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ASSESSING CHILD UNDERNUTRITION USING COMPOSITE INDEX OF ANTHROPOMETRIC FAILURE (CIAF) AND ITS DETERMINANTS: A CROSS-SECTIONAL STUDY IN YOGYAKARTA, INDONESIA

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Abstract

Weight-for-age, height-for-age, and weight-for-height reflect numerous nutritional status factors. Neither alone nor together, standard indicators can show the whole extent of undernutrition. The Composite Index of Anthropometric Failure (CIAF) addresses this weakness with an alternate classification approach. This study examines the extent of child undernutrition using CIAF in Yogyakarta, Indonesia, and its associated factors. This study was conducted using a cross-sectional design using Survey Status Gizi Indonesia (SSGI 2021), a national survey by including 2,877 children aged 0-59 months. Conventional indices and the CIAF were utilized to categorize child undernutrition. We applied multinomial logistic regression using STATA 15 to analyse factors associated with undernutrition among children. This study found that the rates of underweight, stunting, and wasting were 11.16 %, 17.3%, and 5.63%, respectively. The prevalence of undernutrition using CIAF was 19.95%. Factors associated with undernutrition using CIAF included older age children, higher maternal education, having five or more household members, having two or more children under five years, and lower household economic status. Thus, health providers and public health actors should consider the use of CIAF for nutritional anthropometric assessment in a wider context.

Keywords: *CIAF, Children, HAZ, WHZ, WAZ, Malnutrition, Determinant*

1. INTRODUCTION

Child undernutrition is a serious public health concern in developing nations, including Indonesia. Undernutrition is one of the primary contributors to morbidity, mortality, and premature death. Conventional anthropometric measurements of height, weight, and age have traditionally been used to estimate child undernutrition. Three indices of stunting, wasting, and underweight were calculated

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for evaluating nutritional status. These indices reflect distinct biological processes and are necessary for determining appropriate nutritional interventions[1].

However, conventional indices only categorize children into general categories of under-nutrition and do not determine the overall prevalence of under-nutrition associated with multiple anthropometric failures. For example, a child diagnosed with stunted growth may also be underweight and wasted. Therefore, a group's total number of underweight, stunted, and wasted children does not disclose the total number of malnourished children in a population. So, the conventional indices are unable to provide information regarding the overall prevalence of malnutrition in children[2]. This has led to opinations that these indices are insufficient and underestimate the number of under-nourished children.

The Composite Index of Anthropometric Failure (CIAF) is an aggregated anthropometric measure used to estimate under-nourished children. The CIAF includes children with stunting, underweight, wasting, and multiple failures and excludes children with appropriate body height and weight. So, the CIAF is essential for assessing under-nutrition in children. Previous studies have found evidence that CIAF was utilized to determine the severity of the malnutrition of children in China[3], Bangladesh[4], dan India[5]. This study found that the CIAF provides greater precision to identify malnutrition among vulnerable populations including under five children. Further, by identifying double or multiple malnutrition, CIAF disaggregation has the potential to enhance the efficacy of a nutritional intervention program[1]–[6].

Malnutrition is caused by multifactorial both proximate and distal. The distal factors include social, economic, educational level, occupational, housing, water access and sanitation facilities, air pollution, health knowledge, perception and behavior. Meanwhile, the proximate factors include nutritional status during pregnancy, food consumption and infection[7]–[10]. Toddlerhood is a particularly vulnerable age. Young infants are still highly susceptible to infection, resulting in a high risk of morbidity and mortality[11]. However, with proper parenting, they will grow and develop following their milestones[12]. However, this does not mean that older infants have a lower risk of malnutrition[13-14], as they are generally already playing, picky eaters[15], and have new siblings[16], which reduces parental attention, particularly for children from low-income households[7][17]. The study tested hypotheses suggesting CIAF provides a more accurate assessment than conventional anthropometric indices and higher anthropometric failure influenced by socio-economic and demographic factors.

2. METHODS

2.1 Design and samples

We used data from the 2021 Indonesia Nutritional Status Survey (*Survey Status Gizi Indonesia/SSGI*), a national cross-sectional survey in Indonesia. In the present study, we particularly analysed data from a total of 2877 children under five in the Yogyakarta Special Region, one of 34 provinces in Indonesia. Administratively, Yogyakarta Special Region consists of five districts/municipalities: Kulon Progo, Bantul, Gunung Kidul, Sleman, and Yogyakarta City.

2.2 Outcome variables

The primary outcome of this study was child nutritional status. Using the children's age, weight, and height data, we calculated weight-for-age Z scores (WAZ), height-for-age Z scores (HAZ), and weight-for-height Z scores (WHZ). Children with WAZ, HAZ, and WHZ scores ranging from -3.0 to -2.0 SD were categorized as moderately underweight, stunted, and wasted, respectively. Those whose WAZ, HAZ, or WHZ scores were-3.0 SD were categorized as severely underweight, stunted, or wasted,

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respectively. Those whose WHZ and WAZ scores ranged from +1 SD to +2 SD were at risk of obesity while >+2 was obese[18]. Then, we determined CIAF in seven groups, as detailed in Table 1.

Table 1: Classification of CIAF

Group	Description	Wasting (WHZ)	Stunting (HAZ)	Underweight (WAZ)
A	No failure	No	No	No
B	Wasting only	Yes	No	No
C	Wasting and underweight	Yes	No	Yes
D	Wasting, stunting and underweight	Yes	Yes	Yes
E	Stunting and underweight	No	Yes	Yes
F	Stunting only	No	Yes	No
G	Underweight only	No	No	Yes

Resource: Nandy, 2005[19]

2.3 Independent variables

Our independent variables were undernutrition determinants, such as the child's sex (male, female), the child's age (0-11 months, 12-23 months, 24-35 months, 36-47 months, 48-59 months), maternal age (<35 years, >35 years), maternal level of education (no formal education or primary, secondary, tertiary), maternal working status (not working, working), number of household members (<5, >5), number of children under five years (<2, >2), household economic status (poorest, poorer, middle, richer, richest), living residency (rural, urban), geographic areas (Kulonprogo, Bantul, Gunung Kidul, Sleman, Yogyakarta City).

2.4 Statistical analysis

We used descriptive statistics to present the distribution of study participants in frequency and percentage in tables. We also showed the distribution of child undernutrition in a graph. To investigate the differences in the incidence of undernutrition based on the child's age and sex, we performed Chi-square test. We analysed the determinants of undernutrition using multinomial logistic regression. Unadjusted and adjusted odds ratios were presented to show the strength of association between the determinants and undernutrition. We considered the best fit model using Bayesian Information Criterion (BIC). The level of significance was set at 0.05. All of the analyses were done using Stata version 15.

2.5 Ethical consideration

The IRB Poltekkes Kemenkes Yogyakarta Ministry of Health Yogyakarta:
e-KEPK/POLKESYO/0223/II/2022, dated 23 February 2022, approved this study.

3. RESULTS

3.1 Children characteristics

Our study included 2877 children under the age of five whose characteristics are shown in Table 2. Children were distributed equally across sex. There was a higher proportion of children aged above 23 months (63.8%), maternal age <35 years old (69.8%), mothers with secondary education (71.3%), working mothers (52.5%), number of household members >5 (52.8%), number of children under-fives <2 (81.7%), richest households (27.6%), and Bantul living areas (25.6%).

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Table 2: Characteristics of Children Under-Fives in Yogyakarta

Variable	N	%
Child's sex		
Male	1463	50.9
Female	1414	49.1
Child's age (months)		
0-11	435	15.1
12-23	609	21.2
24-35	618	21.5
36-47	648	22.5
48-59	567	19.7
Mother's age (years)		
<35	1988	69.8
>35	859	30.2
Mother's education		
No formal education or primary	209	7.4
Secondary	2031	71.3
Tertiary	607	21.3
Mother's working status		
Not working	1353	47.5
Working	1494	52.5
Number of household members		
<5	1359	47.2
>5	1518	52.8
Number of children <59 months		
<2	2352	81.7
>2	525	18.3
Household economic status		
Poorest	238	8.3
Poorer	682	23.7
Middle	565	19.6
Richer	598	20.8
Richest	794	27.6
Living residency		
Rural	880	30.6
Urban	1997	69.4
Geographic areas	2877	
Kulon Progo	450	15.6
Bantul	737	25.6
Gunung Kidul	578	20.1
Sleman	692	24.1
Kota Yogyakarta	420	14.6

Furthermore, the results of anthropometric analysis by comparing single measurement and CIAF showed that malnutrition using CIAF more sensitive to detect malnutrition, both in male and female toddlers (Fig 1).

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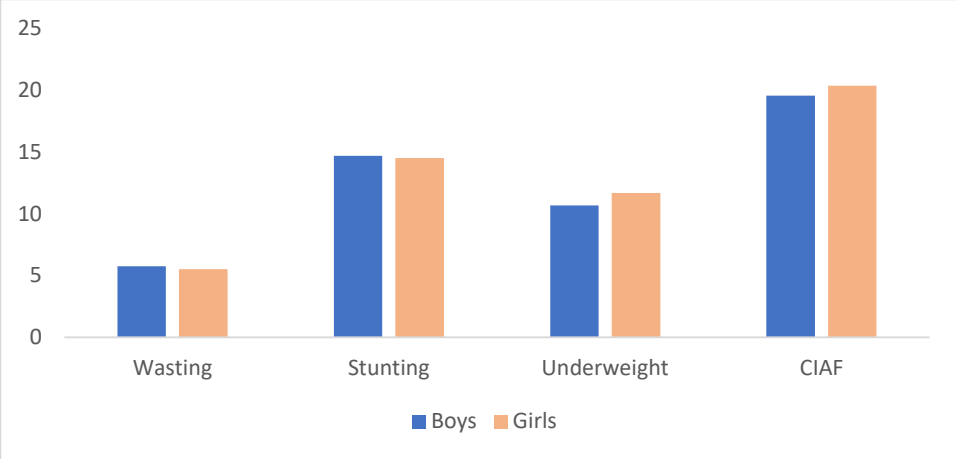

Figure 1: The prevalence of undernutrition using conventional and CIAF indicators among boys and girls in Yogyakarta Special Region

However, there were no statistical differences between boys and girls for the remaining anthropometric variables as detailed in Table 3.

Table 3: Anthropometric Measurements Based On Conventional And Ciaf Indicators In Yogyakarta Special Region Based On The Children's Sex

Categories	Total (n=2877)	Male (n=1463)	Female (n=1414)	Sex difference	
	n (%)	n (%)	n (%)	x2 value	p
Wasting	162 (5.63)	84 (5.74)	78 (5.52)	0.07	0.793
Stunting	420 (14.60)	215 (14.7)	205 (14.5)	0.02	0.881
Underweight	321 (11.16)	156 (10.66)	165 (11.67)	0.73	0.392
CIAF	574 (19.95)	286 (19.55)	288 (20.37)	0.30	0.583

The classification of children that have anthropometric failure can be found in table 3. The Children's International Assessment of Hunger (CIAF) displays a disaggregation of the hungry children into various subgroups. In all, 2303 (80%) of the children under the age of five who were examined had normal anthropometric measurements. It was discovered that the CIAF (the total number of research subjects in groups B–G) was 20%, which means that 574 (20%) of the children displayed some kind of anthropometric failure. The most failuer is stunting (7.1%) and stunting-underweight (5.5%). Prevalence undernutrition among children using CIAF as detailed in Table 4.

Table 4: Prevalence Undernutrition among Children Using CIAF

Group	Description	Total (n= 2877)	Male (n= 1463)	Female (n= 1414)	X2 diff	p
A	No failure	2303 (80.0%)	1177 (80.5%)	1126 (79.6%)	0.30	0.583
B	Wasting only	48 (1.7%)	25 (1.7%)	23 (1.6%)	0.03	0.863
C	Wasting and underweight	58 (2.0%)	30 (2.1%)	28 (2.0%)	0.02	0.893
D	Wasting, stunting and underweight	56 (2.0%)	29 (2.0%)	29 (1.9%)	0.02	0.888
E	Stunting and underweight	159 (5.5%)	81 (5.5%)	78 (5.5%)	0.00	0.981
F	Stunting only	205 (7.1%)	105 (7.2%)	100 (7.1%)	0.01	0.913
G	Underweight only	48 (1.7%)	16 (1.1%)	32 (2.3%)	5.99	0.014*

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3.2 Bivariate table and multinomial analysis

Bivariate analysis showed that according to the CIAF, the following are factors associated to the failure of children's growth such as older children, formal education less than junior high school, maternal age >35 years, number of family members ≥ 5, number of toddlers≥2, very poor to middle economic household, and living in rural area. However, multinomial analysis shows that all factors are connected, with the exception of who live in rural areas and maternal age >35 years (see Table 5).

Table 5: Bivariate and Multinomial Logistic Regression Model Analysis and Associated Risk Factors in Different Groups of Anthropometric Failure (CIAF)

Characteristics	Total		CIAF		OR	95%CI	p(*=sig)	AOR	95%CI	p (*=sig)
Child's sex	n	%	n	%						
Male	1463	50.9	286	19.5	1.22	1.01-1.43	0.59	1.12	1.02-1.53	0.659
Female	1414	49.1	288	20.4	1			1		
Child's age (months)										
0-11	435	15.1	83	19.1	1			1		
12-23	609	21.2	116	19.0	4.01	0.22-9.16	<0.001*	4.81	0.23-9.86	<0.001*
24-35	618	21.5	133	21.5	3.36	2.15-8.27	<0.001*	4.46	2.17-9.17	<0.001*
36-47	648	22.5	134	20.7	3.71	1.76-6.99	<0.001*	3.69	1.78-7.64	<0.001*
48-59	567	19.7	120	21.2	3.21	1.45-6.87	0.002*	3.32	1.58-6.98	0.002*
Mother's age (years)										
<35	1988	68.8	378	19.0	1			1		
>35	859	30.2	164	19.1	2.33	1.01-2.89	0.005*	2.31	0.87-3.02	0.067
Mother's education										
No formal education or primary	209	7.4	51	24.4	1.67	1.18-2.65	0.003*	1.72	1.07-2.87	0.003*
Secondary	2031	71.3	421	20.7	1.46	1.29-3.42	0.002*	1.27	1.19-3.02	0.002*
Tertiary	607	21.3	115	18.9	1			1		
Mother's working status										
Not working	1353	47.5	283	20.9	1.61	0.88-2.33	0.56	1.59	0.89-2.23	0.56
Working	1494	52.5	284	19.0	1			1		
Number of household members										
<5	1359	47.2	258	19.0	1			1		

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>5	1518	52.8	345	22.7	2.22	1.24-4.31	0.018*	2.17	1.14-4.11	0.018*
Number of children under fives										
<2	2352	81.7	447	19.0	1			1		
>2	525	18.3	134	25.5	2.21	1.12-3.66	0.027*	2.01	1.08-3.67	0.027*
Household economic										
Poorest	238	8.3	58	24.4	2.67	1.89-3.89	0.027*	2.78	1.76-4.02	0.027*
Poorer	682	23.7	145	21.3	2.29	1.40-3.54	0.051	2.44	1.35-3.94	0.051
Middle	565	19.6	110	19.5	1.68	1.39-3.24	<0.001*	1.64	1.37-3.04	<0.001*
Richer	598	20.8	98	16.4	1.69	0.78-2.42	0.056	1.72	0.71-2.62	0.056
Richest	794	27.6	78	9.8	1			1		
Living residency										
Rural	880	30.6	205	23.3	1.32	1.12-2.01	0.07 *	1.21	0.52-2.71	0.07
Urban	1997	69.4	379	19.0	1			1		
Geographic areas										
Kulon Progo	450	15.6	86	19.1	Ref			Ref		
Bantul	737	25.6	140	19.0	2.23	0.62-7.06	0.078	2.21	0.63-7.16	0.078
Gunung Kidul	578	20.1	109	18.9	0.77	0.23-2.44	0.066	0.86	0.26-2.89	0.066
Sleman	692	24.1	132	19.1	2.34	0.67-6.99	0.071	2.24	0.68-7.39	0.071
Kota Yogyakarta	420	14.6	80	19.0	2.22	0.55-8.43	0.089	2.15	0.56-8.19	0.089

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4. DISCUSSION

This study found that the prevalence of child undernutrition was higher using CIAF indicators compared to a single or conventional measurement. This finding builds on previous research that examined data from 56 low- and middle-income countries and reported that undernutrition using conventional undernutrition indicators was lower than using CIAF in all countries[20]. Our results are also in line with a study in Mumbai City[6]) and West Bengal [3] in India, India[6], Nigeria[21], Ethiopia[22], and study in Bogor District, Indonesia[23]. The use of CIAF as an undernutrition indicator is generally useful to inform healthcare providers, public health actors, and policymakers to deliver more comprehensive interventions and nutrition services[24].

A single undernutrition issue may impact other malnutrition forms and a child may suffer from more than one type of malnutrition. Thus, the use of a single measurement may result in incomplete nutrition improvement efforts[25]. For example, if wasting, an acute malnutrition form, is not treated, it may cause chronic undernutrition such as stunting[13][24][26-27]. This pathway could be due to the body's response to losing weight is to decrease or stop linear growth as reported previous study among Nigerian children[28] and multi-countries multi-studies[27]. Besides, an intervention that only focuses on single malnutrition indices will give a long-term impact. For example, if stunted children are provided with high-calorie diets will be at risk of obesity and non-communicable diseases since they are more susceptible to impaired fat oxidation[29].

The present study shows that older age children were more likely to experience multiple undernutrition. The results are in accordance with earlier studies in Ethiopia[30] and Bangladesh [31]. The explanation could be that older children received poorer care due to maternal return to work, low quality of solid foods, prone to infections due to their ability and preference to explore their surroundings, and repeated infections[7][9-10].

The higher number of children under five and household members are associated with the burden of child undernutrition. This could be due to the family size may affect the distribution of household resources, including food distribution within the household especially for vulnerable group including younger children[32]. Besides, highly dense households may increase the risk of infectious diseases such as rotavirus and diarrhoea[33] Thus, there is an urgent need for public health workers and the government to encourage family planning programs[34].

Maternal education is significantly associated with multiple undernutrition, which is in line with previous studies in Kenya[35], India[36], and many countries[37]. Maternal educational attainment may mirror women's empowerment that helps them in decision-making in child feeding, nutrition, and health. Highly educated mothers also tend to be more aware of their children's health, thus providing better care[9][38-39]. Another factor that is associated with multiple undernutrition is household economic status. The economy is a fundamental factor which is linked to better access and affordability in healthcare, nutritious food, information, and education[40-41]. Therefore, enhancing education and the economy is a key strategy to halt stunting problems.

5. STRENGTH AND LIMITATIONS

This study has several limitations. The use of cross-sectional design does not allow us to draw causal-effect associations. However, this study involved large sample size and specific study settings (i.e., Yogyakarta with its high Human Development Index and low stunting prevalence), suggested that using CIAF to assess child nutritional status resulted in multiple undernutrition and if implemented in other Indonesian regions may result in greater undernutrition issues, thus better identification and targett diarhoea ed nutrition interventions.

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6. CONCLUSION

Nearly twenty percent of malnourished children experienced multiple forms of undernutrition, indicating severe degrees of malnutrition. Thus, CIAF should be utilized more for nutritional assessment, particularly in developing nations with high rates of malnutrition. Besides, socioeconomic factors which are associated with multiple undernutrition indicate the urgency to consider macro issues, such as economy and education, thus multisectoral approaches are needed to overcome child nutritional issues.

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Conflict of interest

We declare no conflict of interest.

Author Contribution

Conceptualization, T.S. and M.P.R.; methodology, T.S. and J.K.; software, B.A.P.; validation, M.P.R.; formal analysis, B.A.P.; investigation, T.S., J.K., M.P.R.; data curation, T.S. and B.A.P.; writing—original draft preparation, writing—review and editing. All authors read and approve the manuscript.

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