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Improving iron intake through food-based recommendation education based on health belief model: a quasi-experimental study in rural Indonesia

Miratul HAYA[1,3], Yayuk FARIDA BALIWATI[2], Ali KHOMSAN[2], Dodik BRIAWAN[2]

1 Graduate Program of Nutrition Science, Graduate School, IPB University, Bogor 16680, Indonesia.
2 Department of Community Nutrition, Faculty of Human Ecology, IPB University, Bogor 16680, Indonesia.
3 Department of Nutrition, Bengkulu Health Polytechnic Ministry of Health Republic of Indonesia, Bengkulu, Indonesia.

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ABSTRACT

Introduction: Anaemia is associated with low iron intake as a result of inadequate food consumption patterns. Health belief model (HBM)-based education shapes positive perceptions towards anaemia prevention and food-based recommendation (FBR) provides guidance on the consumption of locally available iron-rich foods.

Objective: This study aims to analyse the effect of HBM-based FBR education on iron intake of anaemic female workers.

Method: This study used a quasi-experimental design with a pretest-posttest control group design conducted from February to September 2024. The sample consisted of female workers aged 19–36 years who had mild anaemia and were not pregnant. The sample size was 44 participants, divided into a treatment group that received 12 sessions of FBR education based on the Health Belief Model (HBM) and counselling, and a control group that received one session of nutrition education over 12 weeks. Knowledge and attitude data were measured using a structured questionnaire, iron intake data were measured through a 7-day food consumption survey using a 3x24-hour food recall and a 4-day food record, and data collection was conducted before and after the intervention. Hypothesis testing was performed using the T-test and ANCOVA.

Results: HBM-based FBR education intervention significantly increased iron intake (mean increase of 10.96 mg; $p<0.05$) after controlling for covariates. Knowledge and attitude also improved significantly in the treatment group compared to the control ($p<0.05$) and the level of compliance with food consumption according to FBR reached 86.4%.

Conclusion: The implementation of FBR based on local food consumption patterns and supported by the HBM approach has an effect on increasing knowledge, attitudes and iron intake of female workers.

KEYWORDS

Community health promotion, essential microelements, health belief model, prevention of anaemia.

Correspondencia:
Yayuk Farida Baliwati
baliwati@apps.ipb.ac.id

INTRODUCTION

Anaemia is an important indicator that reflects the condition of malnutrition and various health disorders that affect the balance and performance of the body. Anaemia occurs when blood haemoglobin levels are lower than the normal limit (<120 g/L) as the main indicator to detect iron deficiency[1]. Iron is an essential component of heme, the part of haemoglobin that binds oxygen. When iron levels in the body decrease, the production of haemoglobin also decreases, which in turn reduces the ability of blood to transport oxygen to body tissues. This results in a decline in overall body function, affecting energy, physical endurance and cognitive health[2].

Working women especially those who do physical work such as in plantations have a higher risk of anaemia. This is due to working conditions that are often unhealthy and difficult to access[3]. Rubber plantation workers are at risk of malaria infection because the rubber plantation environment supports the survival of the anopheles vector, the mosquito that spreads malaria. Malaria infection can interfere with iron absorption, increasing the risk of anaemia[4]. In addition, conditions such as menstruation and pregnancy in women require an increase in adequate iron intake. If these needs are not met, women become more susceptible to anaemia[5]. In women when pregnant, anaemia can affect fetal growth and development and anaemia during pregnancy has been shown to have a significant association with stunting ($p<0.001$) so that anaemia is the dominant factor in cases of stunting in children under five years[6]. Anaemia also affects productivity, especially in those who do heavy manual work. A study Blakstad *et al.* (2020) on tea pickers concluded anaemic workers picked 2.02 kg (9.1%) less tea in a 3-hour session compared to non-anaemic workers[7]. These results suggest that although many anaemic workers remain productive, they experience a negative impact of anaemia on work performance.

The prevalence of anaemia among female workers is recorded to be quite high, reaching 41.7%, with the majority of cases falling into the mild anaemia category at around 56%[8]. This high prevalence is mainly found in groups with low socioeconomic status and limited access to iron-rich food sources[9]. Thus, the main cause of anaemia is inadequate iron intake, which is associated with low consumption of iron-rich foods[10,11].

Addressing anaemia through food-based interventions aims to sustainably improve iron status and intake of other micronutrients. This approach offers recommendations on food choices, food groups and diverse consumption patterns to fulfil the nutrient requirements needed to maintain good health. These recommendations are most effective when the recommended consumption patterns are based on locally available foods that are relevant to the target group[12]. Food-based recommendation (FBR) is a food consumption recommendation for certain target groups that provides a food consumption recommendation message in one week that meets nutritional needs by considering local food availability, food consumption patterns, food portions and food affordability based on the nutritional problems of the target group. FBR is prepared based on the results of food consumption data processing using the Optifood application which allows the identification of optimal food consumption patterns to meet nutritional needs by considering local food availability and affordability[13]. Optifood has the ability to optimise diets at low cost using locally available food ingredients[14]. With this approach, optifood is able to identify nutrient gaps in existing food consumption patterns and design appropriate food consumption combinations to close these gaps. In addition, optifood not only proposes locally available foods to increase nutrient intake but also shows the limitations of these foods in fulfilling nutrient requirements. Thus optifood not only helps in meeting daily nutritional needs but also facilitates the implementation of targeted nutrition interventions and makes it a very useful tool in community nutrition improvement programmes[15]. Bridging the gap between FBR and actual food consumption practices requires targeted educational interventions[16].

The health belief model (HBM) is a behaviour change strategy through health psychology that is used to explain and predict individual behaviour in taking health actions[17]. HBM is used to assess how understanding of health risks, benefits, actions, barriers, triggering factors and self-confidence contribute to the formation of individual perceptions which are then reflected in attitudes towards health actions[18]. In an effort to overcome anaemia in female workers, interventions can be carried out by integrating HBM-based education and food consumption guidelines according to FBR, so that the food consumption recommendations given are easier to implement because they are tailored to local food availability. Therefore, in this study, an HBM-based FBR education intervention was conducted, which not only provided information on the consumption of recommended iron-source foods but also changed perceptions and beliefs related to the risk of anaemia and the benefits of changes in consumption patterns that have an impact on increasing iron intake.

METHODS

This study was a quasi-experimental design using a pretest-posttest control group design and was conducted from February to September 2024 in rubber plantations in rural Seluma, Bengkulu province. The study sample consisted of female workers who met the inclusion criteria, namely having haemoglobin levels in the mild anaemia category (110-119 g/L), aged 19-36 years, not pregnant, and having no history of infectious and inflammatory diseases that could affect iron status. In addition, participants were not taking medications that affect iron status, did not smoke, did not consume alcohol, did not have a vegetarian consumption pattern, and were willing to participate in the study by signing an informed consent.

The sample size was calculated using the hypothesis test formula of the mean difference in two independent groups[19] at a confidence level of 95% and a test power of 90%, with iron intake as the outcome. Based on the calculation and the addition of 10% to anticipate drop-outs, a total sample size of 44 people was obtained, 22 people each for the treatment and control groups. Grouping was determined based on the proximity of respondents' residential areas to minimise the potential spread of educational information from the treatment group to the control group.

Educational intervention was conducted in the treatment and control groups. The treatment group received FBR education delivered in 12 sessions over 12 weeks with an HBM structure. This education consisted of 3 group meeting sessions and 9 home visit sessions. The group meetings, which were conducted for @ 60 minutes, served as a forum for material presentation and discussion on anaemia, its risk factors, and FBR. The first education session emphasised on increasing knowledge and awareness of food consumption according to FBR, the second session was based on the components of perceived benefits and barriers, the third session was based on increasing self-confidence. Home visits for @ 50 minutes aimed to increase awareness and motivate participants in determining appropriate actions. The control group received education once in 12 weeks. The FBR educational material is organised into modules as an educational medium for female workers with anaemia. The first module discusses anaemia, including an introduction to anaemia, clinical signs, and iron-rich foods for women. The second module focuses on food consumption in accordance with FBR, which includes food types, consumption frequency, and recommended portions. The third module discusses the causes and risks of chronic anaemia. Some of the risk factors examined include insufficient iron intake, iron absorption disorders, and conditions that increase iron requirements. The fourth part of this education emphasises the preparation of menus in accordance with the types of foods and recommended portions. The recommended menu includes various sources of animal and plant-based iron, as well as vegetables in accordance with the nutritional needs of female workers. The final material in this education programme relates to clean and healthy living behaviours. Some of the aspects emphasised include the habit of washing hands with soap and running water, covering food that is served, covering the mouth and nose when sneezing, and wearing footwear. The education process is monitored through a logbook filled out by each enumerator. Samples that have entered the intervention phase will be excluded from the study if: they cannot be contacted for three consecutive weeks; they decide to withdraw personally; or they do not undergo complete measurements at the end of the study.

FBR messages contain food consumption recommendations according to food types, frequency of consumption and portions in the concept of balanced nutritional intake, food consumption recommendations refer to iron source foods that are locally available and commonly consumed by female workers. The identification of food types recommended for consumption is the result of Optifood application processing based on 7-day food consumption survey data on the population of female workers at the research site[20], the survey has been conducted by the author in previous research. The recommended foods consist of cereal and tuber food groups in the form of biscuits and cassava; animal food groups in the form of peda fish, fresh sardines, chicken liver and lokan; vegetable food groups in the form of tempeh; vegetable groups in the form of lumai/leunca leaves, moringa leaves and katuk.

A Mindray BC-10 haematology analyzer was used to check haemoglobin levels as a marker of anaemia status[21]. Knowledge data, measured using a structured questionnaire with 18 question items, was collected before and after the implementation of the educational intervention. The knowledge asked to the subjects included knowledge about the definition of anaemia and clinical signs, causes and risks of suffering from chronic anaemia, food consumption according to FBR (type of food, frequency of consumption and portion of consumption) and clean and healthy living behaviour. Knowledge data is calculated based on the average percentage of correct answers from all questions contained in the knowledge questionnaire. The questionnaire has gone through a content validation process with an I-CVI value of 1 and face validation with a Cronbach alpha value of 0.845.

Data on HBM components were measured using a structured questionnaire, collected before and after the implementation of the educational intervention. The HBM questionnaire consists of 6 components, namely: (1) perceived susceptibility 8 statement items; (2) perceived severity 4 statement items; (3) perceived benefits 11 statement items; (4) perceived barriers 6 statement items; (5) cues to action 3 statement items; and (6) self-efficacy 4 statement items. The questionnaire contained statements related to the definition of anaemia and clinical signs, causes and risks of suffering from chronic anaemia, food consumption according to FBR (food type, frequency of consumption and portion) within the framework of HBM components. Data on the HBM component variables and attitudes were obtained from the average scores of all statements in the questionnaire. The assessment used a Likert scale with four response options: Strongly Agree (SA), Agree (A), Disagree (DA), and Strongly Disagree (SD). The statements in the scale are favourable, i.e., statements that support the attitude object with a value weight of SA=4, A=3, DA=2, and SD=1, and unfavourable, i.e., statements that oppose the attitude object with a value weight of SA=1, A=2, DA=3, and SD=4. The questionnaire has gone through the content validation process with the I-CVI value of each component is 1 and face validation with Cronbach alpha value for each component is: perceived susceptibility=0.853; perceived severity=0.796; perceived benefits=0.948; perceived barriers=0.775; cues to action=0.8; and confidence=0.725. Attitude data was obtained based on the six components of the HBM, the total score of all statements in the six components was summed to describe the overall attitude of respondents. Intake iron data were obtained through a 7-day survey combining 3x24-hour food recall (with a multiple-pass approach) and 4-day food records[22]. Food portion estimates were conducted using food photo books and standardised household sizes. Iron intake was calculated from the average consumption over seven days and expressed in milligrams per day. Compliance with recommendations is measured based on consumption of at least 65% of the frequency of each type of food in accordance with the frequency listed in the FBR.

Data were analysed through editing, coding, and cleaning to ensure completeness, consistency, and accuracy before analysis. Analyses were conducted using SPSS version 26, Microsoft Excel 2019 and nutrisurvey. Shapiro Wilk normality test was used to determine the distribution of data at a significant level of 5% obtained p-value>0.05. Tests between groups were carried out with independent t-test or Mann-Whitney, tests before and after intervention using paired t-test or Wilcoxon according to data distribution, p-value <0.05 indicates a statistically significant difference between the variables tested[23]. Analysis of Covariance (ANCOVA) was conducted to evaluate the effect of intervention on the response variable by controlling for other quantitative variables. ANCOVA combines the principles of ANOVA and linear regression within a general linear model (GLM) framework, allowing control of the covariate variable, namely the pretest score. Controlling for baseline differences between groups through ANCOVA allows more accurate estimates of intervention effects to be obtained because error variances that are not directly related to the treatment can be minimised[24]. This study received ethical approval from the Faculty of Public Health, Universitas Airlangga (41/EA/ KEPK/2024). Written informed consent was obtained from female workers who agreed to participate after receiving an explanation of the study.

RESULTS

The characteristics of respondents in the treatment and control groups are presented in Table 1. Respondents were

Table 1. Characteristics of respondents in treatment and control groups

Variables	Treatment (n=22)		Control (n=22)		*p* value
	Total	%	Total	%	
Age (years)					0.347[a]
19-25	1	4.5	1	4.5	
26-30	8	36.4	12	54.6	
31-36	13	59.1	9	40.9	
Education					0.216[b]
Primary education	5	22.7	9	40.9	
Junior secondary education	11	50.0	9	40.9	
Senior secondary education	6	27.3	4	18.2	
Income					0.320[b]
Quintile 1	7	31.8	4	18.2	
Quintile 2	2	9.1	9	40.9	
Quintile 3	8	36.4	5	22.7	
Quintile 4	5	22.7	4	18.2	
Energy sufficiency					0.105[b]
Adequate (≥90% RDA)	10	45.5	16	72.7	
Mild deficit (80-89% RDA)	4	18.2	5	22.7	
Moderate deficit (70-79% RDA)	8	36.4	1	4.5	
Protein sufficiency					0.774[a]
Adequate (≥90% RDA)	5	22.7	8	36.4	
Mild deficit (80-89% RDA)	7	31.8	6	27.3	
Moderate deficit (70-79% RDA)	10	45.5	8	36.4	

[a] Independent t-test. [b] Mann whitney.

mostly between 26 to 36 years old with junior high to senior high school education levels, and income distribution spread across four quintiles. The majority of respondents showed adequate levels of energy sufficiency, while protein sufficiency levels were distributed in the sufficient, mild deficit and moderate deficit categories. There were no differences in age, education, income, energy sufficiency, and protein sufficiency between the treatment and control groups prior to the intervention, indicating that both groups had the same initial conditions at the start of the study.

Knowledge is information obtained through learning or education and plays an important role in shaping action. The difference in knowledge before and after the intervention in the treatment and control groups is shown in Table 2. The difference in knowledge between groups after the intervention was statistically significant ($p<0.001$) which can be concluded that there is sufficient evidence to state that there is a difference in knowledge between groups after the provision of the intervention. The results of ANCOVA analysis showed that after controlling for the effect of the covariate, namely baseline knowledge, there was a significant difference in the mean knowledge score between groups ($p<0.001$). The treatment group that received FBR education had a higher knowledge score than the control group.

Differences in attitudes based on HBM components before and after the intervention in the treatment and control groups can be seen in table 3. Before the intervention, attitudes, perceptions of vulnerability, severity, benefits, barriers, cues to action and confidence were not significantly different between the two groups ($p>0.05$). However, after the intervention, the treatment group improved in attitude and all of these components and the difference in scores between the two groups was statistically significant ($p<0.05$). This shows that there is enough evidence to state that there are differences in attitudes based on HBM components between groups after the intervention. The results of the ANCOVA analysis showed that after controlling for the effect of the covariate of attitudes based on baseline HBM components, there was a significant difference in mean attitudes based on HBM components between groups ($p<0.001$). The mean attitude based on HBM components was higher in the treatment group than the control group.

Iron intake was assessed by the average iron intake based on food consumption of iron sources in female workers for one week before and after the intervention. Table 4 shows the difference in iron intake before and after the intervention in the treatment and control groups. Changes in iron intake in the treatment group ranged from 4.3 mg to 14.6 mg with a mean increase of 10.96±2.92 mg. In contrast, in the control group, the change in iron intake ranged from -2.9 mg to 4.5 mg with a mean of 0.09±1.92 mg. The p value obtained ($p<0.001$) indicated that the difference in changes in iron intake between the two groups was significant. This indicates that there is enough evidence to state that there is a difference in iron intake between groups after the interventi on. ANCOVA analysis showed a significant difference in mean iron intake between groups ($p<0.001$), with a higher mean in the treatment group after controlling for the effect of the covariate, i.e. iron intake before the intervention. The results of this analysis suggest that the intervention was effective in increasing iron intake.

DISCUSSION

The HBM-based FBR education intervention had a significant effect ($p<0.05$) on increasing iron intake, after baseline differences between groups were controlled through ANCOVA analysis. The effect size indicated that most of the variation in iron intake could be explained by the treatment, demonstrating the effectiveness of the intervention in increasing iron intake. The mean increase in iron intake was 10.96 mg. When compared to the average iron intake before the intervention of 11.87 mg, the average increase in iron intake of 10.96 mg can meet the recommended daily iron intake for female workers. A significant ($p<0.05$) effect of the HBM-based FBR education intervention was also identified on knowledge and attitude based on HBM components. Both variables increased significantly in the treatment group compared to the control group, reflecting the success of the intervention in changing cognitive, affective and behavioural aspects that are the ba-

Table 2. Differences in knowledge before and after intervention in treatment and control groups

Variables	Treatment (n=22)			Control (n=22)			*p* value
	Min	Max	Media ± DE	Min	Max	Media ± DE	
Knowledge: Before intervention After 12 weeks *p* value	 5.56 83.33	 38.89 100.0	 13.38 ± 8,33 95.95 ± 5.19 <0.001[b]	 0.00 5.56	 33.33 33.33	 15.15 ± 8.43 16.91 ± 7.94 0.308[c]	 0.367[a] <0.001[a]
Knowledge (D)	61.11	94.44	82.57 ± 9.27	-11.1	16.67	1.76 ± 7.92	<0.001[a]

[a] Mann whitney. [b] Wilcoxon. [c] Paired t-test.

Table 3. Differences in attitudes based on HBM components before and after intervention in treatment and control groups

	Variables	Treatment (n=22)			Control (n=22)			*p* value
		Min	**Max**	**Media ± DE**	**Min**	**Max**	**Media ± DE**	
Attitude								
Before intervention		2.08	2.67	2,53 ± 0.14	2.11	2.75	2.58 ± 0.15	0.096[b]
After 12 weeks		3.69	3.97	3.85 ± 0.07	2.08	2.67	2.53 ± 0.14	<0.001[b]
p value				<0.001[d]			0.072[d]	
Attitude (D)		1.06	1.86	1.31 ± 0.18	-0.31	0.17	-0.04 ± 0.09	<0.001[b]
1	Susceptibility							
	Before intervention	2.13	3.00	2.61 ± 0.27	2.25	3.25	2.71 ± 0.23	0.196[a]
	After 12 weeks	3.60	4.00	3.85 ± 0.11	2.38	2.88	2.62 ± 0.15	<0.001[b]
	p value			<0.001[d]			0.077[c]	
	Susceptibility (D)	0.63	1.75	1.24 ± 0.30	-0.50	0.25	-0.09 ± 0.23	<0.001[b]
2	Severity							
	Before intervention	2.00	3.25	2.62 ± 0.31	2.00	3.00	2.53 ± 0.35	0.453[b]
	After 12 weeks	3.25	4.00	3.69 ± 0.24	1.25	2.75	2.31 ± 0.40	<0.001[b]
	p value			<0.001[d]			0.067[d]	
	Severity (D)	0.25	2.00	1.06 ± 0.43	-1.75	0.50	-0.21 ± 0.51	<0.001[b]
3	Benefits							
	Before intervention	2.27	3.18	2.72 ± 0.20	2.18	3.00	2.64 ± 0.21	0.171[a]
	After 12 weeks	3.64	4.00	3.92 ± 0.09	2.36	3.18	2.74 ± 0.15	<0.001[b]
	p value			<0.001[d]			0.084[c]	
	Benefits (D)	0.55	1.73	1.19 ± 0.24	-0.27	0.73	0.10 ± 0.27	<0.001[b]
4	Barriers							
	Before intervention	1.33	2.67	2.08 ± 0.28	1.33	2.67	2.21 ± 0.42	0.074[b]
	After 12 weeks	3.67	4.00	3.80 ± 0.13	1.50	2.83	2.37 ± 0.33	<0.001[b]
	p value			<0.001[d]			0.102[d]	
	Barriers (D)	1.17	2.50	1.78 ± 0.30	-0.34	1.00	0.15 ± 0.36	<0.001[b]
5	Cues to action							
	Before intervention	2.00	3.33	2.60 ± 0.36	1.67	3.00	2.45 ± 0.36	0.189[b]
	After 12 weeks	3.67	4.00	3.83 ± 0.16	1.67	2.67	2.42 ± 0.34	<0.001[b]
	p value			<0.001[d]			0.628[d]	
	Cues to action (D)	0.67	2.00	1.22 ± 0.40	-1.00	1.00	-0.03 ± 0.49	<0.001[b]
6	Self-efficacy							
	Before intervention	2.17	2.90	2.60 ± 0.18	3.00	1.50	2.40 ± 0.39	0.095[b]
	After 12 weeks	3.00	4.00	3.81 ± 0.31	1.50	2.75	2.34 ± 0.42	<0.001[b]
	p value			<0.001[d]			0.464[d]	
	Self-efficacy (D)	0.35	1.65	1.21 ± 0.35	-1.27	0.75	-0.06 ± 0.16	<0.001[b]

[a] Independent t-test. [b] Mann whitney. [c] Paired t-test. [d] Wilcoxon.

Table 4. Differences in iron intake before and after intervention in treatment and control groups

Variables	Treatment (n=22)			Control (n=22)			*p value*
	Min	Max	Mean ± SD	Min	Min	Mean ± SD	
Iron intake: Before intervention After 12 weeks *p value*	9.8 15.4	15.6 25.5	11.87 ± 1.52 22.84 ± 2.77 <0.001[b]	9.0 9.8	15.4 15.6	11.60 ± 1.48 11.72 ± 1.33 0.917[b]	0.597[a] <0.001[a]
Iron intake (D)	4.3	14.6	10.96 ± 2.92	-2.9	4.5	0.09 ± 1.92	<0.001[a]

[a] Mann whitney. [b] Wilcoxon.

sis for food consumption decision making. Research conducted by Fernandez Flores et al. (2024) found that after nutritional education intervention, there were significant changes in knowledge (p=0.001), with an increase from 23% to 90.2% in high levels[25]. Increased knowledge plays a role in shaping individual perceptions of the risk of anaemia and the benefits of implementing food consumption patterns according to FBR. A more positive attitude strengthens the intention to behave according to recommendations. The compliance rate of food consumption according to FBR in the treatment group of 86.4% indicates that the majority of female workers follow and apply the intervention consistently, which strengthens the evidence of the effectiveness of this intervention in improving food consumption behaviour.

Several studies have shown that HBM-based educational approaches are effective in improving food consumption behaviours that support anaemia prevention. Keshani et al. (2019) reported that the application of HBM combined with collaborative learning in adolescents resulted in a better understanding of nutrition and improved healthy food consumption habits[26]. Araban et al. (2017) showed that an HBM-based educational intervention for pregnant women significantly increased intake of iron, folic acid, and energy and other macro- and micronutrients[27]. Baharzadeh et al. (2017) reinforced these findings by showing that the HBM approach can improve iron deficiency anaemia prevention practices. Furthermore, a study Andani et al. (2021) found that HBM-based education was able to improve students' knowledge, attitudes and practices related to the consumption of iron-rich foods and was significantly associated with anaemia status[28]. The study Riazi et al. (2024) provided nutrition education in 4 sessions to pregnant women and concluded that HBM-based nutrition education was effective in improving perceptions on all HBM components which resulted in an average increase of 2.2 mg of iron intake[29]. However, collaboration between the HBM and FBR approaches can provide more targeted interventions related to food consumption, especially in the selection of recommended food types, frequency of consumption, and consumption portions as needed which have an impact on increasing iron intake in female workers.

CONCLUSIONS

Food-based educational interventions based on the health belief model have been shown to influence changes in food consumption behaviour, leading to increased iron intake, while taking into account local food availability. These findings indicate that structured, theory-based food-based educational interventions are a viable intervention strategy in efforts to address anaemia among female workers.

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