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Association Between Vitamin D Levels and Nutritional Status in Hospitalized Children: A Single-Center Cross-Sectional Study at a Tertiary Referral Hospital in Makassar, Indonesia

AYU NURLIYANA PRATIWI*, AIDAH JULIATY ALIMUDDIN BASO, IDHAM JAYA GANDA, HADIA ANGRIANI MACHMOED, EMA ALASIRY and EKA YUSUF INRAKARTIKA

Department of Child Health, Hasanuddin University, Makassar, Indonesia

Abstract

In nations with low and middle incomes (LMICs), malnutrition during early childhood often occurs alongside micronutrient inadequacy, including suboptimal vitamin D status. Whether anthropometric evidence of acute malnutrition parallels circulating vitamin D in children requiring hospitalization, however, remains uncertain. This cross-sectional investigation was carried out at Dr. Wahidin Sudirohusodo Hospital in Makassar, Indonesia, an Indonesian tertiary referral center. According to weight-for-length z-scores (WLZ) or weight-for-height z-scores (WHZ), children between the ages of one month and five years were categorized as well-nourished, undernourished, or severely malnourished. The enzyme-linked immunosorbent assay (ELISA) was employed to quantify the levels of circulating 25-hydroxyvitamin D [25(OH)D]. Kruskal-Wallis analysis was applied for between-group comparison, whereas Spearman rank correlation examined the association of 25(OH)D with ordered nutritional status. A supplementary analysis assessed whether this relationship persisted after accounting for age, sex, and documented gastrointestinal problems. The analysis comprised 80 children. Median 25(OH)D concentrations were 44 ng/mL, 35 ng/mL, and 47 ng/mL in the well-nourished, undernourished, and severely malnourished groups, respectively, without a statistically significant difference among groups ($p = 0.686$). Vitamin D status was normal in 70 children (87.5%), insufficient in 6 (7.5%), and deficient in 4 (5.0%); severe deficiency was not detected. The four deficient cases comprised 2/40 well-nourished children (5.0%), 1/20 undernourished child (5.0%), and 1/20 severely malnourished child (5.0%). Ordered anthropometric nutritional status showed essentially no correlation with serum 25(OH)D ($r = -0.023$; $p = 0.841$), and adjustment did not alter this finding ($p = 0.988$). In this hospitalized cohort, wasting-based anthropometric grouping showed limited correspondence with vitamin D status. Further research should examine factors not captured by anthropometry, particularly dietary exposure, sunlight-related factors, previous supplementation, and severity of illness.

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CONTACT Ayu Nurliyana Pratiw ayunurliyanap@gmail.com Department of Child Health, Hasanuddin University, Makassar, Indonesia

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Abbreviations

25(OH)	D 25-hydroxyvitamin D
ELISA	enzyme-linked immunosorbent assay
LMICs	low- and middle-income countries
WHZ	weight-for-height z-score
WLZ	weight-for-length z-score

Introduction

In low- and middle-income countries (LMICs), early childhood malnutrition continues to be a major health concern and plays a significant role in morbidity and mortality before the age of five.[1] Global predictions for 2022 show that wasting affected 45 million children under five, stunting affected 149 million, and overweight or obesity affected 38.9 million.[2] Indonesia continues to face a considerable burden of undernutrition, with wasting and stunting affecting 7.2% and 19.7% of children under five, respectively.[3] The burden is particularly marked in some regions; in South Sulawesi, stunting prevalence reached 35.74% in 2018.[4] These figures underscore the continuing relevance of childhood malnutrition in settings where growth impairment remains common. Malnutrition may also compromise micronutrient status. Vitamin D, a fat-soluble nutrient, depends partly on dietary fat and adequate intestinal absorption. Reduced food intake, altered intestinal mucosa, fat malabsorption, and gut dysbiosis in malnourished children may therefore reduce vitamin D availability.[5,6] Systemic inflammation may further modify vitamin D metabolism by affecting vitamin D receptor expression, renal 1α-hydroxylase activity, and conversion to the active metabolite.[5] Combined deficiencies of macro- and micronutrients in protein-energy malnutrition may additionally impair physiological function.[7] These mechanisms are particularly relevant to children with wasting, who may experience poor intake, malabsorption, greater metabolic demands, and illness-related nutritional deterioration.[6,8] Because vitamin D also contributes to calcium regulation, bone mineralization, and growth-related processes, differences in vitamin D status across wasting-based anthropometric categories are biologically plausible.[9–11]

Nonetheless, pediatric data continues to be incongruous. Certain research has indicated diminished vitamin D levels or a higher prevalence of vitamin D deficiency in children suffering from severe acute malnutrition; however, the extent of these correlations differs among various demographics and clinical environments.[12–15] A meta-analysis conducted by Song *et al*. identified a correlation between diminished vitamin D levels and wasting, however analogous associations were not consistently noted for other anthropometric measures of undernutrition.[6] Tisha *et al*. additionally reported reduced vitamin D concentrations in children experiencing severe acute malnutrition compared to healthy counterparts and indicated enhanced biochemical and clinical results after vitamin D treatment.[16] These results indicate a potential correlation between vitamin D levels and acute malnutrition, albeit this link is not consistent across different pediatric demographics.

This issue is particularly relevant in Indonesia. Vitamin D contributes not only to calcium homeostasis and bone mineralization but also to hormonal and immune functions.[9,10] Studies in Indonesian children and infants have documented a substantial frequency of suboptimal vitamin D status.[17,18] Mardiah *et al*., for example, reported inadequate vitamin D levels in 87.1% of stunted children aged 12–24 months.[9] Recent SEANUTS II data from Indonesia reported vitamin D insufficiency in 27.1% of the biochemical subsample of children assessed in Java and Sumatra.[19] Vitamin D insufficiency may also interfere with bone formation and growth regulation, including mechanisms involving insulin-like growth factor-1 signaling.[11]

Despite these findings, evidence from hospitalized Indonesian children remains limited. Most local studies have examined community populations, general vitamin D prevalence, or micronutrient status outside hospital settings.[18,20] Hospitalized children constitute a clinically distinct population because acute illness, inflammation, reduced food intake, gastrointestinal dysfunction, limited mobility, and comorbid disease may affect both

nutritional status and vitamin D metabolism. Hospital-based Indonesian evidence is scarce; among children admitted with pneumonia, vitamin D deficiency was reported in 19%, but vitamin D levels were not associated with disease severity and their relationship with nutritional status was not directly examined.[21] International studies in critically ill and hospitalized children likewise indicate that illness-related factors may influence circulating vitamin D levels.[8,22,23] Evidence from Eastern Indonesia, including South Sulawesi, is particularly limited despite the high regional burden of childhood malnutrition. Thus, this study assessed the relationship between anthropometric nutritional status and serum 25-hydroxyvitamin D [25(OH) D] levels in hospitalized children between the ages of one month and five years at Dr. Wahidin Sudirohusodo Hospital, a tertiary referral hospital in Makassar, Indonesia.

Materials and Methods

Study Design and Setting

This hospital-based cross-sectional investigation evaluated serum vitamin D concentrations in children classified into different anthropometric nutritional groups. Data collection was undertaken at Dr. Wahidin Sudirohusodo Hospital, a tertiary referral center in Makassar, Indonesia, from October 2025 through January 2026. Enrollment was maintained throughout this interval until the planned number of participants was obtained.

Study Population and Participants

Children between 1 month and 5 years of age formed the target population and were represented by three nutritional categories: well-nourished, undernourished, and severely malnourished. Recruitment was restricted to children of this age who were receiving inpatient treatment at Dr. Wahidin Sudirohusodo Hospital during the study period and fulfilled the study eligibility requirements. Enrollment required both an age of 1 month to 5 years with anthropometric classification into one of the three predefined nutritional groups and parental or legal-guardian written consent. Children receiving vitamin D therapy or diagnosed with a syndromic disorder, malignancy, renal disease, or hepatic disease were not eligible. Samples affected by hemolysis were omitted from the analysis.

Sampling Technique and Sample Size

Recruitment followed a consecutive approach, with eligible inpatients entered into the study as they were identified until the sampling target was reached. Separate calculations were performed for the comparative and correlation-based objectives. The three-group comparison required 8 children in each category after allowance for possible dropout, giving a minimum of 24 participants. For the correlation analysis, 47 participants were needed on the assumption of a moderate correlation ($r = 0.4$). Increasing this estimate by 15% to accommodate possible data loss produced a minimum requirement of 54 children.

The study ultimately enrolled 80 participants: 40 well-nourished, 20 undernourished, and 20 severely malnourished children. Group sizes were determined by the number of eligible cases encountered during consecutive recruitment, while the overall sample remained above the minimum required for the planned analyses.

Data Collection and Procedures

After consent was documented, trained study procedures were used to obtain body weight together with body length or height using standardized equipment. Anthropometric classification followed Indonesian Ministry of Health Regulation No. 2 of 2020. At ages 0–23 months, weight-for-length z-scores were used, whereas weight-for-height z-scores were applied at ages 24–60 months.

Each child provided 3 mL of venous blood in a plain/red-top collection tube. Serum was separated by centrifugation and maintained at −20°C in the Research and Microbiology Laboratory of Hasanuddin University Hospital until testing. Concentrations of serum 25-hydroxyvitamin D [25(OH)D] were assayed with a Diasino enzyme-linked immunosorbent assay kit following the manufacturer's protocol. Recorded study variables included nutritional category, age, sex, parental occupation, and documented comorbidities. A dichotomous variable for gastrointestinal problems was subsequently generated from the recorded diagnoses for use in the sensitivity analysis.

Outcome Measures

The primary outcome was serum 25-hydroxyvitamin D [25(OH)D], measured in ng/mL. Serum 25(OH)D levels were assessed using four criteria: 30–100 ng/mL indicated normal levels, 20–<30 ng/mL signified insufficiency, <20 ng/mL represented deficiency, and <5 ng/mL indicated severe deficiency.[24] Anthropometric classifications were designated according to the Child Anthropometric Standards outlined in Indonesian Ministry of Health Regulation No. 2 of 2020. Weight-for-length z-scores were used to evaluate children aged 0–23 months, while weight-for-height z-scores were used to evaluate children aged 24–60 months.[25] A measurement below −3 SD indicates severe malnutrition; values ranging from −3 SD to <−2 SD indicate undernutrition; and values from −2 SD to +1 SD signify a well-nourished condition.

Consequently, the nutritional classification employed in this research primarily indicated wasting or acute malnutrition, as it was based on weight in relation to length or height. Chronic linear-growth deficiency was not assessed due to the absence of height-for-age z-scores.

Statistical Analysis

All evaluations were conducted using IBM SPSS Statistics 27 (IBM Corp., Armonk, NY, USA). Categorical attributes are represented by counts and percentages, whereas numerical data that deviates from normal distribution is summarized using median and range. The Shapiro-Wilk test was employed to assess normalcy.

Variations in serum 25(OH)D levels among the three nutritional categories were evaluated using the Kruskal-Wallis test. Analyzes of categorical variables employed the Chi-square test or Fisher's exact test as suitable. Due to the presence of numerous minor anticipated frequencies in the contingency table for vitamin D status, the distribution among nutritional groups was evaluated using the Fisher-Freeman-Halton exact test.

For the association analysis, nutritional status was ordered numerically as 1 = well-nourished, 2 = undernourished, and 3 = severely malnourished. Its relationship with serum 25(OH)D was quantified using Spearman correlation, with the correlation coefficient reported as the corresponding effect-size measure.

A supplementary adjusted analysis was undertaken to examine whether the principal finding was robust to measured potential confounders. A univariate general linear model specified serum 25(OH)D concentration as the outcome and anthropometric nutritional status as the primary factor. Age was incorporated as a covariate, while sex and documented gastrointestinal problems were modeled as fixed factors. This model functioned only as a sensitivity analysis and did not supersede the primary nonparametric analyses. A p-value below 0.05 denoted statistical significance.

Table 1: Participants' baseline characteristics based on their nutritional status

Variable	Well-nourished (n=40)	Undernourished (n=20)	Severely malnourished (n=20)	Total (n=80)	p value
Sex					0.726[1]
Male	24 (60.0%)	14 (70.0%)	12 (60.0%)	50 (62.5%)	
Female	16 (40.0%)	6 (30.0%)	8 (40.0%)	30 (37.5%)	
Age (months)	28.5 (6–59)	29.5 (12–59)	25.5 (12–59)	–	0.270[2]
Parental occupation					0.068[1]
Self-employed	22 (55.0%)	7 (35.0%)	7 (35.0%)	36 (45.0%)	
Private employee	4 (10.0%)	5 (25.0%)	3 (15.0%)	12 (15.0%)	
Civil servant	9 (22.5%)	7 (35.0%)	3 (15.0%)	19 (23.8%)	
Daily laborer	5 (12.5%)	1 (5.0%)	7 (35.0%)	13 (16.3%)	
Comorbidities					0.677[1]
Respiratory system	21 (52.5%)	10 (50.0%)	11 (55.0%)	42 (52.5%)	
Gastrointestinal	8 (20.0%)	6 (30.0%)	4 (20.0%)	18 (22.5%)	
Tropical infection	9 (22.5%)	3 (15.0%)	2 (10.0%)	14 (17.5%)	
Neurological	2 (5.0%)	1 (5.0%)	3 (15.0%)	6 (7.5%)	

Notes: Data are presented as n (%) or median (min–max). [1]Chi-square test; [2]Kruskal–Wallis test. Statistical significance was set at $p<0.05$.

Results

Eighty children were analyzed across the three predefined nutritional groups. Males represented 62.5% of the study population, with a similar sex composition across groups (p = 0.726). Age distributions were also comparable between nutritional categories (p = 0.270). Parental occupation showed no statistically significant variation across groups (p = 0.068), and self-employment was the most common occupation overall. The pattern of comorbid conditions was likewise similar (p = 0.677), with respiratory disorders accounting for the largest proportion of recorded comorbidities (Table 1).

Median serum 25(OH)D concentrations were 44 ng/mL in the well-nourished group, 35 ng/mL in the undernourished group, and 47 ng/mL in the severely malnourished group. Comparison of these values using the Kruskal-Wallis test showed no statistically significant variation across nutritional categories (p = 0.686) (Table 2).

Table 2: Comparison of serum vitamin D levels across nutritional status groups

Variable	Well-nourished (n=40)	Undernourished (n=20)	Severely malnourished (n=20)	p value
Vitamin D (ng/mL)	44 (10–90)	35 (18–89)	47 (18–80)	0.686[1]

Notes: Data are presented as median (min–max). [1]Kruskal–Wallis test. Statistical significance was set at p<0.05.

Normal vitamin D status predominated in the study population, occurring in 70 of 80 children (87.5%). Six children (7.5%) were classified as having vitamin D insufficiency and 4 (5.0%) as having deficiency, while severe deficiency was not detected. Among the four children with vitamin D deficiency, 2/40 (5.0%) were well-nourished, 1/20 (5.0%) was undernourished, and 1/20 (5.0%) was severely malnourished. The Fisher-Freeman-Halton exact test showed no statistically significant difference in vitamin D status distribution among the three nutritional groups (p = 0.718) (Table 3).

Table 3: Distribution of vitamin D status categories across nutritional status groups

Vitamin D status	Well-nourished (n=40)	Undernourished (n=20)	Severely malnourished (n=20)	Total (n=80)	p value
Deficiency, n (%)	2 (5.0)	1 (5.0)	1 (5.0)	4 (5.0)	0.718
Insufficiency, n (%)	2 (5.0)	3 (15.0)	1 (5.0)	6 (7.5)	
Normal, n (%)	36 (90.0)	16 (80.0)	18 (90.0)	70 (87.5)	
Total	40 (100.0)	20 (100.0)	20 (100.0)	80 (100.0)	

Notes: Data are presented as n (%). Vitamin D status was classified as deficiency (<20 ng/mL), insufficiency (20–<30 ng/mL), and normal (≥30 ng/mL). No participants had severe vitamin D deficiency (<5 ng/mL). The p-value was obtained using the Fisher-Freeman-Halton exact test.

When anthropometric nutritional status was analyzed as an ordered variable, its correlation with serum 25(OH)D concentration was negligible and not statistically significant (r_s = −0.023, p = 0.841). The supplementary adjusted analysis produced the same overall conclusion. After accounting for age, sex, and documented gastrointestinal problems, nutritional status was not significantly related to

serum 25(OH)D concentration ($F = 0.012$, $p = 0.988$, partial $\eta^2 < 0.001$). Gastrointestinal problems were also unrelated to serum 25(OH)D concentration ($F = 0.093$, $p = 0.761$, partial $\eta^2 = 0.001$). Neither age ($p = 0.962$) nor sex ($p = 0.353$) reached statistical significance. Accordingly, adjustment for the measured covariates did not change the principal result.

Discussion

This study found no meaningful difference in serum 25-hydroxyvitamin D [25(OH)D] among well-nourished, undernourished, and severely malnourished hospitalized children ($p = 0.686$). Likewise, increasing severity of anthropometric malnutrition showed essentially no correlation with serum 25(OH)D ($r = -0.023$; $p = 0.841$). These results were observed in a setting where childhood malnutrition continues to contribute substantially to illness and death among children younger than five years, particularly in low- and middle-income countries.[26,27] Undernutrition also remains an important health concern in Indonesia.[26] Nevertheless, within this hospitalized cohort, wasting-based anthropometric classification did not correspond closely with circulating vitamin D.

The distribution of vitamin D status further illustrates this pattern. Normal concentrations were found in 70 of 80 children (87.5%), whereas 6 (7.5%) had insufficiency and 4 (5.0%) had deficiency; no severe deficiency was detected. Vitamin D deficiency occurred in 5.0% of each nutritional group. Thus, the limited number of children with low vitamin D and the nearly identical deficiency proportions across groups may have reduced the likelihood of detecting an anthropometric gradient in 25(OH)D.

Clinical illness may partly complicate this relationship. Respiratory conditions predominated among the recorded comorbidities, followed by gastrointestinal, tropical infectious, and neurological disorders. Malnutrition can increase vulnerability to respiratory and gastrointestinal infections, while infection can further compromise nutrition through poorer intake, higher metabolic requirements, and inflammatory activity.[28,29] Acute and chronic illnesses may additionally influence micronutrient handling through changes in absorption, binding proteins, metabolism, and inflammation-related redistribution.[30–32] Therefore, serum vitamin D in hospitalized children may reflect several disease-related processes beyond body-size-based nutritional classification.

Adjustment for available covariates did not change the overall result. After age, sex, and documented gastrointestinal problems were taken into account, anthropometric nutritional status remained unrelated to serum 25(OH)D ($p = 0.988$), and gastrointestinal problems themselves were not associated with 25(OH)D ($p = 0.761$). These findings strengthen the consistency of the primary analysis, although unmeasured influences cannot be excluded.

Environmental exposure is one plausible source of such variation. A large proportion of vitamin D is produced in the skin after ultraviolet B exposure, whereas diet generally provides a smaller contribution.[33–36] Accordingly, outdoor behavior, clothing, sun avoidance, and cumulative sunlight exposure can affect circulating 25(OH)D.[34,35,37] Year-round solar availability in tropical Indonesia could favor adequate vitamin D status in some children. However, sunlight exposure and outdoor activity were not measured, so this explanation cannot be confirmed from the present data.

Vitamin D concentrations may also vary with age, skin pigmentation, genetic background, acute or chronic disease, and polymorphisms involved in vitamin D metabolism.[38,39] In children, sex, age, extremes of nutritional status, and time spent outdoors have also been identified as relevant influences.[40] The broad age span of one month to five years in this study encompasses substantial differences in feeding, supplementation, mobility, outdoor exposure, and endogenous vitamin D production. In hospitalized or chronically ill children, these factors may be further affected by inflammation, impaired absorption, restricted mobility, reduced sunlight exposure, or altered vitamin D binding and distribution.[31,41] Such variability may weaken any direct correspondence between anthropometric category and serum 25(OH)D.

The relatively high vitamin D concentrations observed in all three groups also merit consideration. Median 25(OH)D values were 44 ng/mL in well-nourished children, 35 ng/mL in undernourished children, and 47 ng/mL in severely malnourished children. These levels were higher than those reported in some hospitalized or severely malnourished pediatric

cohorts.[23,42,43] Between-study differences may reflect geography, sunlight exposure, dietary patterns, supplementation, participant characteristics, illness severity, fluid status, or analytical technique.[6,44,45] A study in Brazilian children similarly reported relatively high vitamin D levels despite poor nutritional status, with intense solar exposure proposed as one possible explanation.[46] Measurement technique may also contribute. In the present study, 25(OH) D was quantified by enzyme-linked immunosorbent assay, whereas liquid chromatography-tandem mass spectrometry is commonly used as a reference analytical approach.

The present findings also fit with evidence that associations between vitamin D and malnutrition vary according to the anthropometric indicator examined. A previous meta-analysis linked low vitamin D with wasting but did not demonstrate consistent relationships with stunting or underweight.[6] This distinction is important because the current classification relied on weight-for-length or weight-for-height z-scores, which mainly identify wasting or acute malnutrition. Height-for-age was not assessed; therefore, the study does not address chronic linear-growth impairment or stunting. The findings should consequently be interpreted specifically within the context of wasting-based nutritional categories.

Conversely, other studies have reported lower vitamin D concentrations and more frequent deficiency among children with severe acute malnutrition.[42,43] Differences from the current findings may arise from variation in geography, sunlight exposure, dietary intake, supplementation, comorbidities, population characteristics, and clinical severity.[6,44] Research in critically ill pediatric populations has also linked low vitamin D with greater illness severity.[23] Because severity of illness was not measured here, its potential contribution cannot be established and remains a question for future investigation.

Anthropometric status and micronutrient status should therefore not be regarded as interchangeable measures of nutrition. Micronutrient deficiencies can occur even when weight-based indicators appear normal, a phenomenon often described as “hidden hunger”.[47,48] Conversely, anthropometric undernutrition does not necessarily imply vitamin D deficiency. Vitamin D has important roles in bone metabolism and immune function, and low levels have been associated with susceptibility to infection.[49] The present results therefore caution against using anthropometric category alone as a proxy for vitamin D status in hospitalized children, consistent with previous concerns that anthropometry may not adequately represent clinically relevant micronutrient disturbances.[22]

From a clinical standpoint, biochemical testing may be more informative when vitamin D deficiency is suspected than inference from wasting-based anthropometry alone. This is particularly relevant during hospitalization, where inflammation, gastrointestinal dysfunction, reduced mobility, and other disease processes can influence circulating micronutrients. Conversely, the predominance of normal vitamin D concentrations in this cohort indicates that deficiency should not be presumed merely because a child is anthropometrically undernourished.

This study has several strengths, including direct measurement of serum 25(OH)D, representation of three anthropometric nutritional groups, and generation of hospital-based evidence from Eastern Indonesia. Important limitations remain. Its cross-sectional nature precludes assessment of temporality or causality, and recruitment from one tertiary referral center limits broader generalizability. Nutritional assessment was restricted to weight-for-length and weight-for-height z-scores, so chronic undernutrition based on height-for-age was not captured. Sunlight exposure, dietary vitamin D intake, supplementation history, inflammatory biomarkers, and illness severity were unavailable. Failure-to-thrive, dietary restrictions, and clinical manifestations potentially related to vitamin D deficiency were also not systematically recorded, leaving the possibility of residual confounding. The broad age range may have introduced additional heterogeneity in feeding, growth, supplementation, and outdoor activity. Finally, 25(OH)D was measured by enzyme-linked immunosorbent assay, and intra- and inter-assay coefficients of variation were unavailable; assay-related variability should therefore be considered, particularly in comparison with liquid chromatography-tandem mass spectrometry.

Conclusion

Among hospitalized children aged 1–60 months, serum 25(OH)D showed no significant variation

across well-nourished, undernourished, and severely malnourished groups and was not associated with ordinal anthropometric nutritional status. Most children had normal vitamin D concentrations, while deficiency was uncommon and severe deficiency was absent. Thus, wasting-based classification using weight-for-length or weight-for-height z-scores appears to provide limited information about vitamin D status in this clinical population. Biochemical measurement may be warranted when deficiency is clinically suspected rather than inferring vitamin D status from anthropometry alone. Future multicenter prospective studies should incorporate sunlight exposure, dietary intake, supplementation, inflammatory markers, illness severity, and height-for-age assessment to clarify the determinants of vitamin D status in hospitalized children.

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Data Availability Statement
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Ethics Statement
The study was conducted in accordance with the Declaration of Helsinki and was approved by the Health Research Ethics Committee of Hasanuddin University, Makassar, Indonesia (ethical approval number: 707/UN4.6.4.5.31/PP36/2025; approval date: 22 September 2025).

Informed Consent Statement
Written informed consent was obtained from the parents or legal guardians of all participating children before enrolment.

Clinical Trial Registration
This research does not involve any clinical trials.

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Not applicable

Author Contributions
- **Ayu Nurliyana Pratiwi**: Conceptualization, Methodology, Data Collection, Formal Analysis, Writing – Original Draft.
- **Aidah Juliaty Alimuddin Baso**: Conceptualization, Methodology, Supervision, Writing – Review & Editing.
- **Idham Jaya Ganda**: Methodology, Validation, Supervision, Writing – Review & Editing.
- **Hadia Angriani Machmoed**: Data Collection, Investigation, Writing – Review & Editing.
- **Ema Alasiry**: Data Collection, Resources, Writing – Review & Editing.
- **Eka Yusuf Inrakartika**: Supervision, Resources, Project Administration, Writing – Review & Editing.

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