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Cluster Approach to Understand Malnutrition in Urban India: A Disaggregated Analysis across the States

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ABSTRACT

This paper is an attempt to understand nutrition insecurity and vulnerability in urban India from a cluster approach. Two cluster analyses have been carried out based on nutrition status as well as vulnerability parameters. This helps in actual classification of states while facilitating an understanding into the underlying dynamics. The findings reveal that states with better employment indicators do not necessarily group as clusters with better nutrition outcomes. Instead, few states of India fare better in nutrition outcome despite relatively high unemployment. Two strings that emerge to explain this gap between income and nutrition outcomes are women's status and public intervention..

Main text

1.1 Introduction

Ten years down the line since the research gap on urban food insecurity and malnutrition was identified (see Haddad et al, 1999), the issue remains somewhat under-researched. This is so in a situation when absolute number of underweight children in urban areas is increasing and at a faster rate than the numbers in rural areas (Ruel et al., 1998; Ruel and Garrett, 2004; Garrett, 2004). While childhood malnutrition has typically been a relatively less severe in urban areas, the accelerated rates of urbanization currently observed in the developing world raises new concerns towards urban malnutrition (Smith et al., 2005). At the same time, our understanding of the dynamics of urban food insecurity and malnutrition is incomplete (Ruel and Garrett, 2004; FAO, 2006). Given the trend of rising urbanization in developing countries, urban food security needs to be placed high in the agenda (FAO, 2006). The dynamics behind entitlement failure, coping mechanism and role of gender are few aspects that deserve extensive study. This paper appreciates this fact and attempts to analyze nutrition insecurity in urban India using a cluster approach. This is a macro analysis and proposes to make three salient contributions to the area studied – firstly, it identifies zones in the country on the basis of nutrition security and vulnerability to it. Unlike other country level studies (see MSSRF, 2003; Menon et al, 2008) that have excluded the north-eastern states of India, this study incorporates this region in the analysis. Secondly, this is a cluster approach which unlike the index approach allows for a disaggregation in analysis. Therefore, while identifying the nutrition secure and insecure zones in urban India, we are able to look at underlying dynamics of nutrition insecurity itself. Thirdly, the paper underscores the significant role of gender vis-à-vis food and nutrition security and attempts to integrate the same in the analysis. The paper develops on the premises that income and non-income well-beings do not necessarily coincide. One of the main objectives of this paper is to comprehend whether relatively better off states (in terms of income/employment) also group as nutritionally secure ones and what are the likely factors that result into a particular clustering.

1.2 Framework for Cluster Analysis

Quantitative evidences on urban food/nutrition security are scarce though efforts are on to analyze the issue in different regional context (Ruel and Garrett, 2004).

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Existing works find that determinants of rural and urban nutrition security differ and that levels of those determinants are favorable in urban areas (Smith et al., 2005). In urban areas, dependence on cash becomes prominent, as majority of food is purchased. In major metropolitan cities, 90% of the food is purchased (Ruel and Garrett, 2004). Consequently, purchasing power and employment becomes crucial in urban areas (Arzenti, 2000). Female education is an important determinant of child health and nutrition (Behrman and Skoufias, 2004; Warwadekar, 2005; Block, 2007; Ajieroh, 2009). Maternal education which could be higher in urban areas has profound beneficial effects on a whole array of child care practices, as well as on the care of women themselves, (Burchi, 2008). Due to crucial reproductive link, maternal health and nutrition remain as important factors behind child health and nutrition in urban areas (Milan et al, 2002; Smith, 2005). In fact, maternal health irrespective of rural-urban area is a crucial link to child health and nutrition (see Buckley, 2003; Aldarman et al., 2004; Behrman and Skoufias, 2004)

Thus employment, maternal education and maternal health are the three pillars of urban nutrition security though there are several other factors that would affect the same e.g. household demography, urban agriculture, environment, rural-urban linkages and so on. In present paper we focus on the abovementioned three fundamental factors as determinants of nutrition in urban areas of India. To capture the dynamics properly two cluster analyses have been done – one based on outcome variable and the other based on risk or vulnerability variables. This would classify the states on the basis of actual mal/nutrition status as well as on the basis of vulnerability to malnutrition.

Table 1 gives the list of variables included in the analyses. Given the significance of cash and mother's education, the rates of unemployment and female illiteracy would indicate vulnerability to malnutrition. Percentage of children left out of complete immunization indicates vulnerability to malnutrition (since frequent sickness eats up child's nutrition) as well as to infant mortality. Cluster analysis based on vulnerability indicators would create clusters on the basis of vulnerability to nutrition insecurity. Along

Table 1: variables included in the two cluster analyses

Outcome indicators	Vulnerability/Risk indicators
Incidence of malnutrition among children in urban areas across states in India	Average rate of unemployment i.e. number of the unemployed per 1000 of workforce
Percentage of married women having low BMI	Percentage of the illiterate among adult female population
The infant mortality rate (IMR) i.e. ratio of the number of deaths among children under one year old during a given year to the number of live births during the same year	Percentage of under five children left out of the coverage of complete immunization net

similar lines, cluster analysis on outcome indicator would create clusters on the basis of actual status of nutrition in/security. The analysis would also generate a nutrition insecurity and vulnerability map for urban India.

1.3 Methodology: Data and Cluster Techniques

The cluster analysis classifies the (urban parts of) 28 states on the parameters of actual malnutrition status as well as vulnerability to it. Data for this purpose has been obtained from 61st round of National Sample Survey (2004-05) and third round of National Family Health Survey (2005-06). NSS data covers a range of socio-economic factors while the NFHS data primarily focuses on reproductive health, family planning, child nutrition, maternal and child health and the utilization of health services by women and their children.

The technique of cluster analysis is hierarchical agglomerative using Ward's method since in comparison to other algorithms, Ward's algorithm has been proved to generate good results (see Leschke, 2005).

To decide on the valid number of clusters with least amount of subjectivity, we use Calinski & Harbasz's pseudo F statistic and Duda & Hart Je (2)/Je (1) indices along with the dendogram as these two have been found to be two top performing cluster stopping rules (see Fielding, 2007; Fukuoka et al, 2007).

1.4 RESULTS AND DISCUSSION

As mentioned earlier, we have done two separate cluster analyses for urban areas across the states in India - one on outcome indicators and the other using vulnerability indicators. This section presents results and discussion from these analyses.

1.4.1 Cluster solution based on outcome indicators

The dendogram, the Calinsk/Harbasz index and the t-square statistic – the transformation of Duda/Hart index from cluster analysis using outcome indicators are given in figure 1 and table 2 respectively.

Looking at the consensus between the two indices and the dendogram, the optimal number of clusters would be 8.

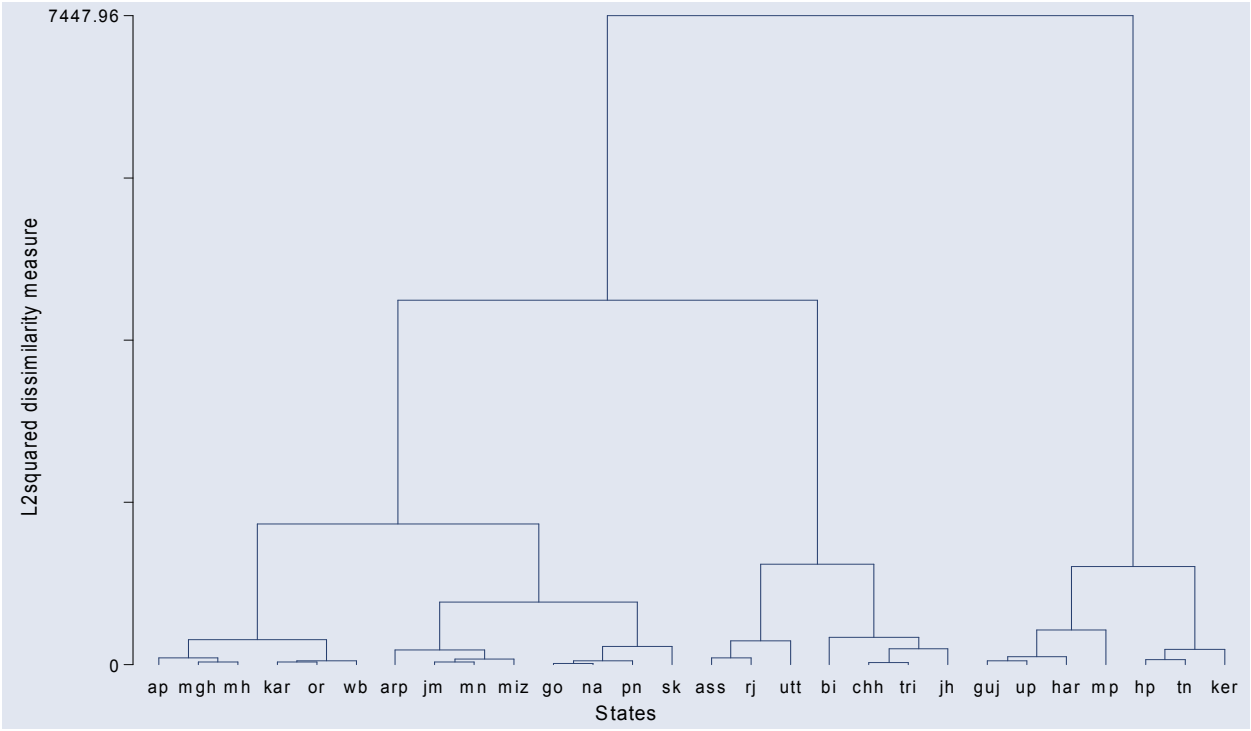

Figure 1: Dendogram from cluster analysis based on outcome indicators

Table 2: Calinski / Harbasz and T-square indices for outcome based cluster

Number of clusters	Calinski/ Harabasz pseudo-F	Duda/Hart Pseudo t- square
1		17.04
2	17.04	14.97
3	20.24	11.43
4	19.00	6.67
5	18.70	7.50
6	20.68	8.25
7	21.95	6.27
8	**21.66**	**3.14**
9	21.38	6.79
10	21.62	3.99
11	22.54	7.30
12	23.16	9.25
13	23.95	2.97
14	25.51	3.78
15	**28.39**	2.28

The list of clusters with their members and descriptive statistics are given in table 3. Cluster 7 having Madhya Pradesh as the only member has highest incidence of malnutrition among women and children followed by cluster 5 comprising other underdeveloped and poorer states of India. Madhya Pradesh singled out as a cluster due to high malnutrition level coupled with relatively low infant mortality level as compared to members of cluster 5. In terms of infant mortality rate, cluster 4 comprising Rajasthan, Uttaranchal and Assam fares worst. Cluster 2, cluster 3 and cluster 8 are on the better half on the scale of health and nutrition in/ security outcomes. It is noticeable that clusters with north eastern states fare better in terms of nutrition security but poorer in mortality outcomes while clusters with developed states of India perform better on mortality indicators compared to nutrition indicators. The cluster solution based on health and nutrition insecurity outcomes is captured by figure 2.

From tables table 3 and figure 2, it is apparent that urban Madhya Pradesh is the most insecure in terms of health and nutrition insecurity and is closely followed by urban parts of states like Bihar, Jharkhand, Chhattisgarh and Tripura. Relatively well off states like Haryana and Gujarat have lower incidence of infant mortality but relatively higher levels of malnutrition (see table A in appendix). That is why these two states have come together in cluster 6 along with Uttar Pradesh.

In contrast, most of the north-eastern states like Arunachal Pradesh, Mizoram, Manipur and Nagaland and also states like Goa and Punjab have relatively lower level of malnutrition but higher level of infant mortality. In fact, all members of cluster 3 come together because, they have relatively lower level of malnutrition but higher level of infant mortality (see table 3 and table A in appendix). Members of cluster 1 are consistently bad on all the three parameters of nutrition and health insecurity. Cluster 4 is especially worse on infant mortality rate which is more than 62 per 1000.

Members of cluster 2 i.e. Arunachal Pradesh, Mizoram, Jammu and Manipur come together due to similar levels of infant mortality and under-nutrition among women (see table A in appendix) and they top in terms of nutrition security followed by cluster 3 and cluster 8.

1.4.2 Cluster solution based on risk/vulnerability related indicators

Based on the rule of thumb, from figure 3 and table 4, 7 clusters' solution seems to be optimum here.

The cluster solution leads us to seven clusters with 11 of the 28 states clubbing in single cluster 4 (table 5). Cluster 7 with Tripura as the only member state, comes out to be the most vulnerable due to very high unemployment rate and high immunization gap. Even though Goa fares much better in nutrition outcomes as compared to Orissa (see table A in appendix), on vulnerability parameters they group together in cluster

Table 3: Clusters, cluster members and summary statistics for the clusters

	low BMI	malnourished children	IMR	Cluster members	Rank in terms of malnutrition
Cluster 1					
N = 6				AP, Karnataka,	IV
Mean	19.433	32.81	35.15	Meghalaya, WB,	
SD	3.061	2.697	5.39	Maharashtra, Orissa	
Cluster 2					
N= 4				Arunachal Pradesh,	VIII
Mean	12.2	19.625	48	Mizoram, Jummu,	
SD	4.336	4.193	2.449	Manipur	
Cluster 3					
N= 4				Goa, Nagaland,	
Mean	11.525	22.6	35	Punjab, Sikkim	VII
SD	4.646	2.270	4.163		
Cluster 4					
N= 3				Assam, Rajasthan,	III
Mean	19.733	33.26	62.66	Uttaranchal	
SD	7.635	3.524	4.1633		
Cluster 5					
N=4				Bihar,	
Mean	24.625	42.7	47.75	Chhattisgarh,	II
SD	1.203	6.418	6.5	Jharkhand, Tripura	
Cluster 6					
N= 3				Gujrat, Haryana,	V
Mean	19.9	40.9	15.33	Uttar Pradesh	
SD	3.218	2.615	3.785		
Cluster 7				Madhya Pradesh	
N= 1					I
Mean	28.7	52.8	22		
SD	--	--	--		
Cluster 8				Himachal	
N= 3				Pradesh,	VI
Mean	11.866	29.233	20	Kerala,	
SD	3.800	5.974	2.645	Tamilnadu	
Overall					
N= 28				All states	
Mean	17.614	32.128	37.496		
SD	6.300	9.552	14.747		

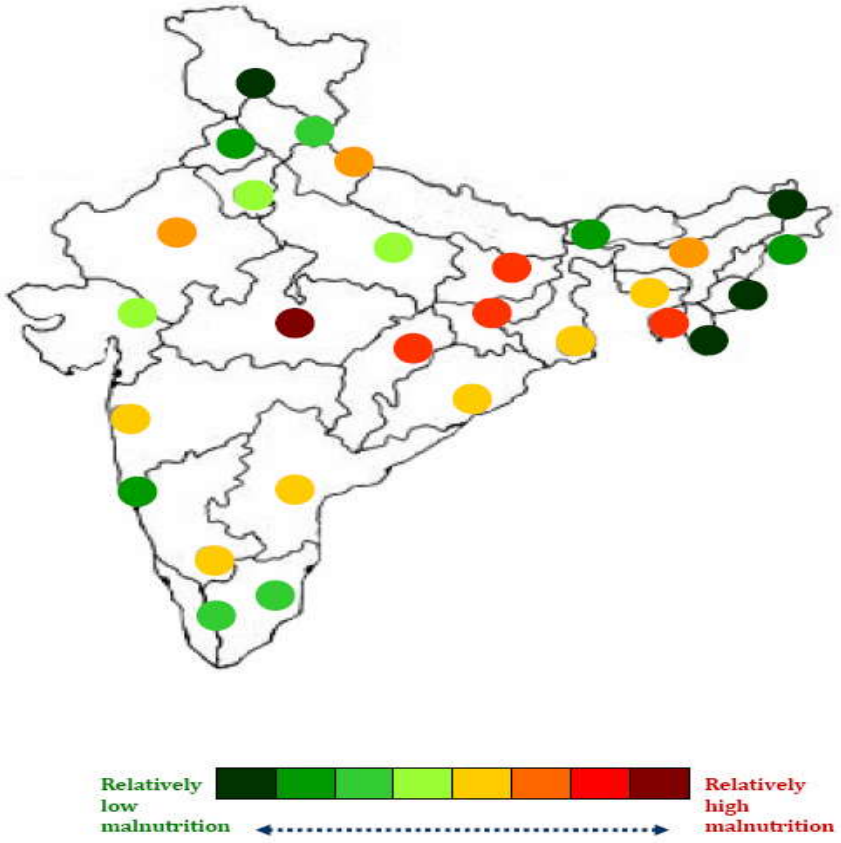

Figure 2: Classification of states through cluster analysis based on outcome indicators

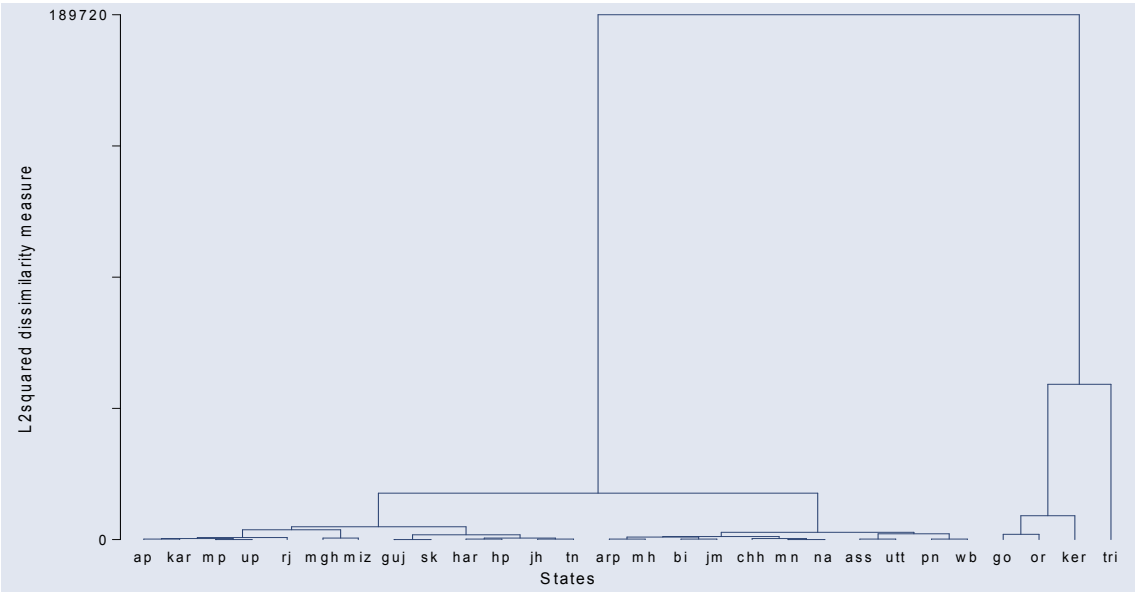

Figure 3: Dendogram from cluster analysis using risk/vulnerability indicators

Table 4: Calinski/ Harbasz and t-square indices for cluster based on risk indicators

Number of Clusters	Calinski/ Harabasz pseudo-F	Pseudo t-square
1		47.42
2	47.42	10.47
3	64.00	18.19
4	67.51	4.40
5	69.67	6.40
6	68.50	9.72
7	**68.86**	**4.87**
8	70.16	13.21
9	72.52	.
10	78.11	7.99
11	88.43	3.22
12	92.25	5.26
13	96.98	3.21
14	103.09	4.82
15	**112.02**	.

5 due to comparable levels of unemployment and immunization gap. Cluster 4 including poorer states like Assam and Bihar as well as relatively well off states like Punjab and Maharashtra are most vulnerable in terms of unemployment, immunization coverage and female illiteracy.

Female illiteracy is rather low in north-eastern states of Nagaland, Manipur and Arunachal Pradesh, yet due to low immunization coverage and high unemployment rate, these states group with other states which are backward in female education (see table B in appendix). Meghalaya and Mizoram single out in cluster 2 due to considerable gap in children's immunization coupled with low unemployment rate and low female illiteracy (see table 5 and table B in appendix). These two states have lowest unemployment which is lower than national average also. Cluster 1 has highest incidence of female illiteracy and it fares bad on all the three indicators of vulnerability. Status of immunization and illiteracy among women is slightly better in cluster 3.

In terms of vulnerability parameters Kerala is a special case in India with lowest female illiteracy and immunization gap along with high unemployment rate (table 5). On the whole, cluster 6 i.e. Kerala is the least vulnerable despite high unemployment rate. Cluster 7 i.e. Tripura is the most vulnerable part/state of India in terms of all the three vulnerability indicators. Cluster 4 closely follows cluster 7 and it is only the unemployment indicator that makes it distinct from the latter i.e. Tripura. Figure 4 represents the classification of urban areas of 28 states of India in terms of the three vulnerability indicators.

1.5 Concluding Observations

The foregoing study does the classification on the basis of cluster approach which unlike the index approach allows for disaggregated analysis. This is important as we have seen that different states/clusters perform differently with respect to different components of vulnerability i.e. some states have low female illiteracy but high immunization gap. The analysis brought forth some interesting insight into the dynamics behind incidence of nutrition insecurity and vulnerability. These are summarized here:

i. States like Madhya Pradesh, Rajasthan, Bihar and Gujarat have lower unemployment levels compared to Kerala or Goa still they group into clusters with highest incidence of malnutrition. This indicates that employment (or income) may not in itself ensure access to nutrition security always. This goes with existing investigations, which find that what is important is nature of growth which matters for health or human development only if it provides social and public services (Anand and Ravallion, 1993). Economic status is found to be significantly associated with child nutrition, but with limited effect (Ajieroh, 2009). While poverty reduction has been somewhat stronger, economic gains do not automatically translate into nutrition benefits (see Webb and Lapping, 2002).

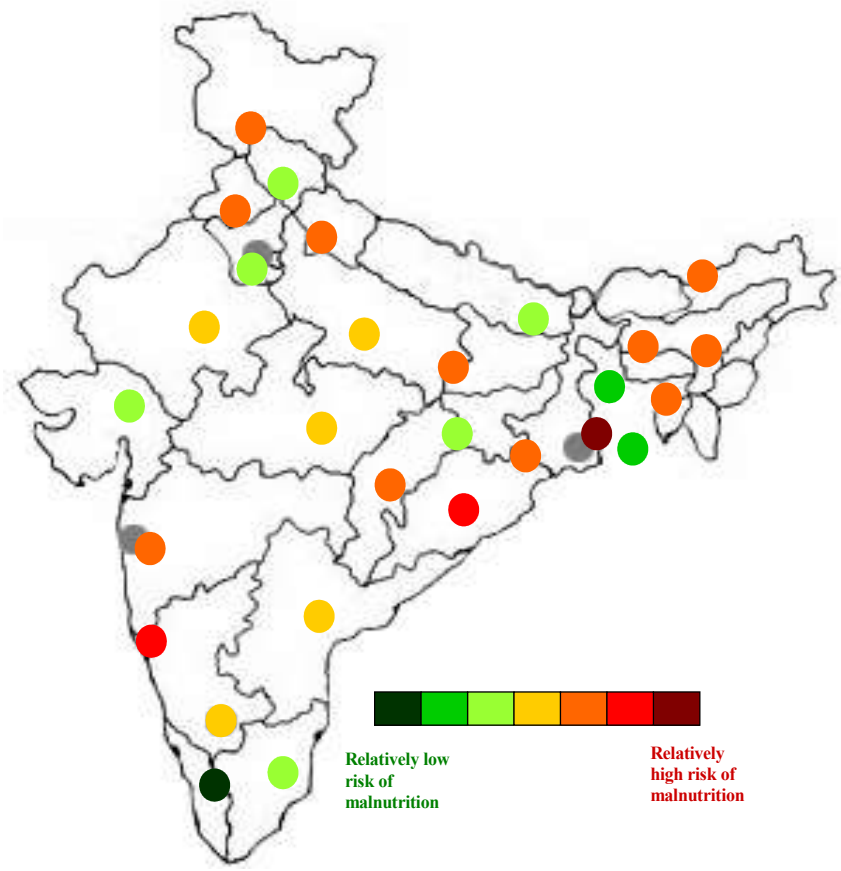

Figure 4: Classification of states through cluster analysis based on vulnerability indicators

Income poverty is lesser in South Asia compared to sub-Saharan Africa, still the incidence of malnutrition is higher in the former. This case is known as 'Asian enigma' (Heltberg, 2009) and seems to have occurred in few states of India like Gujarat, Maharashtra and Karnataka which are better on income and employment front but have been identified here as highly nutrition insecure.

ii. Urban Madhya Pradesh happens to be the most nutritionally insecure in urban India. The latest India State Hunger Index has also identified Madhya Pradesh as the hunger hot spot in India in terms of incidence of malnutrition (Menon et al, 2008)**).** Tripura appears to be the most vulnerable to malnutrition though the actual incidence of it is significantly lower than several other states.

iii. Urban parts of Kerala, Jammu, Goa and most of the urban north-eastern states except Assam and Tripura have low female illiteracy, higher unemployment and low malnutrition. If the underlying dynamics is explored it is likely that higher female literacy (or better status of women, greater bargaining power and entitlement) in these areas have positive correlation with nutrition well being outcomes. Evidently, higher status of women indicates that they would have better access to health, care practices and nutrition which in turn would ensure better child nutrition through the reproductive link (Smith and Haddad, 2000). Further, a better educated mother is known to provide better nutrition content and care to her children (Smith and Haddad, 2000; Smith et al, 2005). Literacy in itself has been linked to better health and nutrition (Isenman, 1980). Due to these

Table 5: Summary statistics for cluster solution based on risk indicators

	No vaccin-nation	Unemp-ployment rate	female illiteracy	Cluster members	Rank in order of risk
Cluster 1				AP, MP Karnataka, Rajasthan, UP	IV
N=5					
Mean	42	46.50	37.74		
SD	10.36	5.62	5.510		
Cluster 2				Meghalaya, Mizoram	VI
N=2					
Mean	36.8	2.55	10.10		
SD	8.202	12.02	3.95		
Cluster 3				Gujrat, Haryana, HP, Jharkhand, Sikkim, Tamilnadu	V
N= 6					
Mean	19.66	57.25	27.18		
SD	4.412	15.22	4.23		
Cluster 4				Arunachal P, WB Assam, Bihar, Jummu, Chattishgarh, Manipur, Maharashtra, Punjab, Nagaland, Uttaranchal,	III
N = 11					
Mean	53.93	77.90	26.5		
SD	13.175	12.68	7.20		
Cluster 5				Goa, Orissa	II
N = 2					
Mean	46.00	15.6	30.4		
SD	1.41	31.11	4.525		
Cluster 6				Kerala	VII
N = 1					
Mean	12	22.8	16.1		
SD	--	--	--		
Cluster 7				Tripura	I
N = 1					
Mean	51.5	37.25	22.4		
SD	--	--	--		
Total				All states.	
N = 28					
Mean	41.08	85.58	27.24		
SD	17.154	71.19	8.77		

APPENDIX

Table A: Outcome indicators for all cluster members

Cluster	States	Outcome indicators		
		% of malnourished children	Infant Mortality Rate	% of women with low BMI
1	Andhra Pradesh	29.1	33	16.4
	Karnataka	33.8	37	19.8
	Meghalaya	35.9	30.4	15.7
	Maharashtra	34.8	28.5	20.7
	Orissa	33.3	40	24.1
	West Bengal	30	42	19.9
	Average	**32.816**	**35.15**	**19.433**
Cluster				
2	Arunachal Pradesh	23.8	50	18.6
	Mizoram	13.8	47	11
	Jammu	20.6	50	9.1
	Manipur	20.3	45	10.1
	Average	**19.625**	**48**	**12.2**
Cluster				
3	Goa	21.6	36	16.1
	Nagaland	21.3	34	13.1
	Punjab	21.5	40	11.8
	Sikkim	26	30	5.1
	Average	**22.6**	**35**	**11.525**
Cluster				
4	Assam	34.1	58	22.5
	Rajasthan	36.3	66	25.6
	Uttaranchal	29.4	64	11.1
	Average	**33.266**	**62.666**	**19.733**
Cluster				
5	Bihar	51.5	54	25.1
	Chhattisgarh	38.9	51	23.5
	Jharkhand	43.3	39	26.1
	Tripura	37.1	47	23.8
	Average	**42.7**	**47.75**	**24.625**
Cluster				
6	Gujarat	42.7	18	19.5
	Haryana	42.1	11	16.9
	Uttar Pradesh	37.9	17	23.3
	Average	**40.9**	**15.333**	**19.9**
Cluster				
7	Madhya Pradesh	52.8	22	28.7
Cluster				
8	Himachal Pradesh	33.9	19	10.3
	Kerala	22.5	18	9.1
	Tamil Nadu	31.3	23	16.2
	Average	**29.233**	**20**	**11.86**

Table B: Summary of risk indicators for all cluster members

Cluster	States	Vulnerability indicators		
		% of children out of vaccination coverage	% of illiterate among women	Average rate of unemployment
1	Andhra Pradesh	49	37.5	5.35
	Karnataka	40	30.6	4.95
	Madhya Pradesh	32	34.9	4.05
	Rajasthan	56	45.1	4.1
	Uttar Pradesh	33	40.6	4.8
	Average	**42**	**37.74**	**4.65**
Cluster				
2	Meghalaya	42.6	12.9	3.4
	Mizoram	31	7.3	1.7
	Average	**36.8**	**10.1**	**2.55**
Cluster				
3	Gujarat	16	26.4	4.25
	Himachal Pradesh	18	21.9	7.4
	Haryana	20	33.1	7.4
	Jharkhand	27	31.3	6.1
	Sikkim	15	26	3.85
	Tamil Nadu	22	24.4	5.35
	Average	**19.66**	**27.18**	**5.725**
Cluster				
4	Bihar	54	39.8	7.1
	Arunachal Pradesh	48.8	16	6.55
	Assam	71	21.2	9.4
	Chhattisgarh	59	31.3	6.1
	Jammu	49	35	8.1
	Maharashtra	40.4	25.2	6.85
	Manipur	67.7	24.6	7.15
	Nagaland	64.4	17.4	6.85
	Punjab	42	26.9	9.7
	Uttaranchal	67	30.2	9
	West Bengal	30	23.9	8.9
	Average	**53.93**	**26.5**	**7.79**
Cluster				
5	Orissa	47	33.6	17.8
	Goa	45	27.2	13.4
	Average	**46**	**30.4**	**15.6**
Cluster				
6	Kerala	12	16.1	22.8
Cluster				
7	Tripura	51.5	22.4	37.25

mechanisms, higher status of women is likely to ensure better nutrition outcomes for themselves and their children.

Ostensibly, the link between individual capabilities (nutrition is one of them) and income is an important issue to be addressed. This link is mediated by many social factors like female education and status.

iv. Kerala is better on nutrition as well as health parameters. It also has high immunization coverage and low IMR unlike the nutritionally better off states of north-eastern India. This makes Kerala better off overall among all the states. The better immunization level (or better health facilities and state health support) might have reduced actual malnutrition level here.

In fact, two factors that fill the gap left by income in reducing malnutrition are direct public intervention and women's status. If income is relatively low but women's status is higher, malnutrition outcome would be better than in case of higher income coupled with poorer status of women. Similarly, despite high income, malnutrition cannot be tackled unless direct public action is taken in this regard. In case of Kerala, it is strong public intervention for food security which also needs to be underscored while mentioning better malnutrition outcomes (see Suryanarayan, 2001).

Unlike in Kerala and many other states, urban parts of north –eastern states except Sikkim happen to face considerable degree of health insecurity as reflected from low immunization coverage and high infant mortality rate. This could be attributed to possible inefficiency of the government. However, inadequate or ineffective government effort can not be assumed to be evident unless a consideration can be taken of the resources and other constraints that the government faces (Fukuda-Parr et al, 2008). The better status in terms of nutrition as discussed above could be possible due to the traditional social structure of these states that assigns higher status to women.

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