

A multiple logistic regression analysis of household food insecurity and dietary diversity is associated with anaemia among toddlers in Tasikmalaya, Indonesia

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ABSTRACT

Introduction: Iron deficiency anemia (IDA) is a highly prevalent nutritional deficiency among children worldwide, primarily driven by inadequate iron intake. Iron intake is influenced by a household's ability to access food and the diversity of foods consumed. Households that are constantly unable to meet their food requirements are affected by the quality of nutrients absorbed by the body. Food insecurity is the inability of a household to meet its nutritional needs due to food unavailability. This study aimed to investigate the relationship between household food insecurity and dietary diversity and the incidence of anemia among toddlers.

Method: This cross-sectional study was conducted in Kawalu, Tasikmalaya, West Java, Indonesia, involving 142 toddlers aged 24-59 months selected using proportional random sampling. This study collected data on household food insecurity using the Food Insecurity Experience Scale (FIES) questionnaire, food diversity using the Household Dietary Diversity Score (HDDS) questionnaire, and iron intake using a Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ). Additionally, the incidence of anemia was determined using blood samples analyzed with a hematology analyzer. Data analysis was performed using SPSS software for univariate, chi-square, and logistic regression tests (p-values ≤ 0.05).

Results: This study found that Household-level food insecurity was associated with anemia incidence in toddlers

($p = 0.049$). Additionally, household dietary diversity was significantly related to anemia incidence ($p = 0.037$), and there was a relationship between toddler iron intake and anemia incidence ($p = 0.050$). However, multivariate logistic regression revealed that iron intake was the only significant determinant of anemia incidence ($p = 0.050$). Adequate iron intake demonstrated a protective effect against anemia (OR = 0.363, 95% CI: 0.132 – 1.000), whereas household food insecurity and dietary diversity did not show statistically significant effects in the multivariate model.

Conclusion: Iron intake is the most critical determinant of anemia in toddlers and offers a protective effect. Household food insecurity and dietary diversity were statistically significant risk factors. Interventions should focus on enhancing family food security and educating on iron-rich diets. Further research exploring other nutritional factors, such as protein, vitamin B12, and folic acid, is warranted to establish a comprehensive framework for anemia prevention.

KEYWORDS

Dietary diversity, food insecurity, iron intake, anaemia incidence, toddler.

INTRODUCTION

Anemia is characterized by a reduced number of erythrocytes or decreased hemoglobin concentration in the blood, resulting in an insufficient capacity of the blood to transport oxygen to meet the body's physiological requirements¹. Physiological needs vary depending on age, sex, altitude above sea level, smoking, and stage of pregnancy². Iron deficiency anemia is the most prevalent type of anemia and the

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most common form of nutritional deficiency among children worldwide, particularly in developing countries, including Indonesia³. Iron deficiency refers to a reduction in the total iron stores in the body. Iron deficiency anemia develops when this deficiency becomes severe enough to impair erythropoiesis, resulting in anemia. Iron is an essential element in red blood cell formation. Iron can be obtained from foods derived from animal meat, nuts, and green vegetables⁴.

Food is a basic necessity for all living things to survive and sustain life. The need for food also increases with the population growth of the region. The quality of food intake is determined by a household's capacity to access food. Household capacity to obtain and access food is a critical factor closely associated with household food security. Economic access plays a crucial role in improving food security⁵. A family's inability to meet basic food needs hinders efforts to escape the shackles of poverty.

Continually neglected food needs eventually lead to serious food problems that can trigger health issues. Food insecurity is a condition in which a region, community, or household experiences insufficient food at a given time to meet the physiological needs for growth and health⁶. Inability to obtain enough food will impact the quality of food and the nutrients absorbed by the body. Low intake of iron, protein, vitamin C, and zinc can cause anemia in toddlers⁷. The factors associated with anemia incidence in toddlers in Indonesia are 1) age group, 2) number of households, 3) economic status, and 4) food intake. Toddlers aged 24-35 months and 36-59 months were 4.0 and 1.9 times more at risk of developing anemia than toddlers aged 0-5 months, respectively. Families with better economic status can prevent anemia in their toddlers. Toddlers who do not consume meat have a 6.4 times greater risk of developing anemia than those who do. Similarly, toddlers who did not consume vegetables had a 2.1 times greater risk of developing anemia than those who did. Toddlers who do not drink milk have a 2.5 times greater risk of developing anemia than those who do.

The prevalence of anemia among toddlers in Indonesia has shown an increasing trend recently. Data from the Basic Health Research in 2007, 2013, and 2018 showed that the prevalence of anemia in toddlers aged 0-59 months was 27.7%, 28.1%, and 38.5%, respectively⁸⁻¹⁰. However, the effects of anemia in toddlers include mortality and delays in psychomotor, cognitive, behavioral, and physical development. Epidemiologically, the highest prevalence occurs during late infancy and early childhood due to iron deficiency during pregnancy and childhood growth spurts, coupled with low dietary iron intake or the use of iron-deficient formula milk¹¹.

A preliminary study was conducted on 14 toddlers in Karanganyar Village on food insecurity using the Food Insecurity Experience Scale (FIES) and iron intake using a food recall. The results showed that 11 families of toddlers were

food insecure and 13 toddlers did not meet the recommended daily iron intake. Based on these considerations, researchers have analyzed the association between household-level food insecurity and iron intake with the incidence of anemia in toddlers aged 24-59 months. This study aimed to analyze the relationship between household-level food insecurity and diversity and the incidence of anemia in toddlers aged 24-59 months in Karanganyar Village, Kawalu District, Tasikmalaya City.

METHODS

Study Design and Data Collection

This study employed a quantitative approach with a cross-sectional design. A cross-sectional design is an analytical design that measures variables at a specific period of time¹². This study was conducted in Tasikmalaya, West Java, Indonesia. The study population consisted of 828 toddlers aged 24-59 months living in Karanganyar Village, Kawalu Sub-district. However, 142 toddlers were selected as the study respondents using proportional random sampling. Respondents who participated in an integrated health post (Posyandu) were selected based on the inclusion criteria: toddlers aged 24-59 months, living in Karanganyar village, and having caregivers who participated voluntarily. Toddlers with a history of infectious diseases, including diarrhea, typhoid fever, tuberculosis, or fever within two weeks before data collection, were excluded from the study. This research has received approval from the IPB University Ethical Commission with number: 855/IT3.KEPMSM-IPB/SK/2023.

Sampling Technique

The sampling technique used in this study was proportional random sampling. At each integrated health post (Posyandu), several toddlers were selected based on the number determined from the calculation of the number of samples at each Posyandu. Names of toddlers aged 24-59 months obtained from secondary data in Posyandu were then grouped based on area, and the toddlers' names were selected by randomization. The names were then compared with the inclusion and exclusion criteria, and randomization was carried out again if the selected name did not meet the criteria.

Quantitative Data

1. Household Food Insecurity

Household food insecurity was assessed using the Food Insecurity Experience Scale (FIES), an instrument developed by the Food and Agriculture Organization (FAO) in 2013. The FIES is used as a global benchmark for comparing the prevalence of food insecurity between countries and regions, adapted to suit different cultures and languages without altering its original meaning. The FIES consists of eight questions arranged in order of general experience of food insecurity worldwide¹³.

2. Toddlers' Food Diversity and Iron Intake

Food diversity and Iron Intake were examined using the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ). The SQ-FFQ assesses an individual's nutritional habits over a specific period. This method assesses food consumption based on the general principle of food consumption frequency as a risk factor for malnutrition. This method is used to determine the specific selected nutrient intake and the quantity, type, and frequency of specific food intake¹⁴. The SQ-FFQ questionnaire covered the last three months.

3. Anemia Incidence

Anemia status was analyzed using a hematology analyzer. A hematology analyzer is a device used to perform automated hematology tests. A 10 ml blood sample was drawn from the cubital vein. The samples were then tested using a Sysmex XN-550 hematology analyzer.

Statistical Analysis

Univariate analysis was used to examine the frequency distribution of the respondents' characteristics, independent variable (household food insecurity), control variable (iron intake), and dependent variable (anemia incidence). A distribution table was used to present the data for each variable. Data analysis using chi-square and logistic regression ($p\text{-value} \leq 0.05$) was performed with SPSS 25 for Windows to investigate the relationship between variables.

RESULT

The respondent characteristics in this study included age, gender, number of household members, maternal age, and family income. However, the caregivers involved in this study were mothers. The respondent characteristics, food insecurity, food diversity, iron intake, and anemia incidence are presented in **Table 1**.

Table 1 shows that most toddlers involved in this study were aged 36-47 months (38%), female (52.1%), and were not the first child (76.1%). Most toddlers had no history of previous worm infestation (97.9%). Based on maternal age characteristics, the majority were aged 26-35 years, which was categorized as early adulthood (44.4%). The highest level of maternal education was elementary school (48.6%), and the highest income level was low income or below the minimum wage (UMK) (69%).

As shown in **Table 1**, 55.6% of the households experienced food insecurity. Most households with sufficient food diversity were in the adequate dietary diversity category (86.6%). The majority of toddlers' iron intake was inadequate (85.9%). Meanwhile, fewer toddlers experienced anemia (76.8%).

Table 2 shows that the median total iron intake was lower than the established recommendation of 7 mg/day for infants

Table 1. Characteristics of the respondents in this study

Variable (s)	n = 142	%
Age (months)		
24 – 35	49	34.5
36 – 47	54	38
48 – 59	39	27.5
Sex		
Male	68	47.9
Female	74	52.1
Birth order		
1 st born	34	23.9
2 nd born and after	108	76.1
Caregiver's age (years)		
17 – 25	22	15.5
26 – 35	63	44.4
36 – 45	47	33.1
> 45	10	7
Caregiver's education		
< Elementary school	169	748.6
Elementary school		
Junior High School	42	29.6
Senior High School	30	21.1
Household Income (monthly)		
Low (< regional min. wage)	98	69
High (≥ regional min. wage)	44	31
Food Insecurity		
Food Insecure	79	55.6
Food Secure	63	44.4
Food Diversity		
Inadequate Dietary Diversity	19	13.4
Adequate Dietary Diversity	123	86.6
Iron Intake		
Inadequate	122	85.9
Adequate	20	14.1
Anemia Incidence		
Anemic	33	23.2
Not Anemic	109	76.8

Table 2. Overview of Iron Intake, Enhancers, Inhibitors, Erythrocyte Indices, and Molar Ratio

Variables	Median $\pm$ SD	Min	Max
Iron Intake			
Iron total (mg/day)	4.7 $\pm$ 4.1	0.7	26.4
Fe Heme (mg/day)	4.1 $\pm$ 4.1	0.7	26.2
Fe Non-Heme (mg/day)	0.5 $\pm$ 0.7	0.0	5.2
Iron Enhancer			
Vitamin C (mg/day)	14.3 $\pm$ 41.2	0.0	281.2
Iron inhibitor			
Phytic Acid (mg/ day)	231.5 $\pm$ 348.8	10.0	1,812
Tannin (mg/ day)	9.5 $\pm$ 73.4	0.0	567
Calcium (mg/day)	94.7 $\pm$ 247.8	1.9	1,434
Erythrocyte Index			
MCV (fL) MCH	76.4 $\pm$ 6.8	54.8	83
(pg) MCHC*	25.5 $\pm$ 2.74	16.2	29.2
(%)	33.1 $\pm$ 1.1	28.8	35.9
Molar Ratio			
Phytic Acid:Iron	8.7 : 1	0.2	24.65
Vitamin C:Iron	1.8 : 1	0.0	71.81

*MCHC: Mean Corpuscular Hemoglobin Concentration.

and toddlers. The median heme and non-heme iron intakes were below the recommendation, at 75% and 25%, respectively, of the total daily iron requirement. The median iron enhancer intake of respondents was lower than the established recommendation of 40 mg for toddlers aged 24-36 months and 45 mg for toddlers aged 37-59 months¹⁵. The median levels of iron inhibitors, tannin and calcium, were below the limits that inhibit iron absorption, at <10.5 g/day and 300 mg/day, respectively. The median phytic acid intake exceeded the inhibitory limit of 0.33 g/day¹⁶. The reference values for MCV are 82-92 fL, MCH 27-31 pg, and MCHC 32-36%¹⁷. **Table 2** shows that the median MCV and MCH values were low at 76.4 fL and 25.5 pg, respectively. However, the other hand, was within the normal range. Additionally, the average phytic acid-to-iron ratio was high, above 8.7:1, suggesting that phytic acid interferes with the absorption of iron. The vitamin C to iron ratio was low (below 2:1), which prevented optimal absorption.

Bivariate Analysis

Bivariate analysis was conducted to measure the relationship between the independent variables (household-level food insecurity and iron intake) and the dependent variable (incidence of anemia in toddlers). The relationship was analyzed using the chi-square test.

The Relationship between Household Food Insecurity, Food Diversity, and Iron Intake with the Incidence of Anemia

Table 3 shows that 26.6% of toddlers from households with food insecurity were anemic, while 73.4% of toddlers

Table 3. Relationship between food insecurity and food diversity, and anemia incidence

Variables	Anemia Incidence				Total		p-value	OR	95%CI
	Anemic		Not Anemic						
	n	%	n	%	N	%			
Food Insecurity									
Low	12	30,8	27	69,2	39	100	0,049	1,539	0,689 – 3,434
Moderate	17	27,4	45	72,6	62	100			
Secure	4	9,8	37	90,2	41	100			
Food Diversity									
Low Diversity	12	37,5	20	62,5	32	100	0,037	0,864	0,266 – 2,810
Moderate	9	14,3	54	85,7	63	100			
High	12	25,5	35	74,5	47	100			

were not anemic. Among respondents who were categorized as food secure, only 19.0% of toddlers experienced anemia, while the remaining 81.0% of toddlers did not experience anemia. The results of the chi-square statistical test showed a p-value of 0.291 (≥ 0.05), which indicates that there is no relationship between food insecurity and the incidence of anemia in toddlers.

Table 3 shows that 37.5% of respondents from households with low dietary diversity experienced anemia, while the majority of the remaining 62.5% did not. In households with moderate dietary diversity, 14.3% of the toddlers experienced anemia and 85.7% did not. In the household group with high dietary diversity, 25.5% of toddlers experienced anemia, whereas the remaining 74.5% did not. The results of the chi-square test obtained a p-value of 0.037 (≤ 0.05), indicating a relationship between household-level dietary diversity and the incidence of anemia in toddlers.

As shown in Table 4, in the group of toddlers with inadequate iron intake, 20.5% of toddlers experienced anemia, while 79.5% did not. Likewise, in the group of toddlers with adequate nutritional intake, 40.0% of toddlers experienced anemia, while 60.0% did not. The results of the chi-square statistical test showed a p-value of 0.083 (≥ 0.05), indicating that there was no relationship between iron intake and the incidence of anemia in toddlers. The Odds Ratio value of 0.387 indicates that toddlers with adequate iron intake have a 0.387 times smaller chance of developing anemia than toddlers with inadequate nutritional intake.

Logistic Regression Modeling

Logistic regression modeling was performed to determine the most dominant variables associated with the incidence of anemia in toddlers, which was carried out in stages.

Selection of Model Candidates

The selection of candidate variables that entered the model was performed using a bivariate analysis of each independent variable with the dependent variable. Variables that entered the modeling variable should have a p-value ≤ 0.25 .

Table 5 shows that food insecurity, food diversity, and iron intake did not meet the statistical criteria ($p \leq 0.25$) for inclusion in the multivariate model. However, these variables were still analyzed multivariately because they are substantially important variables related to the incidence of anemia.

Table 5. Results of Bivariate Analysis of Independent Variables with Dependent Variables

Variables	P value	Multivariate Candidate
Food Insecurity	0,049	Included in modeling*
Food Diversity	0,037	Included in modeling*
Iron Intake	0.050	Included in modeling*

*important substance.

Multivariate Modeling of Factors Causing Anemia Incidence

Variables that entered the candidate model were then analyzed with the dependent variable. Variables with a p-value > 0.05 were removed gradually, starting from the variable with the largest value; thus, the variables included in the next model were those with a p-value ≤ 0.05 .

Table 6 presents the results of the multivariate model analysis for the incidence of anemia in toddlers. Three models were analyzed with different independent variables. Model 1 included food insecurity, food diversity, and iron intake. The re-

Table 6. Results of Multivariate Model Analysis of Anemia Incidence

No	Variables	Multivariate Model 1	Multivariate Model 2	Multivariate Model 3
1	Food Insecurity	0.245	0.248	-
2	Food Diversity	0.676	-	-
3	Iron Intake	0.050	0.050	0.062

Table 4. Relationship between iron intake and anemia incidence

Iron Intake	Anemia Incidence				Total		p value	OR	95%CI
	Anemic		Not Anemic						
	n	%	n	%	n	%			
Inadequate	25	20,5	97	79,5	122	100	0,05	0,387	0,143 - 1,048
Adequate	8	40,0	12	60,0	20	100			

Table 7. OR Changes

Variables	Exp (B) 1	Exp (B) 2	OR Changes
Food Insecurity	1.625	1.619	0.006 (0.37%)
Food Diversity	0.773	-	-
Iron Intake	0.363	0.370	0.007 (1.93%)

sults showed that iron intake was significantly associated with the incidence of anemia, but food insecurity and food diversity variables were not significantly associated with the incidence of anemia. Model 2 shows that there is no significant relationship any between of the variables. Model 3 showed that there was no significant relationship for iron intake.

Final Modeling

After analyzing the results of the multivariate model up to the 3rd model, although the three models do not meet the requirements, in substance or theoretically, these two variables (food insecurity and food diversity) are the main variables of this research; therefore, they are still forced into the logistic regression model.

Table 8 shows that household food insecurity and food diversity were not significantly related to anemia incidence ($P > 0.05$). In contrast, iron intake was significantly associated with the incidence of anemia in tod with ($p \leq 0.05$). The results indicated that iron intake was the only significant determinant in the model. The OR for iron intake was 0.363, implying that adequate iron intake substantially lowers the odds of developing anemia among toddlers and acts as a protective factor against it. Food insecurity and dietary diversity did not significantly affect the incidence of anemia in this population.

Table 8. Final Model of Multivariate Analysis of Anemia Incidence

No	Variables	β	p-value	OR	95% CI
1	Food Insecurity	0.486	0.245	1.625	0.717 – 3.684
2	Food Diversity	-0.258	0.676	0.773	0.230 – 2.590
3	Iron Intake	-1.014	0.050	0.363	0.132 – 1.000

DISCUSSION

The relationship between household food insecurity and food diversity with the incidence of anemia among toddlers

Food insecurity is a condition of insufficient food at a given time to meet physiological and health needs⁶. Food insecurity

influences food quality and quantity, directly affecting nutrient intake. The study results showed that 55.6% of households experienced food insecurity at the food insecurity level, and 44.4% of households were food secure. The data indicated that more households experienced food insecurity in the insecure category. There are three interrelated indicators of food security: food availability, where sufficient food is available to meet needs in both quantity and quality; affordable food access for households; and consumption, where each household has access to sufficient food and can manage it according to nutritional and health standards¹⁵. If these aspects are not met, a household is categorized as food insecure.

Household food insecurity is characterized by mothers' concerns about being unable to provide food for the family, provide a nutritious and balanced diet, purchase affordable food, and reduce family meal portions. Household food consumption is influenced by food availability, which is influenced by household purchasing power and access to food availability. Family income is related to household food security¹⁶. The results of this study indicate that the majority of respondents' household incomes are still low or below the 2023 Tasikmalaya City Minimum Wage (Rp. 2,533,341) (Table 1). This low income level impacts quality food choices and household purchasing power¹⁷. Families with low economic status lack access to iron-rich foods and cannot always guarantee the availability of other food items¹⁸.

Furthermore, low-income households often choose animal and vegetable side dishes at affordable prices according to their means. The prepared vegetables are often sourced from rice paddies or fields, with limited crop variety, resulting in simple and unvaried daily menus. Household size, or the number of family members, is the number of people living in a household and remains the responsibility of the head of the family¹⁹. Based on the research results, the majority

of household members (ART) respondents fell into the small household category (Table 1). The larger the number of household members, the greater the number of dependents in the household, and the more difficult it is to manage daily food expenditures. This results in insufficient food quality and quantity for the family members.

Consuming food that is consistently less than adequate over a period of time can lead to malnutrition and nutritional problems. Children from low socioeconomic backgrounds are at a higher risk of developing iron deficiency, primarily due to inadequate iron intake or a lack of bioavailable iron-rich foods²⁰. The results of this study align with those of previous studies that found that toddlers living in food-insecure households had lower average nutritional adequacy levels (energy, protein, calcium, iron, and zinc) than those living in food-secure households. This condition can make toddlers vulnerable to malnutrition, including anemia.

The results of this study showed that in the group of toddlers living in food-insecure households, 26.6% had anemia and 73.4% did not. Among respondents categorized as food-secure, only 19.0% had anemia, whereas the remaining 81.0% did not. Meanwhile, the Chi-square statistical test results showed a p -value of $0.049 \leq 0.05$, indicating that there is a relationship between food insecurity and the incidence of anemia in toddlers. This is not in line with the findings of the previous study, a p -value of 0.000 was obtained, indicating an overall positive relationship between food insecurity and the risk of anemia (OR=1.27; 95% CI 1.13, 1.40). Furthermore, the study also revealed that food insecurity can increase the risk of iron deficiency anemia (OR=1.4; 95% CI 1.04, 1.86)²¹.

Various factors contribute to the increased incidence of anemia in toddlers, including food insecurity, lack of dietary diversity, stunting, and worm infestation. Toddlers from food-insecure families had a 2.87 times higher risk of developing anemia than those from households with adequate access to food. This occurs because toddlers from food-insecure households lack a nutritious diet containing high-biological-value protein, iron, microminerals, and other nutrients that can increase the risk of anemia in toddlers²². Toddlers from households experiencing food insecurity tend to have limited access to nutritious food, making them more susceptible to developing anemia. The results of this study also indicate that the respondents' low iron intake was due to inadequate iron intake (Table 2). As presented in Table 2, the median total iron intake was 3.5 mg/day, which is below the recommended dietary allowance of 7 mg for toddlers aged 12-36 months and 10 mg for those aged 37-59 months. Based on the results of the study, the median MCV and MCH ranges of respondents were low, namely 76.4 fL and 25.5 pg, respectively (Table 3). Therefore, it can be classified that the anemia experienced by toddler respondents aged 24-59 months in Karanganyar Village, Kawalu sub-district, Tasikmalaya City is included in the group of microcytic hypochromic anemia. Microcytic hypochromic anemia is characterized by red blood cells that are smaller than normal and exhibit reduced coloration (hypochromic) due to decreased hemoglobin content. The main causes of this type of anemia are insufficient iron intake due to reduced iron intake from food, poor absorption of iron from the intestines, and insufficient intake of vitamin C²³.

The findings in Table 2 show a low molar ratio of vitamin C to iron of 1.8:1. This result is lower than the ideal molar ratio of vitamin C to iron, which is 2:1. Meanwhile, the high molar ratio of phytic acid to iron (8.7:1) is higher than the ideal phytic acid to iron ratio of 1:1²⁴. These findings reveal that vitamin C does not increase iron absorption, whereas high phytic acid intake inhibits iron absorption. The intake of iron enhancers and inhibitors depends on the food source. A previous study indicates that households experiencing moderate to severe food insecurity tend to allocate more expenditures to carbohydrate sources or staple foods such as cereals, rice, and vegetables compared to food-secure households. The ANOVA test results revealed significant differences in the average expenditure across all food groups based on food security levels. The study also revealed a significantly lower consumption of meat, milk, and fat in food-insecure households. Furthermore, highly food-insecure households consumed fewer fruits. Consumption of foods such as cereals, rice, and vegetables was higher in the food-insecure group, indicating a consumption pattern heavily reliant on affordable and nutritionally less varied foods.

Cereals are a source of minerals, but their bioavailability is relatively low because they contain antinutritional compounds such as phytic acid, trypsin inhibitors, and polyphenols²⁵. Phytic acid is the most predominant and is almost always present in cereals. Phytic acid has a high ability to form complexes with metal ions, such as zinc (Zn), calcium (Ca), and iron (Fe), preventing these minerals from being effectively absorbed by the human body. Therefore, a higher cereal intake tends to increase the molar ratio of phytic acid to Fe. Vegetables and fruits, both fresh and processed, are the primary sources of vitamin C. However, fruits generally contribute more to vitamin C intake than vegetables²⁶ do. Households experiencing food insecurity tend to consume less fruit, a source of vitamin C that can act as an iron enhancer. Therefore, the intake of antinutritional compounds obtained from consuming larger amounts of cereals, as well as a lack of fruit intake, can inhibit the bioavailability of iron, thereby increasing the risk of anemia²⁷.

The relationship between iron intake with the incidence of anemia among toddlers

Most toddlers in this study had inadequate iron intake (85.9%) (Table 1). It is known that toddlers with insufficient iron intake do not experience anemia as much (20.5%), while toddlers with insufficient iron intake who experience anemia are as many as (79.5%) (Table 4). The results of the chi-square statistical test obtained a p -value of 0.050 (≤ 0.05). This significance indicates that there is no relationship between iron intake and the incidence of anemia in toddlers aged 24-59 months in Karanganyar Village. Although 8 toddlers (40%) had adequate iron intake, they still suffered from anemia because their iron requirements were at or near the limit of adequate iron intake, bordering on inadequate iron intake. They also had low MCV values, bordering on adequate iron intake.

The main cause of anemia is insufficient iron intake. Iron is necessary for the synthesis of hemoglobin. Hemoglobin is an iron-containing protein (metalloprotein) found in erythrocytes that functions to bind and transport oxygen from the lungs to tissues throughout the body. Hemoglobin levels lower than the recommended limit can be categorized as anemia²⁸. Toddlers are a vulnerable group for iron deficiency as their iron needs increase during growth²⁹. A lack of iron in the diet can lead to iron deficiency.

The results of this study indicate that the respondents' low iron intake was due to insufficient iron consumption (Table 2). As presented in Table 2, the median total iron intake was 3.5 mg/day, which is below the recommended dietary allowance (RDA) of 7 mg for toddlers aged 12-36 months and 10 mg for those aged 37-59 months.

The erythrocyte index is a hematological examination parameter used to determine the type of anemia based on morphology. The reference values of Mean Corpuscular Volume) is 82-92 fL, MCH (Mean Corpuscular Hemoglobin) 27-31 pg, and Mean Corpuscular Hemoglobin Concentration) 32-36% (Mersil, 2021). Based on the results of the study, it was found that the median MCV and MCH of respondents were low, namely 76.4 fL and 25.5 pg, respectively (Table 1). However, the MCHC value in the study results was within the normal range of 33.1% (Table 1). Therefore, the anemia experienced by respondents aged 24-59 months in Karanganyar Village, Kawalu District, Tasikmalaya City, can be classified as microcytic hypochromic anemia. Microcytic hypochromic anemia is characterized by lower-than-normal MCV and MCH values¹⁷.

Iron absorption is influenced by both enhancers and inhibitors. Research shows that the median intake of vitamin C is 14.3 mg/day. This is lower than the recommended intake of 40 mg/day for children aged 24-36 months and 45 mg/day for children aged 37-59 months. Vitamin C can aid iron absorption, but if iron intake is limited, its function as an enhancer cannot function. Based on the research results in Table 2, the molar ratio of vitamin C to iron was low, namely 1.8:1. This result is lower than the ideal molar ratio of vitamin C to iron (2:1). A higher molar ratio increases iron absorption²⁴. The data obtained indicate that vitamin C does not increase iron absorption.

The median intake of tannins was 9.5 mg, and that of calcium was 94.7 mg (Table 2). These results are below the inhibitory limits of <10.5 g/day and 300 mg/day, respectively. The median phytate intake was above the inhibitory limit of 231.5 mg (Table 2), which is 0.33 g/day¹⁶. Based on Table 2, the molar ratio of phytic acid to iron was high at 8.7:1, which is higher than the ideal phytic acid-to-iron ratio of 1:1²⁴. These results indicate that phytic acid inhibits iron absorption. Therefore, in this study, the factor causing anemia was an iron inhibitor, namely phytic acid. The results of this study align with a previous study on 20 toddlers aged 24-59 months in Jangli Village, Semarang City. The study demonstrated no

significant association between iron intake and hemoglobin concentrations in toddlers aged 24-59 months³⁰.

Multivariate analysis demonstrated that iron intake was the sole significant determinant of anemia in toddlers in this study ($p=0.050$). This phenomenon aligns with the UNICEF conceptual framework of nutrition³¹, which categorizes nutrient intake as a proximal (immediate) determinant essential for hemoglobin synthesis. Household food insecurity and dietary diversity act as distal (underlying) determinants. Therefore, when evaluated simultaneously in a multivariate model, the direct biological and physiological effects of iron intake statistically overshadow the indirect socio-environmental effects of food security and dietary diversity. This emphasizes that direct interventions focusing on improving actual iron consumption, such as targeted supplementation or iron-fortified foods, are paramount for immediately reducing anemia incidence, even in households facing food insecurity.

CONCLUSIONS

The findings of this study indicate that household food insecurity and dietary diversity are significantly associated with anemia incidence among toddlers in Tasikmalaya, Indonesia ($p\leq 0.05$). Additionally, bivariate analysis showed that toddlers' iron intake alone was directly related to the incidence of anemia. However, multivariate analysis revealed that iron intake was the primary determinant of anemia ($P=0.050$), yielding an OR of 0.387. This implies that adequate iron intake substantially lowers the odds of developing anemia and serves as a protective factor against it. Efforts to improve food security and dietary diversity at the household level are essential for preventing anemia in toddlers. Furthermore, there is a need to increase nutritional knowledge regarding food diversity, especially iron-rich foods, among household food providers. Further studies are needed to investigate other variables that can influence the incidence of anemia, such as the intake of protein, vitamin B12, and folic acid, to complement this study.

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