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Original Research

Development of Self-Regulation Model Based on Health Promotion Model on Anemia Prevention Behavior in Pregnant Women

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ABSTRACT

Background: *Anemia prevention in pregnant women is essential to reduce health risks for both mother and fetus. This study aimed to develop a self-regulation model for anemia prevention behavior based on the Health Promotion Model.*

Methods*: An explanatory design with a cross-sectional approach was applied to 115 pregnant women attending health centers in Surabaya, selected through cluster sampling. Data were collected using a structured questionnaire and analyzed using SEM-PLS.*

Results: *The findings showed that anemia prevention behavior was significantly influenced by behavioral self-regulation (T=2.945) through personal regulation (T=5.932), which was shaped by environmental self-regulation (T=8.611) and individual characteristics (T=3.302). Commitment did not directly affect anemia prevention behavior (T=0.144; p=0.886). The model demonstrated substantial explanatory power, with R^2 values of 71.9% for behavioral self-regulation and 43.1% for anemia prevention behavior. Predictive relevance ($Q^2 > 0$) confirmed the model's robustness across different contexts.*

Conclusion: *This study highlights the pivotal role of self-regulation processes in shaping anemia prevention behavior. The model can serve as a framework for nursing interventions to strengthen self-regulation among pregnant women and improve maternal and fetal health outcomes.*

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INTRODUCTION

Indonesia has a much higher Maternal Mortality Rate (MMR) ratio compared to other countries in Southeast Asia (UNFPA, 2023). The reduction in the Maternal Mortality Rate (MMR) in Indonesia nationally has not yet reached the Sustainable Development Goals (SDGs) target for 2030 (Sharma, 2020). Based on Maternal Perinatal Death Notification (MPDN) 2021 data, the top three causes of maternal death are eclampsia, bleeding and infection with the highest place/location of death being in Hospitals (Kemenkes RI, 2022b).

These are related to the problem of anemia during pregnancy (Edelson et al., 2023). An important step in achieving the SDGs target on MMR is to reduce the prevalence of anemia in pregnancy. Low maternal knowledge about anemia and preventive behavior are still health problems (Balcha et al., 2023).

The World Health Organization (WHO) estimates that 37% (32 million) of pregnant women in the world experience anemia globally (WHO, 2023). The prevalence of anemia is 52% in pregnant women in South and Southeast Asian countries (Sunuwar et al., 2020). The Ministry of Health of the Republic of Indonesia explained that around 5 out of 10 pregnant women in Indonesia suffer from anemia (Kemenkes RI, 2020b).

Riset Kesehatan Dasar (Riskesdas) stated that there was a significant increase in cases of anemia in pregnant women from 37.1% in 2013 to 48.9% in 2018 (Kemenkes RI, 2020a). This incident can be classified as a public health problem because according to WHO, the prevalence of anemia with a range of ≥40% is a severe public health problem (WHO, 2019). Research conducted by Triharini, et al., (2018) showed that as many as 25.3% of pregnant women in East Java experienced anemia.

A preliminary study by researchers on November 2, 2023, showed a significant increase in the incidence of anemia in pregnant women in Surabaya City from 2021 to 2022, from 3,303 mothers to 9,911 mothers. This was conveyed by the Family Health program holder from the Surabaya City Health Office and indicated that the incidence of anemia in pregnant women was still high. On the other hand, data from the 2022 nutrition section showed that the incidence of anemia in pregnant women was 32.9% in South Surabaya, 24.3% in North Surabaya, 24.2% in East Surabaya, 13.1% in Central Surabaya, and 5.6% in West Surabaya.

Anemia in pregnancy is a major contributor to maternal mortality, and pregnant women who suffer from anemia are twice as likely to die during or shortly after pregnancy compared to those who do not suffer from anemia (Queen Mary University of London, 2018). Anemia in pregnancy has a higher risk due to increased iron requirements, physiological factors, infection, and blood loss (Delil et al., 2018). Anemia not only affects the mother, but also the baby (Kemenkes RI, 2022a). Pregnant women with anemia have a high risk during pregnancy, childbirth and fetal growth and development (Kemenkes RI, 2020b).

So far, government efforts have focused more on the physical aspects of pregnant women in preventing anemia. Self-regulation, on the other hand, is one of the key mechanisms involved in changing health behavior (Hennessy et al., 2020). Self-regulation involves managing an individual's thoughts, emotions, and behaviors, which influences the implementation of health-promoting behaviors (Li et al., 2022; Lo et al., 2021). Study shows that self-regulation is an important factor related to behavior in pregnant women (Torkan et al., 2018).

An empirical study applying Health Promotion Model (HPM) highlights perceived benefits and self-efficacy as predictors of participation and explains HPM constructs (including commitment or intention) as the mechanism that sustains behavior (Chen & Hsieh, 2021). In other words, The Health Promotion Model (HPM) emphasizes that individual health behavior can arise and be maintained because of a commitment to behave, not because of fear of the threat of a disease. Self-control influences the implementation of health promoting behaviors (Li et al., 2022).

Both theories are considered suitable to be integrated because they have the same goal, namely determining decision-making to behave or not to behave in preventing

anemia. Previous studies have applied the Health Promotion Model (HPM), but they mainly emphasize decision-making at a single point in time (Goodarzi-Khoigani et al., 2024). Meanwhile, research on self-regulation highlights the processes of maintaining and adjusting health behavior but is rarely linked with broader health-promotion determinants.

To date, there is limited evidence integrating these two approaches to comprehensively explain both the decision to prevent anemia and the sustained regulation of preventive behavior. Therefore, this study lies in developing an integrated self-regulation model based on HPM, which is expected to provide a more holistic understanding of anemia prevention behavior in pregnant women. This study aims to develop a self-regulation model based on the HPM on anemia prevention behavior in pregnant women.

MATERIALS AND METHOD

The research design used is explanatory research with a cross-sectional research approach. At this stage, identification of individual characteristics, cognition of pregnant women, environmental self-regulation, commitment, personal regulation, behavioral self-regulation, and anemia prevention behavior are carried out. The research took place at selected community health centers (Puskesmas) within the Surabaya City Health Office. Data collection was conducted between January and February 2024. This study was conducted to find the relationship between the HPM-based self-regulation model, with the final result in the form of increased anemia prevention behavior in pregnant women.

The study population comprised all pregnant women who attended antenatal care (ANC) at community health centers (Puskesmas) under the Surabaya City Health Office. The research locations were determined based on sub-district distribution. The inclusion and exclusion criteria were applied to define the study sample. Here are the following inclusion criteria: (1) Pregnant women who had received iron supplementation/laduni during ANC at the Health Center; and (2) Pregnant women who were able to read and write. The exclusion criteria in this study were: (1) Pregnant women with complications or severe comorbidities and requiring certain medical therapy such as preeclampsia, gestational diabetes, heart disease, sexually transmitted infections, kidney disease, autoimmune diseases, cancer, mental disorders and others; and (2) Mothers who cannot speak Indonesian or Javanese.

The sample in this study was calculated based on the rule of thumb sample size formula. The required sample size was calculated based on the Maximum Likelihood estimate, which is 5-10 times the number of parameters measured. The development of this HPM-based self-regulation model uses 23 parameters, so the sample size used in this study is 5x23 = 115 respondents.

This study used probability sampling method, namely cluster sampling, because the population is spread across various areas of Surabaya. The locations used in this study were 3 areas in Surabaya with the largest proportion represented by sub-districts and were selected randomly based on data from the Nutrition Section of the Surabaya City Health Office in 2022. The research locations used were the Health Centers representing the South Surabaya area in Wonokromo District with the Ngagel Rejo Health Center, the North Surabaya area in Kenjeran District with the Tanah Kali Kedinding Health Center and the East Surabaya area in Sukolilo District with the Klampis Ngasem Health Center.

The exogenous variables in this study are individual characteristics, cognition of pregnant women, environmental self-regulation, personal regulation, commitment, and behavioral self-regulation. While the endogenous variables in this study are anemia prevention behavior in pregnant women. The research instrument was a self-administered questionnaire consisting of 7 sections with a total of 109 items. The sections measured: (1) individual characteristics, (2) cognition, (3) environmental self-regulation, (4) personal regulation, (5) commitment, (6) behavioral self-regulation, and (7) anemia prevention behavior in pregnant women.

The validity of the instrument was assessed using Pearson's product–moment correlation between each item score and the total score (construct validity). The results showed that all items were valid, with correlation coefficients greater than the r-table value (>0.444). Reliability testing using Cronbach's alpha demonstrated that all constructs were reliable, with alpha values ranging from 0.645 to 0.970, all exceeding the threshold of 0.6.

The analysis used in this study is descriptive and inferential analysis. Inferential analysis is conducted to test the research model and hypothesis using SEM-PLS (Structural Equation Modeling - Partial Least Square). This research was conducted by applying ethical principles based on the Declaration of Helsinki. Ethical approval for the use of this instrument was obtained from the Health Research Ethics Committee (KEPK) of the Faculty of Nursing, Universitas Airlangga, on January 11, 2024 (No. 3066-KEPK).

RESULTS

Description of Research Variables

The description of the research variables is presented in the form of research data constructed according to indicators in the research variables. The constructs studied are individual characteristics (X1), cognition of pregnant women (X2), environmental self-regulation (X3), personal regulation (X4), commitment (X5), and behavioral self-regulation (X6) and anemia prevention behavior (Y1). The following are the results of the descriptive analysis.

Individual Characteristics (X1)

Description of the characteristics of pregnant women includes age, parity, economic status, education, occupation and experience as shown in Table 1.

Table 1. Characteristics of Pregnant Women (n=115)

Characteristics Of Pregnant Women	Indicator	Frequency (n)	Percentage (%)
Supplements Received	Laduni	66	57.4
	Iron	27	23.5
	Laduni and iron	22	19.1
	Total	**115**	**100.0**
Age	< 25 years old	29	25.2
	25 - 35 years old	68	59.1
	> 35 years old	18	15.7
	Total	**115**	**100.0**
Parity	Never given birth/first	38	33.0

Characteristics Of Pregnant Women	Indicator	Frequency (n)	Percentage (%)
	pregnancy (primigravida)		
	1 time (primipara)	39	33.9
	2-4 times (multipara)	37	32.2
	≥ 5 times (grande multipara)	1	0.9
	Total	**115**	**100.0**
Economic Status	Low	90	78.3
	High	25	21.7
	Total	**115**	**100.0**
Education	Elementary School	11	9.6
	Junior High School	19	16.5
	Senior High School	69	60.0
	Graduated from College	16	13.9
	Total	**115**	**100.0**
Occupation	Housewife	73	63.5
	Working	42	36.5
	Total	**115**	**100.0**
Experience	Less	10	8.7
	Enough	34	29.6
	Good	71	61.7
	Total	**115**	**100.0**

Table 1. shows that most pregnant women received supplements in the form of laduni (57.4%), were in the age range of 25-35 years (59.1%), had given birth once/primipara (33.9%), were from low economic status (78.3%), had a senior high school education (60%), were housewives (63.5%), and had good experience (61.7%).

Distribution of Research Variables

Table 2. Distribution of Variables and Indicators (n=115)

Variable	Indicator	Frequency (n)	Percentage (%)
Perceived Benefits (X2.1)	Low	6	5.2
	Medium	10	8.7
	High	99	86.1
	Total	**115**	**100.0**
Perceived Barriers (X2.2)	Low	8	7.0
	Medium	19	16.5
	High	88	76.5
	Total	**115**	**100.0**
Perceived Self-Efficacy (X2.3)	Low	3	2.6
	Medium	40	34.8
	High	72	62.6
	Total	**115**	**100.0**
Family Support (X3.1)	Less	4	3.5

Variable	Indicator	Frequency (n)	Percentage (%)
	Enough	18	15.7
	Good	93	80.9
	Total	**115**	**100.0**
Health Worker Support (X3.2)	Less	4	3.5
	Enough	28	24.3
	Good	83	72.2
	Total	**115**	**100.0**
Group Support (X3.3)	Less	6	5.2
	Enough	21	18.3
	Good	88	76.5
	Total	**115**	**100.0**
Social Experience (X3.4)	Less	3	2.6
	Enough	35	30.4
	Good	77	67.0
	Total	**115**	**100.0**
Metacognition (X4.1)	Less	4	3.5
	Enough	59	51.3
	Good	52	45.2
	Total	**115**	**100.0**
Self Motivation (X4.2)	Low	7	6.1
	Medium	42	36.5
	High	66	57.4
	Total	**115**	**100.0**
Commitment to Action (X5.1)	Weak	8	7.0
	Strong	107	93.0
	Total	**115**	**100.0**
Strategic Commitment (X5.2)	Weak	6	5.2
	Strong	109	94.8
	Total	**115**	**100.0**
Self-Observation (X6.1)	Less	2	1.7
	Enough	67	58.3
	Good	46	40.0
	Total	**115**	**100.0**
Self-Judgement (X6.2)	Less	3	2.6
	Enough	43	37.4
	Good	69	60.0
	Total	**115**	**100.0**
Self-Reaction (X6.3)	Less	3	2.6
	Enough	30	26.1
	Good	82	71.3
	Total	**115**	**100.0**
Consume Food According to Recommendations (Y1.1)	Poor nutritional behavior	25	21.7

Variable	Indicator	Frequency (n)	Percentage (%)
	Good nutritional behavior	90	78.3
	Total	**115**	**100.0**
Compliance with Taking Iron Supplements (Y1.2)	Not obey	50	43.5
	Comply	65	56.5
	Total	**115**	**100.0**
Worm Prevention (Y1.3)	Less	3	2.6
	Enough	8	7.0
	Good	104	90.4
	Total	**115**	**100.0**

Based on Table 2, most pregnant women have good cognition, as indicated by high perceived benefits (86.1%), high perceived barriers (76.5%), and high self-efficacy (62.6%). Environmental self-regulation is also predominantly good, including family support (80.9%), health workers (72.2%), groups (76.5%), and social experiences (67.0%). In personal self-regulation, metacognition is mostly in the adequate category (51.3%), while self-motivation is high (57.4%).

The majority of respondents had strong commitment, both in terms of action commitment (93.0%) and strategy commitment (94.8%). In behavioural self-regulation, self-observation was mostly in the adequate category (58.3%), while self-judgement (60.0%) and self-reaction (71.3%) were mostly in the good category. Regarding anaemia prevention, most respondents had food consumption behaviours in line with recommendations (78.3%), moderate compliance with iron tablet intake (56.5%), and good prevention of intestinal worms (90.4%).

Model Development

Data processing using SEM inferential analysis based on Partial Least Square (PLS) requires two stages to assess the fit of a model in a research model, namely: assessing the outer model or measurement model and testing the inner model. The following are the results of the outer and inner model analysis.

Outer Model

There are several criteria used to assess the outer model in data analysis using SEM PLS in this study, including: convergent validity, discriminant validity, composite reliability and Average Variance Extracted (AVE). Convergent validity was assessed based on factor loading values with a threshold of 0.50. All indicators met this criterion, except for the employment indicator (loading = 0.213), which was excluded from the model. Reliability was evaluated using Composite Reliability (CR) and Average Variance Extracted (AVE) values. All constructs had CR > 0.70 and AVE > 0.50, indicating adequate reliability and internal consistency.

Table 3. Factor Loadings, Composite Reliability (CR), and Average Variance Extracted (AVE)

Construct	Indicator	Loading	CR	AVE	Status
X1 Individual Characteristics	Age	0.656	**0.791**	**0.533**	Valid
	Parity	0.671			Valid

Construct	Indicator	Loading	CR	AVE	Status
	Economic status	0.605			Valid
	Education	0.761			Valid
	Experience	0.583			Valid
X2 Cognition of Pregnant Women	Perceived benefits	0.721	**0.782**	**0.546**	Valid
	Perceived barriers	0.675			Valid
	Perceived self-efficacy	0.813			Valid
X3 Environmental Self-Regulation	Family support	0.711	**0.852**	**0.593**	Valid
	Health worker support	0.705			Valid
	Group support	0.910			Valid
	Social experience	0.736			Valid
X4 Personal Regulation	Metacognition	0.859	**0.856**	**0.748**	Valid
	Self-motivation	0.871			Valid
X5 Commitment	Commitment to action	0.859	**0.869**	**0.768**	Valid
	Strategic commitment	0.893			Valid
X6 Behavioral Self-Regulation	Self-observation	0.575	**0.778**	**0.544**	Valid
	Self-judgement	0.807			Valid
	Self-reaction	0.808			Valid
Y1 Anemia Prevention Behavior	Food consumption compliance	0.881	**0.847**	**0.650**	Valid
	Iron supplement adherence	0.825			Valid
	Worm prevention	0.703			Valid

Discriminant validity was evaluated using the Fornell–Larcker criteria. The results of the analysis showed that the square root of the AVE of each construct was greater than the correlation between other constructs, so it can be concluded that the model adequately meets discriminant validity (Table 4).

Table 4. Fornell–Larcker Criterion

Construct	X1	X2	X3	X4	X5	X6	Y1
X1 Individual Characteristics	**0.658**						
X2 Cognition of Pregnant Women	0.416	**0.739**					
X3 Environmental Self-Regulation	0.261	0.666	**0.770**				
X4 Personal Regulation	0.191	0.454	0.636	**0.865**			
X5 Commitment	0.269	0.643	0.503	0.393	**0.876**		
X6 Behavioral Self-Regulation	0.343	0.586	0.641	0.722	0.685	**0.738**	
Y1 Anemia Prevention Behavior	0.624	0.481	0.285	0.251	0.291	0.406	**0.806**

Based on Figure 1, it is known that all indicators have a loading factor value > 0.5. Based on the loading factor value, individual characteristics are arranged by age, parity, economic status, education and experience. Pregnant women's cognition is arranged by perceived benefits, perceived barriers, and perceived self-efficacy. Environmental self-regulation is arranged by family support, health worker support, group support and social experience.

Personal regulation is arranged by metacognition and self-motivation. Commitment is arranged by action commitment and strategy commitment. Behavior self-regulation is arranged by self-observation, self-judgement, and self-reaction. Anemia prevention behavior is arranged by food consumption according to recommendations, compliance with taking iron supplements and prevention of worms.

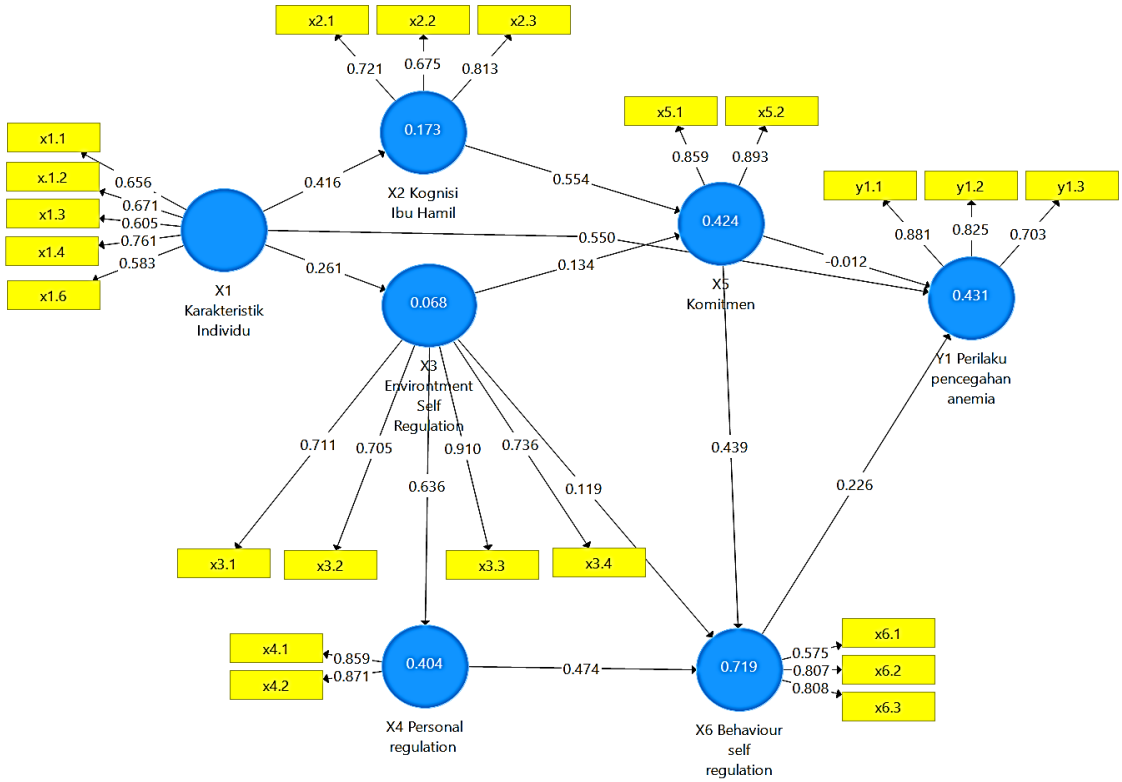

Figure 1. Outer Valid Model on The Development of a Self-Regulation Model Based on HPM on Anemia Prevention Behavior in Pregnant Women

Inner Model

The inner model is a stage for evaluating goodness of fitness, coefficient of determination, predictive relevance and hypothesis testing which will be explained as follows.

Table 5. Coefficient of Determination (R2) Results

Construct	*R Square*	*R Square Adjusted*
X2 Cognition of Pregnant Women	0.173	0.166
X3 Environtment Self Regulation	0.068	0.060
X4 Personal Regulation	0.404	0.399
X5 Commitment _	0.424	0.413
X6 Behaviour Self Regulation	0.719	0.712

Y1 Anemia Prevention Behavior	0.431	0.416

Table 5. explains the R square value of pregnant women's cognition 17.3%, environmental self regulation 6.8%, personal regulation 40.4%, commitment 42.4%, behavior self regulation 71.9%, and anemia prevention behavior 43.1%.

Table 6. Predictive Relevance (Q^2) Results

Construct	Q^2
X1 Individual characteristics	0.174
X2 Cognition of pregnant women	0.084
X3 Environtment self regulation	0.031
X4 Personal regulation	0.297
X5 Commitment _	0.306
X6 Behaviour self regulation	0.373
Y1 Anemia prevention behavior	0.248

Table 6. presents the results of predictive relevance (Q^2), indicating that most values are greater than zero. This demonstrates that the model possesses adequate predictive relevance and remains applicable when tested in different areas. The structural model testing stage is carried out to determine the results of the hypothesis test, namely, to determine the influence between variables directly without the intermediary of other variables. This test was conducted using a t-test comparison, with the criterion that the result is considered significant if the calculated t-value exceeds the critical value ($t > 1.96$) and the p-value is less than 0.05. The results of the significance test with bootstrapping can be seen through the analysis framework image in Figure 2.

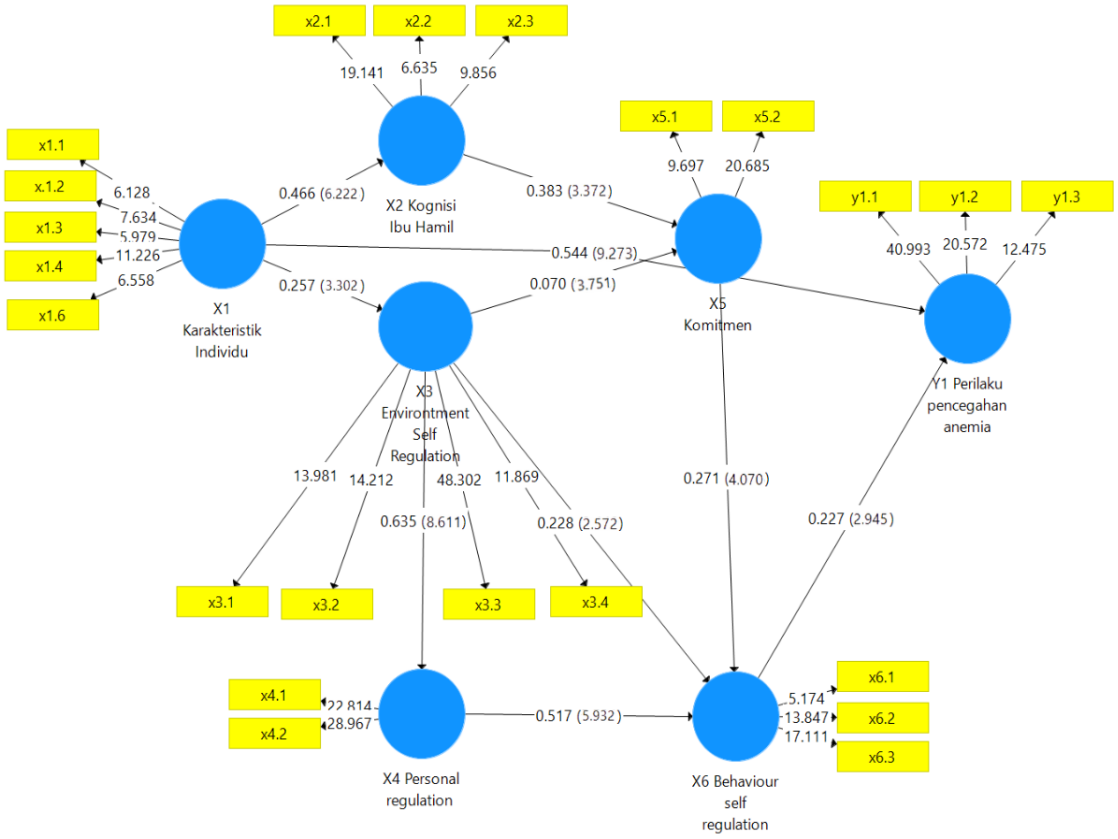

Figure 2. Partial Least Squares (PLS) Analysis

Table 7. The Results of the T-Test Calculation on The Self-Regulation Model for Anemia Prevention Behavior in Pregnant Women

Path	*Original Sample (O)*	*t Statistics*	*p-Values*	Results
Individual characteristics (X1) => Pregnant women's cognition (X2)	0.466	6.222	<0.001	Significant
Individual characteristics (X1) => Environtment self regulation (X3)	0.257	3.302	0.001	Significant
Individual characteristics (X1) => Anemia prevention behavior (Y1)	0.544	9.273	<0.001	Significant
Pregnant women's cognition (X2) => Commitment (X5)	0.383	3.372	0.001	Significant
Environtment self regulation (X3) => Commitment (X5)	0.070	3.751	<0.001	Significant
Commitment (X5) => Anemia prevention behavior (Y1)	0.013	0.144	0.886	Insignificant
Commitment (X5) => Behaviour self regulation (X6)	0.271	4.070	<0.001	Significant
Environtment self regulation (X3) => Personal regulation (X4)	0.635	8.611	<0.001	Significant
Environtment self regulation (X3) => Behaviour self regulation (X6)	0.228	2.572	0.010	Significant

Path	*Original Sample (O)*	*t Statistics*	*p-Values*	Results
Personal regulation (X4) => Behaviour self regulation (X6)	0.517	5.932	<0.001	Significant
Behaviour self regulation (X6) => Anemia prevention behavior (Y1)	0.227	2.945	0.026	Significant

The results of the analysis show that individual characteristics have a significant effect on cognition, environmental self-regulation, and anaemia prevention behaviour. Cognition and environmental self-regulation influence commitment, while commitment only has an effect through behavioural self-regulation and not directly on anaemia prevention behaviour. Environmental self-regulation also influences personal self-regulation, which in turn influences behavioural self-regulation and ultimately has an impact on anaemia prevention behaviour (Table 7).

Table 8. Effect Size (f^2) of Structural Paths

Relationship	f^2	Effect Size
X1 → X2 (Cognition)	0.210	Medium
X1 → X3 (Environment)	0.073	Small
X1 → Y1 (Anemia prevention behavior)	0.468	Large
X2 → X5 (Commitment)	0.297	Medium
X3 → X4 (Personal regulation)	0.679	Large
X3 → X5 (Commitment)	0.017	Very small
X3 → X6 (Behavioral self-regulation)	0.026	Small
X4 → X6 (Behavioral self-regulation)	0.472	Large
X5 → X6 (Behavioral self-regulation)	0.506	Large
X6 → Y1 (Anemia prevention behavior)	0.074	Small

Based on the f^2 analysis referring to Cohen's (1988) interpretation, it can be concluded that the strongest relationships (large effects) are found in the influence of Environment Self-Regulation on Personal Regulation ($f^2 = 0.679$), Personal Regulation on Behavior Self-Regulation ($f^2 = 0.472$), and Commitment on Behavior Self-Regulation ($f^2 = 0.506$). Relationships with moderate effects were found in Individual Characteristics on Pregnant Women's Cognition ($f^2 = 0.21$) and Pregnant Women's Cognition on Commitment ($f^2 = 0.297$). Meanwhile, other relationships such as the influence of Individual Characteristics on Environment Self-Regulation, and Behavior Self-Regulation on Anemia Prevention Behavior had small to very small effects. These findings indicate that internal factors such as personal self-regulation and commitment have a large role in influencing behavioral regulation and ultimately contribute to anemia prevention behavior (Table 8).

DISCUSSION

This study shows that the majority of pregnant women have a senior high school as their last education level. Mothers with higher education are more likely to understand the importance of an iron-rich diet and good nutritional habits and follow

medical advice for anemia prevention. They are more likely to know the symptoms of anemia and how to prevent it (Khani Jeihooni et al., 2021). Education facilitates better access to health information.

Pregnant women with higher levels of education tend to use a variety of information sources, including the internet, medical literature, and health education programs. This allows them to take more effective and timely preventive measures (Khani Jeihooni et al., 2021). Individuals with higher levels of education tend to be more compliant with medical recommendations, including the use of iron supplements and following an iron-rich diet. They are also more likely to have regular health check-ups to monitor their anemia status (Sedlander et al., 2020).

This study shows that the majority of pregnant women have low economic status. Pregnant women with low economic status tend to have difficulty accessing healthy food and quality health services. Consistent with prior studies, low household economic status and food insecurity limit access to iron-rich foods and quality maternal health services, and are associated with increased risk of maternal anemia and poorer diet quality among pregnant women (Zhang et al., 2022).

Pregnant women with low economic status often experience unhealthy eating patterns, such as consuming a lot of processed foods, skipping breakfast, and consuming excessive sugar. This can increase the risk of anemia (Devinia, 2020). These findings confirm that education and socioeconomic status are important foundations for enabling preventive behavior, as also shown in recent studies where literacy and wealth predicted better dietary diversity and iron-rich food consumption in pregnant women (Wakwoya et al., 2023).

This study shows that the majority of pregnant women have group support in the good category. This support includes providing information about pregnancy and also being a good example for other pregnant women. Pregnant women's support groups play a role in increasing commitment to good health behaviors. Pregnant women's support groups provide a platform for mothers to share experiences and obtain relevant information about pregnancy and childbirth. Participation in these support groups increases pregnant women's knowledge of good health behaviors and increases their commitment to implementing these health strategies (Handajani, 2021; Santi et al., 2023).

Social support from groups and appropriate education can increase pregnant women's understanding and commitment to better health practices (Beressa et al., 2024). Similarly, qualitative studies have reported that social support enables adolescent girls to overcome misconceptions and barriers in iron–folic acid (IFA) supplementation, while lack of support often weakens adherence (Hidayanty et al., 2025). These findings indicate that environmental influences are crucial for sustaining motivation and commitment.

This study demonstrates that commitment does not directly influence anemia prevention behavior. Commitment may be overshadowed by more pressing needs or preferences, which weakens the translation of intention into action. Competing demands and barriers—such as poverty, forgetfulness, side effects, and limited understanding—can disrupt individual awareness and reduce adherence to recommended anemia prevention practices (Kebaabetswe et al., 2024).

Moreover, commitment is shaped by perceptions of benefits and barriers; individuals are more likely to adopt healthy behaviors when the perceived benefits outweigh the barriers, whereas dominant barriers increase the likelihood of unhealthy

behaviors (Utami et al., 2020). Consistent with this, the present study found that most pregnant women reported high levels of perceived barriers. This finding aligns with previous research showing that daily educational reminders improved iron-folic acid (IFA) compliance but did not significantly enhance dietary quality, suggesting that intention alone is insufficient without strong self-regulatory mechanisms (Arifah et al., 2023).

Self-regulation emerged as a central mediator in translating commitment into action. Self-observation, self-judgment, and self-reaction enabled pregnant women to monitor their health, evaluate adherence to recommendations, and adjust behaviors accordingly. These findings are supported by prior studies showing that self-regulation strategies, such as goal-setting, self-monitoring, and responding to situational cues, promote sustainable healthy habits (Conner et al., 2023; Heshmati et al., 2020).

The role of self-regulation is also consistent with HPM's construct of self-efficacy, where individuals who feel confident and capable of monitoring and adjusting their behavior are more likely to maintain preventive practices. This study shows that pregnant women have the highest level of self-observation at 58.3%. Pregnant women need knowledge about anemia and how to manage it.

This knowledge allows them to do self-observation, namely monitoring their own health condition and identifying symptoms of anemia. Thus, they can take preventive measures before the anemia condition becomes worse (Risyati et al., 2024). Through self-observation, pregnant women can also monitor their diet and pay attention to whether they are consuming foods rich in iron. This awareness is important in ensuring that nutritional intake is sufficient to prevent anemia.

Self-judgment involves an individual's evaluation of their own decisions and actions. In this context, pregnant women need to assess the extent to which they comply with recommended nutritional and treatment recommendations, such as taking iron tablets. Research shows that the self-efficacy of pregnant women with anemia who are categorized as less can affect their behavior in managing anemia (Handayani, 2021). With proper self-judgment, pregnant women can identify their deficiencies and make changes to improve self-efficacy.

Accurate self-assessment can help pregnant women understand whether they have adequately met their iron and other nutrient needs. If self-judgment indicates that they are not adhering to the recommendations, pregnant women can take steps to improve their compliance. Self-reaction includes actions taken by individuals in response to their self-assessment. Self-reaction in terms of preventing anemia in pregnant women can include changing diets to more iron-rich foods, or increasing compliance with iron supplement consumption according to health workers' recommendations.

In addition, self-reaction can also include other preventive measures, such as maintaining cleanliness and avoiding the risk of worms by taking worm medicine according to medical advice (Risyati et al., 2024). This study shows that pregnant women consume the most recommended foods at 78.3%, compliance with taking TTD is the highest in the compliant category at 56.5%, and behavior to prevent worms at 90.4%. This indicates that compliance with taking TTD in pregnant women is still lacking.

The main contribution of this study lies in the development of a self-regulation model based on HPM that clarifies the optimal pathway of anemia prevention behavior. The results show that the best pathway begins with individual characteristics, which influence environmental self-regulation, followed by personal regulation, leading to

behavioral self-regulation, and ultimately resulting in anemia prevention behavior. Commitment strengthens this pathway indirectly by supporting regulatory processes rather than directly producing behavior.

This finding extends the HPM framework by emphasizing the need to integrate environmental, personal, and behavioral self-regulation as mediators between individual factors, commitment, and health behavior. The formation of this model is expected to be developed in pregnant women so that it can help in preventing anemia. The Goodness of Fit (GOF) value shows that the resulting model is good and if applied to different areas it remains relevant.

In practice, this model can guide nurses in providing counseling and health promotion interventions that not only deliver information but also strengthen self-regulatory skills such as goal setting, self-monitoring, and problem-solving, thereby empowering pregnant women to sustain healthy behaviors. In education, the model can enrich maternal and child health curricula by emphasizing behavioral change approaches and training nurses to apply theoretical models in daily practice. From a research perspective, it offers a framework for further studies on behavioral interventions in maternal health and adherence to anemia prevention strategies.

At the policy level, the model may serve as a basis for maternal health programs in community settings, supporting the development of standardized, culturally sensitive, and empowerment-focused approaches to anemia prevention. This study has several limitations. First, the large number of variables examined required a lengthy questionnaire, which may have caused fatigue among pregnant women when completing it.

Second, the provision of Laduni supplementation in Surabaya was dependent on stock availability, resulting in variations among participants, where some received only Laduni supplements, others received iron tablets (TTD), and some received both. This inconsistency, along with perceived side effects, may have influenced compliance with supplement consumption. Third, the use of food recall questionnaires required a shared understanding between researchers and respondents to ensure accurate data conversion, which may have introduced potential reporting bias.

Future research should employ stronger designs such as longitudinal or experimental studies to enhance the robustness of evidence regarding the effectiveness of the self-regulation model in anemia prevention among pregnant women. Unlike cross-sectional approaches, longitudinal designs enable researchers to capture changes in behavior and health outcomes over time, thereby providing insights into the sustainability of preventive practices throughout pregnancy. Experimental designs, particularly randomized controlled trials, offer greater methodological rigor by minimizing bias and controlling for confounding variables, which strengthens the ability to establish causal relationships. Applying these designs will not only improve the validity and reliability of the findings but also provide a stronger basis for integrating the model into nursing practice and maternal health programs.

CONCLUSION

This study demonstrates that factors such as education, economic status, social support, commitment, and self-regulation significantly influence anemia prevention behavior in pregnant women. While higher education supports better understanding of nutrition and health advice, and economic limitations can hinder access to healthy food and quality services, the most important contribution of this study lies in the

development of a new self-regulation model. The findings reveal that the optimal pathway for anemia prevention is not a direct effect of commitment but rather a sequential process beginning with individual characteristics, followed by environmental self-regulation, personal regulation, and behavioral self-regulation, which ultimately leads to anemia prevention behavior.

This highlights that self-regulation serves as the central mechanism through which pregnant women translate their knowledge and commitment into consistent healthy actions. By integrating individual and environmental factors within the self-regulation framework, this model provides a more comprehensive approach to improving maternal health and can serve as a practical basis for interventions to effectively prevent anemia in pregnancy.

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