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Composite Index of Anthropometric Failure (CIAF) among Sonowal Kachari tribal preschool children of flood effected region of Assam, India

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Abstract: Undernutrition is considered to be a serious public health problem in most of the developing countries. Globally, the anthropometric measures are widely used to estimate the magnitude of undernutrition in children. The Composite Index of Anthropometric Failure (CIAF) provides the overall magnitude of undernutrition as an aggregate single measure over the conventional anthropometric indices and helps in identification of single or double or multiple anthropometric failures in preschool children. The present investigation assesses the age-sex specific prevalence of undernutrition using both conventional anthropometric measures and CIAF among Sonowal Kachari tribal preschool children of Assam, India. This cross-sectional investigation was carried out among 362 (162 boys and 190 girls) Sonowal Kachari tribal children younger than 5 years of flood affected regions of Lakhimpur district of Assam, India. Anthropometric measurements of height and weight were measured using standard procedures. Age-sex specific Z-score value of weight-for-age, height-for-age and weight-for-height were calculated by using WHO-Anthro, v. 3.2.2. A child Z-score <-2.00 of any anthropometric indices was considered to be undernourished and the standard CIAF classification was used to calculate the prevalence of undernutrition. The overall prevalence of wasting, underweight, stunting and CIAF was observed to be 11.6%, 22.9%, 36.2%, and 48.6%, respectively. The sex-specific prevalence of wasting (15.8% vs. 6.9%), underweight (30.5% vs. 14.5%) and stunting (42.1% vs. 29.6%) observed to be significantly higher among girls than boys ($p<0.05$). The girls (61.05%) were found to be more affected than boys (34.9%) by CIAF ($p<0.01$). The present investigation reported higher magnitude of undernutrition using CIAF over conventional anthropometric measures, hence the CIAF is relatively better indicator that reflects higher magnitude of undernourishment as compared to any conventional anthropometric indices in children. This research investigation has also reinforced the importance of appropriate intervention programme and strategies needed to reduce the prevalence of undernutrition in childhood and in population as a whole.

Key words: preschool children, undernutrition, public health, anthropometry, CIAF

Introduction

Prevalence of undernutrition becomes a serious public health problem in several developing countries and is considered to be the principal cause of death for 3.5 million children and 35.0% of the disease burden in preschool children younger

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than 5 years (Black et al. 2003). It is estimated to be approximately 80% of the world's undernourished children under 5 that lives only across 20 countries of Africa, the Middle East countries, Asia and the Western Pacific (Black et al. 2003). Prevalence of stunting (low height-for-age <-2SD) affected an estimated 22.2% or 150.8 million children under 5 globally and wasting continued to threaten the lives of an estimated 7.5% (i.e., 50.5 million) (UNICEF/WHO/World Bank Group 2017). India has recorded the high prevalence of childhood undernutrition over the world (Nandy and Miranda 2008; Black et al. 2013; Khan and Mohanty 2018). During the period 1992–2016, there is a significant decline in the prevalence of stunting (52% to 38%), underweight (53% to 36%) and wasting (17% to 21%) among preschool children in India (Khan and Mohanty 2018). Several research investigations have shown that the health and undernutrition level of the children could be affected by determinant factors including natural calamities, disaster by making children more prone to disease and health-related issues like linear growth retardation (Black et al. 2013; Tamaella et al. 2019).

Anthropometry is a single most non-invasive and easy-to-use technique to assess the nutritional status in clinical and epidemiological investigation (WHO 1995; Hall et al. 2007; Svedberg 2011). Several anthropometric measurements of low-height-for-age (stunting), low-weight-for-age (underweight) and low-weight-for-height (wasting) were widely used to assess the magnitude of undernutrition (<-2SD) among preschool children (WHO 1995; Bose et al. 2007; Mukhopadhyay et al. 2009; Mondal and Sen 2010; Svedberg 2011; Sen and Mondal 2012; Savanur and Ghugre 2015; Jayalakshmi and Jissa 2017; Roy et al. 2018; Kramsapi et al. 2018; Rasheed and Jeyakumar 2018; Biswas et al. 2018; Al-Sadeeq et al. 2019; Tamaella et al. 2019). Several researchers have advocated that these conventional anthropometric indices could extend beyond and may be unable to assess the actual magnitude of undernutrition in children (Svedberg 2000; Nandy et al. 2005; Nandy and Miranda 2008; Nandy and Svedberg 2012). In order to determine the actual magnitude of undernutrition utilizing the conventional anthropometric measures (i.e., stunting, underweight and wasting) and to determine the magnitude of a child with multiple anthropometric failures with the Composite Index of Anthropometric Failures (CIAF) is proposed as more reliable anthropometric measure in preschool children (Nandy et al. 2005; Nandy and Miranda 2008; Svedberg 2011; Nandy and Svedberg 2012; Savanur and Ghugre 2015; Jayalakshmi and Jissa 2017; Biswas et al. 2018; Kramsapi et al. 2018; Rasheed and Jeyakumar 2018; Roy et al. 2018; Ziba et al. 2018; Al-Sadeeq et al. 2019; Tamaella et al. 2019).

The CIAF constitutes typical anthropometric indicators. Seven categories propose a supplementary measure to assess the undernutrition and estimate the prevalence of stunting, wasting and underweight in separate measures (Nandy et al. 2005; Dewan et al. 2015; Dhok and Thakre 2016; Ziba et al. 2018). Several researchers have reported the immensity of child undernutrition using CIAF among Indian children (Nandy et al. 2005; Seetharaman et al. 2007; Biswas et al. 2009; Mandal and Bose 2009; Sen and Mondal 2012; Boregowda et al. 2015; Dewan et al. 2015; Savanur and Ghugre 2015; Dhok and Thakre 2016; Gupta et al. 2017; Vollmer et al. 2017; Kherde et al. 2018; Patsa and Banerjee 2018).

Floods are the most common reported natural disaster worldwide, with an important impact on the health of human populations (Tanoue et al. 2016). Environmental hazards effects are especially dramatic in developing countries of South and South-East Asia. Epidemiological studies in low-income rural areas show evidence for increased risk of disease associated with flooding, such as diarrhea, cholera, acute respiratory infection, or post-traumatic stress disorder (Rodriguez-Llanes et al. 2013). This is particularly worrying, especially vulnerable to environmental adversities because of their greater exposure, greater sensitivity to certain exposures and dependence on caregivers and the health-related risks are more susceptible in children (Ebi and Paulson 2007). Moreover, the preschool children require serious attention because it is the period of rapid physical growth and development, which increase the vulnerability of undernutrition in population (WHO 1995). Natural calamities like flood, affect the children health in a very adverse way with a continuous phenomenon and it severely effect on child nutritional status in Assam (Islam et al. 2014). Assam's main lifeline is surrounded by various rivers and they cause catastrophic flooding. Over 90% of the cultivated land and villages are flood-prone (Islam et al. 2014). The flood leaves the villagers completely isolated from the mainland, thereby preventing access to health infrastructure and services. The present research investigation was undertaken to assess the magnitude of undernutrition utilizing the both conventional anthropometric measure and CIAF among Sonowal Kachari preschool children of age under 5 years in the flood-prone areas of Lakhimpur district in Assam, India.

Material and Methods

This study was carried out among the Sonowal Kachari tribal community of Assam, North-east India. They are belongs to Tibeto-Burman linguistic and Tibeto-Mongoloid ethnic group, they practiced gold washing as their traditional profession during Ahom rule in Assam and shown a close affinity with Bodo Kachari and Dimasa Kachari tribal populations of Northeast India (Das et al. 2008; Singh and Mondal, 2014). The present cross-sectional investigation has been carried out among 362 (172 boys and 190 girls) Sonowal Kachari children of age under 5 years of Lakhimpur district of Assam, India.

The Sonowal Kacharis are mainly inhabited in the districts of Northern Assam, India. They are one of the subgroups of the greater Kachari groups of Assam. Study area covered seven Sonowal Kachari dominated villages situated near the river Subansiri; the largest tributary of Brahmaputra of Lakhimpur district of Assam, India. The district is located at northern part of Assam and its total geographical area covered 2,277 km^2 and having a population of 1,042,137 (male – 512,463, female – 529,674) and literacy rate of 77.20% (male – 83.52%, female – 70.62%) (Census of India 2011). The minimum number of sample size (N) required for estimating the prevalence of undernutrition and CIAF in the present investigation was calculated following the standard method of estimating sample size (Lwanga and Lemeshow 1991). An expected population proportion of 40%, absolute precision of 5% and confidence interval of 90% were taken into consideration in this method to calculate the minimum sample size in this research investigation. The standard equation was used to calculate sample size as follows: $N = (z/\Delta)^2 p\ (1-p)$ [where, $p=0.48$, $\Delta=0.10$ and $z=1.96$].

Several studies have reported the high magnitude of undernutrition and CIAF (≥40.0%) among Indian children (Sen and Mondal 2012; Savanur and Ghugre 2015; Dhok and Thakre 2016). The minimum sample size, thus estimated to be N=360 participants. Hence, a total of 362 Sonowal Kachari preschool children were included and analyzed to estimate the magnitude of undernutrition. At first, the households of those individuals belonging to the Sonowal Kachari tribal population were identified and accordingly verified from Government official documents. Each informant and subject was interviewed and measurements were taken in their respective household. Prior permission to conduct the research was taken from the 'Village Headmen' and Informed consent of the parents/guardian was taken using consent form. Present investigation was carried out in accordance to the ethical guidelines for human experimental research as put down according to the Helsinki Declaration (Portaluppi et al. 2010).

Socio-economic and demographic data collection

Data on age, sex, education and occupation, monthly family income, family size, electricity facility, sanitary system and types of drinking water facilities were collected using a pre-structured schedule by interviewing the parents of the children. The interviews were conducted by household visits. A modified version Kuppuswamy's scale was used to estimate the socio-economic status (SES) of the children. This scale calculates the score from education, occupation and monthly income (Oberai 2015). The determination of SES showed that all the children belonged to lower and middle SES families.

Collection of anthropometric variables

The anthropometric measurements included height/length and weight and were collected using the standard procedures (Hall et al. 2007). The anthropometer rod was used to record height of the children standing erect, looking straight and the head oriented in the Frankfort horizontal plane. However, an infantometer was used to measure the length of the infants unable to stand (e.g., younger than 1.5 years) using standard procedures. The height/length of the children was measured to the nearest 0.10 cm. Weight was taken using a portable digital weighing scale with the participant wearing minimum clothing to the nearest 100 gm. The subjects covered during of this investigation were measured with ample precision to avoid any systematic errors (e.g., instrumental or definition of landmarks) in the process of anthropometric data collection. Intra-observer technical errors of the measurements (TEM) were calculated to determine the accuracy of the anthropometric measurements using the standard procedure (Ulijaszek and Kerr 1999).

The formula was:

$$R = [1 - (TEM)^2/SD^2]$$

where: R – the accuracy of the anthropometric measurements, SD – standard deviation of all measurements.

The technical error measurement was calculated using the formulae:

$$TEM=\sqrt{(\Sigma D^2/2N)}$$

where: D – difference between the measurements, N – number of individuals measured.

For the calculation of TEM, height/length and weight of the 50 children other than the present study were measured. Very high values of R>0.98 were obtained for height/length and weight using TEM analysis of intra- and inter-observer values were found within the cut-off values 0.95. Hence, the results of the TEM were not incorporated for further statistical analysis and the anthropometric measurements taken in this research investigation was reliable and reproducible.

Assessment of nutritional status among children

The WHO age- and sex- specific z-score values of weight-for-age (WAZ), height-for-age (HAZ) and BMI-for-age (BMIZ) was calculated by utilizing the WHO Anthro software (version 3.2.2). The BMI classification was used to assess the nutritional status of children. (WHO 1995) as presented in Table 1.

The CIAF classification was used to calculate the prevalence of undernutrition (Svedberg 2000; Nandy et al. 2005). Interpreting the three conventional indices involved, a comparison with an international reference population to determine undernutrition, and the data from the WHO (1995) were used as the reference population for the evaluation of undernutrition child having the Z-score value below −2.00 in the indices of stunted, underweight and wasted. They were categorized as undernourished (WHO 1995).

The level of public health condition was assessed on the severity of undernutrition in terms of conventional anthropometric measures using the WHO (1995) proposed classification among children (see Table 1). The combination of Svedberg's (2000) model of six groups (stunted only, underweight only, wasted only, wasting and underweight, stunted and underweight and stunted, wasted and underweight) and Nandy et al. (2005) (i.e., underweight only) were utilized for assessing undernutrition using the CIAF. The proposed classification of CIAF for the assessment of undernutrition is presented in Table 2.

The anthropometric variables of the present investigation were statistically analyzed using the Statistical Package for Social Sciences (SPSS) for Windows (Version 16.0). Chi-square (χ^2) analyses were done to determine sex-specific differences in the overall prevalence of undernutrition using conventional anthropometric indices and CIAF. Further, Chi-square analysis was also utilized to calculate the differences in prevalence of CIAF between Indian populations with present investigation. The *p*-values of <0.05 and <0.01 were being considered statistically significant.

Table 1. Prevalence thresholds for underweight, stunting and wasting in children under 5 years (WHO 1995)

Malnutrition status	Low	Medium	High	Very high
Underweight	<10%	10–19%	20–29%	≥30%
Stunting	<20%	20–29%	30–39%	≥40%
Wasting	<5%	5–9%	10–14%	≥15%

Table 2. Classification of children with anthropometric failure assessed by *Composite Index* of *Anthropometric Failure* (CIAF)*

Group name	Description	Wasting	Stunting	Underweight
A	No failure: Children whose height and weight are above the age-specific norm (i.e. above – 2 Z-scores) and do not suffer from any anthropometric failure.	No	No	No
B	Wasting only: Children with acceptable weight and height for their age but who have subnormal weight for height.	Yes	No	No
C	Wasting and underweight: Children with above-norm heights but whose weight for age and weight for height are too low.	Yes	No	Yes
D	Wasting, stunting and underweight: Children who suffer from anthropometric failure on all three measures.	Yes	Yes	Yes
E	Stunting and underweight: Children with low weight for age and low height for age but who have acceptable weight for their height.	No	Yes	Yes
F	Stunting only: Children with low height for age but who have acceptable weight, both to their age and for their short height.	No	Yes	No
Y	Underweight only: Children who are only underweight.	No	No	Yes

* Classification based on Nandy et al. (2005):211.

Results

The age- and sex- specific overall prevalence of wasting, underweight, stunting and CIAF is presented in Figure 1 and Table 3.

The prevalence was observed to be 11.6%, 22.9%, 36.2% and 48.6%, respectively. The sex-specific prevalence of wasting (15.8% vs. 6.9%), underweight (30.5% vs. 14.5%) and stunting (42.1% vs. 29.6%) were observed to be significantly higher among girls than boys ($p<0.05$). Using chi-square, the sex-specific differences in the prevalence of undernutrition were observed to be significant in wasting (Chi-value=5.44;

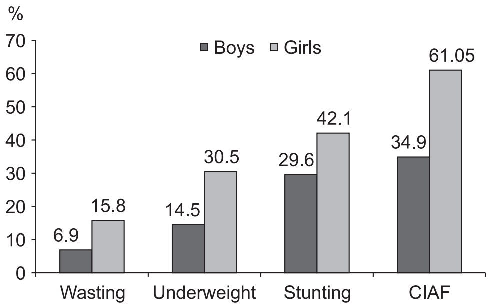

Fig. 1. Prevalence of undernutrition and CIAF among Sonowal Kachari preschool children

Table 3. Prevalence of wasting, underweight, stunting and CIAF in Sonowal Kachari children

Undernutrition category	Boys n=172	Girls n=190	Total N=362	Sex difference (χ^2-value)
Wasting, n (%)	12 (6.9)	30 (15.8)	42 (11.6)	5.44*
Underweight, n (%)	25 (14.5)	58 (30.5)	83 (22.9)	8.28**
Stunting, n (%)	51 (29.6)	80 (42.1)	131 (36.2)	2.86
CIAF, n (%)	60 (34.9)	116 (61.1)	176 (48.6)	8.70**

Sex difference statistically significant at *$p<0.05$, **$p<0.01$.

Table 4. Prevalence of anthropometric failure by Composite Index of Anthropometric Failure in Sonowal Kachari children

Group name	Description	Boys n=172	Girls n=190	Total N=362	Sex difference (χ^2-value)
A	No Failure, n (%)	112 (65.1)	74 (38.9)	186 (51.4)	31.89*** (d.f.,6)
B	Wasting only, n (%)	5 (2.9)	12 (6.3)	17 (4.7)	
C	Wasting and underweight, n (%)	4 (2.3)	14 (7.4)	18 (4.9)	
D	Wasting, stunting and underweight, n (%)	3 (1.7)	4 (2.1)	7 (1.9)	
E	Stunting and underweight, n (%)	18 (10.5)	30 (15.8)	48 (13.3)	
F	Stunting only, n (%)	30 (17.4)	46 (24.2)	76 (20.9)	
Y	Underweight only, n (%)	0	10 (5.3)	10 (2.8)	

Sex difference statistically significant at ***$p<0.001$.

$p<0.05$), underweight (Chi-value=8.28; $p<0.01$), and CIAF (Chi-value=8.70; $p<0.01$).

The sex-specific prevalence of undernutrition in children suffering from single, double and multiple failures of CIAF (Groups B–Y) are depicted in Table 4.

Overall, 51.4% of the children (boys 38.9%, girls 65.1%) were shown no anthropometric failure (i.e., Group A). The CIAF aggregating the children suffering from single, double and multiple failures (Groups B–Y) showed a high prevalence of undernutrition (boys 34.9%, girls 61.1%).The findings revealed that the overall prevalence of undernutrition was found to be highest in Group F (overall 20.9%, boys 17.4% and girls 24.2%) followed by double failures in Group E (overall 13.3%, boys 10.5% and girls 15.8%). Further, sex-specific undernutrition was observed to be higher among girls than the boys in distinct CIAF categories (i.e., Groups B, D, E and Y) among preschool children. The overall sex difference in CIAF categories were observed to be statistically significant using chi-square analysis (Chi-value: 31.89, d.f.6, $p<0.001$).

Discussion

Prevalence of undernutrition is still considered to be a major public health issue related to the child health, causes premature mortality and morbidities in developing countries including India (Nandy et al. 2005; Nandy and Miranda 2008). The magnitude of child undernutrition reported to be much higher in Nepal (56.5%) and Ethiopia (58.0%), but the highest prevalence was observed in India (59.8%). The present research investigation has shown a high prevalence of undernutrition (48.6%) using CIAF among Sonowal Kachari preschool children of Assam, Northeast India. The overall figure was found to be 11.6% of the children suffered from wasting, 22.9% were underweight and 36.2% were stunted (Table 3). These figures were observed to be similar to 18.5% (wasting), 26.0% (underweight) and 35.5% (stunting) among Karbi preschool children of Assam, India (Kramsapi et al. 2018).

Comparative evaluation of CIAF among Indian children is shown in Table 5.

This investigation reveals that amongst the different anthropometric failure within CIAF, a majority of children were suffered from stunting, which indicates the existence of long-term chronic undernutrition in this group. Several researchers have also reported the higher prevalence of undernourishment (i.e., stunting , underweight, wasting and CIAF) among different Indian preschool children (Table 5). Kumar

Table 5. Comparative prevalence of composite index of anthropometric failures among Indian children

Population Ethnic group	Area/Region	Sample size	Age group	Anthropometric failure (%)				Reference
				Stunting	Underweight	Wasting	CIAF	
Slum children of Coimbatore	Tamil Nadu	405	0–5 yrs	48.4	49.6	20.2	68.6	Seetharaman et al. 2007
Children of Hooghly	West Bengal	1012	2–6 yrs	26.6	63.3	50.0	76.3	Mandal and Bose 2009
Bauri caste	Purulia District West Bengal	347	2–6 yrs	39.2	51.2	26.6	66.3	Das and Bose 2009
Preschool children	Darjeeling West Bengal	256	1–3 yrs	46.9	52.3	15.2	65.6	Mukhopadhyay et al. 2009
Chapra Nadia district	West Bengal	2016	3–5.9 yrs	48.2	48.3	10.6	60.4	Biswas et al. 2009
Allahabad	Uttar Pradesh	371	0–5 yrs	40.7	49.1	14.6	62.8	Kumar et al. 2010
Bankura	West Bengal	188	6–59 mo	50.0	53.1	20.2	69.1	Mukhopadhya and Biswas 2011
Midnapore town	West Bengal	658	2–6 yrs	40.6	43.8	23.4	58.2	Sinha and Maiti 2012
Tribal children	North Bengal	3444	1–12 yrs	43.3	52.0	21.5	63.6	Sen and Mondal 2012
Villagers	Melghat Central India	540	0–6 yrs	60.9	66.4	18.8	76.3	Talapalliwar and Garg 2014
Urban Slums	Raipur Chattisgarh	602	0–3 yrs	46.8	45.2	17.8	62.1	Boregowda et al. 2015
Children of Agra city	Uttar Pradesh	458	0–5 yrs	41.9	42.8	22.7	60.0	Agarwal et al. 2015
Slum children	Jammu	250	0–5 yrs	42.8	38.8	20.4	73.2	Dewan et al. 2015
Urban slum	Nagpur City	256	<5 yrs	34.8	45.3	15.2	58.6	Dhok and Thakre 2016
Rural area	West Bengal	142	<5 yrs	16.7	29.2	22.2	36.1	Roy et al. 2018
Karbi tribe	Karbi Anglong Assam	400	2–5 yrs	35.5	26.7	18.5	51.0	Kramsapi et al. 2018
Govt preschool centers children	Pune Maharastra	360	<2 yrs	58.0	34.0	29.0	75.0	Rasheed and Jeyakumar 2018
Pre-school children	West Bengal, India	656	3–5 yrs	26.2	51.1	35.4	61.3	Biswas et al. 2018
Rural Yemen	South Yemen	1292	<5 yrs	38.5	55.1	39.9	70.1	Al-Sadeeq et al. 2019
Sonowal Kachari	Lakhimpur, Assam	362	0–5 yrs	36.2	22.9	11.6	48.6	Present study

and colleagues (2010) found 62.8% in Uttar Pradesh and Shit and colleagues (2012) found 62% in Delhi. The prevalence of this condition amounted 69.1% in Bankura, West Bengal, (Mukhopadhyay and Biswas 2011), 60.04% in Agra (Boregowda et al. 2015), 62.1% in Chhattisgarh (Talapalliwar and Garg 2014), 76.3% in Melghat, Central India (Gupta et al. 2017), 61.3% in Sagar Island, West Bengal (Biswas et al. 2018) and 75% in Pune, Maharashtra (Rasheed and Jeyakumar, 2018).

The present investigation showed that the prevalence of wasting, underweight and stunting is lower than the children of other parts of the country like the Bauri caste children (Das and Bose, 2009), urban-slum children (Dewan et al. 2015), children of Agra (Agarwal et al. 2014), urban children of Midnapore (Sinha and Maiti 2012), Bankura district West Bengal (Patsa and Banerjee 2018), Karbi children, Assam (Kramsapi et al. 2018), Kottayam, Kerala (Jayalakshmi and Jissa 2017), Rural West Bengal (Roy et al. 2018), Pune, Maharastra (Rasheed and Jeyakumar 2018), South 24 Parganas, West Bengal (Biswas et al. 2018) and Yemen (Al-Sadeeq et al. 2019) (Table 5).

Present investigation showed that the prevalence of undernutrition was higher in girls than boys using all conventional anthropometric measure (i.e., wasting, underweight and stunting) and CIAF ($p<0.05$) (Table 3). Similar studies have reported a significant difference between the gender-specific prevalence of undernutrition to be higher among girls than boys in rural/tribal populations in India (Mondal and Sen 2010; Sen and Mondal 2012; Acharya et al. 2013; Solanki et al. 2015; Darsal et al. 2017; Debnath et al. 2018). The findings of the present study revealed that the sex/gender-specific prevalence of undernutrition was significantly higher in girls than boys ($p<0.05$).

Several studies have confirmed that girls have shown higher vulnerability in undernutrition than boys in Indian children (Bose et al. 2007; Mondal and Sen 2010; Sen and Mondal 2012; Kramsapi et al. 2018; Rengma et al. 2016; Roy et al. 2018; Debnath et al. 2018). The high prevalence of undernutrition observed among children in the present investigation indicates a state of acute malnutrition which may be attributed to recent food deprivation and/or the higher prevalence of infectious diseases and socio-economic condition. They were residing in flood affected regions of Assam, India. During this period, there is an acute crisis of food and safe water in the population, which leads to starvation and increased prevalence of infectious and waterborne diseases in children (Rodriguez-Llanes et al. 2011; Islam et al. 2014). It is attributed to the intra-household food allocation, cultural practices, socio-economic, environmental attributes and poor access to healthcare services as being the main causes of such nutritional manifestation in the population (Mondal and Sen, 2010; Sen and Mondal 2012; Mondal et al., 2015; Rengma et al. 2016; Debnath et al. 2018). The CIAF helps to determine the actual proportions and find out the relative risk of undernourishment in various disaggregated sub-groups (Groups B–Y).

Furthermore, to identify the multiple categories of undernourishment (e.g., C, D and E) the segregation of the CIAF categories performs a very important role in children (Nandy et al. 2005; Nandy and Miranda 2008; Sen and Mondal 2012; Vollmer et al. 2017; Biswas et al. 2018; Kramsapi et al. 2018; Patsa and Banerjee 2018; Rasheed and Jeyakumar 2018; Roy et al. 2018; Al-Sadeeq et al. 2019). Children with multiple anthropometric failures (i.e., Group D: stunted, underweight and wasted) were more likely to be develop the ill-health conditions and were at more susceptible of health encounters than those with the single anthropometric failure (Nandy et al. 2005; Das and Bose, 2009; Shit et al. 2012; Acharaya et al. 2013, Dewan et al. 2016; Kramsapi et al. 2018). It is attributed to the childhood encounters may be set the stage for lifetime experiences of both physiological and psychological development and foundation which define lifetime socio-economic potential and demographic disparities in population (Som et al. 2006; Rahman et al. 2009; Babar et al. 2010; Sen and Mondal 2010; Acharya et al. 2013; Rengma et al. 2016; Patsa and Banerjee 2018).

There are some environmental factors that also affect the child growth and development as well as natural disasters (e.g., flood) may harm children, often with long-lasting effects of disasters can damage children's physical health status (Stewart et al. 1990; Choudhury and Bhuiya, 1993; Ninno and Lundberg et al. 2005; Rodriguez-Llanes et al. 2011; Islam et al. 2014).

The present investigation has assessed and identified the potential advantage and appropriateness of using the CIAF over the conventional indices used for the assessment of child undernutrition. The conventional anthropometric indicators are important as they show distinct biological processes, but the new measure of undernutrition (e.g., CIAF) can supplement the information by providing the overall different grades of undernourished children. Moreover, anthropometric measures are found to be most reliable method and these findings of the present investigation, however, are important for the effective implementation of any public health programme (e.g. child health programme). Strategies aiming to reduce childhood undernutrition should identify the most marginalized communities through data desegregation of population-based household surveys or specialized data collections. Therefore, the CIAF is essential for introducing the nutritional intervention program in the population under study too.

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Authors' Contributions

NB conceived conception and design of the study, was responsible for acquisition, analysis and interpretation of data; KHNS drafted the manuscript and revised it critically for important intellectual content; NM was responsible for critical revision and final approval of the version to being submitted. All the listed authors have made substantial contributions to this manuscript.

Conflict of interest

There is no financial conflict for all the authors or conflict of interest among us regarding publication of this manuscript.

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