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Nutrition Intake, Gestational Age, and Age of Young Children as Predictors of Fetal Growth

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Abstract

Background: Research that confirms the success of supplementary feeding programs, significantly increasing macronutrient intake (protein, fat, and carbohydrates) on fetal growth, shows differences in results in fetal growth

Objective: This study aimed to confirm various predictors that affect fetal growth in pregnant women in Pangkalpinang City, Bangka Belitung Islands

Methods: The data in this study included fundal height (FH) as an indicator of fetal growth, the dependent variable. Indicators of energy intake, protein, fat, carbohydrate, Fe, Ca, Vitamin C, weight, height, MUAC, Hb levels, blood pressure, the youngest child, the age of pregnant women, and the husband were determined as independent variables. Risk factors for fetal growth were identified using a backward regression model in IBM SPSS Statistics version 25.

Results: The results showed that energy and carbohydrate intake, gestational age, and the youngest child were responsive predictors of fetal growth in Pangkalpinang City with the regression model $\hat{Y} = -2.338 + 0.003X_1 - 0.025X_4 + 0.841X_{16} + 0.210X_{17}$

Conclusion: This research recommends that policymakers consider improving the socioeconomic conditions of families, especially mothers' education, family income, and social affiliation

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INTRODUCTION

The 2013 Basic Health Research (Riskesdas) recorded the chronic energy deficiency (CED) rate among pregnant women in Indonesia at 24.2 percent, or around 76 million pregnant women. The CED rate for pregnant women, based on the 2018 Riskesdas, decreased to 17.3 percent. This decrease was not followed by other nutritional problems, especially among women of childbearing age (15-24 years), including micronutrient deficiencies such as Iron Deficiency Anemia (IDA). The CED in pregnant women is often one of the contributors to the occurrence of IDA. The condition of IDA in Indonesia increased from 37.1 percent in 2013 to 48.9 percent in 2018. This condition showed that although CED has decreased, the potential for CED problems is essential as long as IDA increases. [1–3]

Nutritional problems such as IDA, CED, and micronutrient deficiencies occur throughout Indonesia, including in the Bangka Belitung Islands Province, particularly in Pangkal Pinang City. The data collected by the Bangka Belitung Islands Provincial Health Office and the Pangkalpinang City Health Office showed that the percentages of CED among pregnant women in 2020 were 8.23 percent and 6.27 percent, respectively. The percentage of IDA even increased in Pangkalpinang City to 6.80 percent in 2021. The Report of the Nutrition Program of the Pangkalpinang City Health Office for August 2022 shows that the highest number of CED pregnant women is in the Gerunggang Health Center work area, with 50 cases out of 89 pregnant women who came to check their pregnancies.[3]

Pregnant women need a healthy and nutritionally balanced diet consisting of adequate intake of energy, protein, fat, carbohydrate, vitamins, and minerals for pregnant women themselves and the fetus [4,5] Conditions that occur due to inadequate food consumption for pregnant women are often not appropriately fulfilled, especially in Indonesia, and are a determinant of nutritional problems. The Indonesian government sets the Recommended Dietary Allowance (RDA) for energy for pregnant women at 180 kilocalories per day in the first trimester and 300 kilocalories per day in the second and third trimesters. Adequacy for protein nutrients also needs to be added to pregnant women by 20 grams per day during pregnancy [3,6]

Pregnant women with consumption that does not comply with the RDA for a long time will experience an imbalance in energy and protein intake, so they will experience CED. [7] Research in Indonesia showed that pregnant women's energy and protein intake are lower in the CED group, namely 50.0 percent and 72.2 percent, respectively. Another study found that CED mothers experienced energy deficits (36.7%) and protein (43.5%). The last critical review conducted in Indonesia found that energy and protein intake are associated with the incidence of CED in pregnant women, so it is necessary to follow up on planning and implementing programs to prevent and control the incidence of CED in pregnant women. [8–10]

Chronic malnutrition in pregnant women can cause fetal growth retardation (FGR). This condition significantly influences fetal development and is characterized by low birth weight (LBW). Other factors associated with low birth weight are maternal nutrition,

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including pre-pregnancy BMI scores, in-adequate weight gain, short stature, anemia, and micronutrient deficiencies. The condition further leads to premature birth, impaired fetal growth, or both. [11]

The supplementary feeding program (SFP) is one of the interventions carried out on CED pregnant women. [12] The success of the SFP in CED pregnant women as part of the inter-vention of pregnant women's food consump-tion has been noted in various studies, although some studies show the opposite condition. The number of pregnant women in the CED was reduced in the SFP carried out in Karawang Regency between 60 and 100 percent in two different locations [13]. The study's results also showed a significant difference in mid-upper arm circumference (MUAC) before and after 90 days of SFP. Research in Surabaya found that the SFP in CED-affected pregnant women could only normalize nutritional status in 13%. The study's results also revealed no difference in energy and protein intake after the SFP between CED and ordinary pregnant women. [14–17]

Research confirms that supplementary feeding programs significantly increase macronutrient intake (protein, fat, and carbohydrates) in relation to fetal growth, leading to differences in fetal growth outcomes. Research showing increased fetal weight estimation with SFP administration was reported in Batu Bara Regency, North Sumatra[18]. Previous experimental studies on the administration of SFP with the primary protein ingredient did not show a significant effect compared with regular SFP as a control ($p > 0.05$) on fetal growth indicators, including femoral length and fetal weight estimates. [19,20] Recent research data revealed that nutrition and exercise support before pregnancy might be more successful in promoting healthy placentation and fetal growth than during pregnancy [11]. This study aimed to confirm various predictors that affect fetal growth in pregnant women in Pangkal-pinang City, Bangka Belitung Islands

METHODS

This analytical observational study with *a cross-sectional* design was conducted in December 2022 in the working area of the Melintang, Gerunggang, and Selindung Health Centers in Pangkalpinang City, Bangka Belitung Islands Province. Research ethics approval has been issued by the Health Research Ethics Commission (HREC), Faculty of Public Health, Sriwijaya University, Palembang, Number 419/UN9.FKM/TU.KKE/2022. The study subjects were 121 people, selected by simple random sampling, who met the inclusion criteria: pregnant women in the second or third trimester of pregnancy or with a gestational age of at least 12 weeks, aged 16-38 years, and with a single pregnancy. The exclusion criteria include if the subject is a pregnant woman with a doctor's diagnosis or has symptoms and signs of high blood pressure (diastolic blood pressure ≥90 mmHg), gestational diabetes (blood glucose levels at ≥ 200 mg/dL), suffering from other chronic diseases, or not at the location at the time of data collection.

The data in this study consisted of the Fundal Height (FH) measured in centimeters with a tape measure from the upper edge of the symphysis pubis to the top of the uterine fundus. Consumption data consisting of

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macronutrient intake (energy, protein, fat, and carbohydrate or KH) and micronutrients (iron/Fe, calcium/Ca, and vitamin C) were obtained using the 1x24-hour food recall method. Pregnant women's anthropometric data (weight, height, and mid-upper arm circumference/MUAC) were measured using standardized tools: Oserio's digital scale, SAGA microtoise, and MUAC measuring tape. Hemoglobin (Hb) and blood pressure (systolic/diastolic) levels, as biochemical and physical data, were measured using the digital Hb Easy Touch measuring instrument and the Omron digital sphygmomanometer, respectively. Identity data and other general characteristics, such as the ages of pregnant women and their husbands, gestational age, and the age of the youngest child, were collected using questionnaires.

In this study, indicators of energy intake (X_1), protein intake (X_2), fat intake (X_3), carbohydrate intake (X_4), Fe intake (X_5), Ca intake (X_6), Vitamin C intake (X_7), the different weight of pregnant women (X_8), height (X_9), MUAC (X_{10}), Hb level (X_{11}), systolic (X_{12}), diastolic (X_{13}), age of respondent (X_{14}), age of husband (X_{15}), gestational age (X_{16}) and age of the younger child (X_{17}) as an independent variable (X_i). This study's dependent variable (Y) was fetal growth using the FH (Y_i). Table 1 below details the indicators of this study.

Risk factors were fixed using a backward regression model with IBM SPSS Statistics. The presentation of research results is carried out through tabulations and text. The mathematical formulation of regression generally uses the equation:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_{p-1} X_{p-1,1} + \varepsilon_i$$

In this case:
Yi is the dependent variable for the i-th observation, for $i = 1, 2, ..., n$.
β0, β1, β2..., βp−1 are parameters
X 1 i, X 2 i..., Xp−1, i is the independent variable, for i =1, 2, ..., n.
εi is a mutually free error that distributes N(0.σ 2).

Table 1. Research variable (n=121)

No	Variable name	Unit
1	Fetal growth or FH (Y)	Centimetre
2	Energy intake (X_1)	Kilo-calorie
3	Protein intake (X_2)	Gram
4	Fat intake (X_3)	Gram
5	Carbohydrate intake (X_4)	Gram
6	Fe Intake (X_5)	Gram
7	Ca Intake (X_6)	Gram
8	Vitamin C Intake (X_7)	Gram
9	Weight of different pregnant women (X_8)	Kilogram
10	Height ($X9$)	Centimetre
11	MUAC (X_{10})	Centimetre
12	Hb Level (X_{11}),	mg/L
13	Systolic (X_{12})	mmHg
14	Diastolic (X_{13})	mmHg
15	Age of pregnant women (X_{14})	Year
16	Age of husband (X_{15})	Year
17	Gestational age (X_{16})	Month
18	Age of the younger child (X_{17})	Month

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RESULTS

Table 2. Model prediction of selected fetal growth (n = 121)

Independent Variable (X_i)	Unstandardized Coefficient		Standardized Coefficient	t	Sig.	R^2	R_{adj}
	B	SE	β				
Constant	-2.338	1.870					
Energy intake (X_1)	0.003	0.001	0.267	2.357	0.020		
Carbohydrate intake (X_4)	-0.025	0.010	-0.277	-2.453	0.016	0.696	0.685
Gestational age (X_{16})	0.841	0.052	0.823	16.052	0.000		
Age of younger child (X_{17})	0.210	0.099	0.109	2.119	0.036		

Source: processed primary data

The backward method in regression involves eliminating the independent variables of the regression model one by one. A regression analysis between the dependent variable (Y), namely fetal growth, and the number of independent variables (Xi) or k value by the rule k+1<n. This research has a sample size of n = 121; therefore, k<120. This regression analysis in this study can include all 17 independent variables (Xi). The significance level in the regression analysis was set at 5% (α = 0.05).

Table 2 describes energy intake (X_1) with a value of ϱ <α (0.0 20), intake of KH (X_4) with a value of ϱ < α (0.016), gestational age (X_{16}) with a value of ϱ < α (0.000) and the age of the younger child (X_{17}) with a value of ϱ<α (0.036) simultaneously influence the fetal growth in Pangkalpinang City. This regression model has R^2 and R_{adj} values of 69.6 percent and 68.5 percent, respectively, indicating that it explains variability in fetal growth in Pangkalpinang City. Other factors can explain other diversity. Based on the R2 and Radj coefficients, the best regression model developed in this study can be used to estimate fetal growth among pregnant women in Pangkalpinang City.

The regression equation that is a model for predicting fetal growth in Pangkalpinang City is stated as follows:

$$\hat{Y} = -2.338 + 0.003X_1 - 0.025X_4 + 0.841X_{16} + 0.210X_{17}$$

This equation indicates that if energy intake (X1), carbohydrate intake (X4), gestational age (X16), and age of the younger child (X17) are zero, the amount of suspected fetal growth ($\hat{Y}$) is reduced by 2.338 centimeters. If energy intake (X_1) is increased by one kilocalorie, fetal growth ($\hat{Y}$) increases by 0.003 centimeters. Similarly, if the gestational age and the age of the smallest child increase by one month, fetal growth increases by 0.841 and 0.210 centimeters, respectively. This equation also states that for each 1-gram increase in carbohydrate intake (X4), fetal growth ($\hat{Y}$) decreases by 0.026 centimeters.

DISCUSSION

The results of this study showed that gesta-tional age was the strongest predictor of fetal growth (β = 0.823) in Pangkalpinang City. The results of this study confirm that fetal growth should align with increasing gestational age.

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This growth chart is often used as a reference to assess growth and calculate size percentiles for a given gestational age. [21] The stages of rapid growth and development and maturation according to gestational age are periods when the fetus is susceptible to stressors such as malnutrition, impaired oxygen supply, infection, or other environmental disturbances. Physiological and metabolic adaptations of the fetus in the most critical periods of short-term development even cause permanent long-term changes in organ morphology, metabolic function, endocrine function, and physiology until postnatal, as a predisposition to the fetal origin of adult disease [22] Recent cohort studies note that decreased fetal growth is associated with young gestational age, stillbirth, and perinatal death. Perinatal mortality and stillbirth increased significantly during a fetal growth decline of ≥50 percent [23].

The growth of the fetus in utero is influenced by many factors, including genetic, physical, environmental, and special conditions of pregnancy[24.] Nutritional intake is a key determinant of fetal growth, especially an adequate maternal energy supply and adequate physical space 25. This study also showed that energy intake is the second-most important predictor of fetal growth after gestational age (β = 0.267). Pregnant women with reduced energy intake are more likely to give birth to babies with LBW. Inadequate macronutrients (protein, fat, and carbohydrate) and micronutrients may inhibit growth, but the optimal mechanism for optimal fetal growth is unclear [25]

The study also noted that carbohydrate intake gave the opposite (negative) prediction on fetal growth. Increased carbohydrate intake yields a different interpretation, whereas, on a broader scale of research, it is recognized as a determinant. This is possible because longitudinal and growth modeling have several weaknesses when conducted in a cross-sectional approach, which is one of the limitations of this study. This modeling can still be considered, as the relationship between suspected fetal growth and the condition's occurrence has been studied theoretically. [26] This model also shows regression and adjustment regression results of 69.6 percent and 68.5 percent, respectively, so they can be used in the decision-making framework for decision-makers in the regions.

The result of this study also identified the younger child's age as a predictor (β= 0.109). There is substantial evidence in some literature that links short (usually less than 18 months) and long (more than 5 years) gestation intervals with infant mortality, stillbirth, preterm birth, and low birth weight. This pregnancy outcome manifests developmental disorders during the fetal period in the womb. It is possible that reducing some nutrient reserves, especially folic acid, acts as a mechanism affecting pregnancy outcomes [27.] However, birth spacing and other predictors are not single-aspect phenomena but depend on various biological, socioeconomic, and demographic factors of families, including lower maternal educational status, low income, and affiliation with a relatively underdeveloped social class [28].

CONCLUSION

Based on this study, it can be concluded that energy intake, carbohydrate intake, gestational age, and age of the younger child are predictors that are responsive to fetal growth in Pangkalpinang City with a regression model

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$\hat{Y} = -2{,}338 + 0{,}003X_1 - 0{,}025X_4 + 0{,}841X_{16} + 0{,}210X_{17}$ with an R2 is 69.6% and R adj of 68.5%. Based on the results of this study, policymakers are expected to consider interventions to improve family socioeconomic conditions, particularly maternal education, family income, and social affiliation. Subsequent fetal growth modeling may consider longitudinal approaches and other indicators of fetal development, such as ultrasound examination with placental biomarkers, as well as a correction to the limitations of this study

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