient or anemic. A higher percentage of students (80.4%) indicated that they were not likely to be iron-deficient or anemic. **(B)** Perception of the seriousness of iron-deficiency/ anemia. Over half of the students (57.4%) perceived iron-deficiency/ anemia as a serious health issue. **(C)** Opinion on preparing meals with iron-rich foods. A higher percentage of students (69.0%) stated they were not good at preparing meals with iron-rich foods such as beef, chicken, or liver. **(D)** Confidence in eating meals with iron-rich foods. More students were not confident (87.8%) that they could eat meals with iron-rich foods. **(E)** Confidence in preparing meals with iron-rich foods. A higher percentage of students (83.2%) were not confident in preparing meals with iron-rich foods. **(F)** Preference for the taste of iron-rich food items or meals. Over half of the students (51.5%) disliked the taste of iron-rich food items or meals.

Variables	Adjusted model		P
	OR	95% CI	
Knowledge <sup>a</sup>			
Poor	1.0	-	-
Moderate	0.9	0.9–1.0	0.173
Good	1.1	1.0–1.2	0.049

**Table 4.** Effect of knowledge on anemia status of female university students. Data reported based on Generalised Estimating Equation (GEE) analysis. <sup>a</sup> Reference category: Poor. The model was adjusted for socio-demographic variables: study location, ethnicity, age, monthly household income, personal allowance, menstrual length, and days of heavy menstrual.

While older age does correlate with higher anemia prevalence, young women may also experience anemia due to other underlying reasons related to environmental factors<sup>36</sup> that could affect their diet. For instance, students who stayed in the hostel within the campus area were more likely to be anemic, probably due to limited access to household resources, stress, long study hours, limited dietary choices, and poor eating habits<sup>37,38</sup>, which might affect their dietary quality and subsequently, nutritional status. This underscores the urgent need for targeted nutritional interventions and educational initiatives to enhance knowledge about anemia and its dietary management, particularly to prioritise the implementation of comprehensive health programmes within university settings.

Almost half of the students in this study were from low-income households or had low personal allowance. Limited knowledge regarding the importance of dietary iron intake, particularly among students from low-income households could contribute to an increased risk of anemia<sup>38</sup>. A comprehensive meta-analysis<sup>39</sup> found that those with food insecurity due to low socioeconomic status had a higher anemia risk. These students might have financial challenges, which affect their dietary choices. For instance, iron-rich foods such as red meat, fish, and some vegetables can be more costly, pushing students towards more affordable but less nutritious alternatives. Hence, there is a high possibility that students may skip meals or rely on low-cost but energy-dense foods, which further exacerbates the risk of anemia<sup>40</sup>. Hence, nutrition education should aim to foster a health-conscious culture by promoting healthy eating, including consumption of iron-rich foods within a budget to mitigate this health concern.

Attitudes towards anemia play a crucial role in its management and prevention which may vary widely based on awareness, cultural context, and personal experience with the condition. Although this study did not identify the association between attitude and anemia status among the study population, the study revealed that 84.1% of female students exhibited poor attitudes towards anemia, indicating a widespread lack of concern or awareness about the condition. The findings were inconsistent with previous data<sup>41</sup>, where positive attitudes were shown with adequate awareness of anemia among female university students in Malaysia, which can be attributed to the medical-related academic background of the participants. In contrast, the current study included students from all fields and not limited to medical, which showed a better representativeness of the population. Students with medical training from a medical university are more likely to have better awareness and understanding of anemia, leading to more proactive attitudes towards the condition. This educational background fosters a proactive approach to health, including regular health check-ups and the incorporation of iron-rich foods into their diet. The knowledge, attitude and practices (KAP) theory suggests that change in practice is a gradual process involving the acquisition of knowledge and the subsequent generation of positive attitudes<sup>42</sup>. Previous study found that enhancing the females' knowledge about anemia prevention is essential for improving their understanding and fostering a better attitude towards managing and preventing the condition<sup>42</sup>.

This study found that female students with good knowledge of anemia were more likely to have better anemia status compared to those with poor knowledge, showing a significant protective effect of knowledge against anemia. This suggests that a better knowledge level may mitigate anemia risk. Previous studies also revealed that the majority of Ghanaian students were aware of anemia and its prevention in theory<sup>43</sup>, but they did not translate the knowledge into practical dietary habits that could improve anemia status. Hence, knowledge as a modifiable risk factor that crucially links to anemia prevention should be highlighted and enhanced through targeted health education and interventions. While health education helps to raise awareness about anemia, its effectiveness must be complemented by practical support measures. Hence, it is essential to conduct further research to identify specific obstacles faced by these students in applying their knowledge. Collaborative efforts from health educators and policymakers are also important in ensuring that awareness translates into practices to foster sustainable behavioural actions that mitigate anemia risks and subsequently, improving the students' overall health outcomes.

The study adds to the existing body of knowledge by providing data on the relationship between knowledge, attitude, menstrual health, and anemia status among female university students in Malaysia. This contribution is valuable for researchers and policymakers working on anemia prevention. By concentrating on females, the study addresses a high-risk group for anemia. This information is crucial for designing targeted educational interventions to meet the specific needs and challenges faced by this demographic. However, this study is not without limitations. The causal relationship between the knowledge and attitudes toward anemia status remains unknown due to the cross-sectional study design. Besides, this study implied the convenience sampling method for subject recruitment in three universities, thus, the participants may not be representative of the broader population of female university students in Malaysia, limiting the generalisability of the findings.

## Conclusion

In conclusion, this study reveals a concerning prevalence of anemia among Malaysian female university students. The prevalence of anemia identified in this study consisted solely of mild and moderate cases, with no occurrences of severe anemia observed. The findings suggest that inadequate knowledge regarding anemia among young women constitutes a significant public health challenge that must be addressed, particularly during reproductive age. There is a pressing need for targeted nutrition interventions aimed at enhancing knowledge and providing practical strategies to achieve adequate iron levels, thereby preventing anemia and promoting overall health. Efforts to raise awareness about the importance of a healthy diet in preventing anemia, especially the consumption of iron-rich foods, should be reinforced and clearly articulated in dietary guidelines. To maximise impact, a multi-sectoral approach involving stakeholder engagement is essential in developing a comprehensive public health campaign. Collaborations among universities, healthcare providers, policymakers, and community organisations will be critical in this endeavour. Initiatives such as regular screening for anemia, educational programmes, and support for menstrual health management represent crucial steps toward reducing the prevalence of anemia among female university students in Malaysia.



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### Data availability

The data generated and/or analysed during the current study are available from the corresponding author on reasonable request.

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### Author contributions

KTM performed the data collection, data analysis and wrote the draft of the manuscript. SK contributed to the conceptualisation, data collection, writing and reviewing the manuscript. YHS, SBS, CP, TM and NAR reviewed and edited the manuscript. All authors reviewed the manuscript.

### Declarations

### Competing interests

The authors declare no competing interests.

### Additional information

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