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Full Length Research Paper

Malnutrition among rural Indian children: An assessment using web of indices

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Childhood malnutrition is an enduring problem in developing countries. Cases with mild-to-moderate malnutrition are likely to remain unrecognized because conventional measures of under nutrition may be missing out a considerable proportion of undernourished children present in the population. With this background, a community based study was conducted to estimate the prevalence of under nutrition among children by using various available indicators. It is a community based on cross sectional study carried out in the rural area of Varanasi, India. A total of 483 children aged 0-36 months were examined that were selected by adopting appropriate sampling methodology. They were subjected to anthropometry (weight, height and Mid Upper Arm Circumference (MUAC)) measurements following standard technique.BMI and other parameters were also assessed, the data thus obtained was analysed using SPSSv16.0. Prevalence of stunting, underweight and wasting were 43.1%, 35.2% and 31.5%, respectively. The Composite Index of Anthropometric Failure (CIAF) shows 62.5% of children suffering from anthropometric failure. As much as 88 (42.9%) children were suffering from malnutrition according to MUAC criteria (< 13.5 cm). Nearly two thirds of the children were in the zone of anthropometric failure. There is a need and scope to construct an alternative indicator to provide a single, aggregated figure of the number of undernourished children in a population.

Key words: Anthropometric measurements, stunting, underweight, wasting, anthropometric failure.

INTRODUCTION

Malnutrition is widely recognized as a major health problem in developing countries. Growing children in particular are most vulnerable to its consequences. Cases with mild-to-moderate malnutrition are likely to remain unrecognized because clinical criteria for their diagnosis are imprecise and are difficult to interpret accurately. Studies have suggested that there is a need to focus on the youngest children in nutrition programmes to prevent long-term effects (Victora CG et al 2008). Undernourished children are also more likely to come from poorer backgrounds (WHO, 1997; Wagstaff A, watanabe 2000), where they do not get enough food and are exposed to poor living conditions (for example, lack of proper sanitation or clean drinking water), which in turn leads to disease and further under nutrition. So, nutritional programmes should focus on sufficient feeding for individuals as well as families, community work, health care delivery systems and other underlying determinants, including poverty (Bhutta ZA, et al 2008). Childhood under nutrition can be evaluated anthropometrically (Bose K, et.al 2007; Lee RD & Nieman DC. 2003). It is an important tool in the study and understanding of human biological variability, including, of course, morphological variation as universally applicable, non invasive and inexpensive methods (WHO, 1995). There are many anthropometric indicators in use, such as Mid-Upper Arm Circumference (MUAC), MUAC for height, weight for age, height for-age, weight for height, and body mass index of Quetlet. Most of these indicators need to be used along with specific reference tables, for example. National Centre for Health Statistics (NCHS) tables or WHO growth standards, for interpreting data (Hamill PV et al 1979) this might not be possible in over-crowded outpatient departments of common tertiary care hospitals. Therefore, to estimate the expected weight or

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height of a child rapidly, especially in emergency situations, many field workers and clinicians use the first formulae introduced by Weech, using age as a variable (Bose K, et al 2007). Paediatricians now widely use these formulae in clinical practice (Behrman RE, et al 2000). Each of the above indicators has advantages and disadvantages, some have high sensitivity while others have high specificity. An ideal anthropometric indicator should have a high sensitivity to detect malnutrition accurately. At the same time, its specificity should be good so that the government resources and facilities meant for malnourished population may reach only those in need of them. The three most commonly used internationally recommended anthropometric indicators are stunting (low height-for-age), underweight (low weight for- age) and wasting (low weight-for-height). While stunting reflects a failure to reach linear growth potential due to suboptimal health or nutritional conditions, underweight reveals low body mass relative to chronological age, which is influenced by both, a child's height and weight. Stunting is an indicator of chronic under nutrition, the result of prolonged food deprivation or disease/illness. Underweight thus cannot distinguish between a child that is small in weight relative to his/her height and a child that is low in height relative to his/her age, but who may be normal in weight-for-height. On the other hand, wasting is an indicator of acute under nutrition, the result of more recent food deprivation or illness; underweight is used as a composite indicator to reflect both acute and chronic under nutrition, although it cannot distinguish between them (WHO, 1995). However, because of their overlapping none is able to provide a comprehensive estimate of the number of undernourished children in a population; some children who are stunting will also have wasting or be underweight; some children who are underweight will also have wasting or become stunted and some children who have wasting will also be stunted and/or underweight (Nandy S M, et al 2005).Development economist peter Svedberg, argues that conventional indices are not sufficient for measuring the overall prevalence of under nutrition among young children (Svedberg P. 2000). Since being underweight (having low weight for age) is a product of stunting and wasting and not the sum, it misses some children who are considered undernourished by the other indices, so producing an underestimate Svedberg suggests that if children with wasting, stunting or who are underweight are all considered undernourished, or to be in a state of “anthropometric failure”, a new aggregate indicator is needed, one that incorporates all undernourished children, be they wasted and/or stunted and/or underweight. He proposes constructing a composite index of anthropometric failure (CIAF). Svedberg's model identifies six groups of children. These groups include children with height and weight appropriate for their age (i.e. who are not in anthropometric failure) and also children whose height and weight for their age are below the norm and thus are experiencing one or more forms of anthropometric failure. The CIAF excludes those children not in anthropometric failure (i.e. Group A) and counts all children who have wasting, stunting, or are underweight (i.e. Groups B to F). It therefore provides a single measure with which to estimate the overall prevalence of under nutrition (Svedberg P, 2000).Based on Svedberg's model (who suggested six subgroups of anthropometric failure (A to F), Nandy et al (2005) had utilised the CIAF on Indian data and recommended its use in preference to the three conventional measures (ST, UW and WS) of under nutrition. Nandy and Miranda (2008) have further supported and validated the use of CIAF in a more recent paper. However, Nandy et al. (2005) identified an additional subgroup: one that includes children who are only underweight but not stunted or wasted (group-Y). Another theoretical combination would be ‘wasted and stunted’, but this is not physically possible since a child cannot simultaneously experience stunting and wasting and not be underweight. The use of CIAF may have profound implications on prevalence reporting, nutrition programming and outcomes. Reporting of accurate prevalence data and targeting highest risk populations for appropriate interventions using CIAF may help to improve the quality and outcomes of global nutrition efforts [(13)].Use of CIAF methods clearly identified risk levels with mutually exclusive categories to identify both prevalence and higher nutritional risk with multiple anthropometric failures (Svedberg P, 2000). Traditionally, stunting, underweight and wasting have been used as anthropometric indicators of under nutrition among children (Bhattacharya AK 2000). However, in studies evaluating childhood nutritional status, CIAF has also been utilised and validated by investigations from Kenya (Berger M et al 2006), South Asia and Sub-Saharan Africa (Harttgen and Misselhorn 2006), China (Dang SN & Yan H 2007), India (Seetharaman et al 2007), Botswan (Mahgoub S, Silo L & Fields-Gardner C 2009) and Cameroon (Emina JBO 2009). Nevertheless, Bhattacharyya (2006) has explained its drawbacks too. According to him, it does not satisfy the long felt need for a combined clinical and anthropometric classification that would be useful for clinical as well as community health work. Three new indices of childhood under nutrition have a proposition which deals with the problem of stunting, underweight and wasting relative to the total prevalence of under nutrition (Boss K, Mandal GC 2010). These three indices are: Stunting Index (SI) = Stunting / CIAF, Underweight Index (UI) = Underweight / CIAF and Wasting Index (WI) = Wasting / CIAF. These indices do not have any unit. This is in contrast to the rates of stunting, underweight and wasting which are absolute measures. The CIAF on the other hand indicates total under nutrition and does not provide any information on the prevalence of stunting, underweight and wasting relative to total under nutrition. Accordingly these three new indices, SI, UI and WI provide information on the significance of the problems of stunting, underweight and wasting with respect to and relative to total under nutrition. Effective health promotion and nutritional interventional programmes can be formulated based on these indices. For example, a higher value of SI would indicate enhanced level of chronic under nutrition relative to total under nutrition necessitating increased long-term nutritional intervention. Similarly, a higher value of UI would indicate greater level of current under nutrition requiring increased immediate intervention. However, it must be pointed out that these three new indices cannot replace the conventional measures of under nutrition. Rather they should supplement them in order to get a more comprehensive picture of the nutritional stress being experienced by a population. They provide additional information on the prevalence of different forms of under nutrition relative to the total level of under nutrition in a particular population. MUAC has been proposed as an alternative index for nutritional status for use where the collection of height and weight is difficult, such as in emergency situations of famine or a refugee crisis. In these situations, low MUAC, based on a fixed cut-off point, such as 12.5 cm, has been used as a proxy for low weight-for-height. A comparison of these two indicators, however, shows that these are poorly correlated (Gayle HD,et al 1988; Trowbridge FL, Staehling N. 1980). MUAC, however, appears to be a superior predictor of childhood mortality compared to anthropometric indicators based on height for- weight (Bairagi R.1981, Briend A, Zimicki S.1986). This led to the proposal of MUAC as an additional screening tool in non-emergency situations. Key operational advantages of MUAC include the portability of measuring-tapes, and the fact that a single cut-off value (12.5 cm or 13.5 cm) can be used for children aged less than five years. Moreover, in community based studies, mid-upper arm circumference (MUAC) appears to be a superior predictor of childhood under nutrition than many other anthropometric indicators (WHO 1995). This study was carried out to estimate the prevalence of under nutrition among children aged 0-36 months by using various available indicators.

METHODOLOGY

This study was conducted for a period of one and half years (December 2009 to July 2011). Initial period of the study was devoted to extensive literature search. The data collection was carried out for a period of one year (February 2010 to January 2011). A community based cross sectional design was adopted for this study. As per extensive literature search and a pilot study on 30 children (aged 0-36 months) conducted in Chiraigaon Community Development Block on non study samples, demonstrated a prevalence of 45% undernutrition. Based on this value, the sample size for this study was calculated using the formula:

$$n = \frac{z^2 pq}{L^2}$$

Where,
n= Sample size, z= 1.96, p= Assumed prevalence (45% in this study), q= 100-p, L= permissible level of error in the estimated prevalence, taken as 10% (10% of 45 = 4.5)
The required sample size was calculated to be:

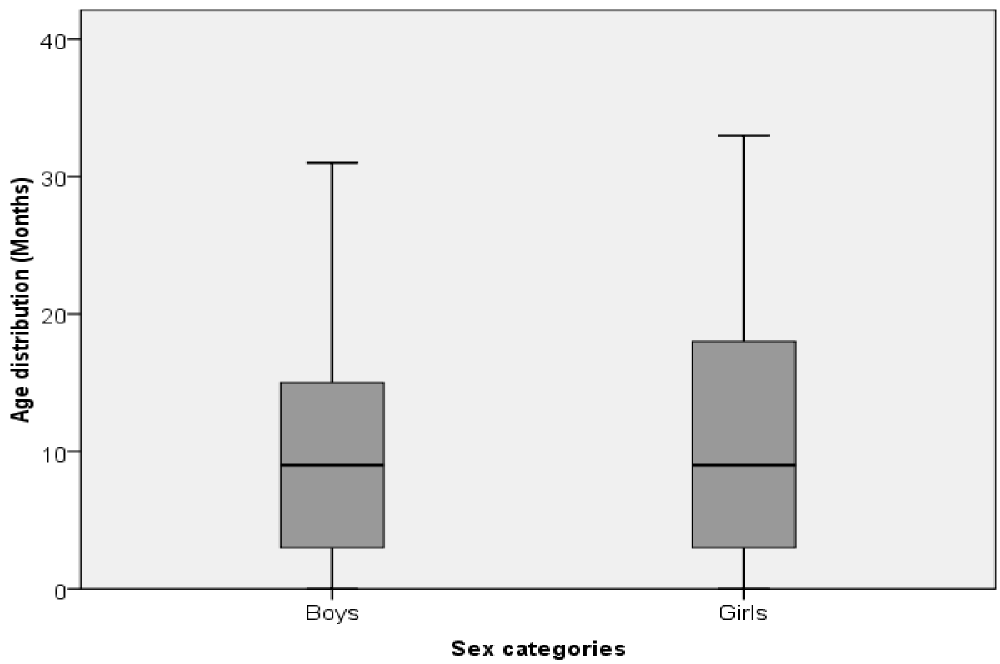
$$n = \frac{1.96 \times 1.96 \times 45 \times 55}{(4.5)^2} = 469.3$$

Thus, the total sample size was round up and fixed to 480.One Community Development Block (i.e. Chiraigaon) was selected from eight Community Development Blocks of Varanasi District by simple random sampling method as socio demographic milieu of all eight Community Development Blocks of Varanasi was found nearly similar as per data collection from BDO offices of the respected blocks. From the Chiraigaon Community Development Block two villages were selected by simple random sampling method. The selected villages were Bariasanpur and Rustampur. In the selected village total enumeration of children age 0-36 months was done to prepare a sampling frame. The required study subjects were selected adopting probability proportion to size (PPS) sampling technique. In order to get required study subjects (480), systemic (every third) random sampling was done. This study was approved by the ethical committee of Banaras Hindu University and prior consent was taken by parents/guardian of the children before interview and examination of the child. The ages of children were recorded using birth/delivery records or *aanganwadi*/ school/crèche records. Children whose age could not be accurately known were excluded from the study. No other inclusion or exclusion criteria were applied. The ages of children was estimated to the most recently attained month (Gorstein J, 1989). Heights of children were measured to the nearest millimetre using a right-angled head-plate non-stretchable tape fixed to the wall. Recumbent length was taken for children under 85 cm and standing height for children over 85 cm. Weight of children was taken using a stand-on scale and infant weighing machine, the accuracy of which was established on a daily basis. MUAC was measured to the nearest millimetre at the exact midpoint of the left arm using a narrow, flexible, and non-stretchable tape made of plastic (WHO 1976 and WHO 1983). All measurements were taken thrice and averaged for the

Table 1. Classification of children with anthropometric failure (CIAF).*

Group Name	Description	Wasting	Stunting	Underweight
A	No Failure	No	No	No
B	Wasting Only	Yes	No	No
C	Wasting and Underweight	Yes	No	Yes
D	Wasting and Stunting and Underweight	Yes	Yes	Yes
E	Stunting and Underweight	No	Yes	Yes
F	Stunting only	No	Yes	No
Y	Underweight only	No	No	Yes

* Classification following Nandy et al. (2005).



final reading. All data and indices were compared with the WHO growth standard tables for weight for age, height for age, weight for height and BMI for age. A value of mean –2SD was taken as the cut-off point for detection of wasting, underweight and stunting. For assessing the CIAF, Svedberg's (2000) model of six groups (stunted only, under-weight only, wasted only, wasting and underweight, stunted and underweight and lastly stunted, wasted and underweight) of children was used. These groups are defined in greater detail in Table 1. Three new indices proposed by Bose K et al., 2010 were used to asses childhood under nutrition which deals with the problem of stunting, underweight and wasting relative to the total prevalence of under nutrition. These three indices are:

Stunting Index (SI) = Stunting / CIAF

Underweight Index (UI) =Underweight / CIAF

Wasting Index (WI) = Wasting / CIAF

Data thus generated were analysed with the help of Microsoft excel 2007 and SPSS version 16th software. Necessary tables were generated and for inferential decisions x^2 test was applied.

RESULTS

A total of 483 children (aged 0-36 months) were examined of which 242 were boys and 241 were girls. Mean age of the study subjects was 10.99 $\pm$ 8.81 months (male 10.97 $\pm$ 8.77 months, female 11.02 $\pm$ 8.86 months). (Figure 1) Table 2 presents rates of stunting, wasting and underweight in all studied children. It also showed the rate of under nutrition as measured by the CIAF. According to the data, 43.1% of children were stunted, 35.2% were underweight and 31.5% had wasting. Stunting was found significantly more among children $\geq$1 year age group while wasting was significantly more among infantile age group as compared to their counterparts. The CIAF shows a higher prevalence of undernutrition, with 62.5% of children (58.3% infants and

Table 2. Prevalence of under nutrition among children aged 0–3 years (n = 242).

Group	Infants	≥ 1 year	Number (%)	x^2	p value
Stunted	82 (29.5%)	126 (61.5%)	208 (43.1%)	49.176	**<0.01**
Wasted	104 (37.4%)	48 (23.4%)	152 (31.5%)	10.716	**0.001**
Underweight	88 (31.7%)	82 (40.0%)	170 (35.2%)	3.603	0.058
CIAF	162 (58.3%)	140 (68.3%)	302 (62.5%)		

Table 3. Subgroups of anthropometric failure among children.

Group Name	Description	Boys	Girls	Number (%)
A	No Failure	74 (30.6%)	107 (44.4%)	181 (37.5%)
B	Wasting Only	30 (12.4%)	24 (9.9%)	54 (11.2%)
C	Wasting and Underweight	22 (9.1%)	16 (6.6%)	38 (7.9%)
D	Wasting and Stunting and Underweight	34 (14.0%)	26 (10.8%)	60 (12.4%)
E	Stunting and Underweight	34 (14.0%)	36 (14.9%)	70 (14.5%)
F	Stunting only	48 (19.8%)	30 (12.4%)	78 (16.1%)
Y	Underweight only	0 (0.0%)	02 (0.8%)	02 (0.4%)
	Total	242 (100.0%)	241 (100.0%)	483 (100.0%)

Table 4. Values of SI, UI and WI among the studied children.

Index	Boys CIAF = 168	Girls CIAF = 134	Overall (sex combined) CIAF = 302
SI = Stunting / CIAF	116/168 = 0.690	92/134 = 0.686	208/302 = 0.689
UI = Underweight / CIAF	90/168 = 0.536	80/134 = 0.597	170/302 = 0.563
WI = Wasting / CIAF	86/168 = 0.512	66/134 = 0.492	152/302 = 0.503

Table 5. Nutritional status of children according to their anthropometric measurements.

Parameters	Boys	Girls	Total	x^2	P value
Weight for Age					
< 2SD (Underweight)	90 (52.9%)	80 (47.1%)	170 (100.0%)	0.845	0.358
≥ 2SD	152 (48.6%)	161 (51.4%)	313 (100.0%)		
Height for Age					
< 2SD (Stunted)	116 (55.8%)	92 (44.2%)	208 (100.0%)	4.691	**0.030**
≥ 2SD	126 (45.8%)	149 (54.2%)	275 (100.0%)		
Weight for Height					
< 2SD (Wasted)	86 (56.6%)	66 (43.4%)	152 (100.0%)	3.720	0.054
≥ 2SD	156 (47.1%)	175 (52.9%)	331 (100.0%)		
BMI for Age					
< 2SD	88 (57.1%)	66 (42.9%)	154 (100.0%)	4.481	**0.034**
≥ 2SD	154 (46.8%)	175 (53.2%)	329 (100.0%)		
Total	**242 (50.0%)**	**241 (50.0%)**	**483 (100.0%)**		

68.3% ≥1 year age group) suffering from anthropometric failure. Table 3 shows the proportions of children in each of the subgroups, of the six subgroups with undernourished children, group F (containing children who are stunted only) is the largest, accounting for 16.1% children in the sample. Among boys largest group was group F (stunting only), accounting for 19.8% boys and among girls largest group was group E (stunting and underweight) accounting for 14.9% of girls. Children who simultaneously have wasting, stunting and are underweight (i.e. those in group D) accounted for 12.4% of the children in the sample (14.0% boys and 10.8% girls). Table 4 presents the sex-specific as well as sex-combined values of the three new indices, SI, UI and WI.

Table 6. Nutritional status of children (1-3 year) according to their MUAC.

Sex	MUAC			Total
	<12.5 cm	12.5 - <13.5	≥13.5 cm	
Boys	6 (5.8%)	22 (21.2%)	76 (73.1%)	104 (100.0%)
Girls	10 (9.9%)	50 (49.5%)	41 (40.6%)	101 (100.0%)
Total	16 (7.8%)	72 (35.1%)	117 (57.1%)	205 (100.0%)
x^2= 22.32, df= 2, p = <0.01				

These sex-combined overall values of SI, UI and WI were 0.689, 0.563 and 0.503, respectively. The corresponding values among boys were 0.690, 0.536 and 0.512. Among girls they were 0.686, 0.597 and 0.492, respectively. Eighty five (35.2%) children (37.2% boys and 33.2% girls) were found underweight (<2SD according to their weight for age). No significant difference was observed in wasting between both sexes. Stunting was present in 43.1% children. Boys (47.9%) were found significantly (p <0.05) more stunted than girls (38.2% girls). As much as 31.5% children (35.5% boys and 27.4% girls) were found wasted. When BMI for age was used 154 (31.9%) children were found underweight (<2SD) and boys (36.4%) were significantly (p <0.05) at higher risk of developing malnutrition compared to girls (27.4%). (Table 5) As much as 88 (42.9%) children were suffering from malnutrition according to MUAC criteria (< 13.5 cm). Out of these malnourished children 18.2% were suffering from severe malnutrition (21.4% boys and 20% girls). Malnutrition was significantly (p <0.05) more prevalent among girls (59.4%) as compared to boys (26.9%). (Table 6).

DISCUSSION

Malnutrition is a fairly wide-spread and complex problem that poses a serious threat to life and India is home to the largest number of underweight and stunted children in the world. The current nutritional status of children not only reflects their well being of the present time but also reflects future outcomes in terms of their health and development. Undernutrition is closely associated with a large proportion of child deaths (Gillespie S, haddad L. 2003; Seetharaman N et al 2007), with undernourished children more likely to suffer ill-health than well nourished children (Biswas S, 2010; Briend A, Zimicki S.1986). Though infant mortality rates have fallen and life expectancy has been rising, health indicators still point to high rates of malnutrition and mortality especially among women and children and a widespread lack of access to health-care. In the present study nearly 4 out of the ten children were found stunted which is higher than the findings of Bose K et al (2010) and NFHS-3 India but lower than the figure given by Seetharaman et al (2007). While percentage of underweight children in the study (35%) is much lower than the findings of Bose K et al (2010), Seetharaman et al. (2007) and NFHS-3 (India). Percentage figure for wasted children is higher than findings from Seetharaman et al. (2007) and NFHS-3 report but lower than the figures from Bose K et al (2010) and Joseph B (2002) .The CIAF provides an overall estimate of the number of undernourished children in a population, something conventional indices do not. As evidenced by the current study, the use of underweight (low weight-for-age) as the sole criterion for identifying undernourished children may be underestimating the true load of under nutrition. Using the CIAF, data on under nutrition can be disaggregated for further analyses, for example. to see which type of anthropometric failure carries the greatest risk of morbidity or mortality. Disaggregating the data in this way enables the identification of groups of children that are missed by conventional indices. It demonstrates that large numbers of undernourished children are not identified by current methods. Nearly 132 (27.3%) undernourished children - would be missed if low weight-for-age is considered as the only indicator of under nutrition. Attempts at estimating the overall prevalence of under nutrition in the population must integrate such an aggregate index of under nutrition. This could be a tool of considerable interest to health planners and policy makers - especially considering the fact that to compute the CIAF, the only additional data that needs to be collected is the height of the child. Measurement of the child's height as part of the routine ICDS growth monitoring is worth considering. The value of CIAF in the present study (62.5%) was higher than the findings of Nandy et al. (2005), but CIAFs found by Seetharaman et al. (2007) and Bose K et al. (2010) were comparatively higher. Three new indices, SI, UI and WI provide information on the significance of the problems of ST, UW and WS with respect to and relative to total under nutrition. As far as SI, UI and WI are concerned Nandy et al. (2005) and Seetharaman et al. (2007) found higher SIs and UIs than the present study but WIs were very low compared to present study. Bose K et al. (2010) found lower SI than present study but UI and WI were higher. The findings of nutritional status based on MUAC shows that arm circumference without correction for age or height is substantially better and easy to use indicator at community level than classical nutritional indices. This statement is supported by a lot of evidences (Biswas S et al. 2006, Briend A et al. 1986, Nyirandutiye DH et al. 2010). Since undernutrition is a function of both food deprivation and disease, which are in turn the consequences of poverty, anthropometric indices can serve only as proxies for evaluating the prevalence of undernutrition among children. This can be considered as a limitation of the study.

CONCLUSION

Overall, only 37.5% of the studied children were anthropometrically normal. In other words, nearly two thirds of the children were in the zone of malnutrition by anthropometric failure. Findings from the current study suggest that conventional measures of undernutrition may be missing out a considerable proportion of undernourished children present in the population. Underestimating this proportion might prevent undernourished children from receiving the benefit of the extra supplementation they deserve. It has shown that an alternative indicator can be constructed to provide a single, aggregated figure of the number of undernourished children in a population. It must be emphasized, however, that conventional indices reflect distinct biological processes and cannot be disregarded, but this issue has been addressed with the construct of the new indicator CIAF and it merits further consideration as a policy and monitoring tool for planning purposes. This is a very serious problem, by any scale. Under such conditions, our intervention efforts need to be broader than providing supplementary nutrition alone.

LIMITATIONS OF THE STUDY

Due to resource constraints the study was restricted to the Varanasi District only which is an area of high prevalence of malnutrition among children. So a comparison with an area of low prevalence of malnutrition could not be made to compare the varied results of those indexes.

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