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Relationship Between Energy, Protein, Iron, and Calcium Intake with Hemoglobin Levels of Pregnant Women

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ABSTRACT

Hemoglobin levels are a parameter that measures the respiratory pigment in red blood cells. A decrease in hemoglobin levels can lead to anemia. Factors contributing to hemoglobin levels include inadequate nutrient intake, particularly iron and protein, as well as the effect of inhibitors on iron absorption such as calcium. This study aims to assess the intake of energy, protein, iron, and calcium in relation to hemoglobin levels among pregnant women. This research employs a Cross-Sectional study design. The sample consisted of 55 pregnant women selected through purposive sampling. Data collection on energy, protein, iron, and calcium intake was done using the SQ-FFQ questionnaire, while hemoglobin levels were measured using an Hb meter (EasyTouch GCHb), and data were analyzed using Spearman's Rank Correlation test. The results showed that pregnant women had adequate energy intake (41.8%), excess protein intake (40%), adequate iron intake (89.1%), and adequate calcium intake (80%). Abnormal hemoglobin levels were observed in the third trimester of pregnancy (16.3%), whereas normal hemoglobin levels were found in the second trimester (34.5%). Statistical tests revealed no significant relationship between energy intake (p = 0.223), protein (p = 0.201), iron (p = 0.327), and calcium (p = 0.641) with hemoglobin levels. The conclusion of this study is that there is no significant relationship between energy, protein, iron, and calcium intake and hemoglobin levels among pregnant women in Parung Panjang District, Bogor Regency. Pregnant women should regularly consume calcium supplements and iron tablets to meet their iron and calcium needs, which can help prevent anemia.

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- Pregnant women are a high-risk group for nutritional issues, particularly anemia due to iron deficiency. Therefore, it is recommended to consume calcium supplements and iron tablets.
- Meeting nutritional intake during pregnancy is an effective way to address nutritional problems in pregnant women.

Introduction

Pregnancy is a unique natural condition because, although it is not a disease, it often leads to complications due to changes in the structure and biological functions of the mother's body. One of these biological changes is the alteration in blood flow dynamics, which can cause hematological disorders during pregnancy. One of the most common hematological disorders is anemia (1). Anemia occurs when red blood cells lack hemoglobin, impairing their ability to meet the body's needs. Hemoglobin is an iron-rich protein in red blood cells that transports oxygen from the lungs to the rest of the body. Low hemoglobin levels in pregnant women are still commonly found in developing countries such as Indonesia (2).

Anemia in pregnant women is a condition where hemoglobin levels fall below the normal range. According to the Guideline on hemoglobin cutoffs to define anemia in individuals and populations, anemia during pregnancy is defined as <11 g/dl in the first and third trimesters, and <10.5 g/dl in the second trimester (3). According to WHO 2019, the prevalence of anemia among pregnant women is high at 41.8% (4). The 2023 Indonesian Health Survey (SKI) reports a prevalence of 27.7% (5), while the 2018 Riskesdas report shows a prevalence of 48.9% (6). This indicates a 21.2% decrease in anemia

prevalence over the past five years. Data from the West Java Health Office in 2021 shows that the highest number of anemia cases in pregnant women was in 2019, with 85,826 cases per year. Bogor Regency ranked third for the highest number of anemia cases in pregnant women in 2020, with 4,968 cases per year. One of the sub-districts in Bogor Regency, Parung Panjang, has a notably high incidence of anemia among pregnant women, making it a significant public health issue that still needs to be addressed (7).

Anemia during pregnancy can impact both maternal and infant health, potentially causing premature birth, low birth weight (LBW), preeclampsia, and increased risks of maternal and infant mortality (8). During childbirth, anemia can also lead to shock, bleeding, and energy deficiency. Additionally, during breastfeeding, anemia can reduce the quantity and quality of breast milk, putting infants at risk of missing out on optimal nutrition during the crucial early life period (9). One factor associated with anemia in pregnant women is Chronic Energy Deficiency (CED), which is influenced by inadequate nutritional intake during pregnancy. Inadequate nutritional intake may result from a lack of food sources and cultural beliefs related to dietary taboos (10). Another factor affecting anemia is insufficient iron intake. Inadequate iron intake results from both low consumption of iron and reduced ability of the body to absorb it (11).

Iron is a crucial micronutrient needed for red blood cell formation. Natural dietary sources of iron include enhancers, such as energy, protein, iron, and vitamin C, which aid in the formation of erythrocytes and hemoglobin, as well as inhibitors, such as tannins found in tea and coffee, and foods high in calcium, phosphate, and phytates when consumed in large amounts, which can impair iron absorption (12). During pregnancy, caloric needs increase due to higher basal metabolic rate and additional weight gain, which increases calorie usage during activity. Energy needs increase by 180 kcal in the first trimester and 300 kcal in the second and third trimesters. Additional energy is used to support fetal and placental growth (13). Similarly, protein needs during pregnancy increase by 68% compared to before pregnancy to ensure proper growth of fetal tissues and organs. Protein plays a crucial role in the formation of red blood cells and hemoglobin and in the transfer of iron within the body for red blood cell formation in the bone marrow. Inadequate protein intake can disrupt erythrocyte and hemoglobin formation and hinder iron transfer, leading to impaired red blood cell production (14).

Calcium needs also increase significantly during pregnancy for fetal development. The fetus stores about 28.2 grams of calcium, with 80% of this amount accumulated in the third trimester. There is an additional need for about 200 mg/day of calcium during pregnancy, which helps provide structure and strength to the developing fetus's bones and teeth (15). Calcium's inhibitory effects become apparent when consumed in doses exceeding 2500 mg per day. Calcium can bind iron before it is absorbed by the intestinal mucosa, forming insoluble compounds that reduce iron absorption (16). This study aims to understand the relationship between energy, protein, iron, and calcium intake with hemoglobin levels in pregnant women.

Methods

This research is a quantitative study using an observational analytic design with a cross-sectional approach. This study is conducted in the Parung Panjang District, Bogor Regency, from August 2023 to May 2024. The respondents for this study are pregnant women in the Parung Panjang District, Bogor Regency, who meet the inclusion criteria: willingness to participate in the study, pregnancy in the first, second, or third trimester, no history of infectious diseases, and being in good physical and mental health. The exclusion criteria for samples in this study include unwillingness to participate, failure to complete the study, and illness.

The sampling technique used in this study is purposive sampling, as there are specific criteria that must be met by the sample. Data on subject characteristics, including age, gestational age, mother's education level, mother's occupation, nutritional status, and food consumption, are obtained through interviews using the SQ-FFQ questionnaire over the past month administered by enumerators. Hemoglobin levels are assessed through examinations by health workers from the Parung Panjang Health Center using an Hb meter (EasyTouch GCHb). The sample size is calculated using the Lemeshow formula, with an unknown population size of 55 people.

The adequacy of energy and protein intake, according to WNPG 2012, is categorized into three levels, insufficient if intake is <80%, adequate if intake is between 80-110%, and excessive if intake is >110% (17). Meanwhile, the adequacy of iron and calcium intake, based on Gibson 2005, is categorized into two levels, insufficient if intake is <77% and adequate if intake is ≥77% (18). Hemoglobin levels are categorized based on gestational age. In the first and third trimesters, hemoglobin levels are considered abnormal if they are <11 g/dL, while in the second trimester, levels are considered abnormal if they are <10.5 g/dL (2).

Data collection preparation involves preparing enumerators and health workers from the Parung Panjang Health Center. Prior to data collection, researchers seek permission from the Bogor Regency Health Office and the Ethics Committee. Consent is obtained from respondents (informed consent), explaining the study's purpose, benefits, procedures, and potential risks. Interviews are conducted in several villages within the Parung Panjang District using the SQ-FFQ questionnaire to assess intake and hemoglobin levels using the Hb meter (EasyTouch GCHb). All data obtained from respondents are carefully recorded and entered into a database. Data security is maintained, and access is restricted to researchers or authorized team members to ensure respondent confidentiality. Data backups are performed to prevent data loss.

Data analysis is conducted using SPSS software. Univariate and bivariate analyses are performed. Univariate analysis presents data in frequency distribution tables for each variable studied. Bivariate analysis is used to determine the relationship between independent and dependent variables through cross-tabulation (crosstab). Before conducting correlation tests, a normality test is performed using the Kolmogorov-Smirnov test. Subsequently, bivariate analysis is conducted with Spearman's rank correlation test due to the data not being normally distributed.

Ethical Clearance

The Health Research Ethics Committee of the Faculty of Health Sciences, Syarif Hidayatullah State Islamic University Jakarta, with the certificate number for ethical clearance: Un.01/F.10/KP.01.1/KE.SP/05.08.083/2024.

Results

Respondent characteristics refer to the identities of the respondents who are part of the research sample, aimed at understanding the diversity of the research subjects based on age, gestational age, education level, mother's occupation, and maternal nutritional status. The frequency distribution of these respondent characteristics is presented in Table 1.

Table 1. Frequency Distribution of Respondent Characteristics

Characteristics	n	%
Age (years)		
16-18	1	1,8
19-29	30	54,5
30-49	24	43,6
Gestational Age		
Trimester I	7	12,7
Trimester II	22	40
Trimester III	26	47,3
Education		
Primary School	20	36,4
First Middle School	16	29,1
High School	12	21,8
College	7	12,7
Mother's Occupation		
Housewife	52	94,5
Civil Servant	1	1,8
Others	2	3,6
Nutritional Status		
Underweight	6	10,9
Normal	41	74,5
Overweight	7	12,7
Obese	1	1,8
Total	**55**	**100**

Based on Table 1, the highest distribution of respondents' ages is 19-29 years, with 30 individuals (54.5%). The majority of pregnant women are in the third trimester, with 26 individuals (47.3%). The most common education level among mothers is elementary school, with 20 individuals (36.4%). The majority of mothers are housewives, with 52 individuals (94.5%), and the nutritional status of the mothers falls into the good nutritional category, with 41 individuals (74.5%). The nutritional status of

mothers during pregnancy reflects the availability of nutrients in the mother's body during this period, including the need for macro nutrients.

Dietary history was obtained from the results of the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ) over the past month and hemoglobin levels were measured using a Hb meter (EasyTouch GCHb). The results of the analysis regarding the relationship between intake and hemoglobin levels are shown in Table 2.

Table 2. Dietary Intake with Hemoglobin Levels of Pregnant Women

Variable	Hemoglobin Levels				Total		r	*p-value*
	Not Normal		Normal					
	n	%	n	%	n	%		
Energy Intake								
Insufficient	8	14,5	13	23,6	21	38,2		
Adequate	3	5,4	20	36,3	23	41,8	0,101	0,223
Excessive	2	3,6	9	16,3	11	20		
Protein Intake								
Insufficient	7	12,7	8	14,5	15	27,2		
Adequate	1	1,8	17	30,9	18	32,7	0,175	0,201
Excessive	5	9,1	17	30,9	22	40		
Iron Intake								
Insufficient	1	1,8	5	9,1	6	10,9	0,135	0,327
Adequate	12	21,8	37	67,3	49	89,1		
Calcium Intake								
Insufficient	2	3,6	9	16,4	11	20	-0,64	0,641
Adequate	11	20	33	60	44	80		
Total	**13**	**23,6**	**42**	**76,4**	**55**	**100**		

Table 2 shows that adequate energy intake with normal hemoglobin levels is 36.3%, which is not significant (p=0.223), and similarly, adequate protein intake with normal hemoglobin levels is 30.9%, which is also not significant (p=0.201). Adequate iron intake with normal hemoglobin levels is 67.3%, with a p-value of 0.327. Adequate calcium intake with normal hemoglobin levels is 60%, showing no significant relationship with a p-value of 0.641, marked by an R value of -0.64, indicating an inverse relationship.

Discussion

The highest distribution of respondents' ages is 19-29 years, which is considered a healthy reproductive age and the safest age for pregnancy. At this age, the uterus and other parts of the body are physically, emotionally, psychologically, socially, and economically prepared to support a pregnancy. Pregnancies occurring before the age of 20 are at risk of anemia because individuals in this age group are still growing and require more nutrients compared to older age groups. If these nutritional needs are not met, there will be a competition for nutrients between the mother and the baby. On the other hand, pregnancies occurring at age ≥35 years are vulnerable to various diseases such as hypertension and eclampsia, due to changes in the reproductive organs and a loss of flexibility in the birth canal (19). The majority of pregnancies are in the third trimester. To support fetal development and prepare the mother for delivery, the mother's body undergoes physiological changes, including in the cardiovascular system. Plasma volume significantly increases, peaking during the third trimester, around 34 weeks of gestation, in line with fetal growth. This increase in plasma volume, not matched by a corresponding increase in red blood cells, results in decreased hemoglobin levels. The decrease in hemoglobin levels is due to the greater expansion of plasma volume compared to the increase in red blood cell volume and hemoglobin (20).

The majority of mothers have an elementary school education. Low maternal education levels can lead to limitations in addressing nutritional and health issues within the family. According to Handayani in 2015, the level of education attained by an individual is related to their knowledge of the nutrition of consumed foods. Nutritional knowledge affects food consumption. The more knowledge one has about nutrition, the more varied the diet, which can ensure adequate nutrition and maintain the health of the individual and family (21). Furthermore, the majority of mothers are housewives. Housewives have more flexible time since they are not bound by job-related activities. This situation allows mothers to better monitor and maintain their pregnancy health, including meeting nutritional

needs during pregnancy, thereby preventing anemia (22). Most mothers are in the good nutritional status category. Maternal nutritional status during pregnancy reflects the availability of nutrients in the mother's body during this period, including macro nutrient needs. Poor nutritional status during pregnancy can affect fetal nutrition, leading to growth disturbances and increased risk of delivering a baby with low birth weight. This is due to the expansion of blood vessels, which increases cardiac output inadequately and reduces blood flow to the placenta (23).

Overview of Energy Intake with Hemoglobin Levels of Pregnant Women

Pregnant women are a vulnerable group for nutritional deficiencies. The process of pregnancy increases the metabolism of energy and other nutrients. Increased energy and nutrient requirements are necessary for fetal growth and development, as well as for the mother's own needs. Failure to meet nutritional needs during pregnancy can lead to anemia. Energy is also required to support the movement of digestive tract muscles, which helps the digestive system in the absorption of nutrients in the intestines (24). The results of this study are consistent with the research conducted by Azizah in 2018, which found no significant relationship between energy adequacy levels and hemoglobin levels ($p>0.05$) (25). The lack of a relationship in this study may be due to the fact that some of the energy intake comes from carbohydrate-rich foods, which do not significantly contribute to iron levels. Iron is the primary nutrient that impacts hemoglobin levels. Energy in the body is derived from macronutrients that are converted into energy, which is also needed to aid the movement of digestive tract muscles. This movement helps the absorption of iron in the intestines (10).

Pregnant women are a vulnerable group for nutritional deficiencies. Pregnancy increases energy metabolism and other nutrient needs. Increased energy and nutrient requirements are necessary for fetal growth and development, as well as for the mother's own needs. Inability to meet nutritional needs during pregnancy can lead to anemia. Energy is also needed to support the movement of digestive tract muscles, which assists in the absorption of nutrients in the intestines (24). Energy is derived from dietary intake, and a good diet can help prevent health issues including anemia. Additionally, a study by Ayensu et al., 2020, reported that pregnant women with low dietary diversity are 1.8 times more likely to experience anemia compared to those with high dietary diversity (26). However, this study does not align with the research conducted by Yuliati in 2017, which investigated pregnant women in the second and third trimesters in Banjarnegara Regency and found a relationship between hemoglobin levels and energy adequacy (24). Insufficient energy intake can affect the availability of other macro nutrients in the body. The body needs energy to perform various physiological processes and support the metabolism of nutrients involved in red blood cell formation, including hemoglobin (27).

Overview of Protein Intake with Hemoglobin Levels of Pregnant Women

Protein plays a crucial role in the transport of iron for hemoglobin formation. Insufficient protein intake can lead to decreased hemoglobin levels and cause anemia during pregnancy (28). The results of this study are consistent with research by Stephanie et al. in 2021, which investigated nutrient intake and hemoglobin levels among pregnant women at the Kebon Jeruk Community Health Center. The study found no significant relationship between protein intake and hemoglobin levels ($p>0.05$) (28). The lack of a relationship between protein intake and hemoglobin levels in this study may be due to respondents' dietary patterns, which included high consumption of iron inhibitors such as tea and coffee, and low intake of vegetables and fruits that contain vitamins enhancing iron absorption and red blood cell formation (29). This study also had limitations, such as not examining factors that increase iron absorption, like vitamin C, which might affect hemoglobin levels.

The findings of this study differ from those of Lestari, 2021, who researched the relationship between nutrient intake and hemoglobin levels among pregnant women at the Jatinegara Health Center, with 59 respondents. Lestari's study found a significant relationship between protein intake and hemoglobin levels ($p<0.05$) (30). Protein is essential for body tissue building, structural formation, growth, oxygen transport, nutrient transport, and immune function. Animal-based high-protein foods generally contain more iron compared to plant-based proteins, as animal proteins have a complete essential amino acid profile closer to what the body needs (31). Animal protein intake can enhance iron absorption in the body. Low protein consumption can lead to reduced iron absorption, causing iron deficiency and potentially resulting in anemia or lower hemoglobin levels (32). Another study by Yuliantisari et al. in 2020 showed a relationship between protein intake and hemoglobin levels in pregnant women, with a p-value of 0.042. This study indicated that pregnant women with anemia tended to have lower protein intake than those who consumed adequate protein. Protein plays a crucial role in iron transport within the body, so inadequate protein intake can hinder iron transportation, potentially causing iron deficiency and resulting in anemia (1).

Overview of Iron Intake with Hemoglobin Levels of Pregnant Women

Iron is a crucial element for forming hemoglobin. Iron plays a role in the transportation, storage, and utilization of oxygen and is found in the form of hemoglobin. The results of this study are consistent with research conducted on pregnant women in the Kebon Jeruk area, with 50 respondents, which found no relationship between iron intake and hemoglobin levels, with a p-value of 0.457 (28). Although iron intake in this study was classified as adequate, statistical tests showed no correlation between iron and hemoglobin levels. This may be due to insufficient intake of iron from food, particularly from animal sources (heme). The iron needs during pregnancy are partly met through iron supplements, such as iron tablets provided by healthcare workers every two weeks, or supplements purchased independently, such as Bundavin, Folamil, and Obimin, which can help fulfill the respondents' iron requirements (33).

The findings of this study are not in line with research conducted by Caesaria in 2018, which investigated iron and vitamin C intake and hemoglobin levels among pregnant women at the Usodo Colomadu Karanganyar Clinic. Caesaria's study found a significant relationship between iron intake and hemoglobin levels, with a p-value of 0.000 (<0.05) (34). Iron is essential for pregnant women to increase red blood cell counts and for the formation of red blood cells in the fetus and placenta. Inadequate iron intake hinders the formation of hemoglobin, disrupting red blood cell production and causing anemia in pregnant women. Therefore, it is recommended for pregnant women to consume additional iron, either through supplements or iron-enriched milk, regularly during pregnancy (35). Research conducted at Klungkung II Community Health Center on adherence to iron tablet consumption and anemia incidence in pregnant women found that those who did not adhere to iron tablet consumption had an 11.4 times higher chance of experiencing anemia compared to those who complied. Iron supplementation is one method to address anemia due to iron deficiency, with a daily dose of 60 mg of iron tablets potentially increasing hemoglobin levels by 1 g% per month (36).

Overview of Calcium Intake with Hemoglobin Levels of Pregnant Women

Calcium is a vital micronutrient and mineral for both the mother and the fetus, with an additional calcium requirement of about 200 mg per day during pregnancy. The results of this study are consistent with research by Diana et al. 2019, which included 152 pregnant respondents with anemia in Madura Island. The study found no significant relationship between calcium intake and hemoglobin levels, with a p-value of 0.078 (>0.05) (37). The lack of a relationship between calcium intake and hemoglobin levels in this study may be due to adequate calcium intake among the respondents, supplemented by calcium supplements consumed during pregnancy.

Calcium intake increases by 200 mg per day during pregnancy. Besides being crucial for the health of the mother's and fetus's bones, adequate calcium intake can prevent premature birth (38). About 30 grams of calcium are transferred from the mother to the fetus during pregnancy. Bone formation and calcium absorption increase to meet the fetus's calcium needs. Calcium needs are highest during the third trimester as the fetus's bones undergo rapid mineralization. These factors contribute to the increased calcium requirements during pregnancy (39). The inhibitory effects of calcium are noticeable when calcium intake exceeds the normal adequacy level, or exceeds 2500 mg per day, which can inhibit iron absorption in the body and reduce hemoglobin levels in the blood (16).

The findings of this study differ from research by Pratiwi and Widari in 2018, which indicated a significant relationship between calcium intake and anemia incidence among pregnant women in the third trimester in Pajarakan District, Probolinggo Regency (p<0.05) (11). Calcium is a nutrient that can inhibit iron absorption. Calcium binds to iron before it is absorbed by the intestinal mucosa, converting it into an insoluble form and thereby reducing its absorption. This reduction in iron absorption can decrease ferritin levels, leading to lower iron availability for hemoglobin synthesis and replacement of damaged hemoglobin, resulting in low blood hemoglobin levels (40).

Conclusion

This study shows that the intake of energy, protein, iron, and calcium among pregnant women is adequate, supporting both maternal and fetal health and reducing the risk of anemia. However, statistical tests did not find a significant relationship with hemoglobin levels. Future research should investigate other factors related to hemoglobin levels and increase sample size and expand the study area to obtain more representative results. Pregnant women are advised to consume Iron Tablets and calcium supplements to meet their iron and calcium needs, which can help prevent anemia.

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Conflicts of Interest: The authors declare no conflict of interest.

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