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Body Mass Index of Pregnant Women and Anemia in Children Aged 6-12 Months in Sidodadi, Pondok Kelapa, Central Bengkulu Regency, Bengkulu, Indonesia

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ABSTRACT

Introduction: Children are more likely to experience psychological and motor developmental difficulties if they or their mothers have anemia. This study aimed to describe the maternal body mass index (BMI) during gestation and the prevalence of anemia in children aged 6-12 months.

Methods: This descriptive study was conducted during integrated service post (posyandu) activities in Sidodadi, Pondok Kelapa, Central Bengkulu Regency, Bengkulu, Indonesia, in February 2023, involving the collection of Maternal and Child Health Handbook (KIA) records and blood sampling on children. A total sample of 35 pairs of mothers and children was collected. The data in this study were analyzed using the Fisher test, with a p-value of <0.05 indicating an association between the variables tested, and employing the International Business Machines Corporation (IBM) Statistical Package for the Social Sciences (SPSS) version 26.0 for Windows.

Results: Underweight mothers had one child with anemia (2.9%), mothers who had normal BMI had five children with anemia (14.3%), overweight mothers had two children with anemia (5.7%), whilst obese mothers had four children with anemia (11.4%). Fisher's exact test results showed no significant difference in the anemia status of children between underweight to normal BMI mothers, as well as when compared to overweight to obese mothers, with a p-value of 0.261 or >0.05.

Conclusion: There was no significant difference in the anemia status of children with underweight up to normal maternal BMI mothers and overweight up to obese mothers.

Highlights:
1. There is still a medium incidence of anemia in infants aged 6-12 months.
2. Pregnant women with high BMI and excessive weight gain are more likely to have anemic infants.
3. Nutrient intake for pregnant women and infants is essential to determining the incidence of anemia.

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Introduction

One of the most serious health cases affecting children and pregnant women worldwide is anemia. According to the World Health Organization (WHO), the worldwide prevalence of anemia in 2019 was 39.8% among children aged 6-59 months.[1] Iron deficiency anemia (IDA) is the most common micronutrient deficiency, affecting approximately 70% of pregnant women and 55-60% of children.[2] Overall, there were more than 1.2 billion cases of IDA in 2016, making it one of the top five global causes of disability.[3] Symptoms of anemia, such as paleness of the skin, conjunctiva, and weakness, are present in most cases of anemia, although they are not typically considered primary complaints.[4]

Iron is essential for brain development, while anemia can lead to insufficient energy metabolism and impaired memory function. Preventing IDA is crucial for infants to ensure their long-term health and development. Anemia can also cause a disturbance in oxygen delivery to tissues, resulting in symptoms such as exhaustion, difficulty concentrating, or reduced productivity. Children are at risk of psychological and motor development problems if they or their mothers suffer from anemia.[5] According to the WHO, a child less than five years old is diagnosed as anemic if their blood hemoglobin level is lower than 11.0 g/dL.[6]

Iron deficiency anemia in infants is still underdiagnosed because most infants do not undergo blood tests unless there is a reasonable clinical event.[7] An increased risk of anemia in children under 6 months of age is associated with maternal obesity, which is exacerbated by maternal anemia during pregnancy.[8] The most common types of anemia occurring during gestation include IDA and anemia caused by acute bleeding. This results in a reduced oxygen-transporting capacity for mother and fetal organs, affecting the health status of the mother and their fetus.[5]

In a Chinese birth cohort study, maternal obesity was associated with a 39% increased risk of anemia in 6-month-old infants, but not in 12-month-old infants.[9] The results for anemia in 12-month-old infants were not statistically significant due to the reduced impact of antenatal factors, such as complementary feeding or treatment of infant anemia within the first 6 months.[9] This study investigated the relationship between maternal body mass index (BMI) during pregnancy and the incidence of anemia in infants aged 6 to 12 months, to identify potential patients at risk of anemia and provide preventive measures accordingly. Antenatal care is also expected to review maternal weight gain during pregnancy and provide education to mothers to maintain a healthy weight.

Methods

This study employed a cross-sectional method, where measurements of variables or data were performed at a single point in time.[10] The number of samples in this study were 35 pairs of mothers and children aged 6-12 months who fulfilled the inclusion criteria: 1) pairs of mothers and children who had pregnancy examination data in the form of Maternal and Child Health Handbook (KIA); 2) mothers did not experience anemia; 3) children aged 6-12 months in Sidodadi, Pondok Kelapa, Central Bengkulu Regency, Bengkulu, Indonesia. Subjects were interviewed, and data on the characteristics of both mothers and children were collected. Hemoglobin levels of child subjects were measured using a hematology analyzer. Data on maternal BMI and weight gain during pregnancy were taken from the KIA records. To describe the BMI of pregnant women and the prevalence of anemia among children aged 6-12 months in Sidodadi, Pondok Kelapa, Central Bengkulu Regency, Bengkulu, Indonesia, Fisher's exact analysis was conducted as an alternative bivariate analysis of the chi-square test when its assumptions were not met. The relationship between variables was then analyzed using the International Business Machines Corporation (IBM) Statistical Package for the Social Sciences (SPSS) version 26.0 for Windows.[11]

Results

Among 35 mother-child pairs, the mean standard deviation (SD) BMI at early pregnancy was 23.79 (4.27) kg/m^2. Out of 35 mothers, five were underweight (14.3%), seven had normal BMI (20.0%), nine were overweight (25.7%), and 14 were obese (40.0%). Based on their occupation, 31 were housewives (88.6%), whilst 21 had received a high school education or more (60.0%). On the other hand, there were 21 male (60.0%) and 14 female children (40%). There were 33 (94.2%) children who received complementary feeding, and all of the children were born full term (Table 1).

Overall, 12 (34.3%) children aged 6-12 months were anemic. Out of the anemic children, 27 (77.1%) had microcytic anemia and 8 (22.9%) had normocytic mean corpuscular volume (MCV) levels (Table 2). Based on the results of the Fisher's exact test analysis, there was no difference in the incidence of anemia in children between mothers with underweight to normal BMI and overweight to obese (17.1%) (Table 3).

There was one anemic child who had an underweight mother (2.9%), five anemic children had normal BMI mothers (14.3%), two anemic children had overweight

mothers (5.7%), and four children had obese mothers (11.4%) (Table 4). Maternal weight gain during pregnancy was classified based on the 2009 Institute of Medicine (IOM) guidelines.[12]

Table 1. Mother and child characteristics

Characteristics	n (35)	%
Mother (Range of Age)		
15-19 years old	5	14.3
20-24 years old	7	20.0
25-29 years old	13	37.1
30-34 years old	6	17.1
35-39 years old	4	11.4
BMI Early Pregnancy (kg/m²)		
Underweight (<18.5)	5	14.3
Normal (18.5-22.9)	7	20.0
Overweight (23-24.9)	9	25.7
Obese (25-29.9)	14	40.0
Gestational Weight Gain (kg)		
Normal	18	51.4
Less	14	40.0
Excess	3	8.6
Work History		
Teacher	2	5.7
Housewife	31	88.6
Private employee	1	2.9
Contract worker	1	2.9
Last Education		
Elementary school	5	14.3
Junior high school	9	25.7
Senior high school	14	40.0
Bachelor	7	20.0
Delivery		
Caesar	13	37.1
Normal	22	62.9
Disease History		
Digestive disease	2	5.7
None	30	85.7
Other	3	8.6
Child (Age/Months)		
6	5	14.3
7	2	5.7
8	3	8.6
9	2	5.7
10	6	17.1
11	3	8.6
12	14	40.0
Gender		
Male	21	60.0
Female	14	40.0
Gestational Age (Weeks)		
37-42 (full term)	35	100.0
Food Consumption History		
Breast milk	2	5.7
Breast milk and complementary feeding	33	94.2
History of Disease		
None	35	100.0

BMI: body mass index
Source: Research data, processed

There was one anemic child who had a mother with underweight BMI and a less than normal weight gain (2.9%), five anemic children with mothers with normal BMI who had a less than normal weight gain (14.3%), and two anemic children with normal BMI mothers who had a less than normal weight gain (5.7%).

Table 2. Anemia status and mean corpuscular volume (MCV) of the child

Anemia Status (g/dL)	n	%
Anemia (<11 g/dL)	12	34.3
Not anemic (≥11 g/dL)	23	65.7
Total	35	100
MCV		
Micrositic (<80 fL)	27	77.1
Normositic (80-100 fL)	8	22.9
Macrositic (>100 fL)		
Total	35	100

Source: Research data, processed

Lastly, three anemic children had obese mothers with normal weight gain (8.6%), and one anemic child had an obese mother with excess weight gain (2.9%) (Table 5).

Table 3. Fisher-exact test

BMI	Anemia Status (n=35)				p-value
	Anemia		Not Anemic		
	n	%	n	%	
Underweight up to normal	6	17.1	6	17.1	0.261
Overweight up to obese	6	17.1	17	48.6	
Total	12	34.3	23	65.7	

BMI: body mass index
Source: Research data, process

Discussion

Based on the results, the age distribution of mothers in this study was within the age group of 25-29 years old. The age characteristics in this study are similar to those in a previous study, where the 25-29 years old age group was also the most common maternal age group.[13] Another study showed that mothers who are younger than 28-year-old are more likely to have anemic children.[14] In contrast, older mothers are more capable of meeting the healthcare demands of their children, resulting in lower risks of anaemic children.[14] A previous study also showed that children born to younger mothers aged 15-29 years old are more at risk of anemia.[13]

Table 4. Mother's body mass index (BMI) and the anemia status of the child

BMI Early Pregnancy (kg/m²)	Anemia Status (n=35)			
	Anemia		Not Anemic	
	n	%	n	%
Underweight	1	2.9	4	11.4
Normal	5	14.3	2	5.7
Overweight	2	5.7	7	20.0
Obese	4	11.4	10	28.6
Total	12	34.3	23	65.7

Source: Research data, processed

Younger children are more prone to suffer from moderate/severe anemia. Specifically, children aged 6-11 months are 4.71 times more likely to develop anemia than older children. Older children have a lower prevalence of anemia due to their increased exposure to and tolerance of iron-rich adult foods.[14] In a study conducted in Jakarta, the prevalence of anemia among children aged 6-36 months was 29.4%, indicating a moderately significant public health concern.[15] The prevalence found in this study was lower than that recorded among children aged 6-59 months in rural areas of Indonesia in 2014 (56.9%) and the data from the 2018 Basic Health Research in Indonesia (38.5%).[15] Special attention must be given, especially for children in the 6-11 months age group, as the prevalence of anemia in this age group was 42.3%, categorizing it as a severely significant public health concern.[15]

In addition to the mother's and child's age, parental occupation and educational background also influence the incidence of anemia in children as risk factors. In a study conducted in Southern Ethiopia, mothers with better incomes are less likely to have anemic children compared to housewives.[16] This is most likely related to the capability of mothers in fulfilling their children's nutritional intake by purchasing appropriate food.[16] Limited household income can affect the accessibility and affordability of nutritional food, contributing to child malnutrition and increasing the risk of anemia.[16]

Table 5. Gestational weight gain and anemia status of the child

Gestational Weight Gain		Anemia Status (n=35)			
		Anemia		Not Anemic	
		n	%	n	%
Underweight	Normal			1	2.9
	Less	1	2.9	3	8.6
	Excess				
Normal	Normal				
	Less	5	14.3	2	5.7
	Excess				
Overweight	Normal				
	Less	2	5.7	4	11.4
	Excess			2	5.7
Obese	Normal	3	8.6	1	2.9
	Less			8	22.9
	Excess	1	2.9	2	5.7
Total		12	34.3	23	65.7

Source: Research data, processed

According to a separate study in Nigeria, occupation was found to be significantly associated with anemia.[17] Results showed that housewives were more likely to be anemic compared to civil servants and dealers, likely due to their limited income, which limits their ability to choose and afford nutritious food.[18] This makes it difficult for housewives to meet adequate nutritional requirements during gestation.[17–19]

Education level enables mothers to access, sort, and effectively utilize nutrition information.[20] One crucial factor is nutritional education, which is essential during pregnancy to maintain the health of both the mother and their infant. One of the available facilities for pregnant women is a series of classes designed to enhance their knowledge.[21]

These classes not only provide mothers and their husbands or families with information for optimizing health during pregnancy, but also prepare them to meet the nutritional needs of infants and breastfeeding mothers. Poor maternal education is significantly associated with an increased prevalence of anemia in infants. This is because maternal education contributes to the mother's perception and understanding of their child's health and nutrition, such as the importance of exclusive breastfeeding and appropriate complementary feeding. Additionally, the mother's education can also influence practices related to their child's healthcare and feeding behavior.[21,22]

According to previous studies, delivery also contributes to the prevalence of anemia in children.[23,24] Children are four times more likely to develop anemia with a history of caesarean delivery due to the weak strength and duration of placental transfusion, which can cause anemia in infants.[23] In this study, it was found that the most common mode of delivery was normal vaginal delivery. The primary difference between this study and previous studies was the small number of children with a history of caesarean delivery, as well as the distinct study design, which focused solely on the variables examined in this study.[25]

This study revealed that the majority of the children in the sample were males. According to studies conducted in Ethiopia and Sub-Saharan Africa, boys have an increased risk of developing anemia.[23,25] This can be explained by the fact that boys experience a higher growth rate than girls during their early childhood. As a result, they require greater amounts of macro- and micronutrients, such as iron, to meet their metabolic needs.[23,25] On the contrary, studies conducted in Indonesia and Southern Ethiopia showed different results, with girls being more at risk of anemia than boys.[15,26] This can be explained by the culture of some communities where gender inequality still privileges boys over girls. As a result, boys' nutritional requirements are often prioritized over those of girls.[15,26]

The incidence of childhood anemia is higher among children who are not exclusively breastfed than among those who are. Additionally, the occurrence of anemia in children is associated with their increased recognition of, need for, and tolerance toward iron-rich adult foods as they age. Studies conducted in Aceh, Indonesia, and Ethiopia have shown that breastfeeding status is associated with the incidence of childhood anemia.[27,28] Children who are not exclusively breastfed are at greater risk of anemia.[27,28]

Breast milk is one of the most essential sources of nutrition for children aged 0-6 months, and it remains crucial until the child is two years old. After six months, breast milk can still provide approximately 5% of a child's iron needs. Although the iron content from breast milk is low in proportion, it has excellent bioavailability values.[29] Iron requirement in infants cannot be fully fulfilled by breast milk. Therefore, 6-month-old infants who are unable to meet their iron intake requirements from complementary foods will have an increased risk of IDA after the age of six months.[30] A study conducted in Nigeria showed that prolonged exclusive breastfeeding without the addition of complementary foods or nutritional supplements increases the risk of anemia.[31] This is due to the growing nutritional

needs of children, which require the intake of a variety of foods, including complementary foods.[31]

Contrary to previous studies, it was found that infants who consumed manually prepared complementary foods were more likely to develop mild IDA due to low hemoglobin concentrations. Iron provided by handmade additional foods often fails to meet the iron needs of infants. By the age of six months, infants' iron storage begins to deplete, increasing the risk of developing IDA. This is particularly true for exclusively breastfed babies, due to the low iron concentrations in breast milk and insufficient additional dietary input.[32]

Obesity and overweight in early pregnancy support a higher risk of IDA for the mother.[33] Several studies from developed and developing countries, as well as recent expert reviews, have highlighted the negative impact of anemia during pregnancy on maternal and newborn outcomes, including the lifelong effect of iron deficiency in newborns.[34,35] In addition, the consequences of anemia in pregnant women include increased risk of maternal and infant mortality, low birth weight, preterm birth, irreversible or partially reversible neurobehavioral and cognitive deficits, as well as short birth length.[34,35]

The potential reasons for reduced hemoglobin levels in obese and overweight women include: 1) poor dietary habits, such as diets low in total iron or animal-sourced iron, coupled with high-calorie diets; 2) increased iron needs due to higher hepcidin levels related to chronic low-grade inflammation associated with obesity.[33] A cohort study in China showed that maternal obesity was linked to an increased risk of anemia in infants at the age of 6 months but not at the age of 12 months, due to the child's complementary feeding needs.[9] Maternal anemia during mid-pregnancy also increases the chance of anemia in 6-month-old children.[9] Although no recent studies have assessed the association of BMI with children's hemoglobin levels or hereditary anemia, there are several studies examining its association with iron index in the umbilical cord conducted in the United States (US) that show an association.[34–36]

This study found that insufficient weight gain during pregnancy increases the likelihood of having anemic children. These findings contrast with the results of a cohort study in China, which found that excessive maternal weight gain increases the risk of child anemia, with adverse effects persisting up to 12 months after birth.[9] The basic mechanisms behind this remain unclear. Some theorists suggest that maternal weight gain may increase blood volume or stimulate the secretion of hepcidin, a biomarker of inflammation and a regulator of iron metabolism.[37] Both increased blood volume and higher hepcidin levels lead to maternal anemia, which may have implications for the health of the offspring. Until now, there have been no studies investigating the relationship between pregnancy weight gain and the incidence of hereditary anaemia. However, two studies examined the association between pregnancy weight gain and hemoglobin concentration or iron index in the umbilical cord and found an association.[35,38]

Strengths and Limitations

The limited sample size and short study period were limitations of this study. Significant bias may occur due to dietary intake affecting hemoglobin levels. Additional bias may also result from the lack of documentation regarding the lifestyle and physical activity of mothers and children. Further research is needed with a larger sample and a wider range of variables. This study can give data for future studies, specifically analytical studies that assess the relationship between BMI and the incidence of anemia in children aged 6-12 months.

Conclusion

Particular attention should be directed toward children under one year of age, as the prevalence of anemia in this age group remains within the medium category. Additionally, based on the mother's BMI at the onset of pregnancy, there appears to be no significant difference in the anemia status of children across different maternal BMI levels.

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Conflict of Interest

The authors declared there is no conflict of interest.

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Ethical Clearance

This study had obtained ethical approval from the Ethics Committee of the Faculty of Medicine and Health, Universitas Bengkulu (No. 21/ UN30.14.9 / LT/ 2023) on 30-01-2023.

Authors' Contributions

Planned the study, wrote the paper, did the statistical analyses: TA. Gave a critical assessment of the paper: NDE and SUF. Had full entry to all data in the study and is responsible for the honesty of the data and the validity of the data analyses: TA. All authors reviewed and approved the final version of the manuscript.

Data Availability

N/A.

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