Determinants of the socioeconomics and spatial pattern of malnutrition in India: A Geoaddative Semi-parametric regression approach

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Background:

Childhood malnutrition is amongst the most serious health issues facing developing countries more specifically India. It is an intrinsic indicator of well being, but it is also associated with morbidity, mortality, impaired childhood development, and reduced labor productivity (Sen, 1999; UNICEF, 1998; Pelletier, 1998; Fahrmeir & Khatab, 2008). The nutritional status of children is usually quantified in terms of anthropometrical measures like weight-for-age, height-for-age or weight-for-height. In adults, nutritional status is commonly expressed as the body mass index (BMI). Malnutrition in children is the consequences of a range of factors often related to insufficient food intake, poor quality of food, severe and repeated bouts of infections and poor nutritional child practices such as delayed breastfeeding in spite of goof food supplementation (Rao *et al.*, 2004; Bawdekar & Ladusingh, 2008). The underlying responsible factors are household food insecurity, inadequate preventive and curative health services and insufficient knowledge of proper care (Measham & Chatterjee, 1999). Poor maternal and demographic situations, poor socioeconomics conditions, poor feeding and immunization practices and regional differentials are the most important factors associated with the high prevalence of sever and moderate stunting among preschool children in various regions of Bangladesh (Rahman & Chowdhary, 2007).

Reduction of child malnutrition is one of the prime challenges that India faces. The burden of malnourished children in India is among the highest in the world and virtually twice that of Sub-Saharan African countries. India's Integrated Child Development Services (ICDS) needs to undergo significant changes to address the current malnutrition crisis in the country (World Bank Report, 2009). The prevalence of underweight children in India is among the highest in the world, and is nearly double that of Sub-Saharan Africa. It also observed that malnutrition in India is a concentrated phenomenon. A relatively small number of states, districts, and villages accounted for a large share of the burden of malnutrition. The consequences of child malnutrition on morbidity and mortality are enormous and there is, in addition, an appropriate impact of undernutrition on productivity so that a failure to invest in combating nutrition reduces potential economic growth. In India, with one of the highest percentage of undernourished children in the world, the situation is dire. Moreover, inequalities in undernutrition between demographic, socioeconomic and geographical groups increased during the 1990s. More, and better, investments are needed if India is to reach the nutrition MDGs.

Exhibiting a sluggish declining trend over the past decade, the recent estimate from National Family Health Survey (NFHS-3) indicates that about 42.5 percent of children under-five years of age are underweight, 19.5 percent are wasted and 48 percent of children are stunted. The decline in prevalence however becomes unimpressive with the average levels marked by wide inequality in childhood malnutrition across states and various socioeconomics groups (Rajaram *et al.*, 2007; Pathak, 2009; Bawdekar & Ladusingh, 2008; Pathak & Singh, 2011; Kanjilal *et al.*, 2010). Growing evidence suggests that in India, the gap in prevalence of underweight children among the rich and the poor households is increasing over the years with wide regional differential (Pathak, 2009). Data shows that undernutrition remains the leading problem of India, but it is most pronounced in the states of Bihar, Uttar Pradesh, Madhya Pradesh and Rajasthan. In these states, more than half of the children are underweight and stunted. Nearly 50 percent children in Orissa, Maharashtra and West Bengal are underweight, while 50 percent in Assam and Haryana are stunted. States with lowest percentage of underweight or stunted children are Goa, Kerala and all the small north-eastern states except Tripura and Meghalaya (Arnold *et al.*, 2004; Mishra, Roy & Retherford, 2004; Nair, 2007; Pathak & Singh, 2011).

The majority of the studies on child malnutrition status have described prevalence of malnutrition among under-five children and analysed socioeconomic, demographic and culture factors associated with it in India (Rao *et al.*, 2004; Nair, 2007; Bawdekar & Ladusingh, 2008). Though Pathak & Singh (2011) attempted to analyze the economic inequality in malnutrition in India and in the various geographical regions, they did not analyze the nutritional aspects in detail. Moreover, other studies have considered and modelled the effects of continuous covariates assuming parametric forms. Such approach of assuming linear predictors has been considered to be too restrictive in realistic complex situation (Adebayo et al, 2013). The best approach is to allow these covariates to be modelled nonparametrically as doing otherwise would lead to high number of parameters which may lead to unstable estimates with high variance. Therefore, we find that there is a dearth of study that examines socioeconomics and spatial pattern at a highly disaggregated level of state, of malnutrition in India. Our study aims to investigate the impact of geographical location as a proxy of distal factors and their influence on nutritional status with flexible geoaddative models. These models allow us to analyze us to analyze usual linear effects of covariates, nonlinear effects of continuous covariates and state regional effect within a unified, semi-parametric Bayesian framework for modelling and inference. Also, there are two possible reasons behind using this methodology; first, for the continuous covariates in the data set, assumption of strictly linear effects on the response variable may not be appropriate. In our study, such covariates were child's age, mother's age at birth and mother's body mass index. Generally, it will be difficult to model the possible nonlinear effects of such covariates through a parametric functional form, which has to be linear in the parameters, prior to any data analysis. Second in addition to usual covariates, geographical information are given in the location variable s, indicating the region, state where the individual or units in the sample size live or come from. Attempt to include such area information using state specific dummy variables would entailed equal to number of states dummy variables and we could not assess spatial inter-dependence. The problem cannot be resolved through conventional multilevel modelling using uncorrelated random effects (Goldstein, 1999). It was reasonable to assume that area close to each other were more similar than areas far apart, so that spatially correlated random effects were required. This will enable us to determine to what extent the substantial spatial pattern of undernutrition will be driven by demographic and socioeconomic, community factors and contextual factors.

Data and Methods:

The present study utilizes data from the third round of National Family Health Survey (NFHS), which was conducted_in 2005-06. The survey was designed to provide estimates on various aspects of demographic behaviour, including fertility, mortality, family planning, HIV related knowledge and on important aspects of nutrition, health and health care. It was done in collaboration with the International Institute for Population Sciences (IIPS), Mumbai, India, ORC Macro, Calverton, Maryland, USA, and the East-west Center, Honolulu, Hawaii, USA. IIPS coordinated these surveys and collaborated with number of Field Organizations for survey implementation. The survey covers a representative sample of about 124, 385 ever-married women in the age group 15-49, who were captured in the two phase from the 29 states of India. The survey adopted two-stage sampling design in rural areas and three-stage sampling design in urban areas. In rural areas, the villages were selected at the first stage using probability proportion to size (PPS) sampling scheme. The required numbers of households were selected at the second stage using systematic sampling. In urban areas, block were selected at first stage, census enumeration blocks (CEB) containing approximately 150-200 households were selected at the second stage, and the required number of household were selected at the third stage using systematic sampling technique.

Nutritional Status: To examine the determinant of the socioeconomics and spatial pattern of malnutrition in India, the present study will consider stunting, wasting and underweight as indicators for child malnutrition.

Stunting: Stunting is an indicator of linear growth retardation relatively uncommon in the first few months of life. However, it becomes more common as children get older. Children with *height-for-age* scores below minus two standard deviations (z-score <-2SD) from the median of the reference population are considered short for their age or stunted.

Wasting: Wasting indicates body mass in relation to body length. Children whose *weight-for height* z-scores are below minus two standard deviations (z-score <-2SD) from the median of the reference population are considered wasted (i.e. too thin for their height) which implies that they are acutely undernourished otherwise they are not wasted.

Underweight: Underweight is a composite index of stunting and wasting. This means children may be underweight if they are either stunted or wasted, or both. In a similar manner children may be underweight, when their z-score is lower than two standard deviations.

Metrical Covariates: Child age in month, mother's education in single year and mother's age at first birth

Spatial Covariates: State where respondent resides.

Categorical covariates: Table 1 provides information on categorical bio-demographic and socioeconomics covariates, their category, frequency and numbers used in the study.

Methods

Consider the following regression model with geoaddative predictors

$$\eta_j^{geo} = \beta_{oj} + x_j^{'}\beta_j + f_1^j(z_1) + \dots\dots\dots + f_k^j(z_k) + f_{geo}^j(s_i)$$

were x_j and β_j are vectors of categorical covariates in effect coding and the corresponding parameters, functions $f_1^j \dots\dots f_k^j$ represents nonlinear effects of continuous covariates $z_1 \dots z_k$, and the function f_{geo}^j represents the geographic effects of spatial variable $s = \{1 \dots 29\}$, indicating states in a country. The spatial effects may be further split into spatially correlated (structured) and uncorrelated (unstructured) effects as:

$$f_{geo}^j(s_i) = f_{str}(s_i) + f_{unstr}(s_i)$$

The rationale behind this is that a spatial effect is a surrogate of many unobserved influential factors, some of which may have strong spatial structures and others only present locally.

Within a Bayesian context, all parameters and function (say *f* for non-linear effects) are considered as random variables upon which appropriate priors are assumed. Independent diffuse priors are assumed on the parameters of fixed effects. For the non-linear effects, a Bayesian P-Spline prior based on Lang & Brezger (2004) and Brezger and Land (2006) were assumed. The P-spline allows for non-parametric estimates of *f* as a linear combination of the basis function (B-spline):

$$p(z)=\sum_{j=1}^{j}\beta_j B_j(z)$$

where $B_j(z)$ are B-splines basis functions and the coefficient β_j correspond to the vector of unknown regression coefficients. Smoothness of function *f* is achieved by penalizing difference of coefficient of adjacent B-splines (Eilers & Marx, 1996) or in Bayesian approach, as in this case, where β_j values are further define to follow first-or second order Gaussian random walk smoothness priors:

$$\beta_1=\beta_{j-1}+u_1 \qquad\qquad \beta_1=2\beta_{j-1}-\beta_{j-2}+u_1,$$

With *i.i.d*. (independent and identically distributed) errors $u_1 \sim N(0,\tau^2)$. The variance τ^2 controls the smoothness of *f*. Assigning a weekly informative inverse gamma prior ($\tau^2 \sim IG(\varepsilon,\varepsilon)$) with ε very small, it is estimated jointly with the basis function coefficients. For further clarification and explanation of the concept, see Eilers & Marx (1996), Lang & Brezger (2004) and Brezger & Lang (2006).

For the geographical effects $f_{geo}^{j}(s_i)$, s= 1…29, a Gaussian Markov random field prior is assumed. Basically, this is an extension of first-order random walk priors to two-dimensional spatial array (Rue & Held, 2005). For the structural spatial effects $f_{str}(s)$ a Gaussian markov random field prior was chosen, which is common in spatial statistics (Besag *et al.*, 1991). Unstructured spatial effects are i.i.d. random effects:

$$(f_{str}(s) \mid f_{str}(t); t \neq s, \tau^2) \sim N(\sum_{t \in \partial_s} f_{str}(t)/N_s, \tau^2/N_s)$$

Where N_s is the number of adjacent sites and $t\varepsilon\partial_s$ denotes that site t is a neighbour of sites s. Again, τ^2 controls the amount of spatial smoothness. In order to be able to estimate the smoothing parameters for non-linear and spatial effects simultaneously, highly dispersed but prior hyper-priors are assigned to them. Hence for all the variance components, an inverse gamma distribution with hyper parameters a=1 and b=0.005 or a=b=0.001 is a common choice. In the present application, sensitivity of the results with the choice of prior was investigated by changing the parameters *a* and *b*. The results turn out to be less sensitive to the various choices. The results reported here are those of a=b=0.001. Also, mixing and convergence of the samples were monitored through plotting of sampling path and estimation of autocorrelations.

Fully Bayesian inference is based on the analysis of posterior distribution of the model parameters. In general, the posterior is analytically intractable, which makes it almost impossible for direct inference. Markov Chain Monte Carlo (MCMC) are therefore used to generate samples from the prior distribution which allow estimation and inference for all parameters to be made. Detail information about this modelling approach for models with geoaddative predictors has been implemented in BayesX, software for Bayesian analysis using MCMC and Restricted Maximum Likelihood technique. For more information on the software see Belitz *et al.*, (2009). All analyses were performed with BayesX software.

Results

Table 1 shows the percentage distribution of children during the last five year preceding the survey by background characteristics. Of the 38,714 under-five children that participated in the survey, almost one-fourth lived in urban area. Among the children, 52 percent are male and majority of the children are in the 2-3 birth order. The proportion of those not receiving Vitamin A is approximately 58 percent while 69 percent were still being breastfed. One-tenth of the children (10 percent) were suffering from diarrhoea, 15 percent from fever and 6 percent from Acute Respiratory Infection (ARI). About 30 percent of the children had their mothers working at the time of the survey and almost one-fourth are in poorest wealth quintiles. Majority of the children (80 percent) belong to Hindu religion and 42 percent were from other backward class (OBC) caste.

Table 1: Percentage distribution of categorical variables included in the study. Data refer last five years preceding the NFHS-3 (2005-06) survey in India

Background Characteristics		**Percentage**	**Number**
Place of residence			
	Urban	25.1	14448
	Rural	74.9	24266
Child Sex			

	Male	52.2	20079
	Female	47.8	18635
Birth Order			
	1	29.8	12275
	2-3	44.2	17395
	4+	26.0	9044
Vitamin A			
	No	57.7	21599
	Yes	42.3	17115
Breastfeeding			
	No	31.2	13220
	Yes	68.8	25494
Diarrhoea			
	No	90.6	35042
	Yes	9.4	3672
Fever			
	No	84.8	32870
	Yes	15.2	5844
ARI			
	No	94.1	36639
	Yes	5.9	2075
Working Status of Mother			
	No	70.5	27430
	Yes	29.5	11284
Wealth Index			
	Poorest	24.9	6848
	Poorer	22.0	6997
	Middle	20.2	6970
	Richer	18.6	8686
	Richest	14.5	8213
Religion			
	Hindu	80.4	27694
	Muslim	15.1	5650
	Other	4.5	5370
Caste			
	Schedule caste	21.2	7166
	Schedule tribe	9.5	6275
	OBC	42.1	13329
	General	27.2	11944

Table 2 displays the estimated posterior means and 95% credible intervals of categorical variables on stunting, wasting and underweight. Findings show that compared with children from urban areas, those from rural areas were less stunted and underweight but more wasted but this was only significant for stunting. Female children were significantly less stunted and wasted but more underweight compared with male children. Those given vitamin A were significantly less stunting and underweight but more wasting. Like findings from previous studies, children of second birth order and above were significantly more stunting, wasted and underweight compared with those of first order. Children who had diarrhoea in the two weeks preceding the survey were also more stunting, wasted and underweight compared with those without the illness and this was significant. Results show that those who had fever were more stunting, wasting and underweight but only significant for wasting. Results for children who had acute respiratory infection were not significant. Children who were being breastfed at the time of the survey were more stunting, wasting and underweight compared with those not being breastfed and this was significant for stunting and underweight. The same finding was obtained for working mothers. Compared with children from the poorest household, findings show that those from households in the other wealth quintile were less stunting, wasting and underweight and these were all significant. Similarly, compared with children from the schedule caste those in the schedule tribe, OBC and general were less stunting, underweight but underweight for schedule tribe is not significant. None of the estimate of wasting for the three caste is significant. Whereas children whose parents belonged to Muslim and other religious group were more stunting when compared with those in Hindu, it was only significant for the Muslim. However, these children were significantly less wasting. In the case of underweight, while children other religious group were significantly less underweight, Muslim children were more underweight but this is not significant.

Figure 1, 2 and 3 show the nonlinear effects of child's age, education of mothers in single year and mother's age at first birth through Bayesian P-splines (Lang & Brezger, 2004) for stunting, wasting and underweight respectively. Shown are the posterior means and 95% credible. The results shows that nonlinear relationship exists between child's age and the nutritional status considered thereby justifying the inclusion as nonlinear effect. Findings show that between ages 0 and 20 months, the rate at which the children were stunting increases as they grow older. After this age, a sinusoidal relationship was evident. Similar pattern was observed for underweight children but the scenario was reversed in the case of wasting children. Results show that the rate at which children were wasting reduces as they grow older. The effect of years spent in school by mothers when single on stunting shows that stunting decreased with every unit increase in years spent in school. Similar patterns were observed for wasting and underweight. Findings on mother's age at birth show those children of women who gave birth around age 28 years were less stunting and underweight than those of any other age. As for wasting, the effect of mother's age is approximately constant.

Figures 4, 5 and 6 give the state specific net spatial effects of stunting, wasting and underweight. The left panels of the figures show the residual spatial effects while the right panel indicates the map of credible intervals used in assessing the significance of the residual spatial effect. From the maps of credible intervals, the level of stunting, wasting and underweight among children from states with black (white) colour were significantly higher (lower) while it was not significant those shaded in gray. The results show stunting was significantly higher among children from Uttar Pradesh, Uttaranchal and Gujarat while, it was significantly lower for those from Tamil Nadu, Arunachal Pradesh and Manipur and Nagaland. Findings on wasting show that it was significantly higher among children from Madhya Pradesh and lower in North-Eastern region excluding Tripura and Meghalaya. Underweight was significantly high in the states of Maharashtra, Gujarat, Uttar Pradesh, Madhya Pradesh Uttaranchal, Meghalaya, Haryana, Bihar, Jharkhand and Himachal Pradesh whereas it was significantly lower in the states of Manipur, Arunachal Pradesh, Mizoram, Sikkim and West Bengal.

Table 2: Results of fixed effects parameters showing posterior mean on stunted, wasted and underweight children NFHS-3 (2005-06), India

	Stunting		Wasting		Underweight	
Background Characteristics	Posterior mean	Credible interval	Posterior mean	Credible interval	Posterior mean	Credible interval
Place of residence						
Urban	0		0		0	
Rural	0.041	[0.002, 0.077]	-0.026	[-0.059, 0.007]	0.004	[-0.023, 0.033]
Child Sex						
Male	0		0		0	
Female	0.046	[0.017, 0.076]	0.028	[0.003, 0.053]	-0.015	[-0.038, 0.008]
Birth Order						
1	0		0		0	
2-3	-0.076	[-0.112, -0.040]	-0.036	[-0.067, -0.005]	-0.070	[-0.098, -0.043]
4+	-0.095	[-0.138, -0.048]	-0.054	[-0.094, -0.054]	-0.095	[-0.130, -0.060]
Vitamin A						
No	0		0		0	
Yes	0.068	[0.033, 0.101]	-0.014	[-0.043, 0.017]	0.034	[0.009, 0.060]
Breastfeeding						
No	0		0		0	
Yes	-0.251	[-0.288, -0.216]	-0.016	[-0.049, 0.014]	-0.157	[-0.184, -0.130]
Diarrhoea						
No	0		0		0	
Yes	-0.084	[-0.138, -0.031]	-0.080	[-0.123, -0.037]	-0.099	[-0.139, -0.056]
Fever						
No	0		0		0	
Yes	-0.010	[-0.055, 0.036]	-0.172	[-0.211, -0.134]	-0.125	[-0.159, -0.092]
ARI						
No	0.000		0		0	
Yes	0.017	[-0.055, 0.089]	0.032	[-0.031, 0.091]	0.031	[-0.023, 0.086]
Working Status of Mother						
No	0		0		0	
Yes	-0.045	[-0.081, -0.009]	-0.010	[-0.039, 0.020]	-0.031	[-0.058, -0.005]
Wealth Index						
Poorest	0		0		0	
Poorer	0.161	[0.111, 0.214]	0.063	[0.021, 0.109]	0.137	[0.098, 0.175]
Middle	0.260	[0.204, 0.317]	0.125	[0.080, 0.171]	0.241	[0.201, 0.282]
Richer	0.430	[0.368, 0.491]	0.179	[0.130, 0.230]	0.382	[0.339, 0.426]
Richest	0.735	[0.660, 0.808]	0.280	[0.222, 0.343]	0.630	[0.576, 0.683]
Religion						
Hindu	0		0		0	
Muslim	-0.104	[-0.149, -0.057]	0.039	[0.002, 0.080]	-0.034	[-0.069, 0.003]
Other	-0.015	[-0.079, 0.051]	0.180	[0.123, 0.234]	0.119	[0.068, 0.118]
Caste						
Schedule caste	0		0		0	

Schedule tribe	0.084	[0.022, 0.146]	-0.028	[-0.081, 0.027]	0.029	[-0.021, 0.076]
OBC	0.079	[0.034, 0.121]	0.023	[-0.017, 0.064]	0.064	[0.028, 0.100]
General	0.190	[0.142, 0.238]	0.027	[-0.013, 0.069]	0.130	[0.095, 0.168]

Note: (R)-reference category

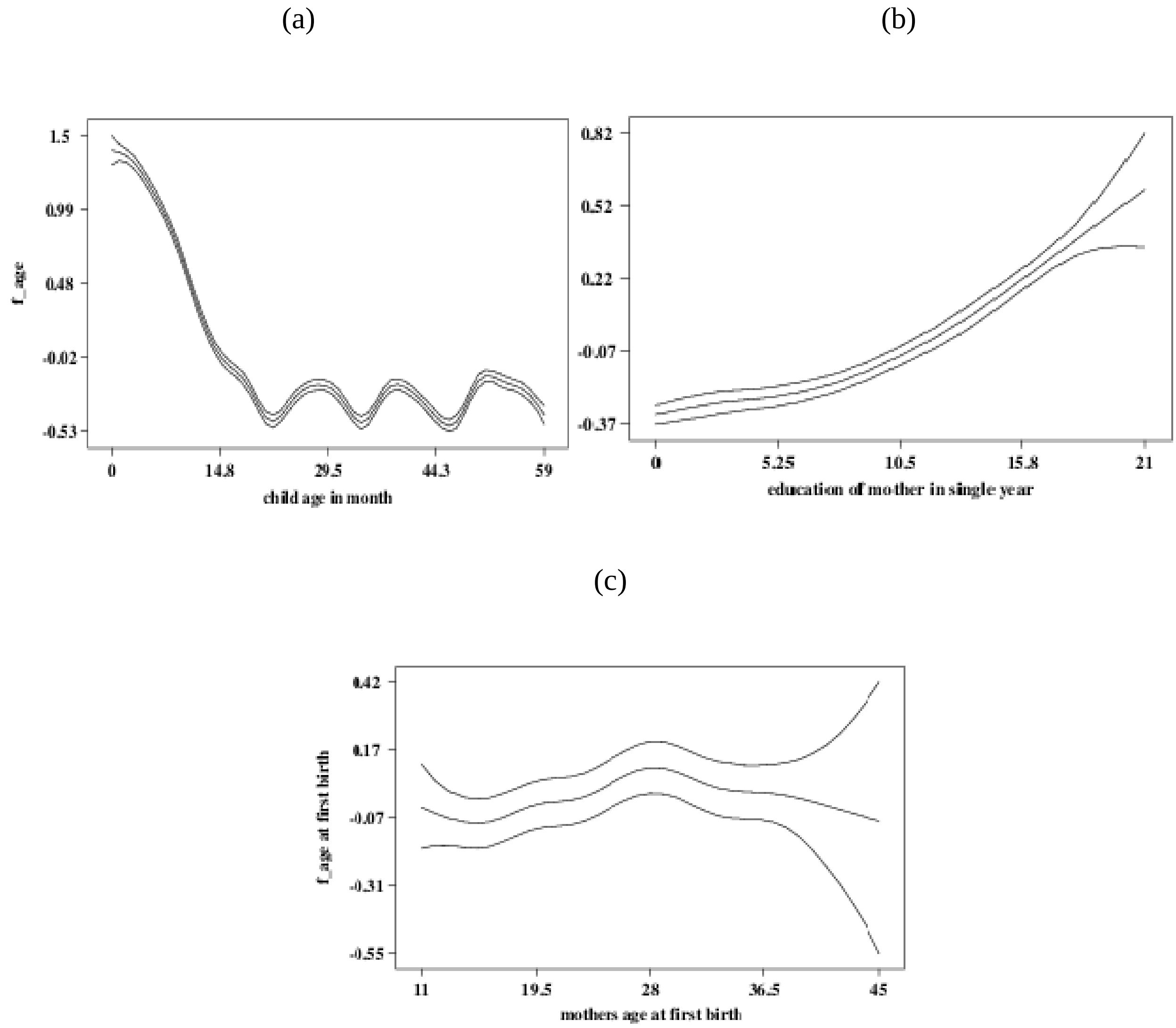
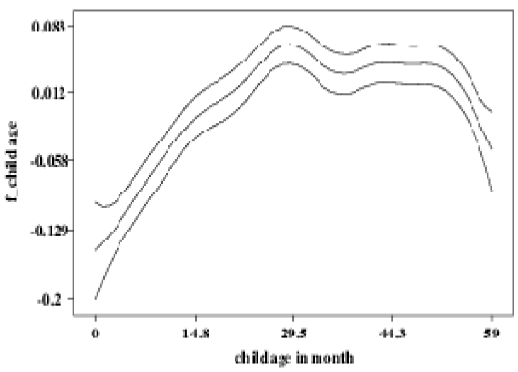
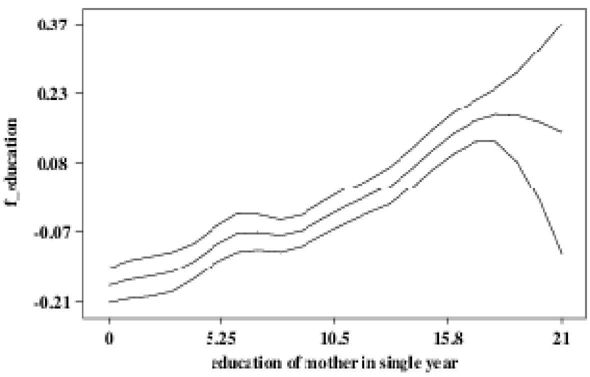


Figure 1: Posterior means of the non-linear effects in stunting for (a)child's age in month, (b) mother's education and (c) mother's age at first birth for Gaussian semi-parametric model.

(a) (b)





(c)

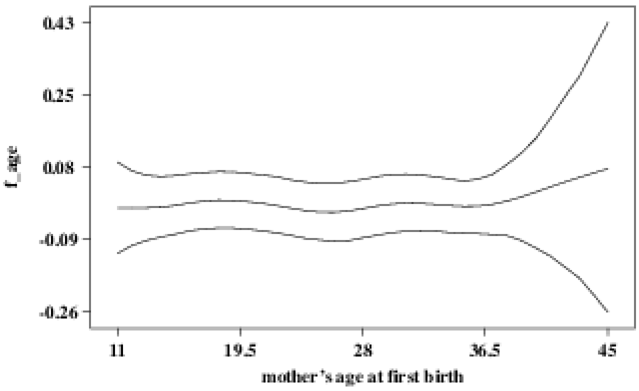
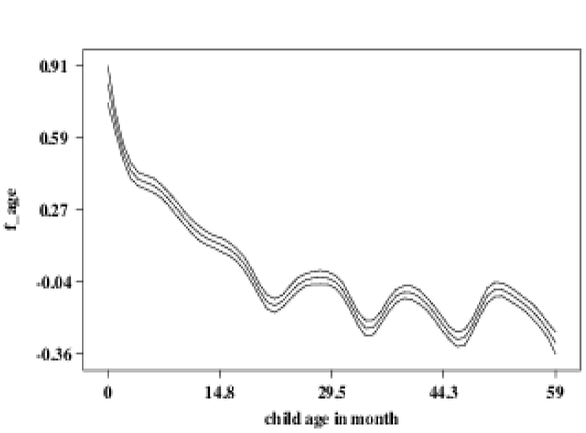
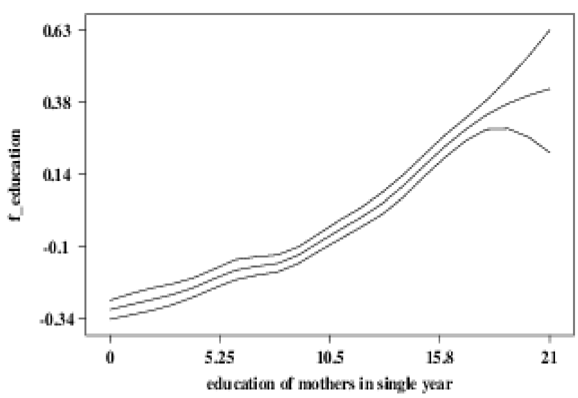


Figure 2: Posterior means of the non-linear effects in wasting for (a) child's age in month, (b) mother's education and (c) mother's age at first birth for Gaussian semi-parametric model.

(a) (b)





(c)

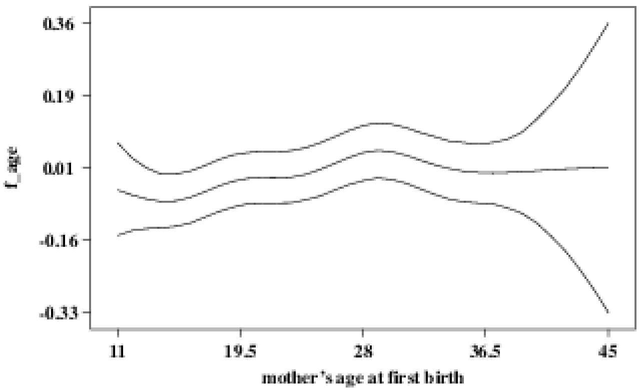


Figure 3: Posterior means of the non-linear effects in underweight for (a) child's age in month, (b) mother's education and (c) mother's age at first birth for Gaussian semi-parametric model.

(a) (b)

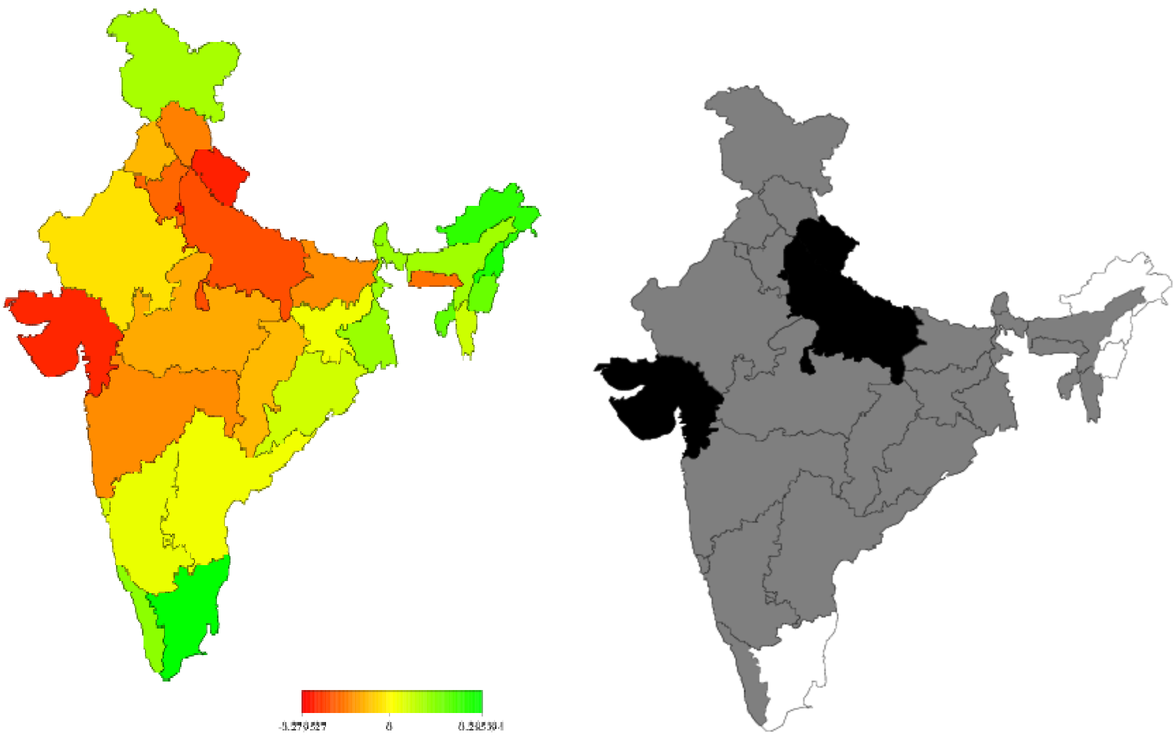


Figure 4: Map of India for Stunting (a) Total residual spatial effect and (b) its corresponding 95 % posterior probabilities

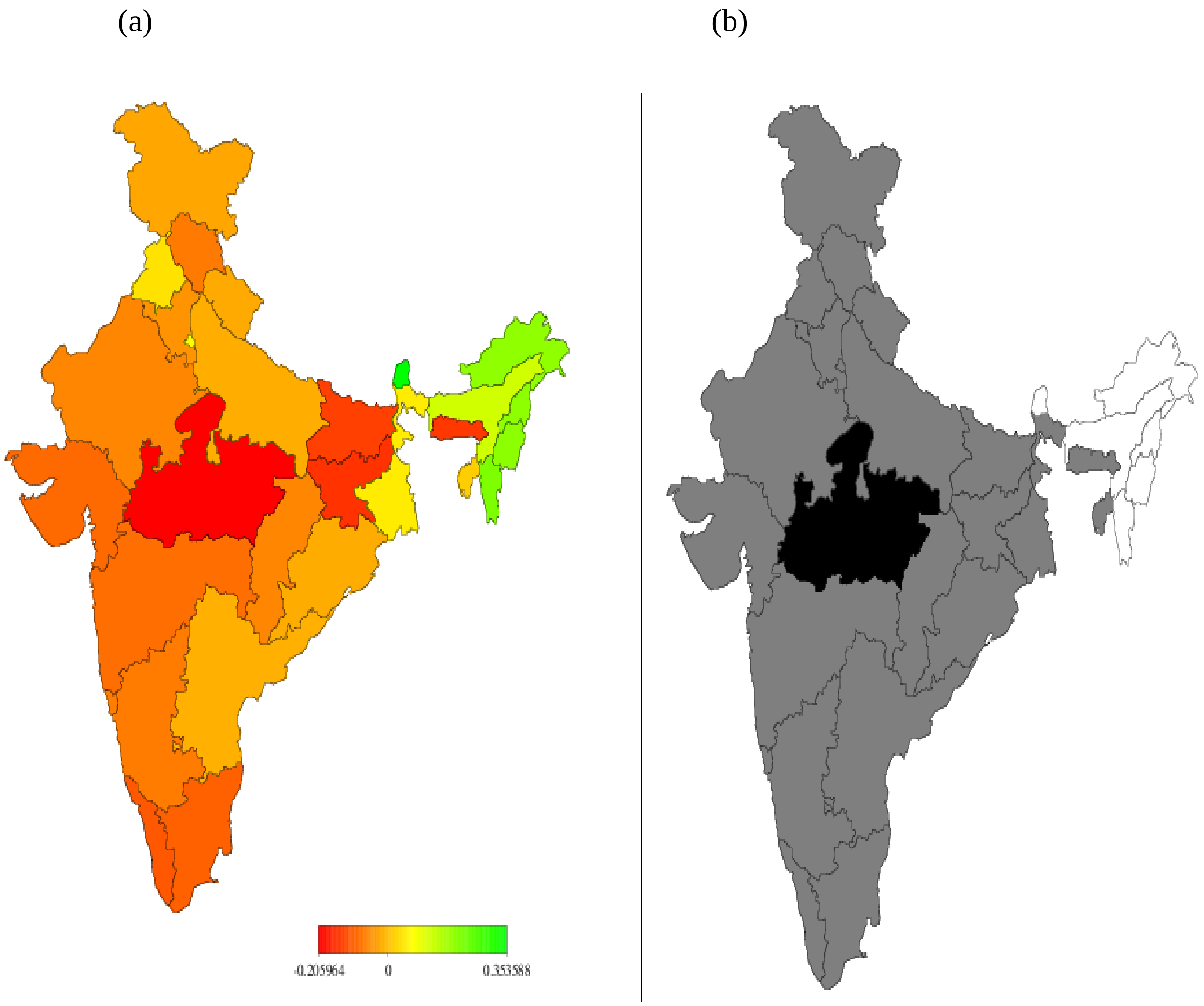


Figure 5: Map of India for Wasting (a) Total residual spatial effect and (b) its corresponding 95 % posterior probabilities

(a) (b)

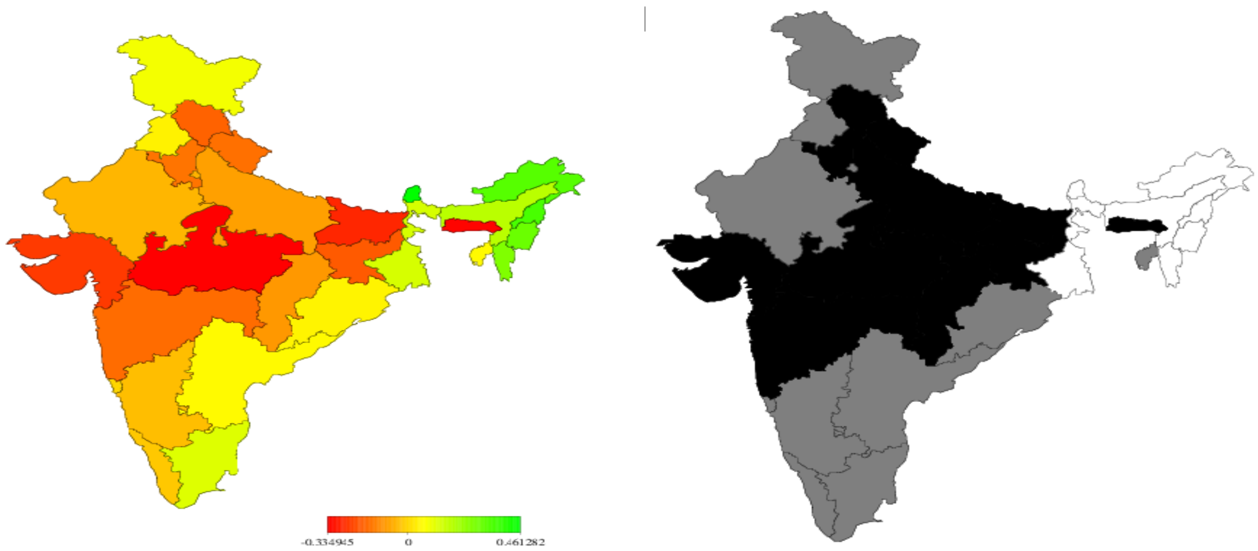


Figure 6: Map of India for Underweight (a) Total residual spatial effect and (b) its corresponding 95 % posterior probabilities

Discussion and Conclusion: This study addresses the status of malnutrition in children under age five in India using stunting (height-for-age), wasting (weight-for-height) and underweight (weight-for-age) as malnutrition indices. The study adopts an approach that allows covariates of different types to be simultaneously considered. Though inadequate nutrition is a problem throughout India, findings from this study has shown that the situation is considerably better in some states than in others. The result based on our analysis indicate that mostly states in the central, eastern and some states of northern region are more likely to be associated with nutritional problem. The major finding of the study is that malnutrition rates remain very in central, northern and eastern region in India. One possible explanation may be found in the nutritional behaviour of the population that do not give certain types of food to children on cultural grounds even though the food is nutritious. These regional disparities may reflect the contribution of other factors such as sociocultural condition and morbidity of children in determining the nutritional status of children under the age of five.

Results on socioeconomic and demographic variables are consistent with previous studies which discuss the relation between various demographic and socioeconomic characteristics on nutritional status. With reference to other variables, male children seem to be more exposed to the risk of stunting and wasting than female children. There is no obvious explanation for this gender differences but in

Asia, for instance, gender's differences has been attributed to boy's preferences over girls (Klasen, 2008). Education of mothers and mother's age at first birth were found to exert positive influence on child nutritional status. In fact, education could make a difference by empowering mother's decision on type of nutrition and /or use of preventive medicine. Similar results have been found in Cameroon (Pongou *et al*., 2006) and in other developing countries (Smith & Haddad, 1999). The results support the suggestion that an educated mother assumes the responsibility of taking a sick child to receive health care. Further the time that mother spend discussing their child's illness with a doctor is almost directly proportional to their education level. These finding are consistent with many studies in the context of maternal education has a strong and significant effect on malnutrition (Borooah, 2002). Working status of mother has negative and significant effect on the malnutrition status (stunting and underweight) of children in India. Working women may not have sufficient time to take care of their children. They often engage unskilled housemaids to care for their children and this often results in malnutrition. Some studies documented that when mother's are working, the household income is increased and hence the access to better to better food will be increased, as well as the access to quality level of medical care. Khatab & Fahrmeir (2009) mentioned that when mothers are working, it curtails the duration of breastfeeding and necessities supplementary feeding which might affect the health of children negatively.

The risk of wasting is higher in rural areas, among children from less educated mothers and living in poorer household after controlling for other variables (Pongou *et al*., 2006). In richer households, children are often well fed, cared for and provided with safe and stimulating environment, through which they are more likely to survive, to have fewer disease and illness and to fully develop thinking, language, emotional and social skills (UNICEF, 2007). Hence the gradient of household socioeconomics characteristics remains crucial determinant of level of nutritional achievements among children. Betterment of such condition thus is expected to improve growth of children likely through better nutritional intake and reduce morbidity.

Underweight becomes prominent as children grow older. The need to implement school feeding program to compliment the food provided by parents can therefore be justified. The needed institution of this program must be set up. This study reveals that attainment of education among women has significant reduction in malnutrition indicators. There is therefore the need to strengthen education institutions in the country in order to be able to cater for education of girls, especially those of rural areas. It was found that children suffering from diseases like diarrhoea, fever and ARI have significantly increasing stunting, wasting and underweight among children. The need therefore arises to strength the health institution in India, in order to be able to cope with financial needs of vaccinating children and pregnant women free of charge. Appropriate institutional arrangements for taking these services to the rural areas must also consider. Children who had suffering from diarrhoea, fever and acute respiratory infection in two week preceding the survey were also likely to have poor nutritional status. Undernutrition and child morbidity have synergetic relationship, the interrelationship of the two is in such as way that on one hand, nutritional deficiencies increase the susceptibility of the child to infectious disease such as diarrhoea, fever and acute respiratory infection, and on the other hand, illness can suppress a child's appetite leading to undernutrition (Pelletier et al., 1993; Scrimshaw & SanGiovanni, 1997).

It might appear that increase in women's age at the time of first birth, adoption of early breast feeding practices and improved awareness among women about factors affecting health, all of which appear to reduce the extent of child malnourishment, are outside the realm of possibility in India in near future (Nair, 2007). There are various prevention and treatment strategies to prevent 60 % of deaths in children which include vaccination, oral rehydration therapy, effective antibiotics and prompt treatment as such illnesses as malaria (Jones et al., 2003). These intervention, however, have to be applied in an integrated approach in order to optimise the children's health status. Since the World Health Organization indicates undernutrition as the main underlying factor for up to half of all deaths of children under-five years of age, therefore, there is need to reduce poverty and hunger. To reduce malnutrition, improving food security is important. These outcomes bear important policy implication and represent a further step towards gaining an improved understanding of the complex determinant of child malnutrition.

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