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Factors of Child Growth Failure Based on the Composite Index of Anthropometric Failure in West Sulawesi Province

Faktor Gagal Tumbuh pada Anak Berdasarkan Composite Index of Anthropometric Failure *di Provinsi Sulawesi Barat*

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ABSTRACT

Background: The composite index of anthropometric failure (CIAF) provides a comprehensive measure of growth failure through various child anthropometric indicators. In regions with a high prevalence of stunting, several factors may contribute to the occurrence of growth failure in children under five years.
Objectives: This study aims to analyze the factors influencing the incidence of child growth failure based on the CIAF in a province with high stunting prevalence in Indonesia.
Methods: The cross-sectional study used the 2022 Indonesian Nutrition Status Survey (SSGI) data. The sample comprised children aged 0-23 months from West Sulawesi Province, totaling 1,573 children. The number of samples analyzed was 1,327 children, excluding incomplete data and outliers that were values outside a certain range and treated as missing values based on the World Health Organization (WHO). Multivariate analysis was conducted using logistic regression with a complex sample facility.
Results: This study found that 24.9% of children experienced growth failure based on the CIAF. Factors associated with the incidence of growth failure based on the CIAF were older age between 12-23 months (OR=4.5; CI=2.36-8.43; p=0.000), birth weight less than 2,500 g (OR=6.85; CI=3.85-12.21; p=0.000), boys (OR=1.56; CI=1.13-2.15; p=0.000), incomplete immunization status (OR=1.8; CI=1.31-2.77; p=0.001), and poor economic status in quintile 1 (OR=2.1; CI=1.08-3.99; p=0.028).
Conclusions: The risk factors for child growth failure based on the CIAF included older age, male sex, low birth weight, incomplete immunization status, and low economic status.

INTRODUCTION

The world is facing a triple burden of malnutrition that remains unresolved, particularly in low- and middle-income countries since 2020[1]. According to the 2022 Indonesian Nutrition Status Survey (SSGI), 7.7% of children experienced wasting, 3.5% were overweight, 21.6% were stunted, and 17.1% were underweight[2]. Stunting remains a serious concern, showing the highest prevalence of cases compared to other nutritional problems[3].

Stunting refers to a condition where children under five have a height that is inappropriate for their age and suffer from irreversible cognitive impairment caused by growth failure[3,4]. Growth failure experienced by toddlers can have negative impacts in the future. The short-term impact includes lower academic achievement during school years due to impaired cognitive development[5,6]. Meanwhile, the long-term impact of growth failure includes reduced quality of life in adulthood in terms of education, employment opportunities, and income[5]. The United Nations International Children's Emergency Fund (UNICEF) 2020 conceptual framework identified various factors contributing to growth failure, categorized as direct factors, indirect factors, and enabling factors[7]. Direct factors include inadequate food intake, both in quality and quantity, and a history of infectious diseases[8,9]. Indirect factors include child food[7], care[5], health services[10], and environmental sanitation[8,11]. In addition, enabling factors include governance, resources, and norms in the community[7].

The period under five years old is crucial for human growth and development[12], with the initial two years being particularly significant for rapid growth and development, while also being highly susceptible to nutritional problems[8,13]. This period presents golden opportunities for social and cognitive development and the formation of body tissues such as the brain. Rapid growth and development makes children vulnerable to both malnutrition and overnutrition with lasting effects[12,14].

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One of the regions with a high prevalence of stunting in Indonesia is West Sulawesi. From 2021 to 2022, this province had the second-highest stunting prevalence in Indonesia, with rates increasing from 33.8% in 2021 to 35% in 2022[2,15]. This rate is significantly higher than the national average of 21.6%, indicating a potential risk if not addressed.

So far, early detection of growth failure is typically assessed using the Weight-for-Age Z-score (WAZ)[16]. Another index that can be used is the composite index of anthropometric failure (CIAF)[17]. Compared to conventional indices, CIAF offers a more comprehensive overview of anthropometric failure[18].

A study conducted using data from the 2013 Basic Health Research (Riskesdas) showed that 2.5% of children in Indonesia were underweight, stunted, and wasted[19]. Children with growth failure have a higher risk of mortality compared to normal children[20]. A study in the Lakhimpur region of Assam, India, reported a 48.6% prevalence of growth failure based on the CIAF[21], while another study in Depok reported a 31% prevalence of growth failure based on the CIAF. The number of children classified as normal according to the CIAF is lower than those classified as normal by conventional indices such as WAZ, Height-for-Age Z-score (HAZ) or Weight-for-Height Z-score (WHZ)[22]. This indicates that the CIAF more comprehensively reflects the overall prevalence of nutritional problems in children.

Many studies have investigated similar topics, but few studies have been conducted in Indonesia using the CIAF to assess growth failure. In addition, this study used the latest secondary data, namely the 2022 SSGI, which has not yet been analyzed in relation to the causes of growth failure according to the CIAF. The results of this secondary data analysis are expected to identify the factors associated with growth failure on a broader scale and serve as a reference for determining appropriate interventions. Based on the aforementioned explanation, this study aims to analyze the factors associated with the incidence of child growth failure based on the CIAF in West Sulawesi Province, which has a high prevalence of stunting in Indonesia.

METHODS

This study used secondary data from the 2022 SSGI, conducted by the Health Research and Development Agency of the Indonesian Ministry of Health (MOH). The Ethics Commission of Health Research of the Faculty of Public Health, Universitas Diponegoro, approved this study with a certificate number 118/EA/KEPK-FKM/2024. The research design adhered to the cross-sectional nature of the 2022 SSGI. The research population comprised all households with children under two years in seven regencies/cities in West Sulawesi Province. The sample was selected based on inclusion and exclusion criteria. The inclusion criteria were: (1) children aged 0-23 months, and (2) children residing in West Sulawesi Province. The exclusion criteria were: (1) incomplete data, and (2) outlier data, defined as values outside a certain range and treated as missing values. The final sample included 1,573 households with children under two years. However, after data cleaning, the sample was reduced to 1,327 households with complete data.

The dependent variable of this study was the incidence of child growth failure based on the CIAF. The independent variables included child factors (age, sex, birth weight, and food diversity), maternal factors (education level, employment status, antenatal care (ANC), gestational age, and parity), household factors (food security and care practices such as early initiation of breastfeeding, exclusive breastfeeding, and complementary feeding), environmental sanitation (source of drinking water and sanitation facilities), household economic status, health services (immunization status, weight measurement, length/height measurement, Mid-Upper Arm Circumference (MUAC) measurement, development monitoring, counseling/consultation, vitamin A administration, and deworming), and history of child infectious diseases.

Descriptive statistics were used to analyzed the data, and hypothesis testing was conducted through multivariate analysis. Before multivariate analysis, a bivariate test was conducted to determine the correlation between several factors (independent variables) and the incidence of child growth failure based on the CIAF (dependent variable). The dependent variables associated with the dependent variable with a p-value of less than 0.25 in the bivariate test were included in the multivariate test. Out of the 29 variables analyzed, 18 variables were eligible for inclusion in the multivariate analysis using logistic regression with complex samples. Data analysis was performed using IBM SPSS Statistics 24, with significance levels at α of 0.05, and p of less than 0.05.

RESULTS AND DISCUSSIONS

A comprehensive overview of the characteristics of the respondents is provided in Table 1. A greater proportion of children under two years were between 12 and 23 months (49.0%) and were girls (51.0%). The prevalence of low birth weight (LBW) was 6.5%. Additionally, 47.0% of children's food intake was not diverse. A significant proportion of mothers had a low level of education (52.5%) and were not employed (69.6%). Furthermore, the majority of mothers had fewer than three children or were not at risk in terms of parity (58.1%). Half of the mothers had more than six antenatal care (ANC) visits, and 26.8% of the mothers had a history of preterm birth. The proportion of households with low food security was 69.1%. The care of children under two years was found to be satisfactory, with the majority being exclusively breastfed (57.4%), receiving age-appropriate complementary foods (57.4%), and receiving early initiation of breastfeeding (61.0%). The environmental sanitation of households was relatively satisfactory, with sources of drinking water meeting the required standards (53.0%) and sanitation being categorized as appropriate (81.9%). Regarding economic status, the highest proportion was found in the poorest or first quintile (30.4%). The majority of children under two years had an incomplete immunization status. however, the majority of children under two years had access to weight and length/height measurement,

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vitamin A administration, counseling, and deworming services according to standards, although access to mid-upper arm circumference (MUAC) measurement and developmental monitoring fell below government standards. The majority of children had no history of diarrhea (85.3%), acute respiratory infections (68.9%), pneumonia (97.1%), or pulmonary tuberculosis (99.2%). Finally, most children (78.8%) resided in rural areas.

Table 1. Frequency distribution of respondent characteristics in West Sulawesi Province, Indonesia

Variable	n (%)
Child Factors:	
Age	
12-23 Months	650 (49.0)
6-11 Months	348 (26.3)
0-5 Months	329 (24.8)
Sex	
Boy	651 (49.0)
Girl	676 (51.0)
Birth Weight (g)	
LBW	87 (6.5)
Normal	1240 (93.5)
Food Diversity	
No	623 (47.0)
Yes	704 (53.0)
Maternal Factors:	
Gestational Age	
Premature	355 (26.8)
Not Premature	972 (73.2)
Education Level	
Low	697 (52.5)
High	630 (47.5)
Employment Status	
Unemployed	923 (69.6)
Employed	404 (30.4)
Antenatal Care	
<6 Times	659 (49.6)
≥6 Times	668 (50.4)
Parity	
Risk	533 (40.1)
No Risk	794 (59.9)
Household Factors:	
Food Security	
Not Good	917 (69.1)
Good	410 (30.9)
Early Initiation of Breastfeeding	
No	517 (39.0)
Yes	810 (61.0)
Exclusive Breastfeeding	
No	566 (42.6)
Yes	761 (57.4)
Complementary Feeding	
Not Age Appropriate	566 (42.6)
Age Appropriate	761 (57.4)
Source of Drinking Water	
Not Good	623 (47.0)
Good	704 (53.0)
Sanitation	
Not Good	241 (18.1)
Good	1086 (81.9)
Economic Status	
Quintile 1	403 (30.4)
Quintile 2	323 (24.3)
Quintile 3	258 (19.5)
Quintile 4	206 (15.5)
Quintile 5	137 (10.3)
Health Services:	

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Variable	n (%)
Immunization Status	
Incomplete	993 (74.8)
Complete	334 (25.2)
Weight Measurement	
Not According to Standards	591 (44.5)
According to Standards	736 (55.5)
Length/Height Measurement	
Not According to Standards	174 (13.1)
According to Standards	1153 (86.9)
MUAC Measurement	
Not According to Standards	1219 (91.9)
According to Standards	108 (8.1)
Development Monitoring	
Not According to Standards	866 (65.3)
According to Standards	461 (34.7)
Counseling/Consultation	
Not According to Standards	1182 (89.1)
According to Standards	145 (10.9)
Vitamin A Administration	
Not According to Standards	487 (36.7)
According to Standards	840 (63.3)
Deworming	
Not According to Standards	475 (35.8)
According to Standards	852 (64.2)
History of Child Infectious Diseases:	
Diarrhea	
Yes	196 (14.7)
No	1131 (85.3)
Acute Respiratory Infection	
Yes	413 (31.1)
No	914 (68.9)
Pneumonia	
Yes	39 (3.0)
No	1288 (97.0)
Pulmonary Tuberculosis	
Yes	10 (0.8)
No	1317 (99.2)
Residence:	
Rural	1046 (78.8)
Urban	281 (21.2)

LBW (Low Birth Weight); MUAC (Mid-Upper Arm Circumference)

The results of anthropometric classification based on the CIAF provided a detailed picture of growth failure among children under two years, as shown in Table 2. This study found that the prevalence of growth failure among underweight children based on the CIAF in West Sulawesi was 24.9%, which is lower than the prevalence of stunting in the region in 2022 (35%). A quarter of children under two years experienced single or multiple malnutrition problems (stunting, underweight, or wasting). This prevalence is lower compared to other regions, such as in Semarang City (34.2%)[17], Bogor (42.1%)[23], as well as Lima Puluh Kota, South Solok, Solok City, and Padang (30.3%)[20]. Internationally, the prevalence is 21.7% in China[24], 36.1% in West Bengal[25], 38.2% in Tanzania[26], 48.6% in Assam, India[21], and 52% in Bangladesh[27]. These differences may be attributed to research duration, feeding practices, information gaps, and socioeconomic factors[28].

Table 2. Percentage of child growth failure based on the CIAF

Category	CIAF n (%)
A: No Anthropometric Failure	997 (75.1)
B: Wasting Only	35 (2.6)
C: Wasting and Underweight	42 (3.2)
D: Wasting, Underweight, and Stunted	21 (1.6)
E: Stunting and Underweight	85 (6.4)
F: Stunting Only	127 (9.6)
Y: Underweight Only	20 (1.5)

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Category	CIAF n (%)
Anthropometric Failure	330 (24.9)

Anthropometric Failure = B + C + D + E + F + Y

Data analysis began with bivariate analysis followed by multivariate analysis. The bivariate analysis identified 18 independent variables suitable for inclusion in the multivariate analysis, namely child age, child sex, birth weight, gestational age, maternal education level, parity, household food security, home sanitation, economic status, immunization status, MUAC measurement, counseling/consultation, vitamin A administration, deworming, history of infectious diseases (diarrhea, acute respiratory infections, and pneumonia), and residence. Table 3 shows the factors associated with the incidence of growth failure according to the CIAF in West Sulawesi Province.

Table 3. Results of multivariate analysis of determinants of child growth failure based on the CIAF in West Sulawesi Province

Variable	CIAF, R^2 = 0.137[a]			
	S.E.	OR	95% CI	p-value
Child Age				
12-23 Months	0.323	4.46	2.36-8.43	0.000*
6-11 Months	0.290	2.24	1.27-3.97	0.006*
0-5 Months	reff			
Child Sex				
Boy	0.165	1.56	1.13-2.15	0.007*
Girl	reff			
Birth Weight				
LBW	0.294	6.85	3.85-12.21	0.000*
Normal	reff			
Gestational Age				
Premature	0.167	1.31	0.94-1.82	0.106
Not Premature	reff			
Mother's Educational Level				
Low	0.183	0.93	0.65-1.33	0.677
High	reff			
Parity				
Risk	0.166	1.20	0.86-1.66	0.284
No Risk	reff			
Food Security				
Not Good	0.192	1.20	0.82-1.75	0.353
Good	reff			
Sanitation				
Not Good	0.219	1.32	0.86-2.03	0.203
Good	reff			
Economic Status				
Quintile 1	0.332	2.08	1.08-3.99	0.028*
Quintile 2	0.356	1.72	0.85-3.47	0.128
Quintile 3	0.365	1.13	0.55-2.23	0.731
Quintile 4	0.342	1.09	0.56-2.14	0.796
Quintile 5	reff			
Immunization Status				
Incomplete	0.191	1.90	1.31-2.77	0.001*
Complete	reff			
MUAC Measurement				
Not According to Standards	0.347	0.89	0.45-1.77	0.743
According to Standards	reff			
Counseling/Consultation				
Not According to Standards	0.264	1.10	0.65-1.85	0.718
According to Standards	reff			
Vitamin A Administration				
Not According to Standards	0.194	0.87	0.60-1.28	0.490
According to Standards	reff			
Deworming				
Not According to Standards	0.238	0.98	0.61-1.56	0.927
According to Standards	reff			
History of Diarrhea				

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Variable	CIAF, R^2 = 0.137[a]			
	S.E.	OR	95% CI	p-value
Yes	0.246	1.16	0.72-1.89	0.542
No	reff			
History of ARI				
Yes	0.163	1.26	0.92-1.74	0.152
No	reff			
History of Pneumonia				
Yes	0.469	0.82	0.33-2.06	0.674
No	reff			
Residence				
Rural	0.217	0.72	0.47-1.10	0.127
Urban	reff			

LBW (Low Birth Weight); MUAC (Mid-Upper Arm Circumference); [a]Logistic regression; *p<0.05

A risk factor for child growth failure based on the CIAF included older child age (12-23 months) (OR=4.4; CI=2.36-8.43; p=0.000). The results of the study are consistent with a study in Tanzania, which showed that children aged 0-6 months have a lower prevalence of growth failure based on the CIAF compared to children aged over six months[26]. Similarly, a study in Ethiopia also showed that children aged 12-23 months have a 2.6 times higher risk of experiencing growth failure based on the CIAF compared to children under six months [29]. Another study found that children aged 12-23 months have a greater risk of growth failure based on the CIAF compared to children aged 0-11 months. This is attributed to the adequacy of nutrients from breast milk during the first six months. Inadequate complementary feeding and premature weaning (before six months) contribute to stunted growth[26].

Moreover, sex was associated with an increased risk of growth failure according to the CIAF. Boys appear to have a higher risk of growth failure compared to girls, with an OR of 1.56**.** (95% CI=1.13-2.15). Several studies have indicated that boys are more likely to be undernourished than girls. A narrative review by Thurstans et al. found that, despite being larger at birth and during growth, boys experienced more undernutrition under conditions of dietary deprivation. The difference is more pronounced in severe malnutrition and socioeconomically deprived contexts. Infectious diseases tend to affect boys more significantly than girls. The differences in the immune and endocrine systems also contribute to this difference[30].

Children with a history of low birth weight had a higher risk of growth failure based on the CIAF than those born with normal birth weight with an OR of 6.85 (95% CI=3.85-12.21). This finding is consistent with a study from Nagpur, India, which found that children with low birth weight had a 3.69-fold higher risk of growth failure based on the CIAF[31]. Another study in Visakhapatnam, India showed that children weighing less than 2,500 g had a 2.6-fold higher risk of growth failure based on the CIAF[32]. Children with low-birth-weight experienced growth failure based on the CIAF[33]. LBW is a predictor of infant growth, with strong correlations with maternal and child factors. Maternal factors are associated with nutrient deficiencies in the fetus. Most pregnancy disorders are related to inadequate maternal food intake, systemic diseases such as diabetes, or abnormal placental function, especially during the third trimester[17].

Low economic status was another risk factor for growth failure based on the CIAF, with an OR of 2.5 (95% CI=1.15-5.57). Economic status was assessed using a quintile index (1-5), where 1 represents the lowest economic status. This assessment was based on the ownership of valuable goods. Each valuable possession was assigned a different value. The statistical technique used to measure economic status was principal component analysis. Households with economic status in quintile 1 (lowest) had a 2.5 times higher risk of having children with growth failure based on the CIAF. The results of a study conducted in Tanzania yielded similar findings, indicating that children from poor households were at a greater risk of growth failure based on the CIAF compared to those from rich households[26]. A study in India also showed similar results, where children from poor households had double the risk of growth failure based on the CIAF compared to those from wealthier families[34]. Poor economic status often leads to food insecurity, resulting in inadequate provision of nutritious food. Poor household sanitation is another contributing factor. Households with food insecurity and poor sanitation tend to have a higher risk of infection, ultimately leading to child malnutrition. Furthermore, households with poor economic status have limited access to health services[26,35].

The incidence of growth failure in children was associated with their immunization status. Children who had received incomplete immunization were at an increased risk of growth failure, as determined by the CIAF, in comparison to those who had received complete immunization, with an OR of 1.90 (95% CI=1.31-2.77). One potential explanation for this correlation is that immunized children are better protected against infectious diseases and less susceptible to illnesses that can lead to malnutrition and growth failure[36]. In addition, vaccination programs often provide nutrition education and health services to mothers and children, which can improve maternal and child health outcomes, including child growth. Thus, immunization can substantially improve child growth and development[37]. A study in Indonesia using data from the Indonesian Family Life Study (IFLS) strengthens the evidence correlating immunization and the occurrence of chronic growth disorders (stunting) in children under five[35].

However, this study has certain limitations, especially in terms of the selection of research variables. This study only focused on postnatal factors, such as child

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factors, maternal factors, household factors, health services, and history of infectious diseases, without considering prenatal factors. Additionally, this study encountered issues with incomplete or missing data from the 2022 SSGI, which may affect the representativeness of the data.

CONCLUSIONS

The prevalence of child growth failure based on the CIAF in areas with high rates of stunting among children under two years reached a quarter of the total number of children (24.9%). Identified risk factors for growth failure based on the CIAF included age (12-23 months), sex (male), low birth weight, incomplete immunization status, and poor economic status. It is recommended that the prevention of growth failure in children should commence as early as possible, ideally during pregnancy, through the provision of comprehensive antenatal care services aimed at reducing the incidence of low birth weight (LBW) infants. Postnatally, the quality and quantity of food and fluid intake should be improved to support optimal physical and cognitive development throughout childhood. Furthermore, it is of paramount importance to ensure that all children are fully immunized, with children from poor households being a particular focus for nutrition interventions.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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AUTHOR CONTRIBUTIONS

HIL: conceptualization, methodology, formal analysis, writing-original draft; SS: conceptualization, supervision, writing-review & editing; AFA: supervision, writing-review & editing.

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