Research Article

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Transition in Childhood Malnutrition in India: Evidence from Various Cross-sectional Surveysconducted during 1998 to 2013

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Introduction

Nutrition plays a significant role in growth and development of children. Progress in reducing malnutrition has been slower and more uneven, especially in developing countries. Reduction in chronic malnutrition among young children was one of the primary objectives of Millennium Development Goals (MDG). However, 162 million young children are still suffering from chronic malnutrition [1]. In 2014, an estimated 159 million children under five years of age globally were stunted, 50 million were wasted and 91 million children were underweight. About half of all stunted children lived in Asia and over one-third in Africa. Similarly, two-thirds of all wasted children lived in Asia and almost one third in Africa [2]. Therefore, the Sustainable Development Goals (SDGs) also concentrate to end hunger, achieve food security, improve nutrition and promote sustainable agriculture (SDG-2) by 2030 [3].

Despite a rapid growth in agriculture and industrial sectors in India in the recent years, undernutrition continues to be a major public health problem,where 48 percent children under five were stunted, 20 percent were wasted and 43 percent were underweight [4]. It accounts for about 40 percent undernourished children in the World, which is mainly due to the dietary inadequacy in relation to their needs [5]. Undernutrition levels in India remain higher than most countries in sub- Saharan Africa, even though those countries are currently much poorer than India [6].

Childhood malnutrition has a profound contribution in the under five deaths in India. Even those, who are able to survive with malnourishment are all impaired across the major parts of their lifecourse and have limited capacity to resist disease and to carry out physical work. Later in the life course, poor diet and malnutrition along with obesity are important causes of many non-communicable diseases (NCDs) like hypertension, diabetes, cancer, stroke, and ischemic heart disease etc (National Health Portal, 2015). Using LiST model, BMGF has recently estimated that about 621000 under five deaths in India (46% of total under five deaths) can be attributed to malnutrition or malnutrition aggravated deaths (BMGF, 2016). India bears 28 percent of the global burden of stunting, where 11% of the global burden of stunting are concentrated in only two states of India namely Bihar and Uttar Pradesh. Despite of a decline in the prevalence of stunting from 51% in 1998-99 (NFHS-2) to 45 percent in 2012-13 (DLHS-4/AHS, 2012), the improvement is neither impressive not uniform across states. The scenario of malnutrition and malnutrition exaggerated deaths enforce to look into the social inequalities and determinants of malnutrition in India and its states. This would be helpful in understanding how is the transition in the socio-economic inequalities in childhood malnutrition in different states/regions of the country after economic liberalization in 1991.Therefore, the present study aims to analyze the nutritional transition in India among children under age 3 along with the major correlates of childhood malnutrition. The study also measures the dynamics of economic inequality in nutritional status of children among different regions over the period of 1998-99 to 2012-13.

Data and Methodology

Survey data

This study is based on the secondary data collected as part of national level household surveys where standard Anthropometric measures were adopted to assess the malnutrition among children. Data collected as part of the second and third rounds of National Family Health Survey conducted during (1998-99, 2005-06), fourth round of District Level Household Survey (DLHS, 2012-13) and latest Annual Health Survey (AHS 2012-13) have been analyzed to achieve the study objectives. The National Family Health Survey (NFHS) is a large-scale, multi-round survey, conducted in a representative sample of households throughout India. The Ministry of Health and Family Welfare (MOHFW), Government of India, designated the International Institute for Population Sciences (IIPS) Mumbai, as the nodal agency, responsible for providing coordination and technical guidance for the survey. However, DLHS is also one of the largest demographic surveys with the large sample size, covering the districts in the country. However, the recent round of DLHS covered districts of demographic developed states (i.e., excluding EAG states) and hence the corresponding AHS data have been used to get information relating to the Empowered Action Group (EAG) states.

Methodology

Appropriate bivariate and multivariate regression analyses have been used to understand the nutrition transition and socioeconomic inequality among children below agethree. Binary logistic regression model has been used to analyze the adjusted effects of various predictors of stunting, wasting and underweight. Logistic Regression Model is commonly estimated by maximum likelihood function. For the Outcome variable, the logistic model takes the following general form:

Login P = ln (P/1-P)= $b_0+b_1x_1+b_2x_2+b_3x_3+$.....+bixi+e,

Where, b1, b2, b3 and bi represent the coefficients of each of the predictor variables included in the model, while e is an error term. ln (P/1-P) represents the natural logarithm of the odds of the outcome. The regression analysis yields odds ratios, which indicates the magnitude of the predictor variable on the probability of the outcome occurring. The odds ratios in this analysis are the measure of the odds of occurrence of stunting, wasting and underweight as an adjusted effect of independent variables included in the model. As regards to the direction of the logitcoefficients, odds greater than one indicate an increased probability of incidence of stunting, wasting and underweight; while those less than one indicate a decreased probability.

Further, Concentration Indices (CI) has been calculated to determine wealth based inequality in childhood malnutrition. The equation below gives the CI, which is computed as twice the (weighted) covariance of the health variables and a person's relative rank in terms of economic status, divided by the variable mean. The children are ranked in ascending order by thehousehold living standard in order to find out the cumulative fraction of, for example, stunted children by their economic status [7].

$$C = \frac{2}{\mu}\mathrm{cov}_w(y_i, R_i)$$

Where, y_i is the nutritional status of the i^{th} individual and R_i is the fractional rank of the i^{th} individual (for weighted data) in terms of *the index of household economic status*; μ is the (weighted) unconditional mean of the nutrition variable of the sample and cov_w denotes the weighted covariance. It reveals the concentration of inequalities among the subgroup of population. The weights are used to adjust for the design effect of the sample survey data. The value of CI lies between -1 and +1, where a negative value implies a concentration of outcome variable among disadvantageous groups and a positive value implies concentration among advantageous groups. A zero value of concentration index implies no inequality.

Results

Levels and Trends in childhood malnutrition in different states of India

In the era of economic liberalization in India, which started in the early 1990s, there has been documentary evidence of profound transformation in the socio-economic conditionsincluding improvements in the quality of life of people. These changes have been primarily resulted due to economic growth and various vertical interventions in welfare measures adopted by the state. Therefore, it is vital to analyze the levels and trend in the childhood malnutrition in the country. The level and trend of malnutrition among children under age three from different cross-sectional surveys conducted during 1998-2013 have been given in (**Table 1**). The study found that the pattern of decline in stunting among children, which measures lower growth in height in relation to their age, is not uniform across the states. This reflects alack of uniform growth of skeletal of children corresponding to their age, which may be primarily due to poor dietary intake over time as well as poor health conditions and reflects a failure to reach growth potential. Table 1 shows that over the period the proportion of children below age three suffering from stunting has been declining, which has been themaximum by 26 percent point in Sikkim, followed by 23 percent point in Haryana.

Arunachal Pradesh is the only state where the pattern gets reversed

Table 1: State wise trends of Malnutrition among children less than three years in India

		Stunting			Wasting			Underweight		
Region	**State**	1998-99	2005-06	2012-13	1998-99	2005-06	2012-13	1998-99	2005-06	2012-13
North	**New Delhi**	43.3	45.7	**	15.7	16.8	**	29.6	27.7	**
	Jammu and Kashmir	43.6	32.9	**	14.3	18.7	**	28.6	24.4	**
	Haryana	55.6	44.0	32.5	7.7	22.8	30.9	30.1	38.7	33.9
	Himachal Pradesh	46.8	33.7	35.9	17.3	19.9	21.9	34.7	31.2	31.6
	Punjab	44.9	35.0	28.9	8.2	10.3	20.6	24.3	23.8	25.8
	Rajasthan	59.7	39.5	44.0*	16.8	22.5	22.5*	47.7	36.6	36.6*
	Uttaranchal	52.1	39.4	40.2*	10.9	18.2	14.7*	37.6	31.4	28.0*
Central	**Chhattisgarh**	60.9	51.7	34.7*	18.8	24.5	32.4*	51.8	47.0	39.4*
	Madhya Pradesh	55.9	44.5	51.5*	25.6	37.4	17.3*	51.5	54.3	40.6*
	Uttar Pradesh	61.0	50.8	62.0*	17.4	18.4	15.9 *	48.7	39.4	44.9*
East	**Bihar**	58.4	48.5	52.0*	25.7	32.4	19.2*	52.2	53.4	40.3*
	Jharkhand	54.2	46.0	50.5*	28.1	35.6	21.3*	52.2	53.2	45.7*
	Orissa	48.5	43.0	41.5*	29.3	22.7	20.2*	49.7	38.3	38.9*
	West Bengal	46.3	39.3	32.1	16.9	18.5	31.0	42.2	34.1	36.9

Northeast	**Arunachal Pradesh**	30.5	36.9	33.3	10.6	16.7	18.0	21.8	28.8	26.2
	Assam	53.6	41.4	37.4*	18.4	17.3	20.2*	34.2	35.5	30.8*
	Manipur	38.3	28.8	36.6	9.8	10.9	16.9	20.2	19.3	27.2
	Meghalaya	49.5	47.6	43.9	15.1	30.4	37.2	28.4	41.5	37.2
	Mizoram	41.5	35.7	37.5	13.1	9.8	19.1	20.2	14.9	27.5
	Nagaland	39.0	31.8	37.5	13.4	15.3	16.6	19.1	22.4	27.3
	Sikkim	36.5	31.5	10.2	6.6	14.0	34.4	15.9	17.6	19.1
	Tripura	44.1	34.3	40.5	18.3	24.4	17.8	37.1	35.5	34.4
West	**Goa**	22.2	26.3	20.4	16.6	13.7	29.8	21.5	22.6	30.4
	Gujarat	52.0	49.8	**	20.6	20.0	**	41.6	41.4	**
	Maharashtra	43.9	42.5	29.7	22.1	17.4	33.3	41.5	33.4	37.5
South	**Andhra Pradesh**	47.4	34.3	30.3	11.0	13.0	20.5	34.0	24.6	27.0
	Telangana	#	#	23.6	#	#	30.2	#	#	29.6
	Karnataka	42.2	42.7	29.3	25.4	19.1	27.1	39.0	34.1	30.0
	Kerala	28.1	26.5	21.9	13.2	15.8	21.5	21.7	21.5	20.6
	Tamil Nadu	36.3	30.3	27.2	21.5	23.0	28.5	31.3	31.3	32.1

*Annul health Survey, 2012-13 (for children less than five years) , ** Data is not available , # State was not existing

with two percent point increase in the prevalence of stunting among children under age three. Overall the pattern of variation in stunting across different states of India clearly provide two contrasting pattern across EAG and non-EAG states. Most of the non-EAG states in India, which are demographically developed including some impressive achievements in maternal as well as child health indicators, have aprofound decline in stunting among children below age three over the past one and half decades. On the hand, EAG states, where demographic developments including maternal as well as child health indicators portrays relatively slower pace of improvements, childhood malnutrition is still very high. Four major states namely Bihar, Jharkhand, Madhya Pradesh and Uttar Pradesh, which constitute about 35 percent of thepopulation in India [8], have very high level of stunting where 51 to 62 percent of under five children are suffering with stunting.

Another indicator of childhood malnutrition is wasting, which presents the effect of acute malnutrition expressed as a low body weight relative to height. Wasting is resulted mainly due to insufficient nutrition intake, poor health status and diseases. It is evident from Table 1 that the present level of wasting is very high for the states like Meghalaya (37%) Sikkim (34%), Maharashtra (33%), Haryana (31%), West Bengal (31%), Telangana (30%), Goa (30%), Tamil Nadu (29%) and Karnataka (27%) and has increased in most of the states except Madhya Pradesh, Uttar Pradesh, Bihar, Jharkhand, and Odisha. Thus, theproportion of children below age threesuffering with wasting has increased in most of the states, where theproportion of children suffering with stunting has been declined. This may be mainly caused by arecent reduction in Infant and child mortality, where various government interventions have been able to prevent infant and child deaths but nut able to ensure very good health to them. That is why, most of theEAG states, where thelevel of Infant and under five mortalities are higher, theirprevalence of wasting is relatively lower.

Underweight reflects a combined effect of stunting and wasting and measures as low weight for age and provides a mixed pattern across various states in India. For underweight, the maximum decline has occurred in Karnataka, Andhra Pradesh and West Bengal, however, the minimum decline has been observed in Tamil Nadu. Prevalence of underweight has increased in states like Goa (nine percent point) followed by Meghalaya. Prevalence of underweight has increased in all the Northeastern states of India except Tripura from 1998 to 2013. Thus, transition in childhood malnutrition in India portrays two contrasting pattern, where the trends in the childhood malnutrition non-EAG states differs significantly than those among EAG states. That is why the subsequent analysis presented in this paper are restricted to only non-EAG states where considerable decline in childhood malnutrition has taken place in the recent years.

Variation in the prevalence of childhood malnutrition in non-EAG states of India by some selected socio-economic and demographic Characteristics

Despite the transition in the level of childhood malnutrition in different states of India, the pattern of changes is not uniform across different socio-economicand demographic characteristics. Table 2 presents the trend and prevalence of childhood malnutrition according to some selected background characteristics. It is evident from the Tables that the Non-EAG states of India have experienced a decline of more than 10 percent points in the prevalence of stunting while there has been almost 10 percent point increase in the prevalence of wasting. However, no significant change has been seen in the prevalence of underweight.

Variation in the prevalence of childhood malnutrition over the last one and half decades portrays thatage of thechild is one of the important cofactors of stunting, wasting, and underweight. Various cross-sectionalsurveys conducted in the last one and half decades present a remarkable decline in theprevalence of stunting among children age one to two (from49% in 1998-99 to 31% in 2012-13). The corresponding prevalence in stunting has changed from 54 percent to 31 percent among children age two to three years. The prevalence of stunting has been reduced by the same magnitude (12 %points) amongboys as well as girls. Religion and caste, which determines the lifestyle of people with varying cultural and traditional prescriptions, are also influential factors in India, which have profound differentials in the childhood malnutrition. Among different religious groups, the

prevalence of childhood malnutrition has the maximum decline among Muslims (46 to 31 %) during this period. In thecase of variation by caste-groups, the maximum decline has been found among Scheduled Caste (SC) children. In 1998-99, more than half of SC children (51 percent) were suffering from stunting, which has been declined by 21 percent points (51 to 30 %) during the last one and half decades. The corresponding decline among Scheduled Tribe children is from 44 to 33 percent andamong OBC children are from40 to 29 percent. Economic status of household is a decisive factor for availability and diversity of food, which affects the nutritional status of children. The prevalence of stunting among under three children was the highest among those coming from the households in the poorest wealth quintiles, followed by those from the poor households. Among the children from the poorest households, the prevalence of stunting was 53 percent in 1998-99, 49 percent in 2005-06 and 32 percent in 2012-13.Highest improvements in stunting over the last one and half decades have been also observed among children from the households from the poorest (21 % points) and poor (17 %t point) wealth quintiles.

Table 2: Trend and Prevalence of malnutrition in India by different background Characteristics

		Stunting			Wasting			Underweight		
Background characteristics		1998-99	2005-06	2012-13	1998-99	2005-06	2012-13	1998-99	2005-06	2012-13
Age of children in years	**Less than One**	24.3	19.6	30.1	19.3	22.9	26.1	24.4	21.4	31.4
	One to Two	48.5	40.8	30.8	16.2	15.6	26.6	33.2	29.0	30.8
	Two to Three	54.3	44.0	31.1	11.7	13.2	26.4	36.6	32.2	31.4
Sex	**Male**	43.7	37.2	31.8	16.5	17.4	26.8	32.7	28.6	31.6
	Female	40.7	34.1	29.4	14.9	16.3	25.9	29.9	27.1	30.7
Religion	**Hindu**	42.6	35.5	29.9	16.8	17.8	28.0	33.9	29.4	32.0
	Muslim	46.2	38.1	30.5	17.6	17.8	27.4	37.1	31.3	32.5
	Christian	38.8	34.7	35.7	13.1	14.4	20.6	20.4	22.2	29.2
	Others	43.0	35.4	29.9	10.2	14.2	22.4	24.4	23.7	27.8
Caste	**Seduced Caste (SC)**	51.2	42.9	30.0	19.0	19.8	27.7	40.5	36.6	31.6
	Scheduled Tribe (ST)	43.5	38.4	33.4	14.2	16.6	22.6	26.0	27.4	29.6
	OBC	40.0	34.4	29.1	16.7	18.1	27.1	32.4	27.0	30.9
	Others	39.4	31.5	31.2	14.3	15.1	27.0	29.0	24.4	32.7
Wealth Quintile	**Poorest**	52.5	48.5	32.2	19.7	22.7	25.8	42.0	38.0	31.4
	Poor	48.1	43.9	31.1	18.1	19.1	25.8	37.6	36.0	31.8
	Middle	43.3	38.5	30.3	15.7	16.9	27.5	30.1	30.8	31.7
	Rich	39.9	33.8	29.5	14.5	16.2	25.6	29.6	26.0	30.6
	Richest	27.9	21.8	30.4	11.0	11.6	26.8	17.7	15.6	30.5
Mother's Education	**No Education**	52.9	47.6	31.1	18.9	22.0	26.4	42.2	39.5	30.8
	Primary	46.5	41.3	31.3	17.3	19.4	26.4	35.6	34.3	31.8
	Secondary	36.4	31.8	29.8	13.6	14.6	26.3	24.7	23.3	30.6
	Higher	23.8	16.9	30.8	11.0	11.9	26.9	14.8	11.9	32.6
Birth Order	**First**	37.4	31.2	30.1	14.0	15.0	26.9	27.2	24.4	31.2
	Second	40.9	35.2	30.2	15.4	16.5	26.3	30.0	27.3	31.0
	Third	45.0	39.4	31.2	16.7	18.7	25.5	35.7	30.8	30.4
	Four and above	51.0	43.4	33.7	18.6	20.4	24.8	37.2	34.3	31.5
Mother's Age	**Less than 20**	43.5	40.7	30.9	20.1	19.4	26.3	38.4	34.3	32.2
	20-24	42.9	36.7	30.8	15.7	17.5	27.9	32.2	28.5	32.2
	25-29	40.5	34.0	30.1	14.9	16.2	26.0	29.4	26.7	30.5
	30-34	42.1	34.3	30.6	15.1	15.1	24.9	28.5	25.9	30.4
	More than 35	46.1	36.3	32.8	15.4	18.4	25.7	31.0	28.5	31.9
Residence	**Urban**	35.8	31.5	30.3	14.7	14.9	26.6	27.4	22.7	31.4
	Rural	45.3	38.7	30.9	16.3	18.3	26.2	33.3	31.6	31.1

Regions	**North**	49.4	37.9	31.0	11.0	31.2	26.1	29.8	31.2	30.2
	East	46.3	39.3	32.1	16.9	18.5	31.2	42.2	34.1	36.9
	Northeast	39.8	33.6	35.9	12.0	15.7	19.6	22.3	23.9	28.6
	West	40.3	38.4	29.3	21.2	16.5	33.2	38.2	30.6	37.3
	South	39.5	34.1	28.1	18.7	17.7	26.7	32.7	27.0	29.9
Total		42.3	35.7	30.7	15.8	16.9	26.4	31.4	27.9	31.2

Maternal education is also an important determinant of child nutrition. The role of mother's education on child nutrition has been well established in many studies [9,10]. Children of the more educated mothers are less prone to stunting, which can be seen in results of first two surveys, where half of the children (53 percent in 1998-99 and 48 percent in 2005-06) of not educated mothers were stunted. On the other hand, among the children of highly educated mothers prevalence of stunting was 24 percent in 1998-99 and 17 percent in 2005-06. Variation among different categories of maternal education has been reduced drastically in the 4th round of DLHS and the prevalence of stunted children was around 30 percent for all the maternal education categories. Further, birth order is strongly associated with stunting, children belong to higher birth order are more likely to suffer from stunting [11]. In NFHS-2 (1998-99) more than half of the children of birth order four and above (51 percent) were stunted. However, during the last one and half decades, the maximum reduction has also been witnessed among them (17 % points).

An urban-rural differential was noticed in each of the three cross-sectional surveys but the magnitude of differences has been narrowing over the period indicating considerable improvements among rural children. This may be due to better awareness among rural folk in addition to improvements in child feeding practices and dietary diversity among mothers in rural areas. The pattern of decline in stunting is not uniform across different regions in India. The northern region showing a maximum decline in the prevalence of stunting among children below age three (from 49 % to 31%) followed by the eastern region with the improvement of 14 percent points. The western region of the country shows a minimal improvement in the prevalence of stunting (4% points), which has been the lowest among the five regions.

In thecase of variation in the prevalence of wasting over the last one and half decades, a reverse pattern has been observed, which is expected primarily due to the implicit relationship between stunting and wastings, as explained in the earlier. Male children under age 3 are more prone to wasting as compared to the female and the scenario is almost same in all the surveys. Prevalence of wasting among the children in all caste groups has increased over the period. Children of the younger mothers are found more wasted compared to older, in 1998-99. In 2012-13, 26 percent of children with mothers' age less than 20 years are suffering from wasting, which is 20 percent in 1998-99. In the western and southern regions, 21 and 19 percent of children were suffering from wasting respectively for the period 1998-99. In 2012-13, the level of wasting has increased in all the regions and the prevalence is the highest in the western region (33 %) followed by the eastern region with 31 percent of wasted children.

Underweight among children presents a mix effect of stunting and wasting. NFHS-2 and NFHS-3 show a noteworthy gap in the prevalence of underweight between the categories of different socioeconomic and demographic factors. On the other hand, the fourth round of DLHS illustrates that difference between categories of various socioeconomic and demographic factors has been reduced. Over the period, the prevalence of underweight has increased from 24 percent to 31 percent among children aged less than one year. Among children belong to scheduled tribes the prevalence has increased from 26 percent to 30 percent. Amongst all the regions, North Eastern region has experienced a substantial increase (from 22 to 29 %) in the prevalence of underweight over time.

Factors having the potential to change the recourse of any social and behavioral process are vital for designing and implementing an effective intervention with high efficacy in outcome indicators. Therefore, adjusted effects of different predictors are important to plan suitable interventions. Determinants of childhood stunting, wasting and underweight have been given in Table 3.a, 3.b and 3.c respectively. It is evident from Table 3.a that increasing age of child increases the likelihood of stunting in India over the period. Children belong to the rural area are more likely to be stunted in NFHS-1 however, there is no urban-rural gap has been seen in stunting in NFHS-2 and DLHS 4th round. The odds of stunting among children are higher among children belongs to 'others' religion (OR=1.2 (1.0-1.5) , $p<.05$ and 0.10) in the 2nd and 3rd round of NFHS conducted in 1998-99 and 2005-06 respectively, but values of these odds decrease as per the results of DLHS-4 conducted in 2012-13 (OR=1.0 (0.9-1.1). The increase in mother's education is found to have a negative relationship with the likelihood of stunting in the year 1998-99 and this relationship also persist in 2005-06 but do not show any consistent pattern in the year 2012-13. This may be mainly due to the fact that educated mother may be better aware of the rearing of their children and the nutritional requirements of their children in comparison to less educated mothers, But various programmes and interventions to address malnutrition in the recent years might have impacted positively in the awareness and practices of even less educated mothers and hence the gap in the prevalence of stunting by mother's education have been eliminated in DLHS-4.

Table.3.a: Results of Logistic Regression (odds ratio and confidence interval) Showing Determinants of Stunting among Children under age three years in India, 1998-2012

Background characteristics		1998-99			2005-06			2012-13		
		Exp(B)	95 C.I. for EXP(B)		Exp(B)	95 C.I. for EXP(B)		Exp(B)	95 C.I. for EXP(B)	
			Lower	Upper		Lower	Upper		Lower	Upper
Age of children (in years)	Less than one®									
	One to two	4.32***	3.90	4.79	3.67***	3.27	4.13	1.03	0.98	1.08
	Two toThree	1.33***	1.21	1.46	1.14***	1.04	1.26	1.04*	0.99	1.10
Residence	Urban®									
	Rural	1.15***	1.05	1.26	0.99	0.90	1.09	1.01	0.96	1.05
Religion	Hindu®									
	Muslim	0.94	0.80	1.10	0.99	0.83	1.19	1.01	0.94	1.08
	Christian	0.84*	0.69	1.02	0.97	0.78	1.20	1.28	1.19	1.38
	Others	1.22**	1.01	1.49	1.22*	0.99	1.51	1.01	0.94	1.08
Caste	SC®									
	ST	0.76**	0.67	0.85	0.74***	0.65	0.846	1.01	0.94	1.08
	OBC	0.85*	0.73	1.00	0.86*	0.73	1.01	0.95*	0.90	1.01
	Others	1.04	0.94	1.15	0.90*	0.81	1.01	1.06*	1.00	1.13
Mother's Education	No Education®									
	Primary	0.47***	0.39	0.55	0.47***	0.38	0.58	1.02	0.96	1.08
	Secondary	0.55***	0.46	0.66	0.55***	0.44	0.69	0.99	0.93	1.05
	Higher	0.72***	0.62	0.84	0.66***	0.55	0.81	1.04	0.92	1.18
Sex	Male®									
	Female	0.86***	0.80	0.93	0.85***	0.78	0.93	0.91***	0.87	0.95
Birth Order	First®									
	Second	1.57***	1.36	1.83	1.52***	1.29	1.79	1.01	0.96	1.06
	Third	1.30***	1.13	1.49	1.24***	1.07	1.45	1.04	0.97	1.11
	Four and above	1.18**	1.02	1.35	1.12	0.96	1.31	1.11**	1.02	1.20
Age of Mother	Less than 20®									
	20-24	0.63***	0.50	0.80	0.50***	0.38	0.64	0.97	0.86	1.09
	25-29	0.74***	0.61	0.90	0.69***	0.57	0.84	0.94	0.83	1.06
	30-34	0.95	0.79	1.14	0.84**	0.70	1.00	0.91	0.80	1.04
	More than 35	0.96	0.79	1.17	0.86	0.72	1.05	0.96	0.84	1.11
Wealth Quintile	Poorest®									
	Poor	0.59***	0.51	0.69	0.44***	0.37	0.52	0.98	0.92	1.05
	Middle	0.64***	0.55	0.74	0.50***	0.42	0.59	0.98	0.92	1.04
	Rich	0.69***	0.60	0.79	0.62***	0.53	0.72	0.94*	0.87	1.00
	Richest	0.75***	0.65	0.85	0.68***	0.59	0.79	0.98	0.91	1.06

® Reference categories, Level of Significant -***P<0.01, **P<0.05 and *P<0.10.

Table. 3.b: Results of Logistic Regression (odds ratio and confidence interval) Showing Determinants of Wasting among Children under age three years in India, 1998-2012.

Background characteristics		1998-99			2005-06			2012-13		
		Exp(B)	95 C.I. for EXP(B)		Exp(B)	95 C.I. for EXP(B)		Exp(B)	95 C.I. for EXP(B)	
			Lower	Upper		Lower	Upper		Lower	Upper
Age of children (in years)	Less than one ®									
	One to two	1.23***	1.09	1.38	1.59***	1.40	1.80	0.96	0.91	1.02
	Two to Three	1.77***	1.56	2.02	1.99***	1.74	2.27	0.99	0.94	1.05
Residence	Urban®									
	Rural	1.08	0.96	1.22	0.98	0.87	1.10	1.01	0.96	1.06
Religion	Hindu®									
	Muslim	0.92	0.79	1.09	1.02	0.86	1.21	1.00	0.92	1.08
	Christian	1.37***	1.11	1.69	1.53***	1.26	1.86	0.89***	0.82	0.97
	Others	1.70***	1.34	2.15	1.43***	1.13	1.82	0.82***	0.76	0.88
Caste	SC®									
	ST	1.15	0.93	1.42	1.08	0.88	1.33	0.93*	0.86	1.00
	OBC	1.1	0.94	1.28	1.03	0.88	1.21	0.94*	0.89	1.00
	Others	1.29***	1.11	1.50	1.21**	1.03	1.42	1.05	0.98	1.12
Mother's Education	No Education®									
	Primary	1.03	0.89	1.18	1.12	0.95	1.32	1.06*	1.00	1.13
	Secondary	1.20***	1.05	1.38	1.31***	1.14	1.51	1.01	0.94	1.08
	Higher	1.28**	1.02	1.61	1.45***	1.12	1.89	1.14*	1.00	1.3
Sex	Male®									
	Female	1.15***	1.04	1.27	1.12**	1.01	1.25	0.98	0.94	1.02
Birth Order	First®									
	Second	0.86**	0.75	0.98	0.92	0.80	1.06	0.99	0.94	1.04
	Third	0.79***	0.66	0.93	0.83**	0.70	0.98	0.99	0.92	1.06
	Four and above	0.72***	0.59	0.87	0.82*	0.67	1.00	1.05	0.96	1.15
Age of Mother	Less than 20®									
	20-24	1.24**	1.04	1.47	0.99	0.79	1.23	1.02	0.89	1.17
	25-29	1.32***	1.08	1.61	1.01	0.79	1.28	0.95	0.83	1.09
	30-34	1.35**	1.06	1.72	1.05	0.80	1.38	0.94	0.82	1.09
	More than 35	1.35**	1.01	1.82	0.91	0.67	1.24	1.00	0.86	1.17
Wealth Quintile	Poorest®									
	Poor	1.1	0.94	1.29	1.24**	1.05	1.47	0.98	0.91	1.05
	Middle	1.24***	1.06	1.46	1.43***	1.19	1.71	0.98	0.91	1.05
	Rich	1.32***	1.12	1.55	1.43***	1.18	1.73	0.93*	0.86	1.00
	Richest	1.58***	1.29	1.93	1.89***	1.51	2.36	0.94	0.87	1.02

® Reference categories, Level of Significant -***P<0.01, **P<0.05 and *P<0.10.

Table. 3.c: Results of Logistic Regression (odds ratio and confidence interval) Showing Determinants of Underweight among Children under age three years in India, 1998-2012

Background characteristics		1998-99			2005-06			2012-13		
		Exp(B)	95 C.I. for EXP(B)		Exp(B)	95 C.I. for EXP(B)		Exp(B)	95 C.I. for EXP(B)	
			Lower	Upper		Lower	Upper		Lower	Upper
Age of children (in years)	Less than one®									
	One to two	2.03***	1.83	2.26	1.84***	1.64	2.07	0.96	0.91	1.02
	Two to Three	1.24***	1.12	1.37	1.13**	1.02	1.25	0.99	0.94	1.05
Place of Residence	Urban®									
	Rural	0.95	0.86	1.04	1.17***	1.06	1.29	1.01	0.96	1.06
Religion	Hindu®									
	Muslim	0.62***	0.52	0.74	0.66***	0.54	0.8	1.00	0.92	1.08
	Christian	0.56***	0.46	0.7	0.62***	0.49	0.79	0.89***	0.82	0.97
	Others	1.27**	1.02	1.58	1.32**	1.05	1.67	0.82***	0.76	0.88
Caste	SC®									
	ST	0.74***	0.66	0.84	0.68***	0.6	0.78	0.93*	0.86	1.00
	OBC	0.92	0.78	1.09	0.76***	0.64	0.91	0.94*	0.89	1.00
	Others	0.91*	0.82	1.01	0.90*	0.80	1.01	1.05	0.98	1.12
Mother's Education	No Education®									
	Primary	0.44***	0.36	0.53	0.46***	0.36	0.58	1.06*	1.00	1.13
	Secondary	0.51***	0.42	0.62	0.51***	0.40	0.65	1.01	0.94	1.08
	Higher	0.73***	0.61	0.87	0.67***	0.54	0.83	1.14*	1.00	1.30
Sex	Male®									
	Female	0.85***	0.78	0.92	0.91**	0.83	0.99	0.98	0.94	1.02
Birth Order	First®									
	Second	1.52***	1.3	1.78	1.28***	1.08	1.52	0.99	0.94	1.04
	Third	1.26***	1.09	1.45	1.15*	0.99	1.35	0.99	0.92	1.06
	Four and above	1.00	0.86	1.15	1.08	0.92	1.26	1.05	0.96	1.15
Age of Mother	Less than 20®									
	20-24	0.57***	0.44	0.72	0.73**	0.56	0.94	1.02	0.89	1.17
	25-29	0.76***	0.62	0.93	0.96	0.78	1.17	0.95	0.83	1.09
	30-34	0.95	0.78	1.15	1.01	0.84	1.22	0.94	0.82	1.09
	More than 35	1.03	0.84	1.27	1.05	0.86	1.29	1.00	0.86	1.17
Wealth Quintile	Poorest®									
	Poor	0.48***	0.41	0.57	0.47***	0.39	0.57	0.98	0.91	1.05
	Middle	0.54***	0.46	0.63	0.49***	0.41	0.58	0.98	0.91	1.05
	Rich	0.71***	0.61	0.83	0.59***	0.51	0.70	0.93*	0.86	1.00
	Richest	0.68***	0.59	0.79	0.68***	0.59	0.80	0.94	0.87	1.02

® Reference categories, Level of Significant -***P<0.01, **P<0.05 and *P<0.10.

The female children are significantly less likely than the male children to be stunted, and this relationship continues to hold true across all the three cross-sectional surveys conducted in the last one and half decades. Moreover, increasing birth order, the age of mother and wealth status portrays a declining odds of stunting among children below age three in the cross-sectional surveys conducted in 1998-99 as well as in 2005-06, but this relationship does not show any significant association in the survey year 2012-13. The reducing gap in the prevalence of stunting may be attributed to the ongoing poverty elevation programme in the country, which might have enriched the dietary diversity of women, especially when they were pregnant. Further, government interventions in ensuring maternal health programs reaching to poor and vertical interventions in the child feeding practices might be responsible to reduce the reach poor gap in the prevalence of stunting among children below age three.

Logistic regression odds ratios for various predictors included in the model and associated with the wasting among children under age three across different rounds of cross-sectional surveys are presented in Table 3b. It is evident from the table that increasing age of child significantly increases the likelihood of wasting among children under three in the cross-sectional surveys conducted in 1998-99 as well as in 2005-06, but this is not true for the year 2012-13. The study also found the significant association between religion and wasting among children. This may be mainly due to the same reasons which have been explained in the case of reducing gaps in stunting over a period of time. The study reveals that children belong to Christian and 'others' religions are more likely to be wasted in the year 1998-99 and 2005-06 but less likely to be wasted in 2012-13. Children belong to 'others' caste are also more likely to be wasted in the year 1998-99 (OR=1.3 (1.1-1.5), p <0.01) and 2005-06 (OR=1.2 (1.0-1.4), p<0.05). Another important finding is that increasing mother's year of schooling increases the likelihood of wasting in all survey year included in this study.

Further, gender differences in the transition in malnutrition among children below age three show that the female children were more exposed for wasting in the year 1998-99 and 2005-06 than the male child. However, in 2012-13 there is no such type of variation has been seen in wasting and sex of the child. Furthermore, higher birth order decreases the likelihood of wasting among children. Mother's age is significantly and positively associated with wasting in the year 1998-99 but not in the year 2005-06 and 2012-13. Similarly, household economic status is also positively and significantly associated with wasting in 1st and 2nd round of NFHS but not in the 4th round of DLHS.

As mentioned earlier, underweight is the combined effect of stunting and wasting portraying the situation of weight- for-age. Logistic regression odds ratios presented in Table 3c reveal that children in age group 1-2 are more likely to be underweight as compared to other categories of their age groups. But the value of the odds of underweight among children below age three was the highest in NFHS-2 in 1998-99 (OR=2.0 (1.8-2.3), p<0.01), which declined in NFHS-3 conducted in 2005-06 (OR=1.8 (1.6-2.1), p<0.01). Subsequently, evidence from DLHS-4 conducted in 2012-13 does not show significant variation in the prevalence of underweight by age of children below age three. This may be primarily due to increasing efficacy in controlling early childhood morbidities like Diarrhea, ARI, etc. Odds of underweight by urban-rural place of residence, which may be a proxy of quality of life of people as well as their access and utilization of health facilities portrays under three children living in rural area are significantly more likely than their urban counterparts to suffer from underweight (OR=1.2 (1.1-1.3), p<0.01) in 2005-06 (NFHS-3). However, in the most recent cross-sectional survey conducted in 2012-13 (DLHS-4), the urban –rural differential has been completely eliminated. Adjusted effects of increasing mother's education reduce the likelihood of malnutrition in 1998-99 and 2005-06, but the pattern is not uniform in 2012-13. Mother's education is very important determinants of underweight of children below age three, which shows a significant impact during all the surveys and hence an important marker of the existing transition in childhood malnutrition in the country. Female children are relatively less likely to be underweight than their male counterparts in all thecross-sectional surveys, which may be rooted in biological and genetic factors as being claimed by a number of studies across developed and developing countries [12,13,14].

These findings reveal two important issues relating to the existing transition in malnutrition among under three children in India. First, a higher level of wasting with continuously improving levels of stunting and reducing differentials by various background characteristics over a period of time, which has almost been vanishing in the most recent cross-sectional survey DLHS-4 in 2012-13. Relatively increasing prevalence of wasting might have been resulted due to continuously declining Infant and under-five mortalities in India [15]. It is worth mentioning that children who are getting cured from early childhood morbidity and able to survive but may not enjoy very good nutrition and health for quite some time and hence resulting into increasing prevalence of wasting. In addition, when there is an improvement in the prevalence of stunting, there is a relative improvement of skeletal of children by their age but there are no corresponding improvements in their weight, which is directly a function of their dietary intake.

Socio-economic inequality in childhood malnutrition in different regions of India

It is worth mentioning that the transition in childhood malnutrition is not uniform across different regions of the country. Even within the region, there is a clustering in certain socio-economic strata. Therefore, this section deals with inequality in childhood malnutrition in different regions of the country by computing Concentration Index (CI). The negative values of CI indicate that the concentration of stunted, wasted, and underweight children are higher in lower wealth quintile, however, the positive value of CI shows that the concentration of stunted, wasted and underweight children is higher in higher wealth quintile. Table 4 demonstrates the degree of socioeconomic. Inequality in stunting, wasting, and underweight among children under age three in different regions of India.

Transition in socioeconomic inequality in stunting reveals a profound shift from higher concentration among poor in 1998-99 to relatively uniform distribution in 2012-13 (Table 4). This may be primarily due to targeted interventions across the country focusing on the BPL families. However, the percentage of stunting appears to be uneven across different regions in the country. The maximum shift in CI (from -0.200 to -0.009) has been observed in the case of theeastern region comprising of West Bengal followed by the western region (-0.154 to -0.013); whereas the northeastern part of the country shows a very slight change (-0.104 to -0.009). thesouthern region shows lowest inequity in Stunting (-.006) during 2012-13, on the other hand, the socio-economic inequality is the highest (-0.013) in the western region comprising of mainly Maharashtra for the same period.

Table 4: Concentration index showing economic inequality in malnutrition among Children across different regions of India, 1998-2012.

	Stunting			Wasting			Underweight		
Regions	**1998-99**	**2005-06**	**2012-13**	**1998-99**	**2005-06**	**2012-13**	**1998-99**	**2005-06**	**2012-13**
North	-0.097	-0.162	0.005	-0.117	-0.131	0.010	-0.142	-0.158	0.001
East	-0.200	-0.175	-0.009	-0.105	-0.105	0.002	-0.179	-0.199	0.004
North East	-0.104	-0.146	-0.009	-0.128	-0.153	-0.012	-0.161	-0.183	-0.024
West	-0.154	-0.169	-0.013	-0.168	-0.132	-0.020	-0.183	-0.187	-0.016
South	-0.109	-0.155	-0.006	-0.078	-0.106	-0.007	-0.139	-0.202	-0.004

Over the period, the highest change in wasting is experienced by the western region (-0.168 to -0.020) followed by the northern region (-0.117 to -0.01) and the pace of progress is very slow in thesouthern region (-0.078 to -0.007). For the period 2012-13, the maximum inequality in wasting has been seen in the western (-0.020) and northeastern (-0.012) regions. Results of CIs for underweight demonstrate that the maximum inequality in underweightexists in the eastern region (-0.179 to 0.004) followed by the southern region (-0.139 to -0.004). The northern (-0.142 to 0.001) and the northeastern (-0.161 to -0.024) part of the country reveal relatively lower progress in reducing inequality in thedistribution of underweight. However, themost recentcross-sectional survey conducted ion 2012-13 shows thehighest concentrationof inequalitiesin the underweight children (-0.024) in thenortheastern region. Thus, an effective decline in inequality in stunting, wasting, and underweight has been observed in all the regions because of interventional programs run by the government butin the northeastern region disproportionately higher value of inequality is concentrated among poor.

Discussion and Conclusions

The pattern of variation in stunting across different states of India evidently presents two contrasting pattern across EAG and non-EAG states. The findings indicate high childhood malnutrition in EAG states, having arelatively larger proportion of households below thepoverty line and also having aslower pace of improvements in maternal as well as child health indicators. The level of stunting among children under age 5 is substantially higher (51 to 62 percent) in four major EAG states namely Bihar, Jharkhand, Madhya Pradesh and Uttar Pradesh Table 1. Furthermore, it is evident from the results of themultivariate analysis that children belong to the poorest and poor strata are more prone to experience stunting, wasting and underweight, which signifies that poverty is a strong determinant of malnutrition. These findings justify the argument that macroeconomic growth is a major, and often the only, policy instrument for improving health and nutrition in developing countries [16,17].

Over the period of 1998-2016, India has experienced faster growth in Gross Domestic Product (GDP). GDP in the country has grown by more than 7 percent on average over the period, which is higher than the world average growth rate of 3.4 percent over the same time span (Figure 1). This positive trend represents a huge opportunity to improve the living standards of millions of Indians, living below the poverty line and to promote inclusive and sustainable development. However, the pattern of microeconomicdevelopment is not uniform across regions/states and hence improvement in GDP (Figure 2) has not beentranslated into significant progress in nutrition. As in most of the states particularly in EAG states the level of malnutrition is high and has not declined over the period (Table 1), which may result into higher levels of infant and child mortality in the near future.

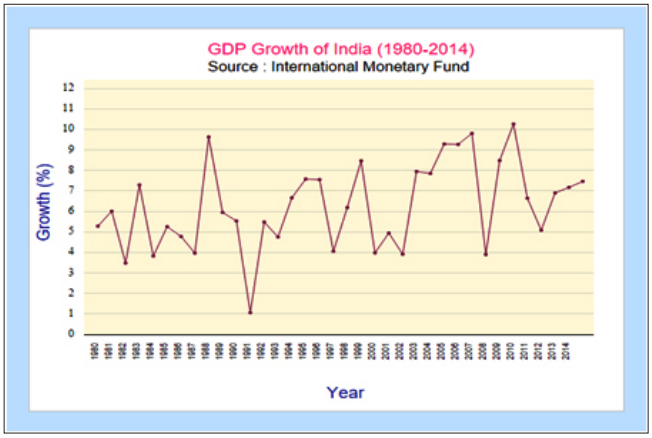

Figure 1: Growth in GDP of India during 1980-2014.

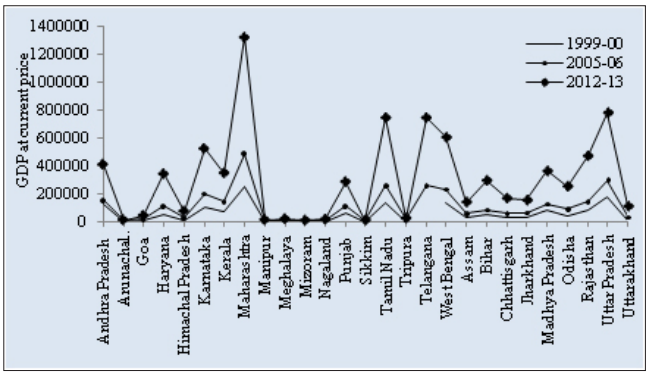

Figure 2 : Variation in GDP across different states (Source: indiastat.com).

It is worth mentioning that nutrition is related to improved infant, child and maternal health, stronger immune system to fight diseases, safer pregnancy and childbirth, lower risk of non-communicable diseases (such as diabetes, stroke and cardiovascular disease) and longevity. Nutritional status of newborn and also children is strongly associated with the mother's nutrition as the health status of a newborn is most important for its growth. Energy deficiency among mothers adversely affects the nutritional status of children, which, in turn, affects their educational attainment, human capital, morbidity and labor productivity. It is expected that women with more than 3 antenatal care visits (ANC) should take 100 or more IFA tablets or anequal dose of syrup which is essential for both the mother and children. However, Figure 3 explains thesignificant gap between 3 or more ANC visits and consumption of 100 or more IFA tablets among mothers in differentIndian states. A substantial gap is observed in all the EAG states and also in the states like Andhra Pradesh, Karnataka, Maharashtra Punjab and West Bengal.

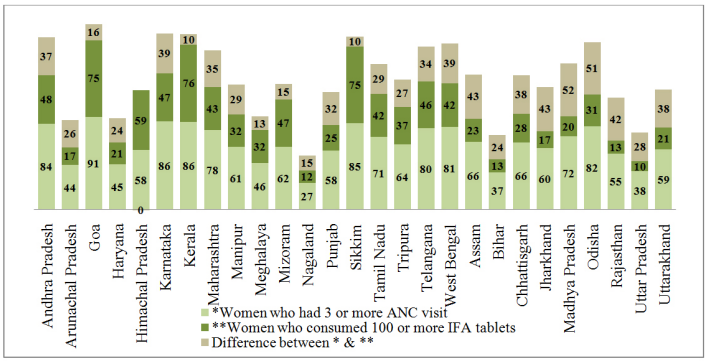

Figure 3: Gaps in percent of women who have three or more ANC and consumed 100+ IFA during the most recent pregnancy in the last five years in different states of India, 2012-13.

Another priority issue as potential strategy to minimize the missed opportunity to address childhood malnutrition may be ensuringcolostrums feeding and exclusive breastfeeding.Exclusive breastfeeding has been well-recognized as an important public health tool for the primary prevention of childhood morbidity and mortality. Exclusive breastfeeding is protective against serious morbidities in the first six months of life. A study in Bangladesh has shown that exclusive breastfeeding affects the nutritional status of the child from 0 to 24 months of age. [18]. It is presumed that in institutional births newborns are immediately breastfed within one hour of birth. Figure 4 depicts the difference between institutional deliveries and children under 3 years breastfed within one hour of birth. The difference is substantial in the states like Punjab (50%) Goa (49%), Telangana (40%) Andhra Pradesh(34%), Tripura (30%)and Tamil Nadu (29%). As children receive 3 doses of DPT vaccination before completion of six months of their age, it is assumed that they should be exclusively breastfed up to six months. Figure 5 shows that the gap between DPT vaccination and exclusively breastfeeding exists in all the states, though the gap is significant in EAG states.

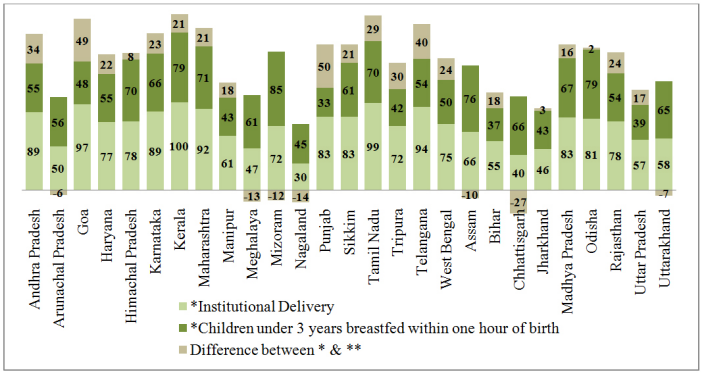

Figure4: Gaps in percent of women who have Institutional delivery and colostrumsfeeding in the most recent birth in the last five years in different states of India, 2012-13.

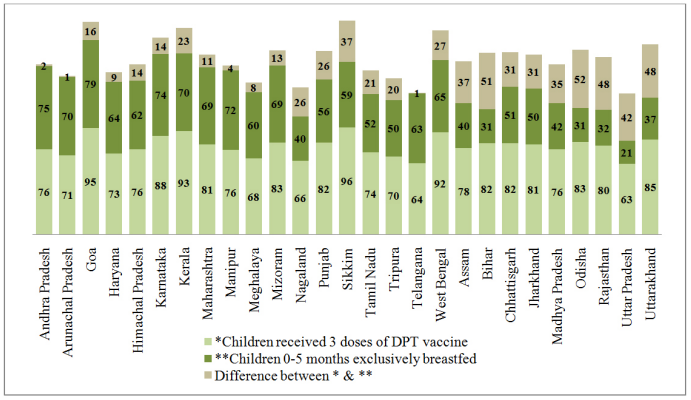

Figure 5: Gaps in percent of children age 12-23 months who received three doses of DPT and exclusive breastfeeding in different states of India, 2012-13.

Results of logistic regression analysis showthat the childhood undernutrition is positively linked with the age of children. Children ages one to two years are more likely to suffer from stunting in comparison toless than one year oldchild (4.3 times in 1998-99 and 3.7 times in 2005-06). These findings are similar to the findings of other studies conducted in a heterogeneous environment in Kenya, Brazil and Ethiopia [19-21].

The study also indicates that male children are more prone to stunting and wasting compared to female children in all the surveys. The same findings are presented in hospital-based studiescompleted in Sudan and a study from democratic republic of congo [13,14].In the study stunting and underweight among children is showing a significantdecreaseinincreasing level of mother's education. In a study for Cameroon, Gwatkin et al. in 2000 found that children of educated mothers are less likely to suffer from malnutrition. However, during the fourth round of DLHS education of mother is not showing significant association with stunting and underweight. Desai and Alva in a study of 22 countries, found that only in five countries, Education of the mother is showing significant impact on stunning. In the results, stunting and underweight are showing a positive correlation between maternal education and wasting is a negative correlation. In a study of Bolivia in 2005, Forst and other schoolers found that maternal characteristics more affect the stunting than wasting.

Higher birth orders children are more prone to stunting and underweight in second and third surveys of NFHS, whereas it was negatively correlated with wasting. The impact of the birth order is not showing any significant correlation with any form of malnutrition apart from stunting where four and higher birth order children are more likely to less height for their age. In a study of Philipines in 1998, Horten found that birth order strongly associated with stunting and less affects wasting. The same results are also observed in studies of other developing countries, that birth order is one of the important predictors of child malnutrition [22,23,24]. Many schoolers tried to establish that how the birth order of children affects their nutritional status. With an increasing number of children in the family, spent on higher birth order children reduced compared to low birth order [25].

Children belong to higher wealth quintile are less likely to suffer from stunting and underweight but wasting is showing an inverse relation with wealth quintile. However, there is no uniform pattern

is visible between these two indicators and wealth quintile; but the results shows that higher wealth quintile children are in better position compare to poorest wealth quintile children. In many studies, Economic status found an important factor which affects stunting among children [12,21,26]. In another study, Sakka & Osman established a link between household wealth status and nutritional status by linking those two with improved dietary diversity and food availability. In which they found that children belong to the higher socio-economic household are more likely to get diverse food and easy food access, which positively affect their nutritional status [27].

The concentration index shows inequality across different wealth quintiles. Distribution of stunted and underweight children is generally higher in lower wealth quintiles during first two rounds of surveys which approaching to equal distribution [28-34]. Findings of concentration index analysis show that impact of socio-economic status does not much affect wasting than stunting and underweight. The results of this study aresimilar to studies done by Ellen Van de Poelet. al., Wagstaff and Watanable two different studies of developing countries. Results of concentration index are also showing that inequality in nutritional status is reducing over the period of time but still, in many regions, inequality in all the form of malnutrition is higher among lower wealth quintile than children of upper wealthquintile [35-38].

Results of inequality analysis showthat the Eastern and Western region shows a maximum decline in the unequal distribution of stunting. Whereas, the Northeastern and the Southern region experienced lowest progressing in reducing inequality [39-41]. Highest reduction in inequality of wasting has been experienced by the Western region followed by the Northern region. The Sothern region shows the least inequality and maximum inequality in wasting found in the children of the western region. Whereas, the Eastern and Southern region show great improvement in inequality of underweight. The North and the Northeastern part of the country shows the lowest progress in reducing inequality in the distribution of underweight [42].

Recommendation

Major issues emerged during the analysis of the results and its discussions recommend the following important strategies to address childhood malnutrition in India:

1. Despite a number of programmes and interventions in the recent years, childhood malnutrition continues to be very high in EAG states, especially in two most populous states in the country namely Uttar Pradesh and Bihar. These two states are also known to contribute asignificantly larger share of under five mortality in India. Therefore, thefocus should be given on maternal nutrition and child feeding practices by identifying potential opportunities for their interaction with health care providers.
2. The implicit relationship between thevariation of stunting and wasting among children below age 3 indicates that improvements in health interventions are able to protect lives of many children suffering with childhood morbidities, but not able to ensure their good health. Therefore, effort should be made to enhance theefficacy of child health programmes with a continuumin services ensuring exclusive breastfeeding, supplementary feeding and growth monitoring.
3. Over the period, inequality in childhood malnutrition has been reducing across different wealth quintiles, which is primarily due to strong poverty elevation and various government interventions enabling even poor to improve upon nutritional status of women and children. However, Western and North Eastern regions of the country are still lagging in reducing the inequality and there is higher concentration of childhood malnutrition among poor. Therefore, some innovative approaches should be adopted to address childhood malnutrition.

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