Re-Estimating Malnourishment and Inequality among Children in North-east India

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This article re-estimates the prevalence of child malnutrition among the under-five age group in eight north-east states using the composite index of anthropometric failure method as proposed by P Svedberg, using the National Family Health Survey-3 data. These data show that in the north-east only about 35% of children under-five are underweight. However, results using the CIAF method indicate a substantially higher malnutrition level of 56%, and evidence of wide interstate differentials by socio-economic and demographic indicators.

Malnutrition, which refers to both under-nutrition and over-nutrition, continues to be a serious health concern among children, particularly in the least and less developing countries (LDCs), including India. However, the policy priority is more on "undernourishment", which is caused by inadequate calories or inadequate diet than what is required by the body for proper growth, maintenance and development. In the developing world, 39% of children under-age five (U-5) are chronically malnourished and about 54% of deaths among children of the same age group are associated with malnutrition (UNICEF 2000). Child malnutrition is a serious and pervasive problem, which impinges on the development of both the mental and physical health of the child, ultimately affecting productivity and national economic growth. According to the World Health Organisation (WHO 1995), children who are underweight or stunted are at a greater risk for childhood morbidity and mortality, poor physical and mental development, inferior school performance, and reduced adult size and capacity for work.

1 Child Malnutrition in India

The Millennium Development Goals (MDGs) recognise the importance of food and good nutrition as a basic human need necessary for the eradication of extreme poverty and hunger. In India, despite the government's efforts to combat hunger and under-nutrition for many decades through the Integrated Child Development Services (ICDS) programmes, millions of children suffer from both acute and chronic malnutrition. According to the Global Hunger Index (2008), India scored 23.7 points and placed 66th among 88 countries (Menon et al 2009). With more than 200 million food-insecure people, India is home to the largest number of hungry people in the world (FAO 2008). One estimate ranked India as second only to Bangladesh (where 47% of the children exhibit degrees of malnutrition) with the highest number of underweight children in the world, which is nearly double than that of sub-Saharan Africa, with dire consequences for mobility, mortality, productivity and economic growth (The World Bank 2009).

Over the years, in contrast to faster economic growth, decline in malnutrition levels among children has been sluggish. For instance, in the early 1990s, over half of the children (53%) aged below five were found to be underweight and 52% were stunted (IIPS and ORC Macro 1994; National Family Health Survey (NFHS)-1)). After about six years, the proportion of children under age 3 who were underweight and stunted declined

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to 47% and 46%, respectively (IIPS and ORC Macro 2000 (NFHS-2)), which further declined, only marginally, to 46% and 38%, respectively (IIPS and Macro International 2007 (NFHS-3)).

Not only is the level of child malnutrition high at the national level, but prevalence is much higher in some regions (central and east India) and in many states. Among the states, Bihar has been consistently among the top five with the highest levels of child malnutrition, followed by Madhya Pradesh. On the other hand, however, survey data show the smaller north-east states having consistently lower levels of child malnutrition, mainly in Sikkim, Nagaland, Manipur and Mizoram. Even some of the economically better-off states in India – Gujarat, Haryana, Maharashtra and Punjab – have levels higher than the north-east states or fail to figure among the top five states in terms of absence of child malnourishment (Nair 2007). An earlier study has also expressed a similar view, wherein it stated, "North-east states showed better performance in terms of nutritional status. In fact, Sikkim (20.9%), Nagaland (24.3%) and Arunachal Pradesh (24.7%) performed better than Kerala and the performance of Meghalaya and Manipur was very close to that of Kerala" (Radhakrishna and Ravi 2004: 673).

The moot point here is: do the younger children in north-east states, perhaps barring Meghalaya, really have a better nutritional status than those in the more progressive or economically well off states? If so, to what extent, or is it simply a matter of difference in the yardstick/method used to measure malnutrition? The other interest of this paper is to examine whether or not there is convergence in the malnutrition levels within the region and across the proximate determinants in the region.

In India, the incidence of child malnutrition is greater than income poverty and its pace of reduction is much slower. Apparently, the fruits of economic development failed to secure a better nutritional status among children, presenting a typical scenario of south Asia, known as the "Asian Enigma", where progress in childhood malnutrition seems to have sunk into an apparent under-nutrition trap despite economic growth and reduction in poverty, still lagging far behind other Asian countries characterised by similar levels of economic development (Radhakrishna and Ravi 2004).

Many studies clearly illustrate that deprivation in child undernutrition is caused by many factors such as income inadequacies, socio-economic marginalisation and other forms of human insecurities, particularly in India. Among them, poverty, measured in terms of the wealth index, has considerable impact on malnutrition, indicating a disproportional burden on the poor that explains for more than half of the inequality in malnutrition. Thus, this signifies the importance of the poverty – nutrition inequality linkage to worsening malnutrition, leading to unequal nutritional outcomes among children (Poel et al 2007; Mazumdar 2010; Kanjilal et al 2010).

2 Child Nutritional Status in the North-east

According to the NFHS-3 (IIPS and Macro International 2007), nutritional status of children in the north-east region is better than at the national level, in terms of the three anthropometric indices used, viz, height-for-age (chronic or stunting), weight-for-height (acute or wasting), and weight-for-age (underweight, the composite index). So, overall, the malnutrition situation among children U-5 in the region has shown an improvement over the years, but is still profoundly unequal among the states, exhibiting a rather interesting pattern – the coexistence of two extremes, one very low and the other very high. For instance, according to the NFHS-3 (ibid), three of the eight states, viz, Sikkim, Mizoram and Manipur, have the lowest proportion of underweight children (20-22%) in the country, ahead of states like Kerala, Punjab and Goa. The five remaining states, particularly Meghalaya, exhibit a very high prevalence comparable to states in east or central India. States like Arunachal Pradesh, Assam and Tripura are comparable with states in the south or north (30-40% of underweight children).

The NFHS-3 results also reveal that in the north-east region, more children U-5 are suffering from chronic malnutrition (36-55%), than from acute malnutrition (9-31%). This means that child malnutrition among the U-5 age group in the north-east region pertains more to stunting (short for their age) than wasting (thin for their height). Therefore, the prevalence of underweight children U-5 in the north-east region is contributed to largely by the proportion of those who are stunted.

3 Methodology: Data and Method

3.1 Data

The present study on malnutrition among children U-5 uses data from the NFHS-3 (ibid), which is a large-scale, multi-round survey conducted in a representative sample of households throughout India. The survey provides state- and national-level information on issues such as fertility, infant and child mortality, the practice of family planning, maternal and child health, reproductive health, nutrition, dietary habits, anaemia, and utilisation and quality of health and family planning services. The NFHS-3 covered a nationally representative sample of about 1,00,000 households; 17.6% from the north-east region (19,216 households), covering nearly 10,000 children U-5 from the region.

3.2 Method

The NFHS-3 measures nutritional status of children U-5 according to three anthropometric indices, viz, height-for-age (chronic or stunting), weight-for-height (acute or wasting), and weight-for-age (underweight, the composite index), based on the WHO growth standard (ibid), which considers for each index a z-score below minus two standard deviations (-2 SD) from the median of the reference population. Each index provides different information about growth and body composition of children who are classified as chronically malnourished (stunted), acutely malnourished (wasted), and underweight (both acute and chronic malnutrition). A further lower z-score below minus three standard deviations (-3 SD) is classified as "severely" malnourished (Dibley et al 1987).

In the recent past, however, Svedberg (2000) proposed methods that provided a comprehensive estimate (or a better aggregated indicator), as the three conventional measures have been found to overlap or lack robustness. He developed a single and more comprehensive index known as the composite index of anthropometric failure (CIAF), which is also applied in this study.

Scholars who applied this modified measure pointed out huge variation in the estimates of malnourished children and/or those missed by conventional indices. They pointed out that an increased risk of multiple anthropometric failures are significantly more likely to result in ill health and an increased risk of dying, and found that some stunted children could also be wasted or underweight, or vice versa. Therefore, as they argued, conventional measures are inadequate to give a true estimate for the burden of under-nutrition among children in a population, and failure to capture those at risk would be simply devastating (Nandy et al 2005; Seetharaman et al 2007; Bose and Mandal 2010).

Svedberg also argued that

> the *w/a* indicator does not identify the *sum* of those who are stunted and/or wasted. The *w/a* indicator will in fact miss some of the children who are undernourished in the two latter dimensions. The total prevalence of anthropometric failure in a population will thus be under-estimated by the weight-for-age indicator (as well as by any of the other two) (Svedberg 2000: 194).

Nandy and Miranda (2008) also observed that,

> From a policy and planning perspective, however, it is also important to know the *overall* scale of the problem, so that sufficient resources are allocated...the CIAF is the only indicator able to do this. Information from conventional indicators about changes in the prevalence of undernutrition overtime may be contradictory and confusing... The CIAF takes the differences between the three conventional indicators into account, and so is more able to provide an indication of changes in undernutrition. It might also be noted that underweight maybe exaggerating the magnitude of change.

Such evidence is shown by a study in West Bengal. The study using the CIAF method found that among the Bauri children, while the conventional measures showed 39.2% children as stunted, 51.2% as underweight, and 26.6% as wasted, the CIAF-based results indicated a higher prevalence of undernutrition at 66.3%, due to at least one type of anthropometric failures (Das and Bose 2009).

The modified method of anthropometric failures (Nandy et al 2005) is used in this study. The original method developed by Svedberg (2000) has six subgroups of anthropometric failures, which has been extended/modified by Nandy et al (2005) to include an additional subgroup y (children who are only underweight, but not stunted or wasted). All the subgroups of anthropometric failures in the CIAF method are listed below (Svedberg 2000 and Nandy et al 2005):

- Group a (no failure)
- Group b (wasting only)
- Group c (wasting and underweight)
- Group d (wasting, stunting and underweight)
- Group e (stunting and underweight)
- Group f (stunting only)
- Group y (underweight only)

The modified CIAF can be expressed symbolically as:

$$\text{CIAF} = (1 - a)/(a + b + c + d + e + f + y) = (1 - a)/1$$

Besides, the Gini index and Lorenz curve have also been used to illustrate inequality and concentration in child malnutrition by socio-economic and demographic status, and the representation of income inequality, respectively. The area under the Lorenz curve is calculated as follows:

Given, $y_1 \leq y_2 \leq \ldots \leq y_n$, in that

$$q_1 = \frac{y_1 + y_2 + \ldots + y_i}{y_1 + y_2 + \ldots + y_n} = \frac{y_1 + y_2 + \ldots + y_i}{y} \rightarrow \text{cumulative proportion of income}$$

$$p_i = \frac{i}{n} \rightarrow \text{cumulative proportion of population}$$

with $q_o = p_o = 0$ and $q_n = p_n = 1$

$$G = 1 - \sum_{i} [(q_i + q_{i-1})(p_i - p_{i-1})]$$

G is the Gini index, which lies between 0 and 1. The nearer the *G* value to 1, the higher is the inequality and vice versa.

The present study uses the modified method of CIAF to derive new estimates of undernourished children, taking the north-east region as an illustration, and comparing the estimates with those of conventional measures (e g, underweight) across selected socio-economic and demographic variables such as:

- **Household Characteristics**: Place of residence, consumption of iodised salt, economic status (wealth quintile/index), ethnicity (social groups), and religion.

- **Child Characteristics:** Age, sex, birth order, size of the child at birth, duration of breastfeeding, intake of iron and vitamin A.

- **Mother Characteristics**: Education, working status, anaemia status, and body mass index (BMI).

Besides the bivariate analysis applied to examine the relationship between two variables, which are the outcome and the exposure variables, a multivariate logistic analysis has been applied with models fitted to assess adjusted effects of socio-economic and demographic characteristics on the outcome variables. The fitted models are:

- Model 1 controls for child characteristics to see the effect on outcome variables after adjusting for other exposure variables;
- Model 2 incorporates both child characteristics and mother characteristics to examine the effect on the outcome variables after adjusting for other exposure variables; and
- In Model 3, child characteristics, mother characteristics, and household characteristics are considered for their effect on the outcome variables after adjustment for the exposure variables.

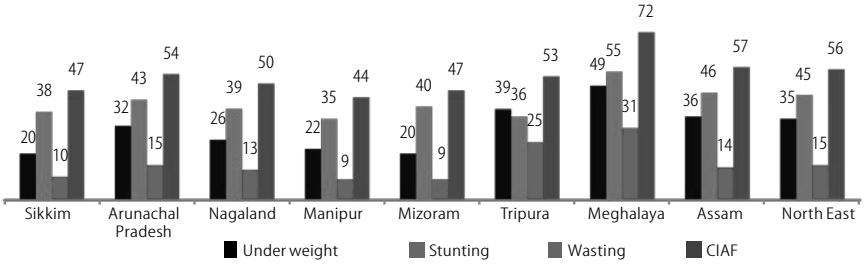
4 Results

4.1 Malnourishment Level and CIAF Disaggregated by Subgroups

Under-nutrition among children U-5 has been recalculated for both, the conventional measures (underweight, stunting, and wasting) based on Z score values (- 2 SD) and the CIAF method

for the states and regions. As presented in Figure 1, it is clearly evident that the CIAF method gives much higher estimates/levels of malnutrition in the region – overall under-nutrition or "anthropometric failure" level of 56%, a nearly twofold increase compared to the level for underweight children (35%) based on WHO standards (z score of -2 SD). Similarly, each state shows an increase by 1.4 to 2.4 times the proportions of underweight children, ranging from 44% (by twice) in Manipur to 72% in Meghalaya (1.5 times), the highest by 2.4 times in Sikkim (47%) and Mizoram (48%), followed by Nagaland (by 1.9 times with 50%), and Arunachal Pradesh (by 1.7 times with 54%). However, in terms of percentage, anthropometric failure is highest in Meghalaya (72%), followed by Assam (57%) and Arunachal Pradesh (54%), and lowest in Manipur and Sikkim (44% and 47% respectively).

Figure 1: Comparative Level of Malnourished Children Age Under 5 by Conventional Measures and CIAF in North-east States/Region (2005-06, in %)



Meghalaya stands out as the worst with 72% of children U-5 with anthropometric failure or overall under-nutrition. Therefore, the state also has the highest proportion of children who are stunted (55%) and who are wasted (31%). Close on the heels of Meghalaya are Assam and Tripura – Assam with the second largest proportion of stunted children (46%) and Tripura with the next highest proportion of children who are wasted (25%). States with the lowest proportion of children who are wasted are Manipur and Mizoram (9%), followed by Sikkim (10%) and Nagaland (13%).

Overall, Manipur has the lowest proportion of children U-5 with any anthropometric failure or overall under-nutrition in the region. As mentioned earlier, one important feature indicated by the WHO standards is that stunting (chronic or Group f), and not wasting (acute or Group b), is a major problem in the north-east region – affecting over two-fifths (45%) of children U-5, but the proportion ranges from 35% in Manipur to 55% in Meghalaya. Wasting or acute malnutrition is a lesser problem in the region, as the proportion of children U-5 in this category ranges from 9% in Manipur and Mizoram to 31% in Meghalaya. Among the states, only Nagaland depicts an under-nutrition pattern similar to the overall region.

Table 1: Prevalence of Overall Under-nutrition/Children Age Under 5 Years Classified as Malnourished in North-east Region and India (2005-06)

Conventional Indicator	North-east India	India
• (a) Stunting (H/A)	45	48.0
• (b) Wasting (W/H)	15	19.8
• (c) Underweight (W/A)	35	42.5
Anthropometric failure (CIAF)	56	61

Source: NFHS-3 (2005-06); CIAF as calculated by authors.

A comparative picture of undernutrition among children U-5 in the north-east region and India is presented in Table 1. Going by the conventional indicators, undernutrition levels in the north-east region appear better, particularly the prevalence of underweight children. However, when using the CIAF method, we find significant difference or advantage in the north-east region – 56% in the north-east region and 61% for India.

A detailed result of overall malnutrition among children U-5, disaggregated by subgroup of "failure" or multiple failures by state and region, is presented in Table 2. In the region, close to half of the children U-5 (44 %) have "no failure" or best nutritional status. Among the states, the highest proportion of children with "no failure is in Manipur (56%), followed by Sikkim (53%) and Mizoram (52%), while the state with the least proportion of children with no failure or worst nutritional status is Meghalaya (28%), followed by Assam (43%).

One common feature observed in all the states is that the prevalence of stunting (Group f) among children is higher than other anthropometric failures such as wasting or underweight, followed by the combined stunting-underweight failures (Group e). Both stunting and underweight account for 17% of total malnourishment or failures – highest in Assam with 23%, followed by Meghalaya and Arunachal Pradesh (about 20% each).

4.2 Prevalence and Differentials

Studies have indicated that malnourishment in children is caused by many factors directly associated with the child, mother, and household environment. Table 3 (p 57) presents the prevalence of malnourishment among children, based on NFHS-3 data, and the differentials that emerge within and across when considering characteristics of the child, mother and household by both the conventional measure (underweight)

Table 2: Disaggregated Anthropometric Failures (CIAF) among Children Age Under 5 by State, North-east India (2005-06, in % age, weighted)

Subgroup	Sikkim	Arunachal Pradesh	Nagaland	Manipur	Mizoram	Tripura	Meghalaya	Assam	North-east
A No failure	53.2	45.6	50.3	55.9	52.2	46.8	28.0	43.4	44.0
B Wasting only	3.6	4.2	5.2	3.8	3.8	4.8	3.9	3.2	4.1
C Wasting and underweight	3.5	5.9	4.3	3.2	2.6	9.8	10.6	4.7	5.0
D Wasting, stunting and underweight	2.7	4.9	3.8	2.1	2.4	10.4	16.5	5.7	6.3
E Stunting and underweight	11.8	19.7	16.3	15.3	13.5	16.5	20.1	23.3	21.9
F Stunting only	23.2	18.3	19.0	18.1	23.9	9.0	18.7	17.0	16.9
Y Underweight only	2.0	1.5	1.1	1.6	1.5	2.7	2.1	2.7	2.4
Total (N)	100 (499)	100 (673)	100 (1,748)	100 (1,599)	100 (691)	100 (523)	100 (697)	100 (1,249)	100 (7,682)

Table 3: Comparative Prevalence and Differentials in Malnourishment (Underweight and CIAF) among Children Age Under 5 by Selected Child, Mother and Household Characteristics, North-east Region, India (2005-06)

Characteristics	Underweight (Weight-for Age)	CIAF
(1) Child		
(a) Age of child		
Less than 12 months	27.3	44.7
12-23 months	35.2	55.9
24-35 months	38.1	58.4
36-47 months	38.6	59.1
48-59 months	37.1	60.1
(b) Sex of child		
Male	33.9	55.0
Female	36.8	56.6
(c) Birth order of child		
1	29.1	49.5
2-3	35.7	55.4
4-5	40.2	59.7
Six or higher	46.8	73.0
(d) Size of child at birth		
Large	30.9	46.9
Average	34.5	55.7
Small	42.5	64.5
(e) Duration of breastfeeding		
Six months	28.8	47.2
Six months – one year	37.3	62.3
>1 year	35.4	55.4
(2) Mother		
(a) Mother's education		
No education	44.5	65.3
Primary	39.3	62.4
Secondary	27.4	46.6
Higher	11.2	27.3
(b) Working status		
Not working	33.9	53.8
In agriculture	35.4	59.2
In non-agriculture	41.1	61.9
(c) Anaemia status		
Severe	36.7	56.8
Moderate	37.5	56.7
Not anaemic	32.8	55.4
(d) BMI		
Thin	47.4	64.6
Normal	30.6	52.8
Overweight/obese	13.4	34.4
(3) Household		
(a) Place of residence		
Urban	25.2	45.9
Rural	37.1	57.5
(b) Wealth index		
Poorest	44.2	66.9
Poorer	42.9	63.4
Middle	33.6	52.5
Richer	21.8	44.0
Richest	10.5	26.4
(c) Ethnicity		
Scheduled caste	35.7	54.4
Scheduled tribe	29.3	53.3
Other (OBC and others)	41.9	63.4
(d) Religion		
Hindu	31.3	49.2
Muslim	44.3	65.6
Christian	33.7	59.5
Others	36.7	59.9
Total	35.3	55.8

and anthropometric failure (CIAF). The overall picture that emerges indicates a similar pattern of malnourishment among children U-5 across the various characteristics, be that of the child, mother or household, but the proportions in each category vary hugely.

4.2.1 Child Characteristics: Each characteristic of the child, namely, age, sex, birth order, size at birth and duration of breast feeding, reflects wide differentials, and mostly an inverse relationship, in the prevalence of under-nutrition in the region. For instance, it was found that as the age of the child increased, say from less than a year to up to five years, the proportion the malnourished also increased, from 19% to 34% respectively. Older children (age 48-59 months) are nearly twice as likely to be malnourished than those who are aged less than one year. The proportion of underweight in the age group 48-59 months in the north-east region is 38%, while the level of anthropometric failure (CIAF) is 60%. A similar inverse relationship in child characteristics is also observed with birth order (one to six or higher order) and size at birth (small to large baby) by 1.4 times. Interestingly, in the north-east region, malnourishment by sex of the child does show a subtle difference in under-nutrition, both by level of underweight (34% for males and 37% for females) and CIAF (above 55% for both) – the gap is the least or smallest.

Among the child's characteristics considered, the best nutritional status or least failure is found among children who are less than 12 months (only 27% underweight or 44% with some failures). In contrast, children who were small at birth (43% underweight or 65% CIAF) or of six or higher birth order (47% underweight or 73% CIAF) were more likely to have the worst nutritional status in north-east India (Table 3).

4.2.2 Mother Characteristics: The influence of the mother's characteristics on the child's health is an established fact. Undoubtedly, failure in addressing mothers' health needs has been food for serious policy concern, resulting in "architectural corrections" in health systems and strategies, particularly in the maternal and health programmes in the country. Recent years have seen the implementation of the Reproductive and Child Health (RCH) programme since 1996, and also the National Rural Health Mission (NRHM) since 2005.

As presented in Table 3, in the north-east region, mothers' characteristics, such as education, working status, and health status (anaemia and nutritional status) largely influence or indicate an inverse relationship with the nutritional status of children. For instance, in the region, as mothers' education increases, the proportion of undernourished children decreases. The proportion of underweight children belonging to mothers with no education is about four times higher (45%) compared to children whose mothers have 12 or more years of education (11%). Similarly, the re-estimated CIAF also shows comparable but higher levels (65% and 27%, respectively).

Educated women are more likely to seek employment, but may not necessarily be working. However, the working status of mothers and the type of work (sector) also appear to show

influence on the children's malnourishment status. It is indicated that children are more likely to be underweight/malnourished if their mothers are not working (34%) or working in the non-agricultural sector (41%). The levels of anthropometric failure among children by working status of mothers also indicate that those with non-working mothers (54%) are more malnourished compared with those with mothers working in the non-agriculture sector (62%).

Unlike other characteristics of the women, the health status of the mothers (anaemia and BMI) indicates a more uniform and lesser influence on child nutritional status than on education or child characteristics. However, variation in the level of malnourishment within this characteristic is indicated. As shown in Table 3, between the two, BMI indicates a more complex relationship with child nutritional status. For instance, while there is more uniformity in anthropometric failure among children by anaemic status of mothers (33-37%), BMI of mothers shows a more varied influence on anthropometric failure/malnourishment among children (34-65%), the highest being 65% among thin women (BMI of <18.5 kg/m^2). Interestingly, in the north-east, mothers who are overweight and obese show lesser anthropometric failure in their children (34%), compared to those with normal or thin BMI.

4.2.3 Household Characteristics: Among the many possible household characteristics, four factors, viz, place of residence, wealth quintile, ethnicity and religion, are considered here to understand the possible influence on or relationship with child

Table 4: Odds Ratios from Logistic Regression Analysis Assessing the Association between Explanatory CIAF among Children Age Under 5 in North-east States of India (2005-06)

Log pseudo-Likelihood	Model 1 -1070.1	Model 2 -968.1	Model 3 -944.1	Log pseudo-Likelihood	Model 1 -1070.1	Model 2 -968.1	Model 3 -944.1
Characteristics				(c) Anaemia status			
(1) Child				Severe ®			
(a) Age of child				Moderate		1.16	1.15
Less than 12 months ®				Not anaemic		1.19	1.18
12-23 months	2.07***	1.12***	1.08***	(d) BMI			
24-35 months	2.40***	2.44***	2.53***	Thin ®			
36-47 months	2.75***	2.47***	2.32***	Normal		0.64***	0.66***
48-59 months	2.98***	2.99***	2.90***	Overweight/obese		0.48***	0.60***
(b) Sex of child				(3) Household			
Male ®				(a) Place of residence			
female	1.03	1.0	0.99	Urban ®			
(c) Birth order of child				Rural			1.01
1 ®				(b) Consumption of iodised salt			
2-3	1.26***	1.12	1.08	No ®			
4-5	1.58***	1.26**	1.12	Yes			0.91
Six or higher	1.94***	1.80**	1.45***	(c) Wealth index			
(d) Size of child at birth				Poorest ®			
Large ®				Poorer			0.96
Average	1.44***	1.42***	1.39***	Middle			0.71***
Small	2.06***	1.87***	1.84***	Richer			0.56***
(e) Duration of breastfeeding				Richest			0.40***
Less than six months ®				(d) Ethnicity			
Six months – one year	1.78***	2.09***	1.94***	Scheduled caste ®			
Currently breastfeeding (12m+)	1.71***	1.74***	1.53***	Scheduled tribe			1.14
(f) Intake of vitamin A				Others (OBC and others)			0.84
No ®				(e) Religion			
Yes	0.86**	0.79***	0.86	Hindu ®			
(g) Intake of iron-rich food				Muslim			1.65***
No ®				Christian			1.34***
Yes	0.79***	0.87	0.89	Others			1.42***
(2) Mother				(4) State			
(a) Education				Sikkim ®			
No education ®				Arunachal Pradesh			1.35**
Primary		0.96	1.00	Nagaland			1.12
Secondary		0.59***	0.74***	Manipur			0.89
Higher		0.32***	0.54***	Mizoram			1.04
(b) Working status				Tripura			1.29**
Not working ®				Meghalaya			2.91***
In agriculture		1.09*	0.94	Assam			1.48***
In non-agriculture		1.10***	1.15**				

® =reference category, *p<0.10 **p<0.05 ***p<0.01 (level of significance).

under-nutrition or anthropometric failure. In general, one needs to understand the social milieu of the region. As shown in Table 3, in the region, differentials in malnutrition among children by urban/rural and economic status seem more conspicuous than either by ethnicity or religion, as indicated by underweight or CIAF percentages. Households in the north-east region most likely to have or be associated with underweight children are in the rural areas, of the poorest, non-scheduled social groups, and of the Muslims. The CIAF level is highest among the poorest households with 67% (44% underweight), followed by Muslim households with 66% (also with 44% underweight). Overall, the poorest households in the north-east are nearly three times (2.6 times) more likely to have children with anthropometric failure (or 4.2 times more than underweight children) compared to the richest households (26%).

4.3 Multivariate Analysis Results

The multivariate modelling based on CIAF results was executed in three stages to examine the effect of dependent variables after controlling for the independent variable (under-nutrition/malnutrition). These three stages are designated as Model I-based on only the child characteristics, Model II-based on both child and household characteristics, and Model III – which incorporates child, woman/mother, and household variables, incorporating the respective states.

The results as presented in Table 4 (p 58) show the parameter estimates for the multivariate models of CIAF for north-east India. Model 1 reveals that there is a positive relationship between the age of the child and child malnutrition ($p<0.01$), which is also found true for birth order. Another important determinant for child malnutrition is the size of the child at birth, and it is found that small size babies are over twice (2.06 times) more likely to suffer from malnourishment compared to large sized babies ($p<0.01$).

Although important, the sex of the child does not seem to influence malnutrition among children (statistically not significant). However, an interesting result is that breastfeeding practices (e g, exclusive breastfeeding for six months or longer) show an inverse relationship with malnutrition – longer the duration of breastfeeding, higher is the likelihood of malnutrition among children ($p<0.05$). Micronutrient food intake (vitamin A and iron-rich foods) of the child shows an inverse relationship with child malnutrition ($p<0.01$).

In Model 2, which incorporates mothers' characteristics such as education, working status, anaemia level and BMI, education of the mother and children's nutritional status show an inverse relationship ($p<0.01$) with CIAF. Interestingly, mother's anaemia status does not show any statistical significance, but the picture is quite different for BMI. The CIAF estimates showed that z-score values of children born to women who were thin, with BMI below 18.5 kg/m^2 (the critical value), were more by 48% compared with overweight/obese mothers and by 64% compared with normal mothers (18-25 kg/m^2), and highly significant ($p<0.01$). These children, thus, have greater tendency to suffer from malnutrition.

In Model 3 we incorporate household-level predictors, such as place of residence, wealth index, ethnicity and religion to examine their influence on the children's nutritional status. The regression results indicate that children belonging to poorest wealth quintile are more likely to suffer from malnutrition (by 60%) than children in the richest wealth quintile ($p<0.01$). Moreover, religion-wise differential in malnutrition among children is also evident, where children belonging to minority religions are nearly twice more likely to suffer than Hindu children ($p<0.01$).

To facilitate the comparative assessment of the relative nutritional status of children across the states in the region, Sikkim has been taken as the reference state, as the state has the lowest proportion of children who are underweight (20%) and the second lowest with anthropometric failure. Results indicate that children in Meghalaya and Assam are 2.9 times and 1.5 times, respectively, more likely to suffer from malnutrition than children in Sikkim ($p<0.01$). Similarly, children in Arunachal Pradesh (35% higher) and Tripura (30% higher) are also more likely to suffer from malnutrition than their counterparts in Sikkim ($p<0.05$).

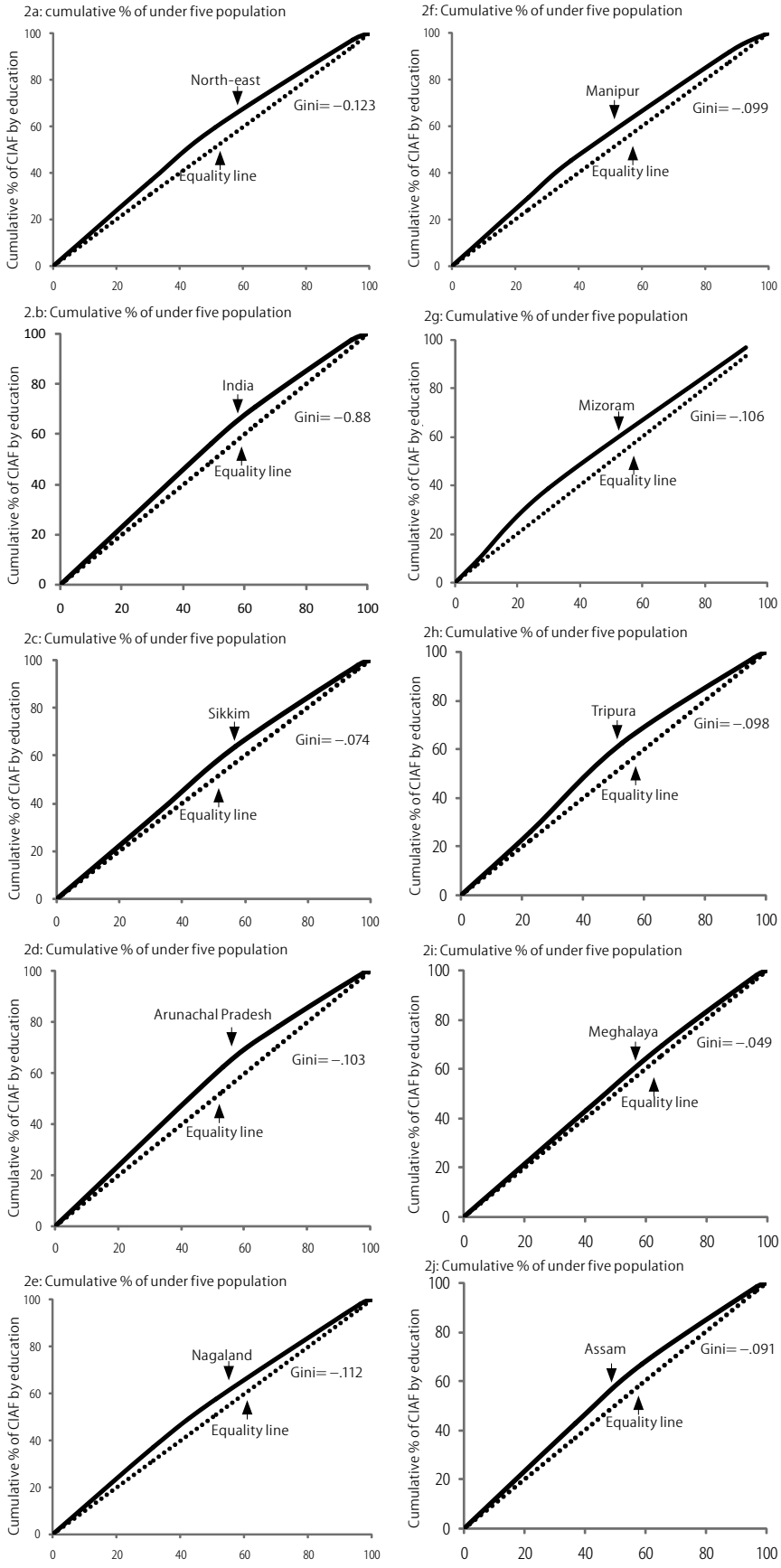
Clearly, the regression results indicate that, after controlling for other variables, child characteristics such as age, birth order, size of the child, duration of breastfeeding, and micronutrient food intake have strong influence on nutritional status. Besides the child characteristics, mother characteristics, such as education, working status and BMI have shown influence on the nutritional status of children. It is also found that household characteristics such as wealth index and religion determine or emerge as important factors for nutritional status, unlike place of residence, despite the fact that more children from rural households suffer from malnutrition.

4.4 Inequality by Education and Wealth

The CIAF and regression results clearly indicate a concentrated inequality in child malnutrition among and within the sub-populations and between states in the north-east. For instance, inequality in terms of education shows that children belonging to educated mothers perform better with respect to their nutritional status compared to those having non-educated mothers. Such difference in education hugely intensifies the inequality in child nutritional status. So, to illustrate the elasticity as well as gap in inequality, such as by education and wealth among states, the Gini index and Lorenz curve have been applied and plotted.

Figure 2 (p 60) shows the Lorenz curves and Gini indices of CIAF by education. We observe in the Lorenz curves that all north-east states lie above the equality line, which signifies that child under-nutrition is concentrated more among uneducated mothers compared to educated mothers. But, overall inequality is low in all the north-east states. However, the inequality level in north-east states (Gini value of minus 0.123) is higher than the national average (Gini value of -0.088). Among states, Meghalaya has the lowest inequality in child under-nutrition, with a Gini index value of only -0.049, while Nagaland has the highest inequality with a Gini index value of

Figure 2: Lorenz Curve and Gini Index Showing Inequality in Under-nutrition Age Under 5 by Education in North-east States, India



-0.112. Mizoram and Arunachal Pradesh have similar inequality values (with -0.106 and -0.103, respectively). As compared to other north-east states, Sikkim has very low inequality of child undernutrition. Assam, Tripura and Manipur have similar Gini index values of -0.91, -0.98 and -0.99, respectively.

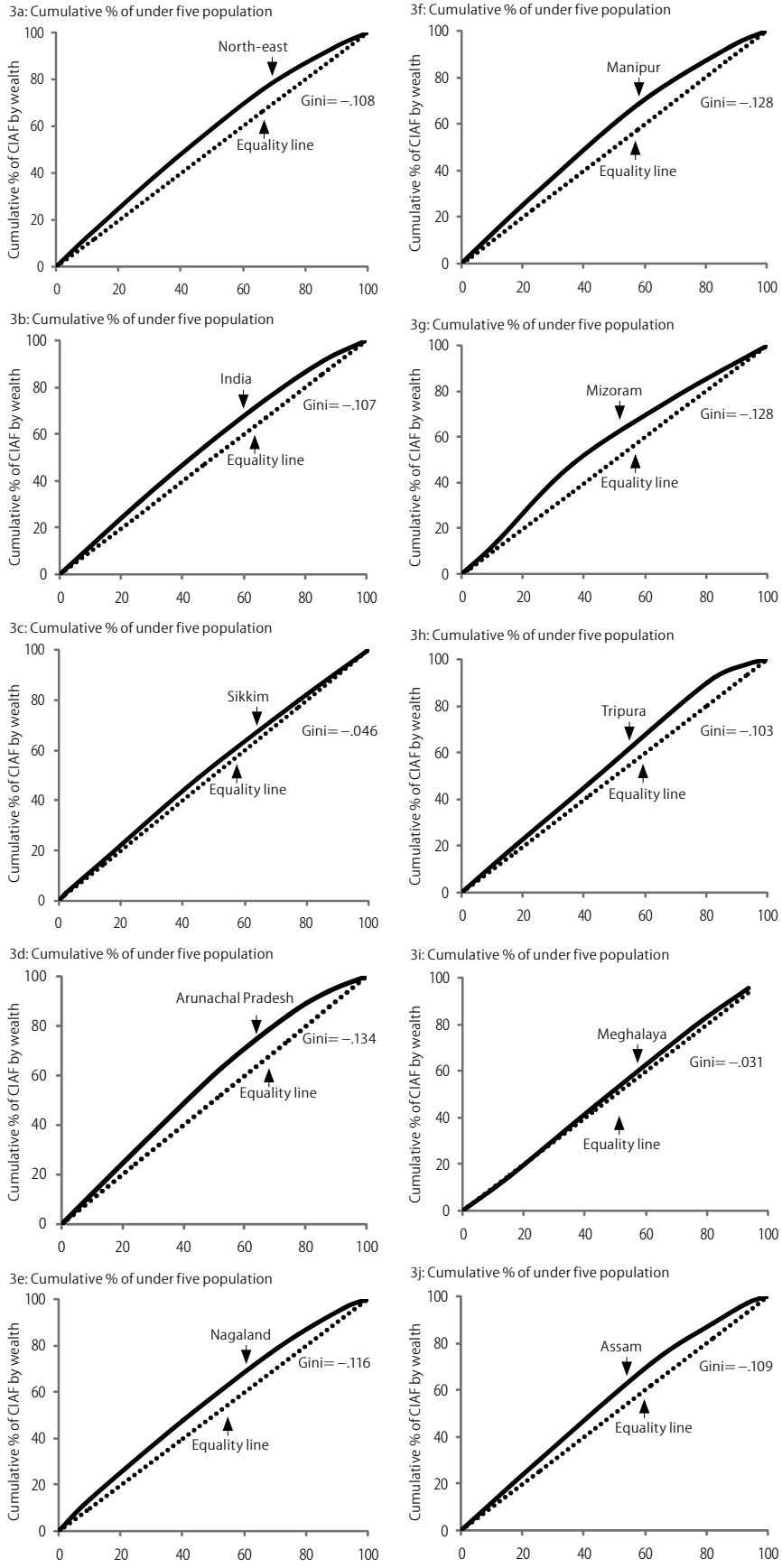
A similar Gini index and Lorenz curve are plotted by wealth to illustrate inequality by economic strength of the households. Figure 3 (p 61) shows Lorenz curves with Gini index values of inequality for the estimated CIAF by wealth quintiles for each of the north-east states. The Lorenz curve lying above the equality line shows a higher concentration of CIAF among the poor than among the rich class. Meghalaya and Sikkim have the lowest inequality compared to other north-east states with a Gini index value of -0.031 and -0.046, respectively, as compared to -0.134 in Arunachal Pradesh, which is also the state with highest Gini index value in the region. The overall Gini index value for the north-east region (-0.108) is marginally greater than the national average of -0.107.

4.5 Inequality by NSDP

At the macro level, economic growth plays an important role in reduction of child malnutrition, but surprisingly this does not appear to be the case for India. This could be due to the presence and role of various crucial proximate variables at play at the micro level in influencing child nutritional status. To illustrate the inequality by economic status in the region a scatter plot has been applied to show the relationship between net state domestic product (NSDP) and Gini index of the estimated CIAF values (Figure 4, p 62).

As illustrated by Figure 4, the per capita NSDP is highest in Tripura followed by Arunachal Pradesh, which is also higher than the national average, whereas inequality in child malnourishment is also very high in these states. On the other hand, per capita NSDP is low in Assam and Manipur as compared to the national average, but these two states exhibit a noticeably higher burden of malnourishment among young children. We also see an instance of a state like Meghalaya

Figure 3: Lorenz Curve and Gini Index Showing Inequality in Under-nutrition Age Under 5 by Wealth Index in North-east States, India



with a low per capita NSDP compared to the national average, but with a lessser burden of malnutrition among the poor (lower negative values of the Gini index).

5 Discussion and Conclusions

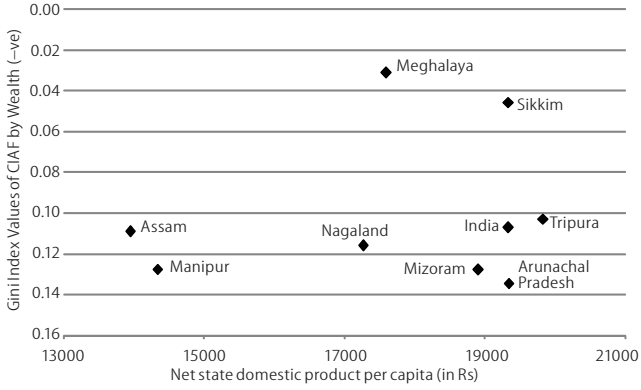
Contrary to expectations, the CIAF estimates too suggest that in the north-east region child under-nutrition (U-5) is quite high (56%), and much worse in states like Meghalaya, Assam, Arunachal Pradesh and Tripura. However, household and state levels show the interplay of different factors despite the fact that education and wealth stand out among them.

Malnutrition in the north-east region rises with the age of the child, a finding endorsed by other studies as well (Mukhopadhyay and Biswas 2011). Also, size at birth and birth order show significant relationship with the children who are malnourished. We see that children of a higher birth order and small size at birth are more prone to being malnourished.

On the other hand, mother's education shows an inverse relationship with child nutritional status, as evident across all the states in the north-east. Better educated mothers are well-informed about required nutrient intake and proper care of the child. As also indicated by Smith and Haddad (2000), maternal education significantly lowered childhood malnutrition, which reflects education generating the necessary income to purchase food. A high level of maternal education could also lower childhood malnutrition through other pathways, such as increased awareness of healthy behaviour, sanitation practices and a more equitable sharing of household resources in favour of the children. Alongside education, women's status in the family also affects the outcome of child nutritional status. As is evident again, children belonging to mothers who are working in the non-agricultural sector are more likely to be malnourished compared to those who have mothers working in the agriculture sector or not working.

In the north-east, maternal nutritional status determines child malnutrition levels. For instance, mothers who are anaemic or have a lower BMI show an inverse relationship with the children who

Figure 4: Scatter Plot Showing Relationship between Wealth (NSDP) and CIAF (Gini index) by State in North-east India



Base year price is 1999-2000.
The values for NSDP has been taken from *Handbook of Statistics on the Indian Economy 2004-05* (2005).

are underweight (also stunted and wasted). Rao et al (2004) have also found that women who suffer from anaemia or have a low BMI are ignorant about proper nutritional diet and general hygiene. Besides, those living in mountainous regions could not access or avail of proper healthcare facilities.

Wealth index shows that children from poorer households suffer more from malnourishment compared to those from richer households. Studies in other parts of the country also concur. Children with multiple anthropometric failures are at a greater risk of morbidity and more likely to come from poorer households. Also, disproportionate burden of stunting is more pervasive among those with a poor socio-economic status, more so in urban areas. Thus, states having lower prevalence of chronic childhood malnutrition show a much higher burden among the poor (Nandy et al 2005; Kanjilal et al 2010).

As expected, malnutrition is more prominent in rural areas compared to urban areas, which clearly indicates that place of residence affects child nutritional status (but not significantly). The advantages in urban areas are observed in terms of availability and accessibility to healthcare services, proper diet, and also proper child feeding practices, etc. It is also found that children belonging to Other Backward Classes and scheduled tribes are more malnourished compared to other social groups. A similar study by Mukhopadhyay and Biswas (2011) found that prevalence of anthropometric failures of 69% and multiple anthropometric failures were more likely among tribal children aged 24-59 months, often associated with irregular utilisation of supplementary nutrition and from households with severe grades of food security. Besides ethnicity, religious affiliation seems to play a role in child nutritional status, as is evident among Muslim children who are more likely to be malnourished.

High prevalence in child malnutrition is also interspersed with wide inequality in the north-east, which is higher than India's average. When considering education, inequality in under-nutrition is found to be highest in Nagaland (-0.112), but lowest in Meghalaya (-0.49). But in terms of the wealth index, Arunachal Pradesh has the highest inequality (-0.13), and

Meghalaya the lowest (-0.031). Inequalities in malnutrition are intensified primarily by household wealth, or in other words, the relative poverty status of the households. Per capita NSDP shows that in the states where per capita is high, inequality is more compared to the states where per capita is low. As a whole, economic growth is necessary in reducing child malnutrition because the effect of economic growth is seen most through increased food availability, and the rest due to improvements in women's education, quality of health environment, and women's status, at the aggregate level (Subramanyam et al 2011). It is quite intriguing that child malnutrition is found to be highest in Meghalaya despite having lower inequality compared to other states.

Economic growth alone as a policy instrument may not be sufficient to reduce the burden of poor health among children from disadvantaged households in India (Poel et al 2007). Simultaneous and direct health investments may be necessary to reduce the high levels of child under-nutrition in India, especially given the strong intergenerational effects of poor nutrition in India (Kumar 2007). There is no direct association between economic growth and reduction in childhood undernutrition, but direct investments in appropriate health interventions may be necessary to reduce childhood under-nutrition in India (Subramanyam et al 2011).

As pointed out by Berger et al (2006), the use of CIAF has profound implications on prevalence of child malnutrition and on nutrition programming, which aims at targeting vulnerable populations for appropriate interventions, and so, using CIAF may help improve the quality and outcomes of global nutrition efforts.

The study highlights that children's characteristics do influence their nutritional status, but the mother's characteristics, such as education or BMI, have a stronger relationship with child nutritional status. There is also a strong relationship indicated between wealth index and malnutrition, and a substantial poor-rich gap in all domains of malnutrition with a disproportionate burden of child malnutrition on the poor. Also interesting is the finding that suggests no significant association between macroeconomic growth and child malnutrition. Economic development per se would not ensure good nutritional status of the children unless it is through inclusive growth. Unless there is proper monitoring and coordination at the household and community levels, there would be no improvement in child nutritional status. Among the eight states in the region, Meghalaya has been a surprise by being the state with the highest percentage of child malnutrition (in all measures – underweight, stunting, wasted and CIAF), but at the same time as having lowest inequality in child malnutrition across all socio-economic groups.

The study could not but agree more that the most important, and maybe debatable, finding has been the insignificant sex differential in malnutrition among children in the region. If true, the moot question is whether it is playing a key role in reducing inequality in the region.

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