Assessment of Undernutrition Using Composite Index of Anthropometric Failure (CIAF) and its Determinants: A Cross-Sectional Study in the Rural Area of Bogor District in Indonesia

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Abstract

Background: Composite Index of Anthropometric Failure (CIAF) can assess anthropometric failure by combining the three conventional index measurements of weight-for-age, length/height-for-age, and weight-for-length/height to determine the nutritional status of children under five years. This study aims to assess undernutrition using the CIAF and its determinants on children under five years in the rural area of Bogor District, in Indonesia.

Methods: A cross-sectional study was conducted during February-May 2019 among 330 pairs of mother-children (under five years). Sample selected by systematic random sampling from four villages as undernutrition pockets in the rural area of Bogor District, Indonesia. The nutritional status of children was assessed by measuring weight and length/height. Then, Z-score was calculated using WHO Anthro software and categorized based on conventional indices that included weight-for-age (WAZ), length/height-for-age (HAZ), weight-for-length/height (WHZ). CIAF is measured based on a combination of conventional index measurements. In addition, the characteristics of mother's and child, and clean living behavior measured by structured questionnaires. Meanwhile, environmental sanitation is assessed by the environment meter. Binary logistic regression analysis with SPSS version 22.0 was used to analyze the dominant factors associated with undernutrition.

Results: The prevalence underweight, stunted, and wasted was 27.8%, 29.7%, and 10.6% respectively. Children who are undernutrition are 42.1% according to the CIAF of which about a quarter (17.8%) of undernutrition children experience a single anthropometric failure, about half (22.2%) had dual failure, and 2.1% had multiple failures. The most dominant factor associated with underweight, stunted, and wasted is family income \([p\text{-value}=0.018; \text{AOR}=5.44; 95\% \text{ CI}: 1.34-22.11]\), mother's height \([p\text{-value}<0.001; \text{AOR}=3.29; 95\% \text{ CI}: 1.83-5.91]\), and child's age \([p\text{-value}=0.013; \text{AOR}=2.59; 95\% \text{ CI}: 1.22-5.47]\) respectively. Mother's height is the most dominant factor associated with anthropometric failure (CIAF) \([p\text{-value}=0.008; \text{AOR}=1.95; 95\% \text{ CI}: 2.19-3.19]\).

Conclusion: CIAF is worthwhile in preventing undernutrition in children under five years. The CIAF can identify more malnourished children than the conventional index. CIAF can use more widely in various regions in Indonesia and other developing countries. Furthermore, improvements in improving nutrition for mother's in the child since the First 1000 days of life period are needed to determine optimal nutritional status as an indicator of growth success.

Introduction

The target of the Indonesian government is to reduce stunting by 14% in 2024 (1). But in fact, the number of stunting and other malnutrition problems in Indonesia is still high. In Southeast Asia, the prevalence of stunting in Indonesia is the second-highest, after Cambodia (2). Based on the results of the 2018 Basic Health Research (Riskesdas), the prevalence of stunting in Indonesia showed a decline of 6.4% over five years, from 37.2% (2013) to 30.8% (2018). While some other nutritional problems, as many as 17.7% were
underweight, and 10.2% were wasting. This malnutrition problem occurs evenly in various provinces. In West Java Province, there are 31.1% stunting, 13.2% underweight, and 8.4% wasting. This serious problem can affect a child's health, making them more susceptible to disease and infection, and impairs their mental and physical development (3, 4). Furthermore, this nutritional problem can hinder economic growth and reduce labor market productivity, contributing to widening inequality, and causing poverty among generations (5, 6).

Efforts to deal with nutritional problems in Indonesia have been started since the early 1980s through surveillance at the village level using integrated weighing and child health in integrated post services (Posyandu) (7). This commitment is strengthened through Presidential Regulation number 72 of 2021 concerning the Acceleration of Stunting Reduction (1). This effort is in line with one of the 2030 Sustainable Development Goals (SDGs) targets, namely eliminating all forms of malnutrition, including reducing the prevalence of stunting and wasting under the age of 5 years by 2025. Undernutrition is a global problem where one in three children under the age of 5 years suffer from stunting, wasting, overweight, and in some cases suffer a combination of the two forms of malnutrition. In Asia, there are 49.9% of children under five years are experiencing growth failure (stunted, wasted, or overweight) (8).

In the population, indicators of undernutrition in children can be identified by anthropometric measurements. This method is used to assess the size, proportion, and composition of the human body. Anthropometry can be used to evaluate the general health status, nutritional adequacy, and growth and development patterns of children (9, 10). The World Health Organization (WHO) report presents the first set of WHO Child Growth Standards using the conventional indices of weight-for-age, length/height-for-age, weight-for-length/height, and BMI-for-age (11, 12). In Indonesia, assessing a child's nutritional status is stipulated in Regulation of the Minister of Health of the Republic of Indonesia Number 2 of 2020 concerning Child Anthropometry Standards. There are four conventional indices which include Weight-for-age, height/length-for-age, and weight-for-height/length (for children aged 0-60 months), and BMI-for-age (for children aged 0-60 months, and children aged >5-18 years (13).

The weight-for-age index indicates general nutritional problems and shows the current nutritional status of the child. This index is used to assess children who are underweight or severely underweight. The height/length-for-age index indicates chronic malnutrition. This index can identify children who experiencing malnutrition for a long time or frequent illness. It is categorized into short (stunted) or very short (severely stunted). This nutritional problem is associated with high poverty, unhealthy living behavior, parenting patterns, failure to give exclusive breastfeeding, early breastfeeding complementary foods, and low balanced nutrition practices (14–16). It is also related to infectious diseases such as diarrhea, Acute Respiratory Infections (ARI), and tuberculosis (14, 17–19). The high prevalence of infectious diseases is also poor environmental sanitation and lack of hygiene practices (20). The weight-for-height/length index describes the condition of poor nutrition that has occurred recently (acute) or that has occurred for a long time (chronic). It is categorized into undernutrition (wasted), severely undernutrition (severely wasted), and children who have a risk of overweight (possible risk of overweight). BMI-for-age is used to determine the categories of poor nutrition, poor nutrition, good nutrition, risk of
overnutrition, and obesity. This index is more sensitive to screen for overweight and obese children. However, the four conventional indices cannot determine the overall prevalence of malnutrition in the population. It is required to choose one category of anthropometric failure to represent the nutritional status of the target population and will lose information on another nutritional status (13).

The Composite Index of Anthropometric Failure (CIAF) method was developed to overcome multiple nutritional failures and report the prevalence of accurate data. This method identifies children with single and/or multiple anthropometric failures and is better at describing the complexities of undernutrition (21). CIAF is an anthropometric index that combines the three indices of weight-for-age, height/length-for-age, and weight-for-height/length to determine the nutritional status of children under five years old (22). The combined index method of the Svedberg model identifies malnourished children into six categories, namely: A) without anthropometric failure; B) wasting only; C) wasting and underweight; D) wasting, underweight, and stunting; E) underweight and stunting, F) stunting only. Furthermore, Nandy et al. added category Y), which is underweight only (23). CIAF is right in strengthening the importance of child feeding practices, family planning practices, appropriate mother's parenting patterns, and mother’s knowledge in preventing the prevalence of undernutrition in children under five years. This measurement model can accelerate the reduction in child mortality by expanding preventive and curative interventions that are more effective in determining the significant causes of undernutrition. The CIAF also describes a comprehensive measure and can detect children with multiple anthropometric failures (24). The prevalence of undernutrition in children based on CIAF is higher than conventional indicators.

Conventional indicators do not provide an overview of the nutritional status of the population. It can only determine the number of children who are underweight, stunted, and wasted. However, it was not possible to identify the group of children who suffered from two or more anthropometric failures. In light of this, Svedberg added three categories to the existing conventional indicators (Group C: wasting and underweight, D: wasting, underweight and stunting, and E: underweight and stunting) (25).

Previous studies have shown that the prevalence of undernutrition in children under five years is still high. Porwal et al. (2021) reported that there were 48.2% of children experienced anthropometric failure in India. The cause of this anthropometric failure is low household income and living in urban areas. Moreover, a high risk of CIAF occurs in children of mother’s who are underweight and have many children (26). Another similar study in Ethiopia on anthropometric measurements using the CIAF method showed that the child's age, previous birth spacing, mother’s educational status, wealth status, and region were factors related to the nutritional status of children independently in rural Ethiopia (27). Another study showed that the risk of anthropometric failure was higher among older children, had low birth weight, mother’s with low BMI, resided in rural areas, had mother’s and fathers without formal education (28). Therefore, the assessment of undernutrition using CIAF is necessary to overcome the problem of malnutrition, especially in Indonesia.

Methods

Study area and period
Bogor Regency is a buffer zone for the national capital, namely DKI Jakarta Province. The population in Bogor Regency based on data from the Central Statistics Agency (CSA) is 5,427,068 people in 2019, the most in West Java Province, even in Indonesia. In 2019 the population growth rate of Bogor Regency was 2.13%, but during the COVID-19 pandemic, the population in this region decreased by around 500 thousand people since the COVID-19 pandemic. The population pyramid in Bogor Regency shows a pyramid of youth. Of the total population in this region, as many as 9.68% children aged 0-4 years in 2019. This number decreased from 2016-2019. Conversely, the Infant Mortality Rate and Toddler Mortality Rate in Bogor Regency is high (29).

Bogor Regency is included in the 100 priority areas for stunting interventions in Indonesia (5). The prevalence of stunted children in this region reached 32.9% until 2018, where this number is included in the category of high prevalence based on the WHO category (30-39%) (30). Likewise, malnutrition and underweight are still the focus of serious handling in this region. This district has 101 health centers spread over 40 sub-districts, where several sub-districts are included in the category of nutrient-prone areas. Sub-districts located in the lowlands, namely in urban areas, have developed into industrial areas. Meanwhile, the sub-districts in the highlands developed as agricultural areas. Resident alternatives to obtain quality drinking water sources vary widely. Most urban communities have used the services of Regional Drinking Water Companies to meet the needs of drinking water sources. In rural, people are relatively more varied, ranging from those using protected wells, dug wells, hand pumping wells, protected springs, rainwater reservoirs to those using water bodies such as lakes and rivers to meet their drinking water needs. The population in general works as factory workers, farmers, entrepreneurs, and a small part as government employees. More than half of the population has low education. More women have less education than men. They generally marry in their teens (less than 18 years). They become housewives and act as the primary caregivers for their children (31).

**Design and samples**

A cross-sectional study was conducted from February-May 2019 in rural areas, in Bogor District, West Java Province, Indonesia. A total of 330 pairs of mother’s and children under five years participated in this study. Participants came from two community health center working areas in one sub-district as a nutrient-prone area in Bogor Regency. Four out of ten villages that became pockets of undernutrition were selected as locations in this study. Participants who met the inclusion criteria and exclusion criteria were selected from the four villages by systematic random sampling.

**Inclusion and exclusion criteria**

Participants in this study are mother’s who have children aged 0-59 months, who have lived for at least six months or more in the village, to obtain homogeneous exposure to people's lifestyles, access to information, and health services in rural areas. Other inclusion criteria are children who are not undergoing intensive health care or suffering from serious illnesses that affect their nutritional status. The exclusion criteria were children who had congenital abnormalities from birth.
Sample size determination

The sample was calculated using the one-sample test of proportions with a two-sided alternative hypothesis using the following assumptions: 5% level of significance, 90% power, 48.5% undernutrition among rural children \( (P_0) \) based on a previous study (27), and \( P_a \) 10% smaller than \( P_0 \), and 10% contingency for loss to follow-up. Therefore, the calculated sample size was 330 for pairs mother-child (32).

Sampling technique and procedure

Four villages as pockets of undernutrition were selected from two working areas of the community health center in Bogor District. Eligible participants were selected using a systematic random sampling technique (Figure 1).

Data collection and measurements

Anthropometric measurements

Anthropometric measurements were performed using conventional indices, namely weight-for-age, length/height-for-age, and weight-for-length/height. In addition, measurements were used using the CIAF, which is an anthropometric index that combines the three indices of weight-for-age, length/height-for-age, and weight-for-length/height to determine the nutritional status of children under five years. Age was obtained from the information provided by the mother, namely the date, month, and year the child was born. Then the child's age is calculated in months.

Weight

Bodyweight measurements were carried out by trained midwives, namely for children less than two years of age, measured with a calibrated SECA digital infant scale. Before weighing, ensure the infant is not wearing any clothes and remove the diaper before measuring the weight. The weight should be measured to the nearest 0.01 kg. For children older than 24 months, an electronic floor scale that has been calibrated to an accuracy of 0.01 kg is used. The children were weighed twice and the results were averaged. The results of the first and second measurements should not be much different, and then the results of the two measurements are averaged and recorded.

Length/Height

Measurement of length/height, namely for children under the age of 2 years or who cannot stand, use a length board or infantometer. Infantometer placed on a table or flat surface, placing the baby on his back, and making sure the baby does not use hat/headgear and footwear. When measuring, the baby's feet must be close together, the baby's knees pressed until they are straight, and the feet are straightened. For babies who are more than 2 years old or can stand up, the height measurement was done using a stadiometer. The child should stand up straight, with buttocks, shoulder blades, and heels together.
touching the back of the stadiometer. The feet should face outward at a 60-degree angle. Their arms should be loosely hanging at the sides with palms facing the thighs. The horizontal bar of the stadiometer should be lowered until the hair is compressed to the crown of the head. The stadiometer accuracy is 0.1 cm. Measurements were carried out twice, to obtain two readings within 0.2 cm. The average of the two closest measurements should be recorded.

Z-Score

To assess nutritional status, the anthropometric index measurements of weight-for-age, length/height-for-age, and weight-for-length/height refer to the child growth standards according to WHO (12). The results of anthropometric measurements were analyzed using the WHO Anthro software to obtain the z-score value.

Composite Index of Anthropometric Failure (CIAF)

Assessment of nutritional status based on failure to thrive in children using the CIAF index is an alternative indicator of malnutrition by referring to the Handbook of Anthropometry: Physical Measures of Human Form in Health and Disease (21). The CIAF identified seven groups of children including those who did not experience anthropometric failure (Table 1). The seven groups are A) without anthropometric failure, B) wasting only, C) wasting and underweight, D) wasting, underweight, and stunting, E) underweight and stunting, F) stunting only, and F) underweight only. The sum of groups B, C, D, E, F, and Y gives the total amount of malnutrition. At the same time, the CIAF index can be used in detecting some anthropometric failures.

Mother and Child Characteristics

Mother and Child characteristics were measured by direct interviews using a structured questionnaire. Mother's age is categorized based on the mean age of the mother, namely 1) < 25 years, and 2) 25 years. Mother's height is categorized based on the mean value, namely 1) short if the height is less than 150 cm, and 2) tall if more than equal to 150 cm. Mother's education is categorized into 1) low if you have never attended school and have a primary school education, and 2) high if you have primary high school education and above. Mother's employment status is grouped into 1) not working, and 2) working. The level of family income is how much income is received by the family in one month. Then, its grouped based on the regional minimum wage in Bogor District (3.800.000 IDR), that is 1) low income, if < the regional minimum wage, and 2) high income, if the regional minimum wage. Parity is the number of children born to the mother, grouped into 1) primipara, if the mother gives birth to one child, 2) multipara, if the mother has given birth to 2-4 children, and 3) grand multipara if the mother has given birth to more than 4 children. The primary caregiver is the person who takes care of the day-to-day children. These variables are categorized into 1) being raised by someone other than the mother, and 2) mother as a primary caregiver. Data regarding the mother's knowledge was measured by asking questions about a balanced diet consisting of 20 questions. Each correct answer was given a score of 1, and 0 if wrong. The total score obtained is divided by the number of questions multiplied by 100 percent (correct answer
score/20 x 100 percent). It is categorized based on the mean score, 1) knowledge is not good if the value is less than 70, and 2) knowledge is good if the value is more than equal to 70.

Characteristics of children (sex, age, immunization history, and early initiation of breastfeeding) were measured using a structured questionnaire. The sex of the children is categorized into 1) boy and 2) girl. Immunization history is the provision of complete basic immunizations that must be given to infants from birth to 9 months of age and categorized into 1) ungiven, if the baby from the beginning of birth to the age of 9 months was not given any immunizations at all, 2) incomplete, if the baby had not been fully immunized and was not even 9 months old, and 3) complete if the baby was given complete all types of immunization from birth to 9 months of age. Early Initiation of Breastfeeding (EIB) is categorized into 1) No, if the baby was not given breast milk immediately after birth for the first 1 hour, and 2) Yes if the baby was breastfed immediately after birth until the first hour after birth.

Data regarding the frequency of consumption of food sources of energy and the frequency of consumption of food sources of protein in children were measured by the A Food Frequency Questionnaire (FFQ). The mother fills out a limited checklist on how often her child consumes food sources of energy and food per day (times/day) in the last six months. For food consumption of energy sources based on the analysis, results are categorized: 1) low consumption if the consumption frequency is < 3x/day, and 2) high consumption if the consumption frequency is 3x/day. Meanwhile, protein source food consumption is categorized into 1) low consumption, if the consumption frequency is < 3x/day, and 2) high consumption if the consumption frequency is 3x/day.

**Environment sanitation and Clean Living Behavior**

Measurements of environmental sanitation include indoor air temperature and relative humidity, while measurements of clean living behavior include sources of drinking water, hand washing habits, and bowel habits. Environmental sanitation measurements were not measured for every house because there were considerations that not every participant allowed data collectors to enter the house. In general, the participants gave reasons that the condition of their house was not suitable and stated that they were disturbed.

Measurement of room temperature and humidity using an environment meter with the code KW0600291. This tool can measure air temperature in the range of -20°C~200°C, with accuracy or resolution of 0.1°C. Room temperature is measured by placing the instrument at chest level, waiting for 5 minutes to measure the temperature steadily. It was measured twice, and the results were averaged and recorded. The measurement results are then categorized based on SNI T-14-1993-037 into 1) uncomfortable, if the room is at a temperature of <20.5°C and >27.2°C, and 2) comfortable if the room is at a temperature of 20.5-27.2°C.

The relative humidity is measured by the environment meter. This tool can measure air relative humidity in the range of 35%RH~95%, resolution 0.1%RH, with an accuracy level (%rdg+digits) of ±5%RH at 25°C. Measurement of relative humidity of the air is done by placing the instrument at chest level, waiting for 5
minutes to measure the temperature steadily. It was measured twice, and the results were averaged and recorded. These results, then categorized based on SNI 03-6572-2001 into 1) uncomfortable, if the humidity is <40% and >70%, and 2) comfortable if the humidity is in the range of 40-70%.

Sources of cooking water were categorized into 1) unprotected springs and 2) protected springs. Handwashing habits are divided into 2 categories, 1) not good if washing hands do not use running water and soap, 2) good, if washing hands do not use running water and soap. Also, the habit of defecating is divided into 1) open place and 2) toilet.

Quality Assurance of Data Collection

Four nutritionists served as data collectors in this study. They lived during the data collection period in each village because access to the area was quite difficult to reach. Data collection was carried out directly by face-to-face interviews through home visits by data collectors accompanied by posyandu cadres in every village, and periodic supervision to ensure the accuracy of data collection. All instruments used in this study were calibrated before use. All data collectors have been given direction and trained to have skills in the use of these tools. Supervision was carried out by two practitioners with a master's degree in public health nutrition and who had experience in research. The questionnaire used was reviewed by experts and tested previously on 10% of the total participants in other villages who have similar characteristics to the study area. After the data is collected, it is verified and checked for completeness by the data collector before being submitted to the supervisor.

Data processing and analysis

All items in the questionnaire were checked for missing values, including mother and child characteristics and environment sanitation. Furthermore, it was coded and input in statistics software using SPSS version 22.0. Descriptive statistics consisting of the mean, standard deviation, and percentage analyzed by univariate analysis. Bivariate analysis using the chi-square test, where the variables are categorical data. A 95% confidence level and a value of P < 0.05 were used to assess the statistical significance. Binary logistic regression analysis were used to analyze the dominant factors associated with malnutrition based on underweight, stunting, wasting, and CIAF.

Ethical approval and consent to participate

Ethics Commission of Health Research of the Faculty of Medicine and Health in Universitas Muhammadiyah Jakarta acceded to this study with approval number 01A/PE/KE/FKK-UMJ/2019. The Government and The Health Office of Bogor District, and two community health centers as the study area also granted permission. The comfort of the mother and childer while participating in the data collection process was prioritized, and the confidentiality of their identity was well guarded. The authors confirmed that all methods were carried out following the relevant guidelines and regulations (Helsinki Declaration).

Result
This study found the prevalence of malnutrition in children under five years old based on CIAF was 42.1%. This number is higher than the conventional index prevalence that there is stunting 29.7%, wasting 10.6%, and underweight 27.9% (Table 1).
Table 1
Classification of Undernutrition in children under five years old

| Categories                        | Aged (0-24 months) | Aged (25-59 months) | Boys | Girls | Total |
|-----------------------------------|--------------------|---------------------|------|-------|-------|
|                                   | n                  | %                   | n    | %     | n     | %     | n    | %     | n     | %     |       |
| **Weight-for-Age**                |                    |                     |      |       |       |       |      |       |       |       |       |
| Severely underweight (<-3 SD)     | 4                  | 2.5                 | 11   | 6.4   | 8     | 4.9   | 7    | 4.2   | 15    | 4.5   |       |
| Underweight (-3 SD to <-2 SD)     | 24                 | 15.1                | 53   | 31.0  | 40    | 24.4  | 37   | 22.3  | 77    | 23.3  |       |
| Normal weight (-2 SD to +1 SD)    | 103                | 64.8                | 97   | 56.7  | 94    | 57.3  | 106  | 63.9  | 200   | 60.6  |       |
| Risk of overweight (> +1 SD)      | 28                 | 17.6                | 10   | 5.9   | 22    | 13.4  | 16   | 9.6   | 38    | 11.6  |       |
| **Length/Height-for-Age**         |                    |                     |      |       |       |       |      |       |       |       |       |
| Severely stunted (<-3 SD)         | 4                  | 2.5                 | 31   | 18.1  | 21    | 12.9  | 14   | 8.4   | 35    | 10.6  |       |
| Stunted (-3 SD to <-2 SD)         | 19                 | 11.9                | 44   | 25.7  | 32    | 19.5  | 31   | 18.7  | 63    | 19.1  |       |
| Normal -2 SD to +3 SD             | 130                | 81.8                | 96   | 56.2  | 107   | 65.2  | 119  | 71.7  | 226   | 68.5  |       |
| Tall (> +3 SD)                    | 6                  | 3.8                 | 0    | 0.0   | 4     | 2.4   | 2    | 1.2   | 6     | 1.8   |       |
| **Weight-for-length/height**      |                    |                     |      |       |       |       |      |       |       |       |       |
| Severely wasted (<-3 SD)          | 8                  | 5.0                 | 5    | 2.9   | 5     | 3.0   | 8    | 4.8   | 13    | 3.9   |       |
| Wasted (-3 SD to <-2 SD)          | 16                 | 10.1                | 6    | 3.5   | 11    | 6.7   | 11   | 6.6   | 22    | 6.7   |       |
| Normal (-2 SD to +1 SD)           | 119                | 74.9                | 147  | 86.0  | 129   | 78.8  | 137  | 82.6  | 266   | 80.6  |       |
| Possible risk of overweight (> +1 SD to +2 SD) | 8                | 5.0                 | 10   | 5.8   | 11    | 6.7   | 7    | 4.2   | 18    | 5.5   |       |
| Overweight (> +2 SD to +3 SD)     | 3                  | 1.9                 | 0    | 0.0   | 3     | 1.8   | 0    | 0.0   | 3     | 0.9   |       |
| Obese (> +3 SD)                   | 5                  | 3.1                 | 3    | 1.8   | 5     | 3.0   | 3    | 1.8   | 8     | 2.4   |       |
| **CIAF**                          |                    |                     |      |       |       |       |      |       |       |       |       |
| Normal                            | 112                | 70.4                | 79   | 46.2  | 92    | 56.1  | 99   | 59.6  | 191   | 57.9  |       |
### Table 2

| Categories                                           | Aged (0-24 months) | Aged (25-59 months) | Boys | Girls | Total |
|------------------------------------------------------|--------------------|---------------------|------|-------|-------|
|                                                      | n  | %   | n  | %   | n  | %   | n  | %   |
| Anthropometric Failure (B+C+D+E+F+Y)                 | 47 | 29.6 | 92 | 53.8 | 72 | 43.9 | 67 | 40.4 | 139 | 42.1 |
| Without anthropometric failure (A)                   | 112 | 70.4 | 79 | 46.2 | 92 | 56.1 | 99 | 59.6 | 191 | 57.9 |
| Wasting only (B)                                     | 8  | 5.0  | 0  | 0.0  | 5  | 3.0  | 3  | 1.8  | 8  | 2.4  |
| Wasting & underweight (C)                            | 13 | 8.2  | 6  | 3.5  | 7  | 4.3  | 12 | 7.2  | 19 | 5.8  |
| Wasting, underweight & stunting (D)                  | 2  | 1.3  | 5  | 2.9  | 4  | 2.4  | 3  | 1.8  | 7  | 2.1  |
| Underweight & stunting (E)                           | 12 | 7.5  | 42 | 24.6 | 30 | 18.3 | 24 | 14.6 | 54 | 16.4 |
| Stunting only (F)                                    | 10 | 6.3  | 28 | 16.4 | 19 | 11.6 | 19 | 11.4 | 38 | 11.5 |
| Underweight only (Y)                                 | 2  | 1.3  | 11 | 6.4  | 7  | 4.3  | 6  | 3.6  | 13 | 3.9  |

Table 2 shows that children with mother's aged above 25 years are more likely to be undernutrition (underweight, stunting, wasting, and CIAF) than mother's under 25 years of age. The children of short mother's are more likely to be undernutrition (underweight, stunting, and CIAF) than children of tall mother's. Children with mother's with low education experience more undernutrition (underweight, stunting, wasting, and CIAF) than mother's with higher education. Mother's who work have more undernutrition children (underweight, stunting, and CIAF) compared with mother's who do not work. Mother's with multiparous were more undernutrition (underweight, stunting, wasting, and CIAF) compared to mother's with primipara and grand multipara. Children with low family incomes are more likely to be undernutrition (underweight, stunting, wasting, and CIAF) compared with those with high family incomes. Children with mother's with poor nutrition knowledge are more likely to suffer from undernutrition (underweight, stunting, wasting, and CIAF) than mother's with good nutrition knowledge. Children who are not cared for by their mother's are more likely to be undernutrition (underweight, stunting, and CIAF) than children who are cared for by their mother's.

Boys are more undernutrition (underweight, stunting, and CIAF) than girls. Children aged over 24 months are more likely to be undernutrition (underweight, stunting, and CIAF) than those under 24 months. Children with a history of infectious diseases are more undernutrition (underweight, stunting, wasting, and CIAF) than children without a history of infectious diseases. Children who are not immunized experience more undernutrition (wasting and CIAF) than children who have incomplete immunization. Children who were not given EIB were more likely to suffer from undernutrition (underweight, stunting, wasting, and CIAF) than children who were given EIB. The frequency of consumption of high energy and protein sources in children is more likely to experience undernutrition (underweight, stunting, wasting, and
CIAF) compared with the low frequency of consumption of energy and protein sources. In this study, most of the participants' homes showed uncomfortable room temperature and humidity. Unprotected springs cause more children to be undernutrition (underweight, stunting, and CIAF) than protected springs. Handwashing habits are not good are more common in children who are undernutrition (stunting) than good handwashing habits. In this study, some participants used public latrines to defecate. There are still many houses that have inadequate toilets with poor sanitation.
| Characteristic                     | Underweight n (%) | Stunting n (%) | Wasting n (%) | CIAF n (%) |
|-----------------------------------|-------------------|----------------|---------------|------------|
| **A. Mother Characteristic**      |                   |                |               |            |
| Age                               | 18(19.6)          | 24(24.5)       | 6(71.1)       | 31(22.3)   |
| < 25 years                        | 74(80.4)          | 74(75.5)       | 29(82.9)      | 108(77.7)  |
| ≥ 25 years                        |                   |                |               |            |
| Height                            | 55(59.8)          | 63(64.3)       | 15(42.9)      | 80(57.6)   |
| Short (< 150 cm)                  | 37(40.2)          | 35(35.7)       | 20(57.1)      | 59(42.4)   |
| Tall (≥ 150 cm)                   |                   |                |               |            |
| Education                         | 66(71.7)          | 74(75.5)       | 23(65.7)      | 99(71.2)   |
| Low                               | 26(28.3)          | 24(24.5)       | 12(34.3)      | 40(28.8)   |
| High                              |                   |                |               |            |
| Working Status                    | 72(78.3)          | 70(71.4)       | 30(85.7)      | 107(77.0)  |
| Unemployed                        | 20(21.7)          | 28(28.6)       | 5(14.3)       | 32(23.0)   |
| Employed                          |                   |                |               |            |
| Family Income                     | 12(70.6)          | 14(56.0)       | 3(60.0)       | 15(55.6)   |
| Below the regional minimum wage   | 5(29.4)           | 11(44.0)       | 2(40.0)       | 12(44.4)   |
| Above the regional minimum wage   |                   |                |               |            |
| Parity                            |                   |                |               |            |
| Primipara                         | 19(20.7)          | 20(20.4)       | 7(20.0)       | 28(20.1)   |
| Multipara                         | 62(67.4)          | 65(66.3)       | 25(71.4)      | 93(66.9)   |
| Grandemultipara                   | 11(12.0)          | 13(13.3)       | 3(8.6)        | 18(12.9)   |
| Nutrition knowledge               | 68(73.9)          | 72(73.5)       | 28(80.0)      | 103(74.1)  |
| Not good                          | 24(26.1)          | 26(26.5)       | 7(20.0)       | 36(25.9)   |
| Good                              |                   |                |               |            |
| Parenting                         | 11(12.0)          | 15(15.3)       | 2(5.7)        | 16(11.5)   |
| Other                             | 81(88.0)          | 83(4.7)        | 33(94.3)      | 123(88.5)  |
| Mother                            |                   |                |               |            |
| Characteristic                                                                 | Underweight n (%) | Stunting n (%) | Wasting n (%) | CIAF n (%) |
|-------------------------------------------------------------------------------|-------------------|----------------|--------------|------------|
| **B. Child Characteristic**                                                  |                   |                |              |            |
| **Sex**                                                                      |                   |                |              |            |
| Male                                                                         | 44(47.8)          | 45(45.9)       | 19(54.3)     | 67(48.2)   |
| Female                                                                       | 48(52.2)          | 53(54.1)       | 16(45.7)     | 72(51.8)   |
| **Age**                                                                      |                   |                |              |            |
| < 24 months                                                                  | 28(30.4)          | 23(35.5)       | 24(68.6)     | 47(33.8)   |
| ≥ 24 months                                                                  | 64(69.6)          | 75(76.5)       | 11(31.4)     | 92(66.2)   |
| **History of Infectious Diseases**                                          |                   |                |              |            |
| Yes                                                                           | 59(64.1)          | 65(66.3)       | 25(71.4)     | 92(66.2)   |
| No                                                                            | 33(35.9)          | 33(33.7)       | 10(28.6)     | 47(33.8)   |
| **History of Immunization**                                                  |                   |                |              |            |
| Ungiven                                                                       | 8(8.7)            | 7(7.1)         | 5(14.3)      | 14(10.1)   |
| Incomplete                                                                    | 46(50.0)          | 48(49.0)       | 17(48.6)     | 69(49.6)   |
| Complete                                                                      | 38(41.3)          | 43(43.9)       | 13(37.1)     | 56(40.3)   |
| **Early Initiation of Breastfeeding**                                        |                   |                |              |            |
| No                                                                            | 66(71.7)          | 73(74.5)       | 25(71.4)     | 101(72.7)  |
| Yes                                                                           | 26(28.3)          | 25(25.5)       | 10(28.6)     | 38(27.3)   |
| **Frequency consumption of energy sources**                                  |                   |                |              |            |
| Low (< 3x/day)                                                               | 7(7.8)            | 2(5.9)         | 3(9.1)       | 10(7.4)    |
| High (≥ 3x/day)                                                              | 83(92.2)          | 94(37.0)       | 30(90.9)     | 125(92.6)  |
| **Frequency consumption of protein sources**                                 |                   |                |              |            |
| Low (< 3x/day)                                                               | 15(17.2)          | 16(17.2)       | 10(31.3)     | 27(20.6)   |
| High (≥ 3x/day)                                                              | 72(82.8)          | 77(82.8)       | 22(68.8)     | 104(79.4)  |
| **C. Environment Sanitation and Clean Living Behavior**                     |                   |                |              |            |
| Room temperature                                                             | 44(81.5)          | 46(79.3)       | 12(75.0)     | 62(78.5)   |
| Uncomfortable (<20.5°C and >27.2°C)                                          | 10(18.5)          | 12(20.7)       | 4(25.0)      | 17(21.5)   |
| Comfortable (20.5-27.2°C)                                                    |                   |                |              |            |
Table 3 shows that the factors related to the nutritional status of children under five years old based on being underweight are mother’s height (0.028), family income (0.043), child age (<0.001), and frequency of consumption of protein sources (0.015). Meanwhile, mother’s age, mother’s education, mother’s occupation, parity, mother’s knowledge of nutrition, parenting, sex of a child, history of infectious disease, history of immunization, EIB, frequency of consumption of energy sources, room temperature, humidity, source of the cooking water, hand washing habits, and defecation habits have no significant effect on underweight.

Factors related to the nutritional status of children under five years of age based on stunting were mother’s height (0.001), mother’s education (0.018), mother’s occupation (0.013), parenting (0.029), child’s age (<0.001), EIB (0.034), frequency of consumption of energy sources (0.001) and protein (0.010). Meanwhile, mother’s age, family income, parity, mother’s knowledge of nutrition, parenting, child’s gender, history of infectious diseases, history of immunization, EIB, room temperature, humidity, source of the cooking water, hand washing habits, and defecation habits had no significant effect on stunting.

Factors related to the nutritional status of children under five years of age based on wasting is the child’s age (0.018). Meanwhile, mother’s age, mother’s height, mother’s education, mother’s occupation, parity, mother’s knowledge of nutrition, parenting, gender of the child, history of infectious disease, immunization history, EIB, frequency of consumption of energy and protein sources, room temperature, humidity, water source cooking, hand washing habits, and defecation habits had no significant effect on wasting.
Factors related to the nutritional status of children under five years of age based on CIAF are mother’s height (0.017), child’s age (<0.001), history of infectious disease (0.034), EIB (0.026), frequency of consumption of energy sources (0.047), and protein (0.024). Meanwhile, mother’s age, mother’s education, mother’s occupation, family income, parity, mother’s knowledge of nutrition, child’s gender, immunization history, room temperature, humidity, source of the cooking water, hand washing habits, and defecation habits had no significant effect on CIAF.
Table 3
Factors associated with undernutrition (underweight, stunting, wasting, and CIAF) in children under five years old

| Characteristic | Underweight |  |  |  |  |  |  |
|----------------|-------------|----------------|----------------|----------------|----------------|----------------|----------------|
|                | P-value     | OR (95% CI)    | P-value         | OR (95% CI)    | P-value         | OR (95% CI)    | P-value         |
| A. Mother Characteristics |            |                |                |                |                |                |                |
| Age            | 0.189       | 0.64           | 0.967           | 0.95           | 0.343           | 0.59           | 0.374           |
|                | (0.35-1.16) | (0.55-1.64)    | (0.23-1.46)     | (0.46-1.28)    | (0.46-1.28)     | (0.46-1.28)    | (0.46-1.28)     |
| Height         | 0.028       | 1.78           | 0.001           | 2.36           | 0.510           | 0.74           | 0.017           |
|                | (1.09-2.90) | (1.45-3.85)    | (0.36-1.50)     | (1.13-2.73)    | (1.13-2.73)     | (1.13-2.73)    | (1.13-2.73)     |
| Education      | 0.173       | 1.49           | 0.018           | 1.65           | 1.000           | 1.01           | 0.078           |
|                | (0.88-2.52) | (1.15-3.32)    | (0.48-2.12)     | (0.98-2.50)    | (0.98-2.50)     | (0.98-2.50)    | (0.98-2.50)     |
| Working Status | 0.670       | 0.84           | 0.013           | 0.47           | 0.531           | 1.53           | 0.248           |
|                | (0.46-1.52) | (0.27-0.83)    | (0.57-4.12)     | (0.40-1.20)    | (0.40-1.20)     | (0.40-1.20)    | (0.40-1.20)     |
| Family Income  | 0.043       | 4.11           | 0.362           | 1.91           | 0.898           | 1.76           | 0.348           |
|                | (1.19-14.13)| (0.65-5.60)    | (0.27-11.47)    | (0.66-5.65)    | (0.66-5.65)     | (0.66-5.65)    | (0.66-5.65)     |
| Parity         | 0.617       | -              | 0.620           | -              | 0.551           | -              | 0.379           |
| Nutrition knowledge | 0.871       | 1.09           | 0.951           | 1.05           | 0.412           | 1.57           | 0.724           |
|                | (0.63-1.87) | (0.62-1.80)    | (0.66-3.72)     | (0.67-1.85)    | (0.67-1.85)     | (0.67-1.85)    | (0.67-1.85)     |
| Parenting      | 0.434       | 1.48           | 0.029           | 2.44           | 0.629           | 0.56           | 0.351           |
|                | (0.68-3.22) | (1.15-5.15)    | (0.13-2.44)     | (0.73-3.20)    | (0.73-3.20)     | (0.73-3.20)    | (0.73-3.20)     |
| B. Child Characteristics |            |                |                |                |                |                |                |
| Sex            | 0.662       | 1.15           | 0.360           | 1.28           | 0.749           | 0.84           | 0.589           |
|                | (0.71-1.86) | (0.80-2.06)    | (0.41-1.69)     | (0.75-1.80)    | (0.75-1.80)     | (0.75-1.80)    | (0.75-1.80)     |
| Characteristic                         | Underweight | Stunting | Wasting | CIAF |
|---------------------------------------|-------------|----------|---------|------|
|                                       | P-value     | OR (95% CI) | P-value | OR (95% CI) | P-value | OR (95% CI) | P-value | OR (95% CI) |
| Age                                   | <0.001      | 0.36 (0.21-0.60) | <0.001  | 0.22 (0.13-0.37) | 0.018   | 2.59 (1.22-5.47) | <0.001  | 0.36 (0.23-0.57) |
| History of Infectious Diseases        | 0.302       | 1.34 (0.81-2.20) | 0.106   | 1.54 (0.94-2.53) | 0.165   | 1.84 (0.85-3.97) | 0.034   | 1.67 (106-2.63) |
| History of Immunization               | 0.821       | -        | 0.450   | -        | 0.426   | -        | 0.526   | -        |
| Early Initiation of Breastfeeding     | 0.173       | 0.67 (0.40-1.13) | 0.034   | 0.55 (0.32-0.93) | 0.550   | 0.73 (0.34-1.59) | 0.026   | 0.57 (0.35-0.91) |
| Frequency consumption of energy sources | 0.218       | 0.53 (0.22-1.28) | 0.001   | 0.11 (0.02-0.45) | 0.820   | 0.72 (0.21-2.51) | 0.047   | 0.43 (0.20-0.94) |
| Frequency consumption of protein sources | 0.015       | 0.44 (0.24-0.83) | 0.010   | 0.43 (0.23-0.80) | 0.765   | 1.23 (0.55-2.73) | 0.024   | 0.52 (0.30-0.90) |

C. Environment Sanitation and Clean Living Behavior

|                          | P-value     | OR (95% CI) | P-value | OR (95% CI) | P-value | OR (95% CI) | P-value | OR (95% CI) |
|--------------------------|-------------|-------------|---------|-------------|---------|-------------|---------|-------------|
| Room temperature         | 0.618       | 1.32 (0.60-2.93) | 0.955   | 1.10 (0.52-2.34) | 0.477   | 0.82 (0.25-2.70) | 1.000   | 1.03 (0.51-2.08) |
| Humidity                 | 0.284       | 0.54 (0.22-1.35) | 0.756   | 0.77 (0.31-1.94) | 0.103   | -           | 1.000   | 0.91 (0.38-2.20) |
| Cooking water source     | 0.098       | 3.56 (0.78-16.23) | 0.120   | 3.25 (0.71-14.80) | 0.764   | -           | 0.230   | 3.53 (0.67-18.45) |
| Hand washing habit       | 0.218       | 0.71 (0.44-1.16) | 0.842   | 1.08 (0.67-1.73) | 0.484   | 0.73 (0.36-1.47) | 0.533   | 0.85 (0.55-1.31) |
| Characteristic | Underweight | Stunting | Wasting | CIAF |
|---------------|-------------|----------|---------|------|
|               | P-value     | OR (95% CI) | P-value | OR (95% CI) | P-value | OR (95% CI) | P-value | OR (95% CI) |
| Defecation habit | 0.394 | 1.57 (0.37-6.71) | 0.559 | 0.78 (0.16-3.95) | 0.404 | - | 0.545 | 0.82 (0.19-3.50) |

Table 4
Binary logistic regression analysis of factors associated with undernutrition (underweight, stunting, wasting, and CIAF) in children under five years old

| Categories | Characteristics | p-value | Adjusted OR | 95% Cl |
|------------|----------------|---------|-------------|--------|
| Underweight | Family income | 0.018 | 5.44 | 1.34-22.11 |
|             | Child’s age    | 0.026 | 0.07 | 0.006-0.72 |
| Stunting    | Mother’s height | <0.001 | 3.29 | 1.83-5.91 |
|             | Child’s age    | 0.002 | 0.34 | 0.17-0.66 |
|             | Frequency consumption of energy sources | 0.003 | 0.09 | 0.02-0.46 |
| Wasting     | Child’s age    | 0.013 | 2.59 | 1.22-5.47 |
| CIAF        | Mother’s height | 0.008 | 1.95 | 1.19-3.19 |
|             | Child’s age    | 0.046 | 0.57 | 0.32-1.00 |

In Table 4, binary logistic regression analysis shows that family income is the dominant factor influencing underweight (OR: 5.44, 95% CI: 1.34-22.11) after being controlled by the variables of mother’s height, frequency of consumption of energy sources, and protein. Low family income is 5.4 times more likely to cause underweight among children than high family income. Mother’s height was the dominant factor influencing stunting (OR: 3.29 95% CI: 1.83-5.91) after being controlled by the variables of mother’s education, mother’s occupation, parenting, EIB, frequency of consumption of protein sources, and sources of the cooking water. Mother’s with short bodies are three times more likely to cause stunting in children compared with tall mother’s. The child’s age child is the most dominant factor influencing wasting (OR: 2.59, 95% CI: 1.22-5.47) after being controlled by the variable history of infectious disease. Young children are 2.6 times more likely to cause wasting than older children. Mother’s height was the dominant factor influencing CIAF (OR: 1.95, 95% CI: 1.19-3.19), after controlling for the variables of mother’s education, mother’s occupation, history of infectious disease, source of the cooking water, and EIB. Mother’s with short stature are two times more likely to fail to thrive in children than tall mother’s.

Discussion
In this study, the prevalence of undernutrition among children based on CIAF was higher than the conventional index. This study is in line with the research conducted by Savanur & Ghugre in 2015 in the city of Mumbai, Boregowdwa et al. 2015 in Chhattisgarh, and Fenta et al. 2021 in Ethiopia (25,33,34).

**Weight for age and influencing factors**

In this study, the mother's height, family income, child's age, and frequency of consumption of protein sources are factors associated with undernutrition based on underweight. Family income is the dominant factor influencing undernutrition based on underweight. Substantial increases in mortality and overall disease burden are due to child malnutrition in low-income and middle-income countries (35). The occurrence of undernutrition depends on the level of poverty and the standard of living of the community. It is necessary to improve the quality of housing, and access to clean water and effective sanitation, as well as food of sufficient quality and quantity to prevent undernutrition (21). Following other studies which found that family income, child's age (36), mother's height (37), were factors associated with underweight. Several studies showed different results, namely mother's height (38), income (36), child age (37) were not associated with underweight.

Mother's age, mother's education, mother's occupation, parity, mother's knowledge of nutrition, parenting, gender of child, history of infectious disease, history of immunization, EIB, frequency of consumption of energy sources, room temperature, humidity, source of the cooking water, hand washing habits, and defecation habits have no significant effect on underweight. Another study also revealed the same result that mother's education (39), mother's occupation, mother's knowledge of nutrition, gender, history of infectious disease, food adequacy, source of drinking water (36,37) were not associated with undernutrition based on underweight. In contrast to other studies which found that gender (38), hand washing habits (36) were associated with undernutrition based on underweight.

**Height for age and influencing factors**

Factors related to undernutrition based on stunting in this study were mother's height, mother's education, mother's occupation, parenting, child's age, EIB, frequency of consumption of energy, and protein sources. Mother's height is the dominant factor associated with undernutrition based on stunting. Mothers who are short (less than 150 cm) will have short children too. According to WHO, a 19-year-old woman with a height of less than -2 standard deviations (SD) (less than 150 cm) has a short stature (40). In line with this study, it was found that mother's height, mother's education, mother's occupation (38,41,42), child's age (38,43,44), EIB (45,46), frequency of consumption of energy, and protein sources (47) were factors associated with stunting. However, there are still differences in results in several studies which state that mother's education, mother's occupation (37,44,48) are not related to undernutrition based on stunting.

In this study, older children were stunted, the increased risk of stunting in older children may be due to the unhygienic preparation of complementary foods that expose children to infections. The limited access to safe drinking water in the study area also makes these children vulnerable to various types of infections and diarrheal diseases which further increase the risk of chronic undernutrition.
Mother's age, family income, parity, mother's knowledge of nutrition, gender of children, history of infectious diseases, history of immunization, room temperature, humidity, source of the cooking water, hand washing habits, and defecation habits had no significant effect on stunting. In line with the research which stated that mother's age, sex (44,49), history of infectious disease, mother’s knowledge of nutrition (37), parity (46), family income, immunization history (46) were not related to undernutrition based on stunting. This study is not in line with other studies which state that family income or socioeconomic status (49,50), gender (38), history of diarrhea, water sources and processing (44,45), hand washing habits, defecation habits (38,51) is associated with undernutrition based on stunting.

**Weight for height and influencing factors**

In this study, the age of the child is a factor associated with undernutrition based on wasting and is the dominant factor. This study is in line with other studies which have found that the age of the child is associated with undernutrition based on wasting (44,52) and is the dominant factor in wasting (44). In contrast to the results obtained by Girma et al. (39).

Mother's age, mother's height, mother's education, mother's occupation, family income, parity, mother's knowledge of nutrition, parenting, sex of a child, history of infectious disease, history of immunization, EIB, frequency of consumption of energy, and protein sources, room temperature, humidity, source of the cooking water, hand washing habits, and defecation habits had no significant effect on wasting. This is in line with other studies which stated that mother's age, mother's education, mother's occupation, family income, mother's knowledge of nutrition, sex of the child, history of infectious diseases, history of immunization, drinking water treatment (37,44,48,52), were not associated with undernutrition based on wasting. In contrast to other studies which found that mother's age, mother's height, source of drinking water, disease history (52), mother's education, mother's occupation (53), income (41), gender (38), were associated with undernutrition based on wasting.

**CIAF and influencing factors**

Factors associated with CIAF in this study were mother's height, child age, history of infectious disease, EIB, frequency of consumption of energy, and protein sources. Mother's height is the dominant factor associated with undernutrition according to CIAF. Several studies show that children's age (26,27,54), history of infectious disease (diarrhea), EIB in the 2011 Ethiopian Demographic and Health Surveys (EDHS) survey (28) are factors associated with undernutrition based on CIAF.

This study revealed that children in the older age group had a higher risk of CIAF than the younger age group. This study revealed that children in the older age group had a higher risk of CIAF than the younger age group. The children at a younger age get more optimal nutritional intake at the beginning of life, namely from breastfeeding to weaning. However, as children get older, children need more nutritional consumption that must be fulfilled from their daily intake. Several studies show results that are not in line with this study. The child's age, a history of infectious disease (26,55,56), EIB in the 2016 EDHS survey (28) was not associated with undernutrition based on CIAF.
This study found that mother’s age, mother’s education, mother’s occupation, family income, parity, mother’s knowledge of nutrition, child’s gender, immunization history, room temperature, humidity, source of the cooking water, hand washing habits, and hand defecation habits were not associated with undernutrition. CIAF-based nutrition. In line with other studies which stated that mother’s education, mother’s occupation, knowledge of mother’s nutrition, gender of child, source of drinking water were not related to undernutrition based on CIAF (56,57).

Other studies show different results that mother’s age, mother’s education, mother’s occupation, family wealth, parity, mother’s knowledge of nutrition, gender, immunization status, drinking water, and household sanitation (26,27,33,54–57) were related to undernutrition according to CIAF. The study explained that children from poor families were found to have a higher risk of undernutrition than children from rich families. Households with poor sanitation access are 1.116 times more likely to have an effect on CIAF than those with better sanitation facilities.

**Environment Sanitation and Clean Living Behavior**

In this study, environmental sanitation variables were not associated with undernutrition based on underweight, stunting, wasting, and CIAF. The method used in this study to measure room temperature is SNI T-14-1993-037. This study is not in line with Tusting et al. (2020) who found that children living in hotter regions of sub-Saharan Africa were more likely to be wasting, underweight, and simultaneously wasting and stunting, but was less likely to be stunting than in colder regions (58). Research conducted in the appropriate location (sub-Saharan Africa) in 2019 showed an increase in temperature exposure for 470 hours above 30°C, the possibility of an increase in wasted by 3% and stunting by 6% (59). Research conducted in an urban area of Bangladesh found that environmental sanitation is associated with undernutrition in children (60).

Likewise, clean living behavior is not related to undernutrition based on being underweight, stunting, wasting, and CIAF. This study is inconsistent with an observational study in rural Bangladesh finding that environmental pollution, associated with open defecation, causes linear growth retardation through environmental enteropathy and that children have in a clean household environment 0.54 standard deviation of WAZ scores higher than children living in a dirty environment (61). Washing hands with good soap can prevent almost half of all cases of diarrhea in children. Drinking clean water and washing hands with soap are also thought to provide nutrition through diarrhea and reduce stunting by up to 15% in children under five years, providing them with a better chance of maintaining good health and growing up to thrive (20).

**Conclusion**

Measuring undernutrition with CIAF significantly shows the prevalence of children under five years who are undernutrition is higher than conventional measures of stunting, underweight, and wasting indices. Therefore, CIAF needs to be used more widely in various areas, both in rural and urban areas, because the prevalence of undernutrition in children under the age of 5 years in Indonesia is still high. The dominant
factors associated with being underweight, stunted, and wasted are family income, mother's height, and child's age. Mother's height is also a dominant factor associated with failure to thrive in children (CIAF). Meanwhile, environmental sanitation factors and clean living behavior did not show a significant relationship in this study. There is a need for sensitive multi-sectoral nutrition interventions, and specific nutrition interventions to improve the nutrition of prospective mother's, which is carried out from the pre-pregnancy period, especially during the second stage of rapid growth during adolescence. Likewise, the nutrition improvement for children since the first 1000 days of life-period is needed to determine optimal nutritional status as an indicator of growth success.

**Abbreviations**

CIAF  
Composite Index of Anthropometric Failure  
WHO  
World Health Organization  
BMI  
Body Mass Index  
SDGs  
Sustainable Development Goals  
ARI  
Acute Respiratory Infections  
CSA  
Central Statistics Agency  
EIB  
Early Initiation of Breastfeeding  
EDHS  
Ethiopian Demographic and Health Surveys

**Declarations**

**Ethics approval and consent to participate**

Persetujuan etik diperoleh dari Ethics Commission of Health Research of the Faculty of Medicine and Health in Universitas Muhammadiyah Jakarta, yaitu dengan nomor surat etik 01A/PE/KE/FFK-UMJ/2019. Informed consent is ensured by the study participants. Confidentiality was maintained throughout the study by excluding personal identifiers from the data collection form. Kenyamanan participants (mother and children) menjadi prioritas selama pegumpulan data. In this study, the authors confirmed that all methods were carried out following the relevant guidelines and regulations (**Declaration of Helsinki**).

**Consent for publication**
Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing Interests

We, the authors, declare that we have no competing interests.

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Authors’ contributions

TAEP: have study ideas, drafting, and design research, perform statistical analysis and interpretation of results, and draft a manuscript. The author review and approved the manuscript. YCH: compiling and designing the study, providing direction and supervision in measuring environmental sanitation, analyzing and interpreting measurement results, and preparing the manuscript. The author reviews and approved the manuscript.

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Figures

Two working areas of community health centers in one sub-district that are vulnerable to nutrition are designated as research locations

4 villages were selected as pockets of undernutrition problem

2 villages in working area community health center (CHC1)  
2 villages in working area community health center (CHC2)

268 eligible mother-child pairs

270 eligible mother-child pairs

Excluded (n=15), resided < 6 months in selected villages

Excluded (n=16), resided < 6 months in selected villages

253 pairs mother-child pairs selected by systematic random sampling technique

254 pairs mother-child pairs selected by systematic random sampling technique

n =165 mother-child pairs, in 2 villages  
(village 1, n = 82; village 2, n = 83)

n =165 mother-child pairs, in 2 villages  
(village 3, n = 82; village 4, n = 83)

Total Number of Study participants, n=330 mother-child pairs

Figure 1

Sampling procedure of mother-child pairs