

Prevalence of Undernutrition and Associated Factors: A Cross-sectional Study among Rural Toddlers in Bangka Belitung, Indonesia

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ABSTRACT Malnutrition among toddlers remains a significant public health concern in Indonesia, particularly in rural regions such as Bangka Belitung, where traditional assessment methods may underestimate the true prevalence of nutritional disorders. The conventional tools often fail to capture the complexity of undernutrition, emphasizing the need for more comprehensive evaluation techniques. This study aims to determine the prevalence of undernutrition among children under five in West Bangka Regency using the Composite Index of Anthropometric Failure (CIAF) and to identify the key factors influencing its occurrence. Employing a descriptive analytical design with a cross-sectional approach, the research was conducted over a ten-month period and involved a sample of 155 toddlers selected via multistage random sampling. Data collection involved structured questionnaires addressing sociodemographic variables, household economics, and parental characteristics, alongside anthropometric measurements utilizing calibrated digital scales to assess nutritional status. The results revealed that nearly half (48.4%) of the children experienced growth retardation, including stunting and underweight conditions. Notably, the distribution of nutritional failure was predominantly in the stunting and underweight categories, while wasting alone was rare. Interestingly, variables such as the child's gender, age, maternal age, maternal education level, and household income did not demonstrate a statistically significant relationship with nutritional status in this population. These findings underscore the complexity of malnutrition determinants in the region and highlight the limitations of conventional assessment tools. The study advocates for the adoption of the CIAF method to accurately capture the scope of undernutrition and emphasizes the necessity for further research involving a broader range of potential influencing factors. Implementing comprehensive and context-specific strategies is essential for effective intervention and policy formulation aimed at reducing malnutrition among vulnerable childhood populations.

INDEX TERMS Malnutrition, undernutrition, Composite Index of Anthropometric Failure (CIAF), toddlers, West Bangka

1. INTRODUCTION

Malnutrition remains a pervasive global health crisis, particularly affecting children under five years of age, leading to severe consequences for individual growth, development, and subsequent societal productivity [1]–[3]. The World Health Organization (WHO) estimates that over 45 million children globally are underweight, with malnutrition accounting for approximately 45% of childhood deaths annually [4], [5]. Such conditions not only predispose children to increased mortality but also cause long-term impairments, including stunted growth, cognitive deficits, and diminished immune function, thereby burdening health systems and economies worldwide [6], [7].

The etiology of malnutrition is multifaceted, influenced by a complex interplay of socio-economic, environmental, and biological factors [8], [9]. Conventional assessment methods primarily utilize single anthropometric indices, such as weight-for-age (WAZ), height-for-age (HAZ), or weight-for-height (WHZ), to identify nutritional deficits [10]. However, these unidimensional tools often underestimate the prevalence of malnutrition, especially in

cases where multiple forms of growth failure coexist, such as stunting, wasting, and underweight [11]. This limitation underscores the critical need for more comprehensive assessment approaches capable of capturing the multifaceted nature of childhood malnutrition.

Recent advances in anthropometric evaluation have introduced the Composite Index of Anthropometric Failure (CIAF), which integrates various anthropometric parameters into a singular classification system [12], [13]. CIAF offers a holistic perspective by simultaneously accounting for stunting, wasting, and underweight, thereby providing a more accurate estimation of the true burden of malnutrition within populations [14], [15]. Several studies within the recent past have demonstrated the superior diagnostic performance of CIAF compared to traditional single indices in identifying cases of growth failure [16], [17].

Despite the advantages of CIAF, its adoption remains limited in certain geographical contexts, especially in rural and resource-constrained settings, owing to challenges in data collection, operator training, and lack of awareness [18], [19]. Furthermore, most existing research focusing on

malnutrition assessment emphasizes broad regional or national trends, often neglecting specific local determinants and the unique socio-economic features influencing childhood nutrition. Many studies have concentrated on the prevalence alone, without adequately exploring the contextual factors that contribute to malnutrition or validating the application of CIAF in diverse settings [20], [21].

In addition, the majority of recent assessments have utilized cross-sectional study designs, which, while effective for prevalence estimation, fail to elucidate causal relationships or temporal changes in nutritional status [22], [23]. Moreover, there is a notable research gap concerning the application of comprehensive anthropometric failure indices such as CIAF in rural Indonesian populations, particularly in geographically isolated regions like Bangka Belitung. These areas are characterized by unique socio-economic dynamics, including predominant agricultural livelihoods, limited healthcare access, and cultural practices influencing nutritional outcomes [24], [25].

Given these limitations, there is an imperative to enhance the understanding of childhood malnutrition using multidimensional measurement tools such as CIAF within these specific contexts. This study aims to bridge the research gap by assessing the prevalence of undernutrition among children under five in West Bangka, Indonesia, employing the CIAF as a comprehensive evaluative method. The specific objectives are to quantify the extent of anthropometric failure and to identify socio-economic and demographic factors associated with malnutrition in this region.

The contributions of this study are threefold: first, it provides the first detailed application of CIAF within the rural Bangka Belitung population, offering insights into the local prevalence rate; second, it facilitates a better understanding of demographic and socio-economic determinants influencing childhood malnutrition; and third, it underscores the potential for integrating multidimensional anthropometric indices into routine nutritional assessments in resource-limited settings, potentially informing policy and intervention strategies.

The remainder of this paper is organized as follows: Section II elaborates on the methodology, including the study design, population, and data collection techniques. Section III reports the results, highlighting prevalence estimates and associated factors. Section IV discusses the implications of findings in the context of existing literature. Lastly, Section V concludes with recommendations for policy and future research avenues.

II. METHODS

This research employed a descriptive analytical design with a cross-sectional approach to assess the prevalence of undernutrition among children under five years in West Bangka Regency, Bangka Belitung Islands Province. The study was conducted over a period of ten months, from October 2022 to July 2023. The primary aim was to determine the extent of undernutrition utilizing the Composite Index of Anthropometric Failure (CIAF) and to identify potential sociodemographic determinants influencing nutritional status within the study population.

A. STUDY POPULATION AND SAMPLING TECHNIQUE

The target population consisted of all children aged 6 to 59 months residing in West Bangka Regency. Inclusion criteria stipulated that respondents were willing to participate voluntarily, with no history of prematurity, low birth weight (LBW), or congenital anomalies as verified through health records and parental reports. Exclusion criteria incorporated any child with congenital abnormalities or chronic diseases that could distort anthropometric measurements. The sampling frame encompassed households within the area served by selected community health centers (Puskesmas).

A multistage random sampling method was employed to ensure representative sampling. Initially, two Puskesmas in West Bangka were selected randomly from the available health centers, considering their geographical distribution to capture diverse socioeconomic segments. Subsequently, within each Puskesmas jurisdiction, Posyandu (integrated health posts) and preschool (PAUD) centers were randomly chosen. Participants were then selected from registered households with eligible children through systematic random sampling, ensuring each eligible child within the population had an equal chance of participation. The determined sample size was 155 children, calculated based on previous prevalence data of undernutrition in the region, with a confidence level of 95% and a margin of error of 5%, adjusted for potential non-response or incomplete data in accordance with standard sampling formulas [23].

B. DATA COLLECTION INSTRUMENTS AND PROCEDURES

Data collection involved three primary instruments: a structured questionnaire, calibrated anthropometric measurement tools, and health record verification. The questionnaire was designed to gather demographic and socioeconomic data, including child age, sex, parental education level, household income, and parental age. The questionnaire was developed based on validated tools adapted from national health surveys and recent studies, ensuring content validity and reliability [24], [25].

Anthropometric measurements height and weight were conducted using standardized procedures recommended by WHO [26]. Height was measured with a portable, calibrated stadiometer, ensuring the child was in a erect standing position, with the head aligned in the Frankfurt plane. Weight was measured with a digital, calibrated infant or toddler scale with an accuracy of 0.1 kg. All measurements were performed twice, and the average was used for analysis to minimize measurement error. Operators in charge of measurements were trained extensively to ensure consistency and adherence to protocol.

C. STUDY DESIGN AND ETHICAL CONSIDERATIONS

This research was designed as a cross-sectional observational study. The purpose was explicitly communicated to respondents, and voluntary informed consent was obtained prior to participation, aligning with ethical standards for human research articulated in the Declaration of Helsinki [27]. The study protocol was reviewed and approved by the Health Research Ethics Committee of the Ministry of Health, Pangkalpinang, with approval number 01/EC/KEPK-PKP/V/2022.

D. DATA PROCESSING AND ANALYSIS

Collected data were coded, entered, and verified using IBM SPSS Statistics version 26.0. Anthropometric data were processed according to WHO growth standards, involving calculations of weight-for-age, height-for-age, and weight-for-height z-scores. The CIAF classification was employed to categorize nutritional status, with children classified as having no anthropometric failure or belonging to one of the anthropometric failure groups based on combinations of low weight, height, or both [12], [13].

Statistical analyses included descriptive statistics to estimate the prevalence of undernutrition. Bivariate analysis using Chi-square or Fisher's exact test was performed to identify associations between sociodemographic variables and nutritional status. A p-value of less than 0.05 was considered statistically significant. To examine potential confounders or interactions, logistic regression analyses were subsequently performed.

E. OPERATIONAL DEFINITIONS

1. Undernutrition defined as any child exhibiting anthropometric failure as classified by CIAF criteria.
2. Anthropometric failure presence of stunting, wasting, underweight, or any combination thereof.
3. Socioeconomic status assessed via household income and parental education levels adjusted for regional standards. The methodology outlined follows recent standardized protocols and aligns with best practices in nutritional epidemiology to ensure data quality and study reproducibility [23]–[28].

III. RESULT

TABLE 1.
Characteristics of Respondents and Their Relationship with Nutritional Status

Category	Mean ± SD Frequency (%) n=155	p
Child Gender		
Female	66 (42.6)	0,050*
Male	89 (57.4)	
Child Age (months)		
6 – 11	12 (7.7)	0,094**
12 – 23	25 (16.1)	
24 – 35	30 (19.4)	
35 – 47	46 (29.7)	
48 – 59	42 (27.1)	
Mother age (years)		
< 20	3 (1.9)	0,077**
20 – 35	135 (87.1)	
> 35	17 (11)	
Mother's education		
No School	11 (7.1)	0,585**
Basic education	100 (64.5)	
Further Education	44 (28.4)	
Household Income		
< Rp.3264.884	82 (52.9)	0,644*
≥ Rp.3.264.884	73 (47.1)	

Based on the results of the study obtained (TABLE 1), it can be seen that the gender of the children in this study was more boys (57.4%) than girls (42.6%). Statistical tests show that gender does not affect the nutritional status experienced by these toddlers. This contradicts research conducted in India and in sub-Saharan Africa where boys are more at risk for malnutrition although further research is needed on these findings. The possible cause is due to the non-fulfillment of

children's nutritional needs in line with increasing age. The average age of the children in the study was $35.49 \pm 14,794$ months (TABLE 1). The most children's age categories are in the age range of 35–47 months (29.7%) and 48–59 months (27.1%). There was no significant difference between the age of the child and the nutritional status of the child. Mother's education was found to be more in the basic age category in this study (TABLE 1). Statistical results show that there is no significant relationship between mother's education and child's nutritional status. TABLE 2 shows the prevalence of malnutrition based on CIAF. As many as 48.4% or almost half of the respondents experienced growth and development failure.

IV. DISCUSSION**A. INTERPRETATION OF FINDINGS**

This study investigated the prevalence of undernutrition among toddlers in West Bangka using the Composite Index of Anthropometric Failure (CIAF), a method that integrates weight-for-age (W/A), height-for-age (H/A), and weight-for-height (W/H) indicators. The CIAF identified that 48.4% of children in the sample experienced at least one form of anthropometric failure, signifying a high burden of undernutrition in the area.

Gender distribution revealed that boys (57.4%) slightly outnumbered girls (42.6%), yet statistical analysis indicated no significant relationship between gender and nutritional status. This aligns with findings from Southeast Asian contexts where gender disparities in nutritional outcomes were not consistently observed [29]. However, contrary findings from Sub-Saharan Africa and South Asia suggested boys are generally more vulnerable to undernutrition, potentially due to cultural and biological factors [30].

The mean age of children was approximately 35.49 months, with the highest proportion falling between 35–59 months. Despite the age range's relevance to growth milestones, no significant association was detected between age group and nutritional status. This contrasts with several studies conducted in Ethiopia and the Oromia region, where a significant correlation was observed between increasing age and undernutrition, possibly due to prolonged exposure to poor dietary practices or infections [31], [32].

Maternal age, another key factor, averaged 28.35 years among respondents. Although it is widely acknowledged that younger maternal age may be associated with poor child nutrition outcomes due to limited parenting experience and socioeconomic constraints [33] this study did not identify a statistically significant relationship. This may be attributable to the age homogeneity of the sample, with most mothers falling within the 20–35 age bracket, potentially minimizing variation in nutritional outcomes.

TABLE 2.
Malnutrition prevalence based on CIAF in children under five in West Bangka

Group	CIAF category	Frequency (%)
I	Normal	80 (51,6)
II	Wasting only	2 (1,3)
III	Stunting only	19 (12,3)
IV	Underweight	5 (3,2)
V	Stunting and Underweight	33 (21,3)
VI	Wasting and Underweight	5 (3,2)
VII	Wasting, Stunting and Underweight	11 (7,1)
Total		155 (100)

Regarding maternal education, a majority of respondents had attained only basic education. While some literature has established a strong linkage between maternal education and better child nutritional outcomes arguing that educated mothers are more likely to access health information and adopt better feeding practices [34] our findings did not support this assertion. The lack of association may be influenced by limitations in the quality of education or health knowledge dissemination, suggesting that formal education alone may not suffice without targeted health education programs.

Household income also failed to demonstrate a significant effect on nutritional status, despite 52.9% of families earning below the regional minimum wage. This contradicts findings from low- and middle-income settings like India and Bangladesh, where income is a determinant of dietary diversity, food security, and healthcare access [35], [36]. One plausible explanation is that subsistence activities such as agriculture and fishing, which dominate the local economy partially buffer income disparities by directly contributing to household food availability.

B. COMPARISON WITH RELATED STUDIES

The CIAF-based prevalence rate of undernutrition in this study (48.4%) aligns closely with data from Ethiopia, where similar CIAF methods yielded a prevalence of 48.5% [32]. This validates CIAF as a sensitive measure capable of detecting multiple overlapping forms of undernutrition. Unlike conventional indicators (W/A, H/A, W/H used separately), CIAF provides a more comprehensive assessment, especially for policy planning and intervention prioritization [37].

The most prevalent subcategory of anthropometric failure in our study was the combination of stunting and underweight (21.3%), followed by the co-occurrence of wasting, stunting, and underweight (7.1%). These results mirror patterns found in similar socioecological settings in South Asia and sub-Saharan Africa, indicating the chronic and multifactorial nature of malnutrition [31], [38].

It is also noteworthy that wasting alone had the lowest prevalence (1.3%), suggesting that acute undernutrition is less common than chronic or mixed types in this context. This pattern supports the notion that in many rural regions, poor long-term dietary intake and environmental conditions are more influential than temporary food shortages.

Despite widespread support in the literature for the importance of gender, maternal age, education, and income in determining child nutrition outcomes, this study did not find statistically significant relationships between these variables and nutritional status. Such discrepancies may reflect unique contextual dynamics, limitations in variable measurement, or the influence of unmeasured confounders such as sanitation, dietary diversity, food taboos, or access to health services.

C. LIMITATIONS AND IMPLICATIONS

Several limitations should be acknowledged. First, the cross-sectional nature of the study precludes causal inference. While associations can be observed, it is not possible to determine the directionality or temporality of the relationships. Longitudinal designs would be more

appropriate for understanding the developmental trajectory of malnutrition.

Second, the sample size, while statistically adequate, may not fully capture the heterogeneity within West Bangka, particularly between coastal and inland areas or among different ethnic groups. The reliance on a multistage random sampling approach may also have excluded more marginalized households, such as those in remote hamlets.

Third, the study did not assess environmental or dietary variables, which are critical components of child nutrition. Factors such as access to clean water, frequency of illness, dietary diversity, and feeding practices were not evaluated. Including these variables would allow for a more robust and multidimensional analysis.

Fourth, the measurement of income as a binary variable (<Rp. 3,264,884 or ≥Rp. 3,264,884) may oversimplify the complex relationship between socioeconomic status and nutritional outcomes. Future studies should consider more nuanced measures such as household wealth indices or food security scores.

Despite these limitations, the findings carry important implications for public health policy and nutritional programming in Indonesia. The high prevalence of undernutrition as captured by CIAF underscores the urgent need for multisectoral interventions. These should include health education for mothers and caregivers, improvements in sanitation and clean water access, food supplementation programs, and community-based monitoring of child growth.

Furthermore, the results highlight the limitations of relying solely on traditional anthropometric indicators for national surveillance. The CIAF method offers a more integrated and sensitive approach to identifying at-risk children and should be incorporated into Indonesia's national health surveys and routine community health assessments.

Health workers at Posyandu (integrated service posts) and Puskesmas (community health centers) should be trained in using CIAF-based assessments and interpreting the results for targeted interventions. Health education programs should also focus on equipping caregivers with practical knowledge on balanced nutrition, age-appropriate feeding, and hygiene practices.

Lastly, intersectoral collaboration between health, education, agriculture, and social protection agencies is essential for addressing the root causes of undernutrition. Integrating nutrition-sensitive interventions into existing poverty alleviation programs may enhance their effectiveness and sustainability.

V. CONCLUSION

The primary objective of this study was to determine the prevalence of undernutrition among toddlers in West Bangka Regency using the Composite Index of Anthropometric Failure (CIAF) and to examine associated sociodemographic factors. The CIAF approach was employed to provide a more comprehensive assessment of nutritional status by integrating three anthropometric indicators—weight-for-age, height-for-age, and weight-for-height. The findings revealed that 48.4% of the children assessed exhibited at least one form of anthropometric failure, indicating a high burden of undernutrition in the study area. The most prevalent category was the combination of stunting and

underweight (21.3%), followed by multiple deficits including wasting, stunting, and underweight (7.1%). The lowest prevalence was found in children with wasting only, accounting for 1.3% of cases. Interestingly, statistical analysis showed no significant associations between child nutritional status and key independent variables such as gender ($p = 0.050$), age ($p = 0.094$), maternal age ($p = 0.077$), maternal education ($p = 0.585$), or household income ($p = 0.644$). These findings suggest that undernutrition in this region may be influenced by more complex or unmeasured factors, such as dietary diversity, food security, sanitation, maternal health knowledge, or environmental conditions. The use of CIAF proved valuable in capturing overlapping forms of malnutrition that might otherwise be overlooked by conventional single-index measurements. Given these outcomes, it is recommended that future research incorporate a broader set of explanatory variables, including environmental, dietary, and health-related indicators, to gain a more comprehensive understanding of the multifaceted determinants of child malnutrition. Additionally, future studies should consider employing longitudinal designs to establish causal relationships and assess the long-term impact of various risk factors. Expanding the sample size and geographical coverage will also enhance the generalizability of the findings. Lastly, adopting the CIAF method for national surveillance may significantly improve the accuracy of undernutrition monitoring in Indonesia and inform more targeted interventions.

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DATA AVAILABILITY

The data supporting the findings of this study are available from the corresponding author upon reasonable request. Due to privacy and ethical considerations involving human participants, the dataset is not publicly accessible.

AUTHOR CONTRIBUTION

Eka Safitri Yanti contributed to the conceptualization, study design, data collection, and manuscript drafting. Tesza Rezky Permata was responsible for data analysis, interpretation of findings, and critical revision of the manuscript. Both authors reviewed and approved the final version of the manuscript and are accountable for all aspects of the work.

DECLARATIONS

ETHICAL APPROVAL

This study was approved by the Health Research Ethics Commission of the Ministry of Health Polytechnic,

Pangkalpinang, Indonesia, with approval number 01/EC/KEPK-PKP/V/2022. All procedures involving human participants were conducted in accordance with the ethical standards of the institutional research committee and the 1964 Helsinki Declaration and its later amendments.

CONSENT FOR PUBLICATION PARTICIPANTS.

All participants involved in this study were informed about the purpose, procedures, and potential use of the research findings. Written informed consent was obtained from all participants or their legal guardians for the publication of anonymized data.

COMPETING INTERESTS

The authors declare that they have no competing interests related to the content of this research.

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