Mal J Nutr 31(2): 245-257, 2025

Development and validation of a food frequency questionnaire for iron intake among pregnant women (P-FeFFQ)

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ABSTRACT

Background: Iron deficiency anaemia is common among pregnant women in Malaysia, posing risks to both maternal and foetal health. This study aimed to develop and validate a Food Frequency Questionnaire (FFQ) to assess iron intake among pregnant Malaysian women. **Method:** The Pregnancy-Focused Iron Food Frequency Questionnaire (P-FeFFQ) was created using data from 24-hour dietary recalls and literature reviews on iron-rich foods. An expert panel reviewed an initial list of 74 food items, which was refined to 63 based on content validity index (I-CVI) scores and feedback. Validation was performed against three-day dietary records from 21 pregnant women. Descriptive statistics summarised sociodemographic data and iron intake, while Pearson's correlation and Bland-Altman plot analyses assessed validity. **Results:** Participants had mean age of 29.8 years and pre-pregnancy body mass index (BMI) of 26.0 kg/m². P-FeFFQ showed excellent content validity (I-CVI score of 0.93) and was culturally relevant. Mean iron intake estimated by P-FeFFQ was 14.09 mg/day compared to 12.38 mg/day from dietary records. Pearson's correlation coefficient was 0.648 (p=0.001), indicating moderate positive relationship. Bland-Altman analysis showed mean difference of 1.71 mg/day, with most data points within the limits of agreement, suggesting reasonable accuracy. **Conclusion:** P-FeFFQ is a valid tool for assessing dietary iron intake among pregnant women in Malaysia.

Keywords: anaemia, food frequency questionnaires (FFQ), iron deficiency anaemia, pregnant women

INTRODUCTION

Anaemia during pregnancy is a significant global public health issue, affecting approximately 37% of pregnant women, with the highest prevalence observed in Southeast Asia (WHO, 2023). This condition, characterised by a reduction in the number of red blood cells or haemoglobin in the blood, compromises oxygen transport and leads to symptoms such as tiredness, weakness, and difficulty breathing (WHO, 2023). In Malaysia, the prevalence of anaemia among pregnant women ranges from 19.3% to 57.4%, with Terengganu having the highest rate at 57.4% and Selangor

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doi: https://doi.org/10.31246/mjn-2024-0112

showing a prevalence of 33% (Rahman *et al.*, 2022; Soh *et al.*, 2015). According to the World Health Organization (WHO), anaemia can result from various factors, including insufficient dietary intake or absorption of nutrients, infections, inflammation, chronic illness, gynaecological and obstetric issues, as well as inherited disorders affecting red blood cells. Among these, iron deficiency is the most common cause of anaemia in pregnancy, especially in low socioeconomic countries, as highlighted by Rahman *et al.* (2022). Besides, anaemia poses severe health risks, including increased maternal mortality due to severe haemorrhage and heart failure, as well as adverse foetal outcomes such as preterm birth and low birth weight (Beckert *et al.*, 2019; Khaskheli *et al.*, 2016; Nair *et al.*, 2016). These risks highlight the critical need for effective management and prevention strategies during pregnancy.

Accurately assessing dietary iron intake among pregnant women in Malaysia is crucial, given their elevated iron requirements during pregnancy [27 mg/day as recommended by the Malaysian Recommended Nutrient Intakes (RNI) 2017]. However, there is a notable lack of validated dietary assessment tools specifically designed to evaluate iron intake in this population. Most existing tools, such as food frequency questionnaires (FFQs) and 24-hour dietary recalls, were either developed in non-Malaysian contexts or validated for general nutrient intake rather than for iron, specifically among pregnant women (Loy *et al.*, 2011). Traditional methods, such as 24-hour dietary recalls and food diaries, often fall short in capturing habitual dietary intake and are not tailored to the cultural and dietary specifics of Malaysian pregnant women (Bezerra *et al.*, 2023). Existing FFQs, like those developed for general nutrient intake or specific vitamins, do not adequately assess iron intake or reflect the diverse dietary patterns and food availability in different Malaysian regions (Zaleha *et al.*, 2015). For instance, an FFQ that was developed and validated for pregnant mothers in Kelantan may not be applicable nationwide due to regional dietary differences (Loy *et al.*, 2011).

The development of a validated FFQ specifically tailored to assess iron intake among pregnant women in Malaysia is essential for accurate dietary assessments, identifying at-risk individuals, and informing nutritional interventions. This study aimed to fill this critical gap by creating and validating a culturally sensitive FFQ, thus providing healthcare professionals with a robust tool to identify dietary gaps, recommend appropriate dietary modifications, and monitor the effectiveness of nutritional interventions over time. Such a tool is crucial for reducing the prevalence of iron deficiency anaemia, subsequently improving maternal and foetal health outcomes, and ultimately contributing to better public health in Malaysia.

METHODOLOGY

This was a cross-sectional study conducted in two phases.

Development of the Pregnancy-Focused Iron Food Frequency Questionnaire (P-FeFFQ)

In Phase 1, food intake data were collected from 116 pregnant mothers attending health clinics in Selangor, namely, Klinik Kesihatan Meru, Klinik Kesihatan Kapar, Klinik Kesihatan Sungai Buloh, and Klinik Kesihatan Bandar Botanik. Sample size was calculated using the Cronbach's alpha calculator with a confidence level of 90% and an expected drop-out rate of 10%. Inclusion criteria included pregnant mothers aged 18 to 45 years old who were Malaysians and able to understand Malay or English. Pregnant mothers who were fasting, on diet restriction, or had chronic diseases such as chronic kidney disease, diabetes, pregnancy complications, or multiple pregnancies were excluded to avoid confounding factors. Food lists were obtained from 24-hour diet recalls and the Malaysian Adult Nutrition Survey (MANS) 2014 (IPH, 2014). During 24-hour diet recalls, participants were required to provide detailed descriptions of their food consumption over the previous 24 hours, including portion sizes, cooking methods, ingredients, and brands. Iron content in foods was then obtained from the Malaysian Food Composition Database (MyFCD) and entered into Nutritionist Pro Software Version 3.1.0 2024 (Axxya Systems, Stafford, Texas, U.S.A.). Initially, foods with iron content over 0.1 mg per 100 grams were included, but this threshold was raised to 2 mg per 100 grams based on expert suggestions.

Validation of the P-FeFFQ

Content validity was conducted by six experts and face validity was tested by ten pregnant women, similar to Zaleha *et al.* (2015). Six experts in clinical nutrition or dietetics, with at least eight years of experience, were recruited to assess each food item in the P-FeFFQ using Content Validation Forms. They rated the relevance and essentiality of each item on a scale of 1 (not relevant/ not essential) to 4 (very relevant/very essential). Items receiving scores of 3 or 4 were deemed both relevant and essential, while those receiving scores of 1 or 2 were considered neither relevant nor essential. Adjustments and corrections were made based on the feedback received. The final P-FeFFQ required participants to record their frequency of food intake over a day, week, or month. The P-FeFFQ was validated against interview-based three-day diet records, administered by the same interviewer to each of the ten participants. Relative validity of the P-FeFFQ was assessed by comparing iron intake estimates from P-FeFFQ with those from three-day diet records. For three-day diet records, participants were taught to record detailed information on food consumption, including portion sizes, cooking methods, ingredients, and brands for three days, including two weekdays and one weekend.

Sociodemographic, anthropometric, and obstetric information

Sociodemographic and anthropometric data were collected at the start of the study. These included age, residential area, employment status, education level, and socioeconomic status. Pre-pregnancy weight, current weight, height, and body mass index (BMI) were calculated and classified according to CDC guidelines. Obstetric information was also collected to ensure participants from early to late trimesters were included.

Statistical analysis

Data were analysed using IBM SPSS Statistics for Windows version 27.0 (IBM Corporation, Armonk, New York, U.S.A.). Descriptive statistics summarised sociodemographic, anthropometric, and obstetric information, as well as iron intake data from the P-FeFFQ and three-day diet records. Pearson's correlation coefficients were calculated to explore the relationship between P-FeFFQ and three-day diet records, determining the validity and reliability of the P-FeFFQ (Pallant, 2020; Franzese & Iuliano, 2018). A high positive Pearson's correlation coefficient validated the P-FeFFQ, indicating consistent estimates with the three-day diet records. Statistical significance was determined with a p-value <0.05 (Field, 2018). Bland-Altman plots assessed agreement between the P-FeFFQ and three-day diet records (Bland & Altman, 1999; Bland & Altman, 1986).

Ethical considerations

The research protocol was reviewed and approved by the Medical Research and Ethics Committee (MREC) of the Ministry of Health (NMRR ID 24-00066-HMT) and the Faculty Ethics Review Committee of the Faculty of Health Sciences, Universiti Teknologi MARA (FERC/FSK/MR/2024/00034). All participants provided informed consent prior to their involvement in this study. They were thoroughly informed about the study's purpose, procedures, potential risks, and benefits. Participation was entirely voluntary and participants were given the option to withdraw at any point without any consequences. Confidentiality of participants' information was maintained in accordance with ethical guidelines and all data were anonymised to protect their privacy.

RESULTS

A total of 116 pregnant mothers, aged 19 to 44 years (mean age 29.8±4.6 years), participated in this study. The majority were Malays (93.1%) and 51.7% were in their third trimester of pregnancy. Most participants lived in urban areas and 64.7% were employed. Mean dietary iron intake, based on 24-hour diet recalls, was 16.45 mg/day. Table 1 provides a detailed overview of the sociodemographic and obstetric characteristics of the pregnant women involved in the development of P-FeFFQ.

Development of food list

The development of P-FeFFQ, based on literature reviews and 24-hour diet recalls, resulted in 74 items that were classified into eight categories, which were cereal and cereal products, poultry, meat and fish, milk and products, legumes and products, vegetables, fruits, drinks and confectionaries. This

Table 1. Characteristics of pregnant women participating in the development of P-FeFFQ (Pregnancy-Focused Iron Food Frequency Questionnaire)

Variables	*Mean±SD (n=116)*	*n*	*(%)*
Age (years)	29.8±4.6		
Pre-pregnancy weight (kg)	64.0±14.5		
Current weight (kg)	69.1±13.7		
Pre-pregnancy BMI (kg/m^2)	26.0±6.2		
Iron intake (mg/day)	16.5±8.8		
Ethnicity			
Malay		108	93.1
Indian		5	4.3
Others		3	2.6
Residential area			
Urban		60	51.7
Rural		56	48.3
Trimester			
1st trimester		12	10.3
2nd trimester		44	37.9
3rd trimester		60	51.7
Employment status			
Unemployed		41	35.3
Employed		75	64.7

SD: Standard deviation; BMI: Body Mass Index

Table 2. Calculations of I-CVI and CVR for the relevancy and essentiality of food items

	Items	*Result of content validity index*			*Result of content validity ratio*		
		Number in agreement	*I-CVI*	*Interpretation*	*Number in agreement*	*CVR*	*Interpretation*
A	**Cereal & cereal products**						
A1	White rice	6	1.00	Appropriate	6	1.00	Remained
A2	*Nasi goreng, nasi kerabu, nasi minyak, nasi lemak*	4	0.67	Need to be revised	4	0.33	Eliminated
A3	Brown rice	6	1.00	Appropriate	6	1.00	Remained
A4	White bread	6	1.00	Appropriate	6	1.00	Remained
A5	Wholewheat bread	6	1.00	Appropriate	6	1.00	Remained
A6	Roti canai	5	0.83	Appropriate	4	0.33	Eliminated
A7	*Capati*	5	0.83	Appropriate	6	1.00	Remained
A8	Corn	6	1.00	Appropriate	6	1.00	Remained
A9	*Mee-hoon, kuey teow, mee, laksa*	5	0.67	Need to be revised	5	0.67	Eliminated/ Refined
A10	Ready to make cereals	6	0.83	Appropriate	6	1.00	Remained
B	**Poultry, meats & fish**						
B1	Chicken	6	1.00	Appropriate	6	1.00	Remained
B2	Lamb	6	1.00	Appropriate	6	1.00	Remained
B3	Cow	6	1.00	Appropriate	6	1.00	Remained
B4	Duck	6	1.00	Appropriate	6	1.00	Remained
B5	Internal organs (Liver, spleen, lungs)	6	0.83	Appropriate	6	1.00	Remained
B6	Squid	6	1.00	Appropriate	6	1.00	Remained
B7	Prawn	6	1.00	Appropriate	6	1.00	Remained
B8	Clams	6	1.00	Appropriate	6	1.00	Remained
B9	Chicken eggs	6	1.00	Appropriate	6	1.00	Remained
B10	Duck eggs	6	1.00	Appropriate	6	1.00	Remained
B11	Salted eggs	6	1.00	Appropriate	6	1.00	Remained
B12	Quail eggs	6	1.00	Appropriate	6	1.00	Remained
B13	*Ikan kembong, tenggiri, tongkol, cencaru*	6	0.83	Appropriate	6	1.00	Remained
B14	Fishballs	6	1.00	Appropriate	6	1.00	Remained
B15	Anchovy	6	1.00	Appropriate	6	1.00	Remained
B16	Fish/squid/prawn crackers	5	0.67	Need to be revised	5	0.67	Eliminated/ Refined
C	**Milk & Products**						
C1	Fresh milk	6	1.00	Appropriate	6	1.00	Remained
C2	Milk powder	6	1.00	Appropriate	6	1.00	Remained
C3	Cheese	6	1.00	Appropriate	6	1.00	Remained
C4	Yogurt	6	1.00	Appropriate	6	1.00	Remained
D	**Legumes**						
D1	Legumes (chickpeas, mungbeans, red beans, peanuts)	5	0.83	Need to be revised	6	1.00	Remained
D2	Tempe (fermented soybeans)	6	1.00	Appropriate	6	1.00	Remained
D3	Soy milks	6	1.00	Appropriate	6	1.00	Remained

to be continued...

Table 2. Calculations of I-CVI and CVR for the relevancy and essentiality of food items (continued)

Items		*Result of content validity index*			*Result of content validity ratio*		
		Number in agreement	*I-CVI*	*Interpretation*	*Number in agreement*	*CVR*	*Interpretation*
E	**Vegetables**						
E1	Green leafy vegetables (spinach, water spinach, kale, fiddlehead)	5	0.83	Appropriate	6	1.00	Remained
E2	Cruciferous vegetables (broccoli, cabbage, cauliflower)	5	0.83	Appropriate	6	1.00	Remained
E3	Legumes vegetables (*kacang Panjang, petai, kacang botor*)	5	0.83	Appropriate	6	1.00	Remained
E4	Cucumber	6	1.00	Appropriate	5	0.67	Refined
E5	Local fresh salads (*pegaga, ulam raja*)	5	1.00	Appropriate	6	1.00	Remained
E6	Mushrooms (*Cendawan cina, cendawan tiram*)	6	1.00	Appropriate	6	1.00	Remained
E7	Tomato	6	1.00	Appropriate	5	0.67	Eliminated/ Refined
E8	Carrots	6	1.00	Appropriate	5	0.67	Eliminated/ Refined
E9	Chilli	4	0.67	Need to be revised	4	0.33	Eliminated
E10	Eggplant	6	1.00	Appropriate	4	0.67	Eliminated/ Refined
E11	Bean sprout	6	1.00	Appropriate	6	1.00	Remained
F	**Fruits**						
F1	Mango	6	1.00	Appropriate	6	1.00	Remained
F2	Papaya	6	1.00	Appropriate	6	1.00	Remained
F3	Guava	6	1.00	Appropriate	6	1.00	Remained
F4	Watermelon	6	1.00	Appropriate	6	1.00	Remained
F5	Water apple	6	1.00	Appropriate	5	0.67	Eliminated/ Refined
F6	Banana	6	1.00	Appropriate	5	0.67	Eliminated/ Refined
F7	Apple	6	1.00	Appropriate	5	0.67	Eliminated/ Refined
F8	Orange	6	1.00	Appropriate	6	1.00	Remained
F9	Grapes	6	1.00	Appropriate	5	0.67	Eliminated/ Refined
F10	Mangosteen	6	1.00	Appropriate	6	1.00	Remained
F11	Jackfruit	6	1.00	Appropriate	6	1.00	Remained
G	**Drinks**						
G1	Fruit juices	4	0.67	Need to be revised	4	0.33	Eliminated
G2	Malted drinks	5	0.83	Appropriate	6	1.00	Remained

to be continued...

Table 2. Calculations of I-CVI and CVR for the relevancy and essentiality of food items (continued)

Items		Result of content validity index			Result of content validity ratio		
		Number in agreement	*I-CVI*	*Interpretation*	*Number in agreement*	*CVR*	*Interpretation*
H	**Confectionaries**						
H1	Peanut butter	6	1.00	Appropriate	6	1.00	Remained
H2	Margerine	6	1.00	Appropriate	6	1.00	Remained
H3	Coconut milk	6	1.00	Appropriate	6	1.00	Remained
H4	Granulated sugar	4	0.67	Need to be revised	4	0.33	Eliminated
H5	Honey	5	0.83	Appropriate	6	1.00	Remained
H6	Condensed milk	5	0.83	Appropriate	6	1.00	Remained
H7	Chilli sauces	5	0.83	Appropriate	5	0.67	Eliminated/ Refined
H8	Soy sauces	5	0.83	Appropriate	5	0.67	Eliminated/ Refined
H9	Tomato sauce	5	0.83	Appropriate	5	0.67	Eliminated/ Refined
H10	Oyster sauce	5	0.67	Appropriate	5	0.67	Eliminated/ Refined
H11	*Belacan*	5	0.83	Appropriate	5	0.67	Eliminated/ Refined
H12	*Cincalok*	5	0.83	Appropriate	5	0.67	Eliminated/ Refined
H13	*Budu*	5	0.83	Appropriate	5	0.67	Eliminated/ Refined
		S-CVI/Ave	0.93	Excellent			

I-CVI: Item Content Validity Index; CVR: Content Validity Ratio; S-CVI/Ave: Scale Content Validity Index/Average

initial list of 74 items included foods and beverages containing more than 0.1 mg of iron per 100 grams (Głąbska *et al.*, 2017).

Item-Content Validity Index (I-CVI)

The I-CVI calculations for the relevancy of food items are presented in Table 2. I-CVI scores of at least 0.83 indicated that the majority of the items had excellent content validity (Yusoff, 2019). Specifically, only seven items required revision due to lower I-CVI scores. Despite these minor adjustments, the overall Scale-Content Validity Index/ Average (S-CVI/Ave) for the FFQ was calculated to be 0.93, reflecting an excellent content validity of the P-FeFFQ.

Content validity ratio (CVR)

Results in Table 3 showed the essentiality of each food item in this newly developed P-FeFFQ. Five food items scored 0.33 and 17 food items scored 0.67, in which a refinement or elimination was done to make the final food list.

Experts' comments on FFQ

Six experts reviewed the food list for the newly developed P-FeFFQ and suggested the separation of grouped items to enhance relevance and specificity. For example, item D1, which grouped legumes like chickpeas, mung beans, red beans, and peanuts, and item E1, which grouped green leafy vegetables like spinach, water spinach, kale,

Table 3. Final food list (63 food items)

Items groups	*Foods*	
Cereal & cereal products	White rice Fried rice Brown rice White bread Wholewheat bread	*Capati* Corn *Kuih-teow* Ready to make cereals
Poultry, meats & fish	Chicken Lamb Cow Duck Chicken liver Beef liver Beef lung Squid Clams Chicken eggs	Duck eggs Salted eggs Quail eggs *Ikan kembong* *Ikan tongkol* *Ikan cencaru* Anchovies Fish crackers Squid crackers
Milk and products	Full cream milk Cheese Yoghurt	
Legumes and products	Chickpeas Green beans Red beans Peanuts Soybeans	Fermented soy beans (*tempeh)* Soy bean curd Soy milk custard *(taufu-fah)* Soy milk
Vegetables	Spinach Swamp cabbage *(Kangkung)* Bitter gourd Fiddlehead (*pucuk paku)* Kale	Petai Bean sprout *Pegaga* *Ulam raja* Chinese mushrooms
Fruits	Mango Papaya Guava Orange Jackfruit Coconut flesh	
Drinks	Malted drinks	
Confectionaries	Peanut butter Margerine Coconut milk Shrimp paste *Cincalok* *Budu*	

and fiddlehead, were recommended to be split into individual items. One expert suggested adding portion sizes, such as using a cup measurement for legumes, a rice scoop for vegetables, and a tablespoon for confectionaries, to improve dietary data accuracy. Another expert recommended adding soybean custard (*taufu-fah*) to the legumes and products group. Additionally, the experts suggested increasing the cut-off points for iron content to focus on high-iron foods, enhancing the accuracy of iron intake assessment.

Table 4. Correlation coefficients and agreement for nutrient intake between P-FeFFQ and 3-day dietary records

	Mean iron intake (mg/ day)	*SD iron intake (mg/ day)*	*Mean difference (mg.day)*	*Correlation coefficient*†	*p-value**
P-FeFFQ	14.09	6.02	1.71	0.648	0.001
3DDR	12.38	4.07			

P-FeFFQ: Pregnancy-Focused Iron Food Frequency Questionnaire; 3DDR: 3-day dietary records

†*Correlation Coefficient: Pearson's*

**p*-value from Pearson Correlation (significant if <0.05)

Food list refinement

Based on the calculations of I-CVI, CVR, and feedback from the expert panel, the final food list for the newly developed P-FeFFQ was refined to include 63 food items across eight food groups. Table 4 details the finalised food items included in the P-FeFFQ, providing a clear and organised framework for dietary evaluation.

Face validity

Face validity of the P-FeFFQ was evaluated by ten pregnant mothers to ensure the questionnaire and listed foods were easily understood. Feedback showed that most participants comprehended the questions and food items without difficulty. To enhance understanding, the P-FeFFQ was translated into Malay, the primary language for many participants. The completion time for the questionnaire was under 20 minutes, indicating that it was user-friendly and could be efficiently administered. Overall, face validity testing confirmed that the P-FeFFQ was comprehensible and practical for use among pregnant women in Malaysia.

Concurrent validity

The P-FeFFQ was validated against three-day diet records with 21 subjects due to time constraints. This is supported by Cade *et al.*, (2004), who found that small sample sizes (20–30 participants) are common in feasibility studies for FFQ validation. Furthermore, a Bland-Altman plot was used to assess the agreement between the FFQ and the 24-hour diet records. This method is considered robust, particularly with small sample sizes, as it evaluates the agreement at the individual level rather than relying solely on population-level correlations (Bland & Altman, 1986).

Table 5 summarises the means and standard deviations (SDs) of iron intake estimated by both methods. The Pearson's correlation coefficient for iron intake between P-FeFFQ and three-day dietary records was 0.648 (p=0.001), indicating a strong positive relationship. Figure 1 presents the Bland-Altman plot, showing the differences between P-FeFFQ and three-day diet records against their average. The mean difference was 1.71 mg/day, with P-FeFFQ generally reporting higher iron intake values. The limits of agreement (mean difference±1.96 SD) were wide, indicating variability. After adding ±1.96 SD for the limits of agreement (LOA), an interval ranging from –6.189 (lower limit) to 9.648 (upper limit) was obtained.

DISCUSSION

Iron deficiency is a leading cause of anaemia among pregnant women in Malaysia, with prevalence rates ranging from 19.3% to 57.4% (Rahman *et al.*,

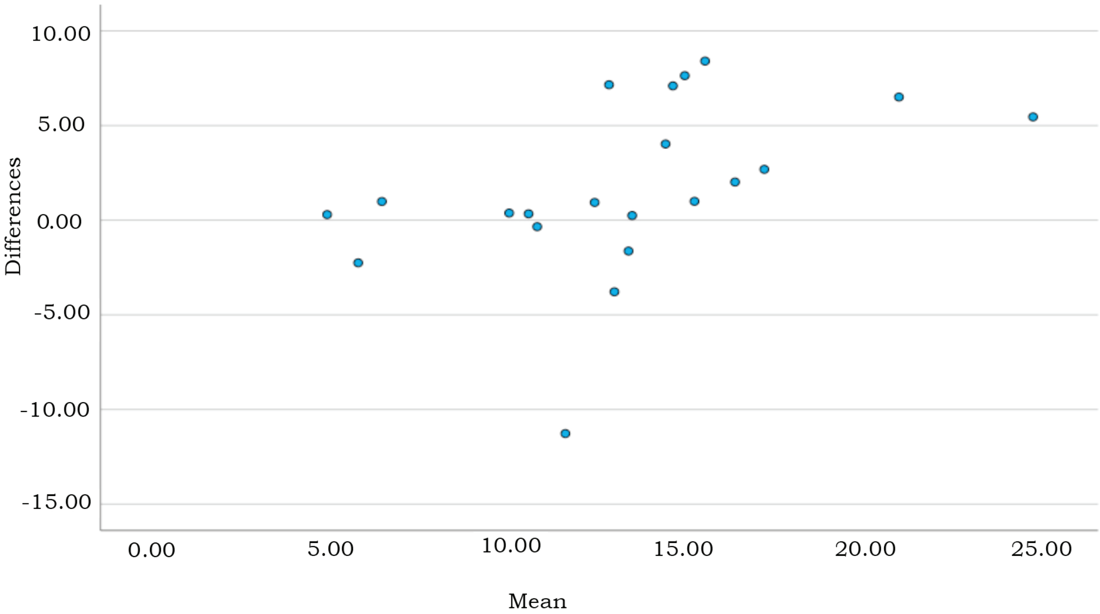

Figure 1. Bland-Altman analysis comparing the P-FeFFQ (Pregnancy-Focused Iron Food Frequency Questionnaire) and three-day diet records for iron intake

2022). During pregnancy, the demand for iron significantly increases as the mother's blood volume expands and the foetus grows (Georgieff, 2020). According to Di Renzo *et al.* (2015), iron deficiency is the most common cause of anaemia in pregnancy, accounting for 75% of cases. This high prevalence is due to dietary iron intake being insufficient to meet the increased requirements during pregnancy (Di Renzo *et al.*, 2015). Thus, this study aimed to develop a P-FeFFQ and validate it against 3-day diet records (3DDR). The P-FeFFQ was developed using 24-hour diet recalls from pregnant women in both early and late trimesters, ensuring comprehensive coverage of habitual intakes. The initial list of 74 items, based on foods containing more than 0.1 mg of iron per 100 grams (Głąbska *et al.*, 2017), was refined to 63 items with a cut-off of 2 mg of iron per 100 grams (Beck *et al.*, 2012). The final P-FeFFQ contained more items than the IRONIC-FFQ by Głąbska *et al.* (2017), but fewer than those developed by Beck *et al.* (2012) and Galante and Colli (2008).

Content validity, assessed by a panel of experts, resulted in an I-CVI score of 0.93, indicating high relevance. Face validity was confirmed through participants' feedback, ensuring the questionnaire's ease of understanding and cultural relevance. It was found that the participants spent no more than 20 minutes filling in the P-FeFFQ, which was a shorter time compared to the study by Fayet *et al.* (2011), where approximately 45 minutes were required to complete the 235 items, semi-quantitative FFQ. However, a shorter FFQ, such as the IRONIC-FFQ by Glabska *et al.* (2017), required only five to ten minutes, which was a shorter time compared to the time needed to fill in the P-FeFFQ.

3DDR was used as the reference method to validate the P-FeFFQ. The mean±SD iron intake measured by the P-FeFFQ was 14.09±6.02 mg/day, while the 3DDR showed 12.38±4.07 mg/day, indicating a tendency for the P-FeFFQ to overestimate iron intake. This overestimation is consistent with findings from previous studies on nutrient intake assessment tools (Loy *et al.*, 2011; Zaleha *et al.*, 2015). The correlation coefficient for iron intake between P-FeFFQ and 3DDR was 0.648 (p=0.001), indicating a moderate positive relationship. This level of agreement, while reasonable, suggests some variability in how well the P-FeFFQ reflects actual dietary intake. The correlation coefficient from this study was higher compared to Glabska *et al.* (2017) with 0.48 and Heath, Skeaff & Gibson (2000) with 0.52, demonstrating a relatively better performance of the P-FeFFQ.

The Bland-Altman plot assessed the agreement between iron intakes estimated by P-FeFFQ and 3DDR. The mean difference was 1.71 mg/day, indicating that the P-FeFFQ slightly overestimated iron intake compared to the 3DDR. The LOA ranged from -6.208 to 9.628, showing some variability but generally reasonable estimates. This LOA was narrower than that in a study by Głąbska *et al.* (2017), which ranged from -7.580 to 11.750. The tendency of the P-FeFFQ to overestimate iron intake aligns with another study (Zaleha *et al.*, 2015), likely due to participants' awareness of the study's focus, the number of food items in the FFQ, and potential misreporting in both methods. Furthermore, the dietary records were collected over a specific time frame, potentially omitting seasonal dietary patterns captured by the FFQ (Willett, 2013). Besides that, participants may have over- or underreported their intakes through 24DDR due to short-term memory, which could lead to inaccuracies. FFQ also estimates habitual intake over a longer period, while dietary records reflect short-term intake, which can lead to systematic differences (Bland & Altman, 1986; Shim *et al.*, 2014).

The P-FeFFQ demonstrated excellent content validity with an I-CVI score of 0.93, indicating high relevance for assessing iron intake. Face validity was confirmed through participants' feedback, ensuring the questionnaire was clear and culturally appropriate. The P-FeFFQ is practical and can be completed in under 20 minutes. Despite its reasonable validity, the P-FeFFQ has some limitations. It does not account for other essential nutrients, which would provide a more comprehensive dietary assessment. Its applicability across diverse ethnic groups in Malaysia, such as the Orang Asli and native peoples of Sarawak and Sabah, needs further exploration (Cabigas *et al.*, 2020). The small sample size of 21 participants in the validation study limits the generalisability of the findings. Larger studies are required to confirm these results. The moderate correlation coefficient of 0.648 suggests that the P-FeFFQ requires refinement to enhance its accuracy.

CONCLUSION

This study successfully developed and validated the P-FeFFQ, a questionnaire to assess iron intake among pregnant women. Validation against three-day diet records showed a moderate positive correlation (r=0.648, p=0.001), indicating reasonable accuracy despite a tendency to overestimate iron intake compared to the three-day diet records. Future research should focus on refining the P-FeFFQ to enhance its accuracy and explore its application in different regions and populations within Malaysia.

Acknowledgement

We would like to express our gratitude to all participants who contributed to this study and the staffs of the Maternal and Child Health Clinic of Meru, Kapar, Sungai Buloh, and Bandar Botanik, Selangor. This work was fully supported by the Ministry of Higher Education (MOHE) under the Fundamental Research Grant Scheme [600-RMC/ FRGS 5/3 (152/2022)]. We would like to thank the Director General of Health Malaysia for his permission to publish this article.

Authors' contributions

Hamid SBA, principal investigator, conceptualised and designed the study, prepared the draft of the manuscript, and reviewed the manuscript; Ringgit C, conducted the study, data analysis and interpretation, assisted in the drafting of the manuscript, and reviewed the manuscript.

Conflict of interest

The authors declare that there are no conflicts of interest in this study.

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