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Modeling hidden hunger in toddlers to determine the most influential micronutrients in stunting

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ABSTRACT

Background: Risk factors that directly influence the incidence of stunting are the level of macronutrient and micronutrient intake. Micronutrient deficiencies cause about 1.1 million of the 3.1 million annual child deaths. This condition leads to hidden hunger, a condition of insufficient intake of micronutrients (especially iron, zinc, and iodine deficiencies). This study aimed to analyze hidden hunger in stunted and non-stunting toddlers with a multivariate model.

Methods: A comparative cross-sectional study. A total of 71 toddlers were taken as respondents for the stunting group and 71 toddlers for the non-stunting group. The study used data collection was 2 x 24-hour food recall, FFQ, and blood serum collection to check zinc deficiency, iodine, hemoglobin, and urine tests. For data analysis, multivariate logistic regression and then bivariate analysis were used. The regression method used is "backward". Data was considered statistically significant with a p-value of <0.05.

Results: Toddlers with stunting were much more likely to have inadequate iron (92.95%) and zinc intake (91.54%) compared to the non-stunting group (78.87% and 77.46% respectively). A significantly higher proportion of the stunting group (40.84%) had anemia compared to the non-stunting group (5.63%). Unlike iron, zinc, and anemia, there wasn't a statistically significant relationship between iodine deficiency (p = 0.459) or hidden hunger (p = 0.058) and stunting. The results of the multivariate analysis suggest that iron intake, anemia status, and zinc deficiency are all important risk factors for stunting in toddlers. The anemia status variable was the most dominant cause of stunting because it had the highest OR value of 41.733.

Conclusion: Toddlers with stunting are significantly more likely to have inadequate iron and zinc intake and suffer from anemia compared to non-stunted toddlers, with anemia being the most dominant risk factor for stunting, evidenced by the highest OR value of 41.733.

KEYWORDS

Malnutrition, Growth Impairment, Biomarkers, Risk Factors, Nutritional Deficiency.

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INTRODUCTION

Some Indonesians are known to still have nutritional problems until now, one of which is the low fulfillment of micronutrients, leading to hidden hunger. According to data from the Global Hunger Index in 2020, Indonesia is in position 70 out of 107 countries, and around 20-40 percent of people in Indonesia experience micronutrient deficiencies[1]. In addition, other malnutrition problems include stunting, wasting, and underweight, which are growth disorders in children under 5 years old due to malnutrition[2,3].

Based on the Indonesian Basic Health Study of 2018 carried out by the Ministry of Health of Indonesia, the prevalence of stunting problems in toddlers was 30.79%, the prevalence of wasting in toddlers was 10.19%, and the prevalence of underweight was 17.68%[4]. Based on the results of the Indonesian Nutritional Status Survey, known as SSGI, in 2019[5], the prevalence of stunting was 27.7%; in 2021, it was 24.4%; while in 2022, stunting toddlers decreased by 2.8%; then, the stunting rate in 2022 was 21.6%. There are 18 provinces with high prevalence (30-40%), and according to the SSGI Data of 2021, the stunting prevalence of West Java Province reached 24.5%, slightly above the national average stunting rate of 24.4%[6].

According to Marivoet et al. (2021), hidden hunger is the presence of multiple micronutrient deficiencies (particularly iron, zinc, iodine, and vitamin A), which can occur in the absence of an energy intake deficit as a result of consuming an energy-dense but nutrient-poor diet[7]. Iron, zinc, and iodine are micronutrient deficiencies of global concern due to their high prevalence and associated health consequences[8]. According to Godecke (2018), common proxies used in measuring hidden hunger include stunting children, wasting, micronutrient availability below recommended thresholds of micronutrient intake, and deficiency status in the body[9].

The high prevalence of stunting in Indonesia is also followed by a high prevalence of wasting in toddlers and malnutrition in toddlers[10]. West Java is the province with a stunting rate above the average Indonesian stunting rate. Tasikmalaya City has three urban villages with above-average stunting rates and is now facing severe public health problems related to hidden hunger, a condition of insufficient micronutrient intake (vitamins and minerals) in toddlers. This study was conducted to determine the effect of hidden hunger (micronutrient deficiencies) on the incidence of stunting in children under five in Tasikmalaya City.

METHOD

Study Design

A comparative cross-sectional study was conducted over four months in Karanganyar village, Kawalu sub-district, which has the highest prevalence of stunting. The selected toddlers must meet the inclusion criteria, such as the chosen stunting toddlers being in good health and their mothers being willing to participate, as evidenced by the mother signing informed consent. The chosen non-stunting toddlers were not obese or in good health, and their mothers were willing to participate, as evidenced by the mother signing informed consent. The population in this study were all toddlers aged 1-5 years in Karanganyar village, Kawalu sub-district, which had the highest prevalence of stunting (26.42%), totaling 822 toddlers.

The sample calculation was determined by the sample size formula to estimate the proportion of the population with absolute precision (Lwanga and Lemeshow 1991), and a sample that met the inclusion criteria of 71 people for one stunting group (case) was obtained. For the control group (non-stunting), as many as 71 people, the total sample size was 142. The sampling technique was purposive sampling. The flowchart of the participant selection procedure is described in Figure 1.

Data Collection

Demographic data included the toddler's age (in months), gender of the toddler, mother's age, mother's latest education, and family income level. Anthropometric data, micronutrient intake, iron, zinc, and iodine deficiency as hidden hunger modeling were conducted with the following details.

Quantitative Data

<u>Micronutrient Intake</u>

The method used to determine the intake of micronutrients and macronutrients was using the food frequency method

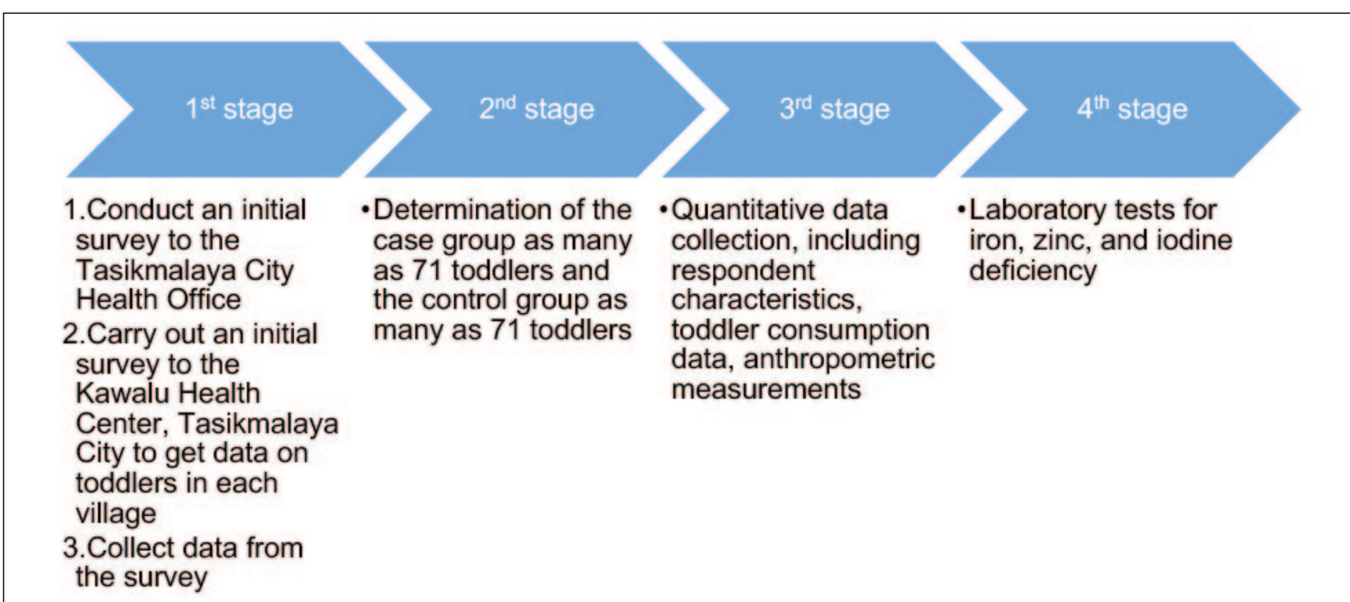

Figure 1. Flow chart of the whole research.

(Food Frequency Questionnaire). The FFQ method was used to find out or obtain data about individuals' eating patterns and habits at a certain time. The information obtained was eating patterns and habits (habitual intakes). Food consumption that was asked is food containing micronutrients such as iron, zinc, and iodine. The steps in collecting data using the food frequency method were:

a. Prepare the FFQ form.

b. Introduce and explain the purpose of data collection to the respondents.

c. Ask for the types of food that could be eaten in the last month. The officer invited the respondents to mark the list of foods on the questionnaire.

d. If the respondent was unable to mark on the form, the officer asked for details of the food that was usually eaten, starting from daily, weekly, and monthly, and then marked in the time column.

e. Columns were filled in only in one-time groups. For example, if the sample usually eats rice 3 times a day, the week and month columns should not be filled in. Conversely, if the sample eats meat 3 times a month, the day and week columns do not need to be filled in.

f. Repeat asking back what has been marked on the fill-in format.

To strengthen the FFQ data, food intake of calories (kcal), protein (g), and iron (mg) were measured using 3×24-hour food recall, and average intake was calculated. We used food photos to improve the accuracy of household size estimates (teaspoons, tablespoons, and other eating utensils). Nutri Survey was used to analyze the food intake data. Food intake was measured by four trained students from the Department of Nutrition.

Iodine Deficiency

Data on iodine deficiency was collected through urine collection to test for iodine with the help of Prodia laboratory medical personnel. Data was categorized as normal with 20-30 µg/dl levels and deficiency if <20 µg/dl.

Iron Deficiency

Iron deficiency/anemia data was collected by taking blood serum to test hemoglobin with the help of Prodia laboratory medical personnel. Categorical data, with categories of anemia and not anemia, declare as anemia for toddlers with below 11 g/dl hemoglobin level.

Zinc Deficiency

Data on zinc deficiency was collected by taking blood serum to test for Zn with the help of Prodia laboratory medical personnel. A level of 70-150 µg/dL (10.7-22.9 µmol/L) of serum Zn was categorized as normal, and serum level <70 µg/dl was categorized as deficiency.

Anthropometric Data

Body weight measurements used a scale with an accuracy of 0.1 kg for two replicates. While for height, using a stadiometer. Stunting status will be assessed directly by measuring the child's length using a stadiometer. Then analyzed using WHO Anthro Survey Analyzer Software. Height for age (Normal (z-score ≥ -2.0); Stunting (z-score -3.0 to -2.0 or z-score < -3.0).

Hidden Hunger

If a toddler experienced three micronutrient deficiency conditions, including iron, zinc, and iodine, then the toddler was categorized as experiencing hidden hunger; if experiencing only one or two of those micronutrient deficiencies, it was not declared as hidden hunger.

Ethical Approval

The Research Ethics Committee of the Faculty of Nutritional Sciences, IPB University, Indonesia, approved this study (Protocol Number: 855/IT3.KEPMSM-IPB/SK/2023).

Statistical Analysis

Raw Data was entered into Excel 2019. Statistical analysis was conducted using Statistical Package for Social Science (SPSS). Descriptive analysis included (1) estimation of basic statistics (mean and standard deviation) for all quantitative variables and (2) estimation of proportions for all categorical variables. Univariate analysis was used to describe the frequency distribution of both independent-dependent variables and the description of respondent characteristics. Bivariate analysis was used to test the relationship between the independent and dependent variables using the Chi-Square or Fisher Exact Test/Continuity Correction because it uses categorical-categorical data. Logistic regression (categorical data/odds ratio) was conducted to analyze the factors that influence the determinants of stunting. Data was considered statistically significant with a p-value of <0.05. Meanwhile, categorical data was identified using the odds ratio (OR) value.

RESULTS

Characteristics of Mothers and Toddlers

More toddlers were 36-47 months (45.1%) in the case group and 24-25 months (45.1%) in the control group. Most of the toddlers in the case group were female (57.7%), and the control group was male at 53.5%. Based on the mother's age characteristics, most were 26-35 years old, which was included in the early adulthood category (42.3%) in the case group and 46.5% in the control group. The last education of mothers with the highest number was elementary school both in the case group (57.7%) and in the control group (38.4%), with the majority income being low or below city district minimum wage both in the case group (73.2%) and the control group (64.6%) shown in (Table 1).

Bivariate Analysis

The relationship between independent variables, namely iron intake, zinc intake, iodine intake, anemia status, zinc deficiency, iodine deficiency, and hidden hunger, with the dependent variable, the incidence of stunting. For hidden hunger variables based on the combined variables of anemia status, zinc deficiency, and iodine deficiency. If respondents experienced all three conditions, they would be declared to experience hidden hunger (Table 2).

Table 2 shows that toddlers with stunting conditions mostly had iron intake that did not meet (92.95%), and the non-stunting group mostly did not meet 78.87%. The chi-square statistical test results obtained a value of p=0.030 (<0.05), indicating a relationship between iron intake and the incidence of stunting in toddlers in Karanganyar Village, Kawalu District, Tasikmalaya City.

Table 1. Frequency Distribution of Mother and Toddler Characteristics (n=142)

Variable	Stunting (Cases)		Non-stunting (Control)		P-Value
	n	%	n	%	
Toddler Age (months)					0.240
24 – 35	17	23.9	32	45.1	
36 – 47	32	45.1	22	31.0	
48 – 59	22	31.0	17	23.9	
Gender					0.029
Male	30	42.3	38	53.5	
Female	41	57.7	33	46.5	
Mother's Age (years*)					0.169
17 – 25 (late teens)	9	12.7	13	18.3	
26 – 35 (early adulthood)	30	42.3	33	46.5	
36 – 45 (late adulthood)	29	40.8	18	25.4	
> 45 (elderly)	3	4.2	7	9.9	
Mother's Last Education					0.113
Not completed in elementary school	0	0.0	1	1.4	
Elementary school	41	57.7	28	39.4	
Junior high school	19	26.8	23	32.4	
Senior high school	11	15.5	19	26.8	
Family Income					0.364
Low (<city district minimum wage)	52	73.2	46	64.8	
High (≥city district minimum wage)	19	26.8	25	35.2	

* = Republic of Indonesia Ministry of Health, 2009

Table 2. Chi-square Test Results

Variable	Toddlers				Total	P Value	OR (95% CI)
	Stunting		Non Stunting				
	n	(%)	n	(%)	n		
Iron intake							
insufficient	66	92.95	56	78.87	122	0.03	3.356 (1.209-10.338)
Sufficient	5	7.04	15	21.13	20		
Zinc intake							
Insufficient	65	91.54	55	77.46	120	0.037	2.255 (1.145-4.441)
Sufficient	6	8.46	16	22.54	22		
Iodine Intake							
Insufficient	47	66.2	33	46.48	80	0.028	3.661 (1.709-7.841)
Sufficient	24	33.8	38	53.52	62		
Status Anemia							
Anemia	29	40.84	4	5.63	33	0.001	11.565(3.795-35.244)
Not anemic	42	59.16	67	94.37	109		
Zinc Deficiency							
Deficiency	32	45.07	13	18.31	33	0.001	3.661
Not Deficiency	39	54.93	48	81.69	109		(1.709-7.841)
Iodine Deficiency							
Deficiency	18	25.35	23	56.1	41	0.459	-
Not Deficiency	53	74.65	48	32.39	101		
Hidden Hunger							
Yes	5	7.04	0	0	5	0.058	-
No	66	92.96	71	100	137		

For zinc intake, toddlers with stunting and non-stunting conditions mostly had insufficient zinc intake (91.54%) in the case group and (77.46%) in the control group. The chi-square statistical test results obtained a value of p=0.037 (<0.05), indicating a relationship between zinc intake and the incidence of stunting in toddlers in Karanganyar Village, Kawalu Subdistrict, Tasikmalaya City. For iodine intake, toddlers with stunting conditions mostly had iodine intake that did not meet (66.2%), while toddlers with non-stunting conditions had iodine intake that met (53.52%). The statistical test results using chi-square obtained a value of p=0.028 (<0.05), indicating a relationship between iodine intake and the incidence of stunting in toddlers in Karanganyar Village, Kawalu Subdistrict, Tasikmalaya City.

From the results of laboratory tests, for anemia status, toddlers with stunting conditions mostly had a non-anemia status (59.16%), and the control group had a non-anemia status of 94.37%. The statistical test results using chi-square obtained a value of p=0.000 (<0.05), indicating a relationship between anemia status and the incidence of stunting in toddlers in Karanganyar Village, Kawalu District, Tasikmalaya

City. In zinc deficiency, toddlers with stunting conditions mostly had a status of no zinc deficiency (54.93%), and the control group had a status of no zinc deficiency of 81.69%.

The statistical test results using chi-square obtained a p-value = 0.001 (<0.05), indicating a relationship between zinc deficiency and the incidence of stunting in toddlers in Karanganyar Village, Kawalu District, Tasikmalaya City. For iodine deficiency variables (p = 0.459) and hidden hunger (p = 0.058), because the p-value => 0.05, there was no relationship between iodine deficiency and hidden hunger with the incidence of stunting in Karanganyar Village, Kawalu District, Tasikmalaya City.

Logistic Regression Modeling

Logistic regression modeling was performed to determine the most dominant variables associated with the incidence of stunting in children under five years of age, which was carried out in stages:

Selection of Model Candidates

The selection of candidate variables that enter the model was carried out using bivariate analysis of each independent variable with the dependent variable. Variables that enter the modeling variable should be with a p-value ≤ 0.25.

Table 3 shows that iron intake, zinc intake, iodine intake, zinc deficiency, anemia status, and hidden hunger were included in the multivariate model. Iodine deficiency was not included in the model.

Multivariate Modeling of Factors Causing Stunting Incidence

Variables that enter the candidate model would then be analyzed simultaneously with the dependent variable. Variables with a p-value > 0.05 would be removed gradually, starting from the variable with the largest value, so the variables entered in the next model were variables with a p-value ≤ 0.05.

Table 3. Results of Bivariate Analysis of Independent Variables with Dependent Variables

Variable	P-value	Multivariate Candidates
Iron Intake	0.030	Enter modeling
Zinc Intake	0.037	Enter modeling
Iodine Intake	0.028	Enter modeling
Zinc Deficiency	0.001	Enter modeling
Anemia Status	0.000	Enter modeling
Iodine Deficiency	0.459	No Entry modeling
Hidden Hunger	0.058	Enter modeling

The results of the multivariate model analysis for the incidence of stunting in children under five are presented (Table 4). Four models were analyzed, with different independent variables in each model. Model 1 only included the variables of iron intake, zinc intake, iodine intake, anemia status, zinc deficiency, and hidden hunger. The results showed that there was a significant relationship for all variables. Model 2 showed that iron intake, zinc intake, iodine intake, anemia status, and zinc deficiency were significantly associated, but hidden hunger did not have a significant association with the incidence of stunting. Model 3 showed that only the variables of iron intake, zinc intake, anemia status, and zinc deficiency had a significant relationship with the incidence of stunting. Model 4 showed that iron intake, anemia status, and zinc deficiency had a significant relationship with the incidence of stunting.

Final Modeling

After analyzing the results of the multivariate model up to the 4th model, the 4th model was finally found to be all significant and presented in table 5.

Table 4. Results of Multivariate Model Analysis of Stunting Incidence

Variblae	Multivariate Model 1	Multivariate Model 2	Multivariate Model 3	Multivariate Model 4
Iron Intake	0.003	0.004	0.003	0.004
Zinc Intake	0.068	0.068	0.095	-
Iodine Intake	0.113	0.089	-	-
Anemia Status	0.001	0.001	0.000	0.000
Zinc Deficiency	0.047	0.030	0.022	0.014
Hidden Hunger	0.999	-	-	-

Table 5. Final Model of Multivariate Analysis of the Incidence of Stunting in Toddlers

Variables	β	p-value	OR	95% CI
Iron Intake	3.278	0.004	26.530	2.842-247.665
Anemia Status	3.731	0.000	41.733	5.349-325.603
Zinc Deficiency	1.072	0.014	2.923	1.248-6.846

It is known that the variables of iron intake, anemia status, and zinc deficiency had a significant relationship with the incidence of stunting in toddlers (Table 5). The results also show that the anemia status variable was the most dominant cause of stunting because it had the highest OR value of 41.733. The OR value indicated that toddlers with anemia would be 41.733 times more likely to have a stunted nutritional status. It is also known from the statistical test results that the Nagelkerke R Square value was 0.399 and Cox & Snell R Square was 0.300, which indicated that the ability of the independent variable to explain the dependent variable is 0.399 or 39.9%, and there were 100% - 39.9% = 60.1% other factors outside the model that explain the dependent variable.

DISCUSSION

According to our findings, toddlers with anemia will have a 41.733 times greater risk of having a stunted nutritional status. Iron intake, anemia status, and zinc deficiency are significantly related to the incidence of stunting in toddlers. From the model, it was found that iron intake, anemia status, and zinc deficiency had a significant relationship with the incidence of stunting. Our findings are in line with research conducted by Yudhistira et al. Iron deficiency anemia occurs due to iron deficiency in the blood, meaning that the concentration of hemoglobin in the body is reduced due to disruption of the formation of red blood cells due to a lack of iron levels in the blood[11].

Sirajuddin et al. 2020 examined iron intake on stunting. Their findings support our research that the lack of iron intake in toddlers causes growth retardation, so if this event continues for a long time, it can cause stunting[12]. Iron intake plays an important role because iron is the core of hemoglobin[13]. The function of iron is to help hemoglobin circulate oxygen to all body tissues and carry oxygen in red blood cells to the brain[14].

The results of this study are in line with the research of Mutiara et al. (2021) on 32 children in the Cibeber Health Center Working Area, Cimahi City, which showed that there was a relationship between iron intake and the incidence of stunting in toddlers aged 1-3 years with a value of $p = 0.028$ ($p < \alpha$) [15]. Research by Mutiara et al. (2021) also shows that iron intake is lacking more in toddlers who suffer from stunting (75%)[15]. In line with the research of Sunardi et al. (2021) on 612 toddlers aged 6-59 months in Babakan Madang District, Bogor City, in 2019, it showed a significant relationship between iron intake and the incidence of stunting in toddlers[16]. Toddlers who experience insufficient iron intake have a chance of suffering from stunting 1.807 times greater than toddlers who have adequate iron intake. Supporting these findings, other studies have employed multivariate analysis to identify iron deficiency as the most significant factor influencing children's nutritional status[17–19]. This highlights a potential link between inadequate iron intake and stunting in toddlers, as proper nutrition is crucial during this critical growth period. Moringa leaves, which are rich in health benefits, should be utilized as well as possible by including them in various nutritious recipes which can function as an iron supplement for growing children[20].

Zinc is an essential mineral that has an important role in synthesizing and degrading carbohydrates, lipids, proteins, and nucleic acids[21]. In addition, zinc also plays a role in activating and synthesizing Growth hormone (GH), maintaining immunity, as an antioxidant, taste and reproductive function, and membrane stabilization[22]. Zinc absorption occurs in the small intestine; after being absorbed, zinc is transported by albumin and transferrin into the bloodstream and taken to the liver[23]. Excess zinc will be stored in the liver as metallothionein, while the rest will be carried to the pancreas and other body tissues such as skin, hair, nails, bones, retina, and other reproductive organs[24].

Zinc requirements increase rapidly during the toddler years to support growth and development[25]. This further affects the occurrence of zinc deficiency in toddlers if they do not get adequate food intake, especially foods derived from animal sources. Some signs of zinc deficiency, such as impaired growth, impaired sexual maturity, impaired digestive function, impaired immune function, impaired appetite, and slowed wound healing, can even interfere with the central nervous system and brain function in chronic zinc deficiency[26,27]. This will also affect the nutritional status of toddlers, including stunting.

STUDY LIMITATIONS

There are several limitations in this study. The number of samples is limited due to expensive laboratory tests and the difficulty of getting toddlers who want to take blood samples. Also, even though blood samples from toddlers have been taken, some samples have been lysed, broken, and clotted so that the samples cannot be examined, which is also a potential limitation. Finally, although we have accounted for and controlled for several confounding variables, other potential confounding variables, such as health conditions at the time of blood draw, may have influenced the results and the toddler's history of infectious diseases. We suggest that future research be conducted with a large sample size, considering confounding variables that have not been measured in our study. The advantage of this research is that it measures hidden hunger in toddlers, which is still rarely done because it uses laboratory tests by taking blood and urine; with the data related to hidden hunger and its association with stunting, we expected that it could become a comprehensive recommendation for dealing with the problem of stunted toddlers.

CONCLUSION AND RECOMMENDATIONS

Our results indicate that inadequate iron and zinc intake, as well as anemia, are significant risk factors for stunting. Specifically, toddlers with stunting were significantly more likely to have inadequate iron (92.95%) and zinc intake (91.54%) compared to their non-stunting counterparts (78.87% and 77.46%, respectively). Additionally, a higher proportion of stunted toddlers (40.84%) were found to have anemia compared to non-stunted toddlers (5.63%). Our multivariate analysis revealed that iron intake, anemia status, and zinc deficiency are critical predictors of stunting, with anemia emerging as the most dominant factor, as evidenced by an OR value of 41.733. This suggests that toddlers with anemia are 41.733 times more likely to experience stunting. However, no statistically significant relationship was found between iodine deficiency or hidden hunger and stunting. The statistical test results, including the chi-square test, reinforced these findings, showing a significant relationship between zinc deficiency and stunting ($p = 0.001$). The Nagelkerke R Square value of 0.399 and Cox & Snell R Square value of 0.300 indicate that the independent variables in our model explain 39.9% of the variability in stunting incidence, leaving 60.1% to other factors outside the model.

These findings underscore the importance of addressing iron intake, anemia, and zinc deficiency in efforts to reduce stunting in toddlers. Future research should focus on quantifying nutrient deficits more precisely to further refine these predictive models. The recommended strategy is providing iron and zinc supplements, which can be recommended as an effective program to reduce hidden hunger, influencing the prevalence of stunting in toddlers.

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