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PROTEIN AND IODINE ADEQUACY AS RISK FACTORS FOR STUNTING IN CHILDREN AGED 2–4 YEARS
(*Kecukupan Protein dan Iodium sebagai Faktor Risiko Stunting pada Anak Usia 2–4 Tahun*)

Tysa Runingsari [1]*, Ani Margawati[2], Suhartono[3], Mohammad Zen Rahfiludin[4], Ali Rosidi[5]

[1]Departeman Ilmu Gizi, Fakultas Kedokteran, Universitas Diponegoro, Indonesia
[3]Departemen Kesehatan Lingkungan, Fakultas Kesehatan Masyarakat, Universitas Diponegoro,
[4]Bagian Gizi Kesehatan Masyarakat, Fakultas Kesehatan Masyarakat, Universitas Dipenegoro
[5]Fakultas Ilmu Keperawatan dan Kesehatan, Universitas Muhammadiyah Semarang, Indonesia
*email korespondensi: tysaruningsari06@gmail.com

ABSTRACT

Background: *Stunting is a chronic nutritional issue that can hinder a child's growth and development. Nutrient adequacy plays a crucial role in child growth; specifically, protein is required for tissue formation, while iodine is essential for thyroid hormone synthesis.* ***Objective:*** *This study aimed to analyze protein and iodine adequacy levels as risk factors for stunting in children aged 2–4 years.* ***Method:*** *It was an observational study with a case-control design, conducted from November 2019 to January 2020 within the working area of the Bulu Community Health Center (Puskesmas), Temanggung Regency. The study subjects consisted of 40 stunted children (case group) and 40 non-stunted children (control group). Anthropometric data were obtained through height and weight measurements, while data on protein and iodine intake were collected via interviews using a Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ). Data were analyzed using the chi-square test and logistic regression. The results showed that protein adequacy levels were associated with stunting (p<0.001).* ***Results:*** *Iodine adequacy levels were also associated with stunting (p<0.001). Multivariate analysis revealed that inadequate protein intake was a risk factor for stunting (OR=36.358; 95% CI: 3.286–402.255), and inadequate iodine intake was also a risk factor for stunting (OR=23.756; 95% CI: 5.950–94.858).* ***Conclusion:*** *Inadequate protein and iodine intake levels are risk factors for stunting among children aged 2–4 years in the working area of the Bulu Community Health Center, Temanggung Regency.*

Keywords: *stunting, protein adequacy level, iodine adequacy level.*

INTRODUCTION

Stunting remains a nutritional issue among children in Indonesia. This condition represents impaired linear growth resulting from various long-term factors and can impact a child's growth and development ((Diarsvitri et al., 2026). Efforts to address stunting in Indonesia have shown positive progress. Results from the 2024 Indonesian Nutritional Status Survey. (SSGI) indicate that the prevalence of stunting among children under five declined from 21.5% in 2023 to 19.8% in 2024 (Kemenkes, 2025). Despite this decline, stunting still requires attention, as it is linked to various factors affecting child growth, including nutritional adequacy.

Stunting is a condition influenced by various interconnected factors. These factors include maternal and child characteristics, birth history, feeding practices, infectious diseases, socioeconomic conditions, and the living environment (Arief et al., 2025;

KPurwani et al., 2025). Among these factors, adequate nutrient intake plays a role in supporting a child's linear growth. Research on children aged 24–59 months in Indonesia indicates that stunted children have a lower intake of essential amino acids compared to non-stunted children, even though overall protein adequacy is not necessarily low (Rizky Maulidiana & Sutjiati, 2021). These findings demonstrate that child growth is linked not only to the quantity of food consumed but also to the adequacy and quality of nutrients obtained from that food.

Protein is a macronutrient that plays a crucial role in child growth by providing the amino acids necessary for the formation and maintenance of body tissues. Adequate protein intake—specifically protein with a high-quality amino acid profile—is essential to support a child's linear growth. Since the body cannot synthesize essential amino acids in sufficient quantities, they must be obtained through the diet. A deficiency in essential amino acids can disrupt the metabolic processes that drive linear growth (Rizky Maulidiana & Sutjiati, 2021). Research involving children aged 24–59 months in Malang City revealed that the intake of nine essential amino acids was lower in the stunted group compared to the non-stunted group. Significant differences were observed in the intake of histidine, isoleucine, and methionine (Rizky Maulidiana & Sutjiati, 2021). These findings indicate that ensuring adequate protein intake—in terms of both quantity and quality—is vital for supporting child growth.

In addition to protein, iodine is a micronutrient that plays a crucial role in a child's growth and development. Iodine is essential for the synthesis of thyroid hormones, which regulate metabolism and physical growth. Iodine deficiency can impair thyroid hormone function and potentially affect a child's linear growth (Abbag et al., 2021). A study involving children aged 2–5 years in Bengkulu demonstrated a link between low iodine intake and the prevalence of stunting; 73.1% of children with insufficient iodine intake were stunted, whereas only 4.8% of those with adequate intake were stunted (Simbolon & Hapsari, 2018). Other studies have also indicated an association between low iodine status and stunting, although the relationship between iodine status and child growth may vary depending on population characteristics and the specific indicators used to assess iodine status. These findings highlight the importance of considering iodine adequacy as a nutritional factor linked to a child's linear growth (Abbag et al., 2021; Li et al., 2024).

Research findings regarding the relationship between protein and iodine adequacy and stunting remain varied. A study of children aged 12–24 months in Magelang Regency indicated that protein intake is associated with the occurrence of stunting, whereas iodine intake did not show a significant association (Setyaji & Sulistyani, 2024). Recent reviews also suggest that the link between iodine and stunting has not been consistent across studies (Setianingsih et al., 2026). These discrepancies highlight the need for further research across different age groups and population characteristics. Unlike previous studies, this research analyzes both protein and iodine adequacy simultaneously in children aged 2–4 years from farming families in Temanggung Regency. This analysis was conducted to determine the association of each nutrient with stunting, including when both are considered within a multivariate

analysis. Consequently, this study is expected to provide additional evidence regarding the connection between protein and iodine adequacy and stunting among children from farming families. Therefore, this study aims to analyze the levels of protein and iodine adequacy as risk factors for stunting in children aged 2–4 years within the working area of the Bulu Community Health Center (Puskesmas), Temanggung Regency.

METHODS

This study is an observational, case-control study conducted between November 2019 and January 2020 within the working area of the Bulu Community Health Center (Puskesmas Bulu), Bulu District, Temanggung Regency. The study sites included the villages of Wonosari, Pagergunung, and Gondosuli. A case-control design was chosen to compare the history of protein and iodine adequacy between stunted and non-stunted children, allowing for the analysis of the relationship between these two nutritional factors and the occurrence of stunting via the odds ratio (OR).

The study population consisted of children aged 2–4 years from farming families residing within the working area of the Bulu Community Health Center. Participants were selected using purposive sampling based on predetermined inclusion and exclusion criteria. The case group comprised children with stunting, whereas the control group consisted of children without stunting from the same study area. The study employed an unmatched case-control design, with an equal number of participants in each group (1:1 ratio). No individual matching was performed based on sex, age, or other participant characteristics. The minimum calculated sample size was 36 participants per group. This number was increased by approximately 10% to account for potential dropouts, resulting in 40 participants in each group and a total sample of 80 children.

Confounding factors were controlled by restricting the study population to children aged 2–4 years from farming families and by selecting both the case and control groups from the same geographical area. Furthermore, in the parent study, potential confounding variables were analyzed bivariately and included in a logistic regression model if they yielded a p-value < 0.25. A multivariate analysis was performed to evaluate the association between protein and iodine adequacy and stunting, while accounting for the variables included in the modeling process.

The use of purposive sampling carries the potential for selection bias, as subjects were not chosen randomly. Although the case and control groups were drawn from the same study area and selected based on established criteria, the possibility of unmeasured differences in characteristics between the two groups should be considered when interpreting the study results.

Inclusion criteria comprised children aged 2–4 years from farming families who possessed records of maternal prenatal care—specifically the Maternal and Child Health (MCH) Handbook and the Child Growth Chart (KMS)—resided permanently in the study area, lived with their biological parents, and whose parents consented to their participation. Exclusion criteria included children with physical disabilities that could interfere with height measurement, children who were ill during the study, those who moved away or left the study area, and those who withdrew from the study. Stunting status was determined based on the

height-for-age (H/A) index. Children's height was measured using a stadiometer, while age was calculated based on the date of birth relative to the time of the study. Children were categorized as stunted if they had an H/A z-score <−2 SD and non-stunted if they had an H/A z-score ≥−2 SD, based on WHO growth standards.

Data on protein and iodine intake were obtained through interviews with mothers using a Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ). This instrument is used to estimate nutrient intake based on the type, frequency, and quantity of food consumed by the child. Intake was calculated based on all food, beverages, and supplements consumed by the child. Consumption data, initially recorded in household measurements, were converted into grams and analyzed using NutriSurvey 2007. The resulting intake levels were then compared against the Recommended Dietary Allowances (RDA)—referred to in Indonesia as *Angka Kecukupan Gizi* (AKG)—for the relevant age group and expressed as a percentage of adequacy. According to the categorization used in this study, iodine intake is classified as "insufficient" if it is <77% of the RDA and "sufficient" if it is ≥77% of the RDA; protein intake is classified as "insufficient" if it falls between 80% and <100% of the RDA, and "sufficient" if it is ≥100% of the RDA. The study documentation does not provide the results of specific validity and reliability testing for the SQ-FFQ employed. Furthermore, data collection via interviews with mothers carries the potential for recall bias, as the information regarding intake relies on the respondent's ability to accurately remember the frequency and quantity of food consumed by the child**.**

Data analysis was performed using SPSS. Univariate analysis was used to describe subject characteristics and the distribution of research variables. Bivariate analysis was conducted using the Chi-square test to examine the relationship between protein and iodine adequacy levels and the incidence of stunting, with a significance level of $p<0.05$. Variables with p-values <0.25 in the bivariate analysis of the parent study were considered candidates for the multivariate analysis. Multivariate analysis was performed using logistic regression to identify factors associated with the incidence of stunting. The strength of the association in the final model was expressed as an odds ratio (OR) with a 95% confidence interval (CI). This study received ethical approval from the Health Research Ethics Committee of the Faculty of Medicine, Diponegoro University (reference number 111/EC/KEPK/FK/UNDIP/IV/2019). Consent to participate in the study was obtained from the subjects' parents or guardians prior to data collection.

RESULTS AND DISCUSSION

Subject Characteristics

The study involved 80 children aged 2–4 years, comprising 40 stunted children (case group) and 40 non-stunted children (control group). The mean age of the children was 36.30 ± 6.93 months in the case group and 34.52 ± 7.15 months in the control group. There was no significant difference in age between the two groups (p=0.263). Regarding gender, the case group consisted of 21 boys (52.5%) and 19 girls (47.5%), while the control group consisted of 16 boys (40.0%) and 24 girls (60.0%). There was no significant difference in gender between the case and control groups (p=0.262).

Table 1. Comparison of Subject Characteristics Between Case and Control Groups

Characteristic	Case		Control		P-value
	Mean ± SD	n (min, maks)	Mean ± SD	n (min, maks)	
Age (months)	36,30 ± 6,93	40 (24 – 48)	34,52 ± 7,15	40 (24 – 48)	0,263 [a]
Gender		*n (%)*		*n (%)*	
Male		21 (52,5)		16 (40)	0,262 [b]
Female		19 (47,5)		24 (60)	

Note: a, T-test; b, Chi-square test

Table 1, which presents the characteristics of the study subjects, shows no significant differences in age or gender, indicating that the case and control groups possessed relatively comparable profiles regarding these two baseline characteristics. Subsequently, the analysis focused on protein and iodine adequacy levels as the nutritional factors examined in relation to the incidence of stunting.

Protein Adequacy Level and Stunting

The study results indicate that 14 children (35.0%) in the case group had inadequate protein intake, whereas no children in the control group exhibited inadequate protein intake. A total of 26 children (65.0%) in the case group and all children in the control group had adequate protein intake. Chi-square test results show a significant association between protein intake adequacy and the incidence of stunting ($p<0.001$). These results are presented in Table 2.

Table 2. Association between Protein Adequacy Level and Stunting Incidence

Variable		Stunting Incidence				P-value
		Case		Control		
		n	%	n	%	
Protein Adequacy Level	Inadequate	14	35	0	0	<0,001[a]
	Adequate	26	65	40	100	
	Total	40	100	40	100	

Note : [a] Fisher's Exact Test (two-sided)

The higher proportion of inadequate protein intake observed in the stunted group indicates a link between protein adequacy and children's linear growth. These findings suggest that protein adequacy is a nutritional aspect requiring attention to support child growth; however, as stunting is a multifactorial condition, it cannot be explained solely by protein adequacy. Research involving Indonesian children also indicates that growth issues often coexist with various nutrient intake deficiencies, highlighting the need to consider overall dietary quality when assessing child growth (Endrinikapoulos et al., 2023). This study aligns with research Elisanti et al., (2023) involving 132

children under five in Jember, which found that mean protein intake was lower in the stunted group compared to the non-stunted group, with a significant difference between the two. Similarly, a study by Rizky Maulidiana & Sutjiati, (2021) on children aged 24–59 months in Malang City showed that the intake of nine essential amino acids was lower in stunted children than in non-stunted children, with significant differences observed in histidine, isoleucine, and methionine levels.

Protein plays a role in growth by providing the amino acids necessary for the synthesis and maintenance of body tissues. During periods of growth, adequate protein intake must be accompanied by high protein quality, as essential amino acids cannot be synthesized by the body in sufficient quantities and must be obtained from the diet (Rizky Maulidiana & Sutjiati, 2021) Therefore, the relationship between protein and child growth depends not only on the quantity of protein consumed but is also influenced by the quality of the protein source and the amino acid composition derived from the diet.

In this study, the protein sources consumed by the children included animal-based proteins—such as meat, eggs, milk, fish, and their processed products—and plant-based proteins, such as soybeans, legumes, tempeh, tofu, and soy milk. Although the majority of stunted children had protein intake levels categorized as adequate, 35.0% still had inadequate protein intake. These results indicate that protein adequacy is a nutritional aspect requiring attention to support child growth; however, stunting remains a multifactorial condition that cannot be explained solely by protein adequacy (Endrinikapoulos et al., 2023).

Iodine Adequacy and Stunting

As shown in Table 3, 34 children (85.0%) in the case group had inadequate iodine levels, whereas 10 children (25.0%) in the control group did. Adequate iodine levels were found in 6 children (15.0%) in the case group and 30 children (75.0%) in the control group. Chi-square test results indicated a significant association between iodine levels and the occurrence of stunting ($p<0.001$). Children with inadequate iodine levels had 17 times the odds of experiencing stunting compared to children with adequate iodine levels (OR=17.000; 95% CI: 5.520–52.359).

Table 3. Relationship between Iodine Adequacy Level and Stunting Incidence

Iodine adequacy level	Case n (%)	Control n (%)	OR (95% CI)	p
Insufficient	34 (85,0)	10 (25,0)	17,000 (5,520–52,359)	<0,001[a]
Sufficient	6 (15,0)	30 (75,0)	1,00 (ref.)	
Total	40 (100,0)	40 (100,0)		

Note : [a]Uji *Chi Square*

These results indicate that inadequate iodine intake is more frequently observed in stunted children compared to non-stunted children. These findings align with the study by Simbolon & Hapsari,

(2018) on children aged 2–5 years in Bengkulu, which demonstrated a link between iodine intake and linear growth. In that study, 73.1% of children with inadequate iodine intake were stunted, whereas the proportion of stunting among children with adequate iodine intake was 4.8%.

Iodine is a micronutrient required for the synthesis of thyroid hormones, which play a role in metabolism, growth, and development. The link between iodine status and growth is also demonstrated by a study of schoolchildren in the Aseer region of Saudi Arabia, where low urinary iodine levels were associated with stunting after adjusting for other factors in a multivariate analysis. Although the age group and iodine assessment methods in that study differed from those in the present study, the findings support the role of iodine status in children's linear growth (Abbag et al., 2021).

A community-based study in Ethiopia also demonstrated the link between iodine and child growth. Increased use of iodized salt in the intervention group was associated with improvements in iodine status and linear growth compared to the control group. These findings indicate that iodine adequacy is a factor that must be considered in supporting child growth (Ferede et al., 2024).
However, the relationship between iodine and child growth does not always follow a simple pattern. In a study of 5,920 children aged 3–6 years in China, Li et al., (2024) found that the association between urinary iodine concentration and certain growth indicators—including the height-for-age z-score—exhibited a non-linear pattern in specific subgroups. Discrepancies in findings across studies may be attributed to factors such as population characteristics, levels of iodine exposure, dietary sources, geographical conditions, and the methods used to assess iodine status or adequacy.

The geographical characteristics of the study area must also be considered when interpreting the results. Parts of Bulu District are mountainous, whereas seafood is a source of iodine. However, this study did not measure iodine content in household salt, food, soil, or water, nor did it assess iodine status biomarkers such as urinary iodine concentration. Therefore, the findings indicate an association between estimated iodine adequacy based on intake and the occurrence of stunting, but they cannot be directly used to characterize the children's actual iodine status.

Protein and Iodine Adequacy Levels in Multivariate Analysis

The logistic regression results indicate that the adequacy levels of protein and iodine remain associated with the occurrence of stunting in the final model. Children with inadequate protein intake have 36.358 times the odds of experiencing stunting compared to children with adequate protein intake (OR=36.358; 95% CI: 3.286–402.255; p=0.003). Meanwhile, children with inadequate iodine intake have 23.756 times the odds of experiencing stunting compared to children with adequate iodine intake (OR=23.756; 95% CI: 5.950–94.858; p<0.001).

Table 4. Multivariate Logistic Regression Analysis of Protein and Iodine Adequacy Levels Associated with Stunting

Variable	B	SE	Adjusted OR	95% CI	p-value
Inadequate protein adequacy	3.593	1.226	36.358	3.286–402.255	0.003
Inadequate iodine adequacy	3.168	0.706	23.756	5.950–94.858	<0.001

Nevertheless, the OR value for protein should be interpreted with caution due to its very wide confidence interval. This is likely related to a limited sample size and an imbalanced data distribution—specifically, the absence of children with inadequate protein intake within the control group. Such a situation indicates "sparse data," which can lead to the problem of "separation" in logistic regression, potentially rendering the OR estimate unstable (Mansournia et al., 2018). Therefore, while these findings support an association between protein adequacy and stunting, the magnitude of the OR cannot be considered a precise estimate and requires confirmation through further research with a larger sample size.

Multivariate analysis results indicate that protein and iodine adequacy are nutritional factors associated with the incidence of stunting among children aged 2–4 years in this study. These findings can be explained by the roles these two nutrients play in the growth process. Protein provides the amino acids necessary for tissue formation and maintenance, whereas iodine is required for the synthesis of thyroid hormones, which regulate metabolism and growth. Thus, ensuring adequate intake of both macro- and micronutrients is essential to support children's linear growth (Inzaghi et al., 2022).

Nevertheless, the magnitude of the OR—particularly regarding protein adequacy levels—requires cautious interpretation. The very wide confidence interval for protein (95% CI: 3.286–402.255) indicates a substantial degree of uncertainty in the estimate. This is likely attributable to the relatively limited sample size and the unbalanced distribution of protein adequacy levels, given the absence of children with inadequate protein intake in the control group. Such "sparse data" conditions can result in unstable odds ratio estimates and wide confidence intervals; therefore, the magnitude of the OR should be interpreted with caution (Mansournia et al., 2018).

This study has several limitations. Data on protein and iodine intake were obtained using an SQ-FFQ, thereby relying on respondents' ability to recall the types, frequency, and quantities of food consumed by the children. Iodine assessment was based solely on estimated intake and did not include biomarker analysis of iodine status. Furthermore, while the

case-control design allowed for the identification of an association between nutrient adequacy and the occurrence of stunting, it could not establish a causal relationship. Nevertheless, the findings indicate that protein and iodine adequacy are nutritional aspects requiring attention to support the growth of children aged 2–4 years, particularly within farming families.

CONCLUSIONS AND SUGGESTION

Insufficient protein and iodine intake are associated with higher odds of stunting among children aged 2–4 years in the working area of the Bulu Community Health Center (Puskesmas), Temanggung Regency. Multivariate analysis indicates that both variables remain statistically associated with the occurrence of stunting. However, given that this study employs a case-control design, the findings demonstrate an association rather than a causal relationship. Furthermore, the estimate regarding the association with protein intake should be interpreted with caution, as it carries a very wide confidence interval.

Ensuring adequate protein and iodine intake warrants attention as part of efforts to support children's linear growth. Future research should employ more comprehensive dietary intake assessments and incorporate biomarker testing for iodine status to obtain a more objective picture of the children's iodine status.

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