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UNDER-FIVE CHILD GROWTH AND NUTRITION STATUS: SPATIAL CLUSTERING OF INDIAN DISTRICTS

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Abstract

Variation in human growth and the genetic and environmental factors that are influencing it have been described worldwide. The objective of this study is to assess the geographical variance of under-five children nutritional status and its related covariates across Indian districts. We use the most recent fourth round of the Indian National Family Health Survey conducted in 2015-2016, which for the first time offers district level information. We employ principal component analysis (PCA) on the demographic and socio-economic determinants of childhood morbidity and conduct hierarchical clustering analysis to identify geographical patterns in nutritional status among children of age under five at the district level. Our results reveal strong geographical clustering among the districts of India. Throughout most of Southern India, children are provided with relatively better conditions for growth and improved nutritional status, as compared to districts in the central, particularly rural parts of India. Looking at average weight, as well as the proportion of children that suffer from underweight and wasting, northeastern Indian districts seem to be offering living conditions more conducive to healthy child development. The geographical clustering of malnutrition, as well as below-average child height and weight coincides with high poverty, low female education, lower BMI among mothers, higher prevalence of both parity 4+ and teenage pregnancies. The present study highlights the importance of combining PCA and cluster analysis methods in studying variation in under-five child growth and nutrition at the district level. We identify the geographical areas, where children are under severe risk of undernutrition, stunting and wasting and contribute to formulating policies to improve child nutrition in India.

Keywords

Malnutrition, India, principal component analysis, cluster analysis, socio-economic status, districts.

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Under-Five Child Growth and Nutrition Status: Spatial Clustering of Indian Districts

Erich Striessnig, Jayanta Kumar Bora

1. Introduction

Child growth and nutritional development are largely influenced by living conditions, including socio-economic, cultural, demographic and climatic factors that can vary dramatically across nations. National variation in human growth patterns across the world have been well documented for decades (Eveleth et al., 1990, 1976) and average child height and weight are important indicators of population health and human capital (Coffey and Spears, 2018). However, despite the strong role of neighbourhood and community level effects found in various national contexts (Fotso, 2007; Uthman, 2009; Avan and Kirkwood, 2010; Alam, 2012; Geruso and Spears, 2018), disparities in child height and weight at smaller spatial scales within nations have been studied to a lesser extent.

The need to do so is particularly evident in a country like India, where vast spatial heterogeneity in the social, cultural, demographic and economic circumstances of growing up persists in the 21st century. For instance, levels of fertility and mortality, educational attainment, as well as the provision of maternal and child health services still vary widely across India (KC et al., 2018; KS, 2011). Climatic variation across the subcontinent leads to differences in agricultural patterns and yields that affect children's growth chances and the risk of malnutrition. Consequently, substantial inter-state, as well as intra-state differences in child health have been observed (IIPS and ICF, 2017). While levels of malnutrition and differences in child growth have been examined at the individual and household level for India (Kanjilal et al., 2010; Sarkar et al., 2013), similar studies, particularly on the association between poverty and child malnutrition at the district level are mostly missing (Khan and Mohanty, 2018).

Moreover, despite recent advances Indian children are still shorter than elsewhere in the developing world at similar levels of economic development (Coffey and Spears, 2018). According to the recent Global Hunger Index (GHI) 2017 report (von Grebmer et al., 2017), India is ranking 100th out of 119 countries investigated and has the third highest score in Asia. This severe situation is driven to a large extent by high child malnutrition and underlines the need for a stronger commitment to poverty alleviating social policies. As of 2015-16, more than a fifth (21%) of children in India suffered from wasting (low weight for height) and although there has been progress with respect to stunting (low height for age), down by 20% since 2005, the rate still stands at a staggering 38.4%. Similarly, the underweight rate is down by 16% since 2005, but even that progress leaves India with a relatively high rate of 35.7% (IIPS and ICF, 2017).

These elevated rates of childhood malnutrition have large public health implications. Most importantly, widespread undernutrition is strongly correlated and without a doubt causally linked to higher infant mortality (Schroeder and Brown, 1994; Rice et al., 2000; Black et al., 2008; Liu et al., 2016). Undernutrition has been shown to be the underlying cause for a large number of child deaths from diarrhoea, pneumonia, malaria or measles occurring in the developing world (Caulfield et al., 2004). Undernourished children are more likely to suffer from poor health compared to well-nourished children (Latham, 1997; Cunha, 2000; Gillespie and Haddad, 2003) and consequently perform worse in educational terms. By the time children enter school, undernourished children already lag behind with regard to not just physical, but also cognitive, behavioural and emotional development, which cannot be compensated through schooling (Alderman et al., 2006; Ruel and Alderman, 2013). In the aggregate, these effects amount to large-scale losses in productivity and economic costs (Heckman and Masterov, 2007; Galasso et al., 2016; Masoud et al., 2018) that prevent countries like India from achieving further development goals.

The aim of this study is to understand the geographical variation in growth and nutritional patterns of children under the age of five among the districts of India. The two main objectives are (i) to identify geographical clusters based on the demographic and socioeconomic characteristics of the households within them; and (ii) to identify differences or similarities in height, weight and nutritional status of children living in different clusters. Clustering the districts based on socio-economic characteristics of the households with children under the age of five may help identify factors that affect child growth and development in these diverse communities. Our results can help in designing and implementing appropriate regional and/or state-specific strategies and intervention programs to prevent child undernutrition in India. The findings of this study provide an improved understanding of the district-level nutritional conditions children are exposed to in India today, which may in turn help reduce avoidable child deaths in the future and to meet the targets set by the SDGs for Indian districts and states.

2. Data and Methods

The anthropometric and socio-economic data used in this study are taken from the most recent wave of the National Family Health Survey (NFHS-4) conducted in 2015-2016 by the Health Ministry, Government of India. For the first time in the history of the NFHS surveys, district information corresponding to households is made publicly available (IIPS and ICF, 2017). The survey, which does not contain any information that would make individual survey participants identifiable, is based on a sample of 1,315,617 children born to a total of 699,686 women aged 15-49 years from 601,509 households. In our analysis, we rely on the restricted sample of 259,627 children that were born in the five years before the survey. The sample was selected through a two-stage sample design and covers all the 640 districts as per the 2011 Census of India. The individual level data are available from the Demographic Health Survey (DHS) data repository and can be accessed upon request. For our study, the unit of analysis are the 640 districts of India.

To measure growth of children aged 0-59 months, we use average height and weight at the district level. Further indicators of nutritional deprivation derived from height and weight are stunting, wasting and underweight in children under the age of five. Following WHO guidelines (WHO, 2011, 2006), in our analysis we classify children as stunted, wasted and underweight, respectively, if their height-for-age, weight-for-height and weight-for-age Z-scores are below minus two standard deviations from the median of the reference population (set by the median of the WHO child growth standards). While the three phenomena often appear in combination, they generally measure different types of undernourishment: while stunting results from chronic nutritional deprivation, wasting indicates acute nutritional deficiency and underweight represents the combination of the two.

In accordance with the literature, we also compose a set of district-level determinants of child growth and malnutrition from the household-level information available in NFHS. These determinants can be broadly differentiated into three main categories. Among the health-related determinants, we choose the proportion of children that were fully immunized at the age of 12-23 months, the proportion of children that have never been breastfed, and mothers' body mass index (BMI). For demographic determinants, we calculate the proportion of parity 4+ births, the proportion of female children under five, the proportion of teenage pregnancies, as well as the average birth interval within a district. Similarly, socio-economic determinants were derived at the district level using information on the proportion of households that are female-headed, the proportion of the district population living in urban areas, the proportion of mothers with mass media exposure, the proportion of mothers with at least secondary or higher level of educational attainment, the proportion Hindu, the proportion belonging to a Scheduled Caste (SC)/Scheduled Tribe (ST), as well as the prevalence of using safe cooking fuels, improved water supply and sanitation. Finally, we account for the geographic location of the district by using longitude and latitude information of the district centroid. Summary statistics for each of these variables can be found in Table 1.

Table 1. Descriptive statistics of the selected district level variables, India, 2015-16

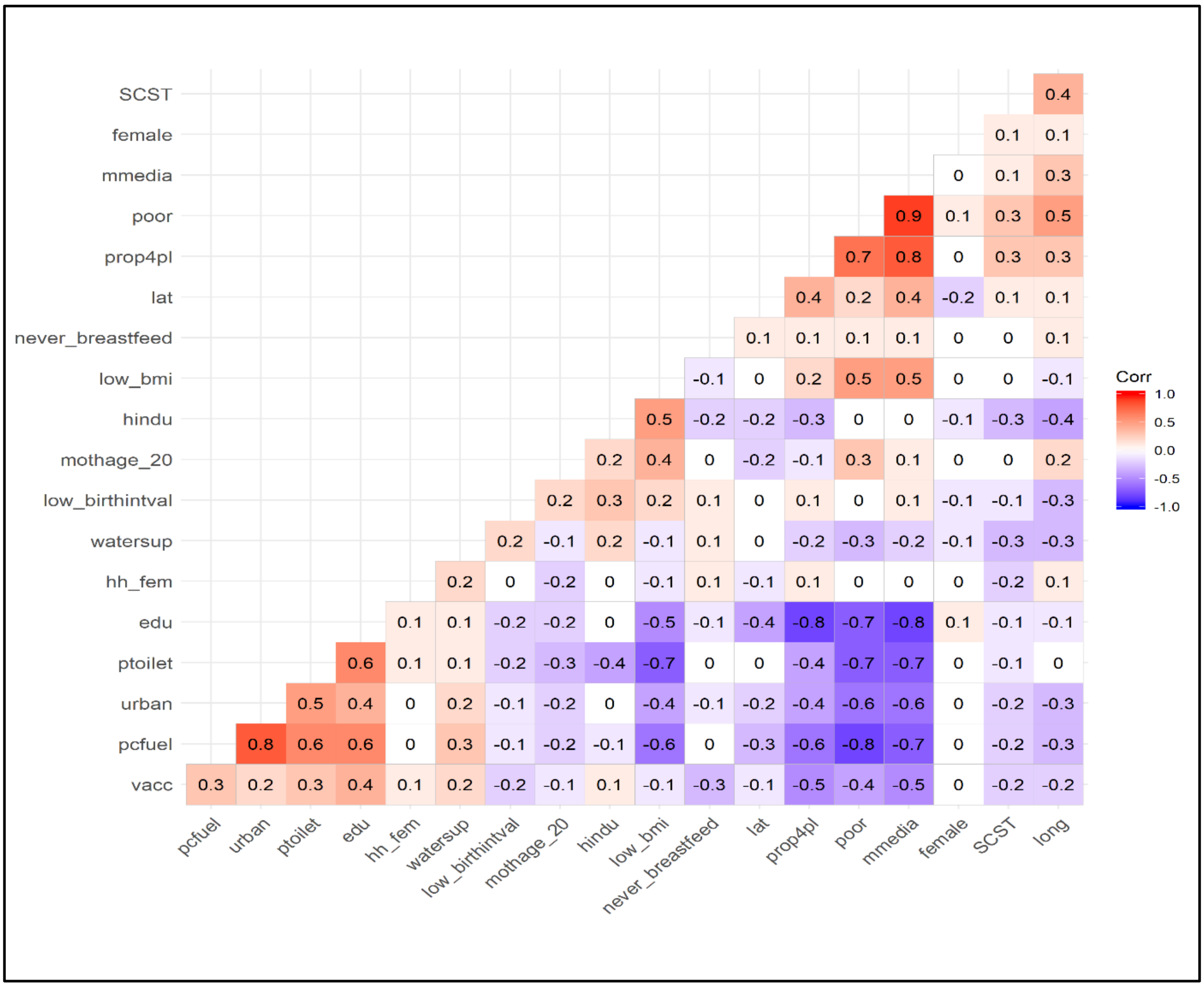
Independent variables (%)	Abbreviation#	Mean	Stdev	Median	Minimum	Maximum	nobs
1 Population in two lowest wealth quintiles	poor	0.42	0.26	0.41	0.00	0.93	640
2 Children never breastfed	never_breastfed	0.10	0.05	0.09	0.01	0.32	640
3 Children age 12-23 month with basic vaccination	vacc	0.62	0.17	0.63	0.07	1.00	640
4 Hindu population	hindu	0.73	0.28	0.84	0.00	1.00	640
5 SC/ST population	SCST	0.39	0.23	0.33	0.01	1.00	640
6 Mothers age at birth below 20 years	mothage_20	0.12	0.06	0.12	0.00	0.36	640
7 Children birth order 4 and above	prop4pl	0.13	0.09	0.12	0.00	0.40	640
8 Mothers with low BMI (<18.5 kg/m^2)	low_bmi	0.22	0.10	0.22	0.01	0.54	640
9 Female-headed households	hh_fem	0.12	0.07	0.10	0.01	0.51	640
10 Mothers with mass media exposure	mmedia	0.32	0.23	0.27	0.00	0.87	640
11 Household use safe cooking fuel	pcfuel	0.35	0.25	0.27	0.02	1.00	640
12 Household has improved water for drinking	watersup	0.89	0.13	0.94	0.30	1.00	640
13 Household has improved toilet facility	ptoilet	0.53	0.26	0.51	0.07	1.00	640
14 Children birth interval <24 months	low_birthintval	0.34	0.06	0.35	0.17	0.49	640
15 Female child	female	0.48	0.03	0.48	0.38	0.62	640
16 Urban population	urban	0.25	0.22	0.19	0.00	1.00	640
17 Women with at least secondary education	edu	0.60	0.21	0.60	0.10	1.00	640
18 Longitude of district centroid	long	81.05	6.29	79.10	69.78	96.83	640
19 Latitude of district centroid	lat	23.41	5.81	24.61	7.52	34.53	640

#Abbreviation for the variable used in the analysis

NFHS did not ask participants about their household's income situation. Therefore, to account for low income status at the district level, a wealth indicator was recreated following the procedure outlined in the DHS report on NFHS-4 (Rutstein, 2015), where women's economic status was assessed through a composite index of household characteristics, such as possession of consumer durables and assets, as well as building characteristics. The three components from that wealth index that are particularly relevant to our study subject, namely access to modern sanitation, cooking fuels and clean sources of drinking water, were excluded from our reconstruction of the wealth index at the district level because they are explicitly controlled for as part of our analysis.

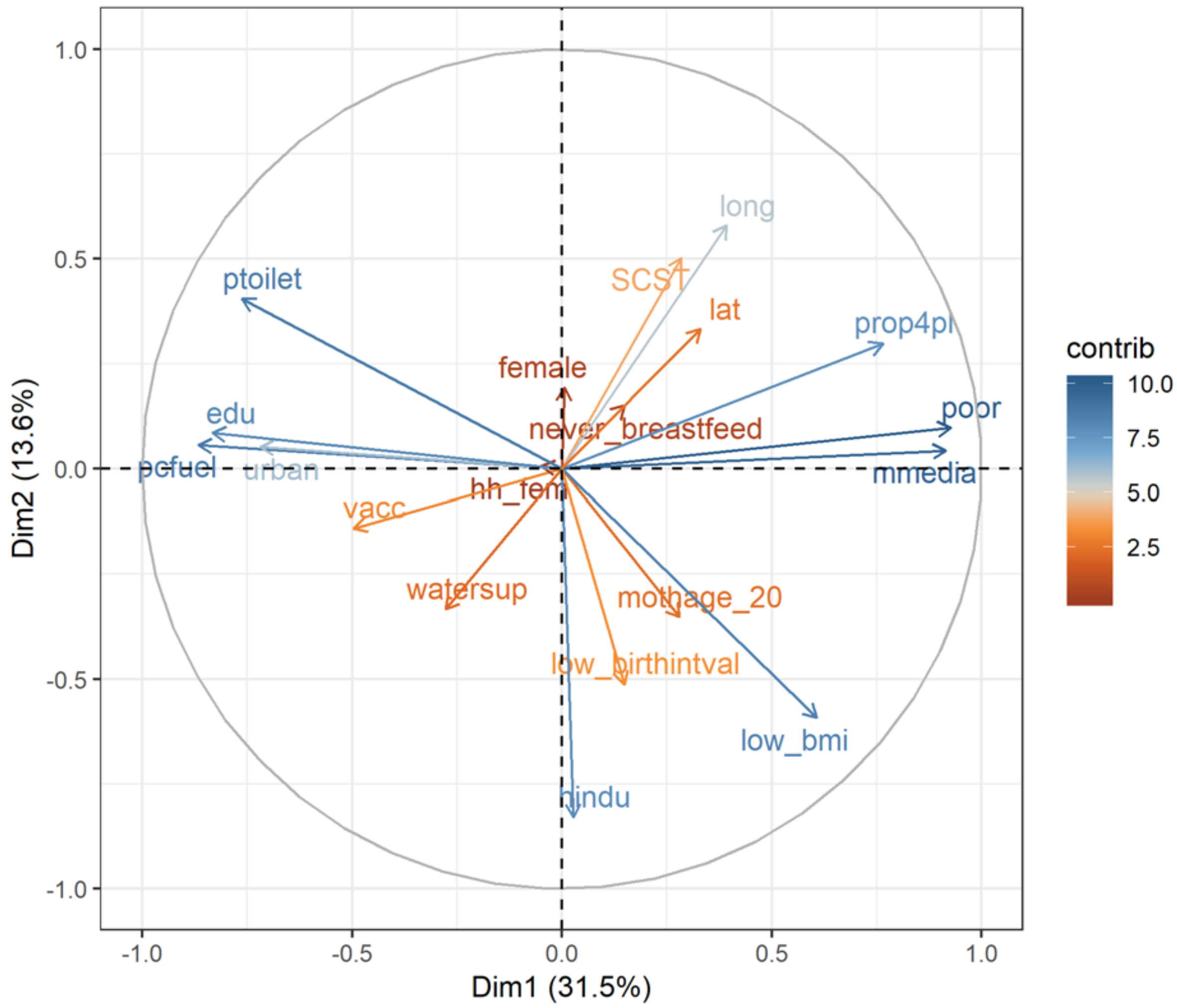
Due to the large number of often correlated variables, before identifying district clusters we first use principal component analysis (PCA) as a preprocessing step to denoise the data. Once the complexity of the data set has been reduced to its principal components, we perform cluster analysis on the principal components to identify regional child growth and nutritional status patterns across India. All the analyses are conducted using R Statistical Software, in particular the "FactoMineR" package (Escofier et al., 2017). The correlations between the variables are depicted in Figure 1 sorted by hierarchical clustering.

Figure 1. Correlogram for independent variables identified as relevant for explaining differences in average height and weight of children under the age of five



Combining PCA with cluster analysis is useful in various ways. Most importantly, the results of any subsequent clustering will be more robust if the less meaningful information has already been cleared from the data. The principal components drawn from the full set of variables contain only the information that will be most meaningful in describing statistical relations within any random subset of the data. This is particularly useful in case there are reasons to doubt the accuracy of specific survey items. The more variables there are in the dataset, the more useful PCA becomes. The contribution of each variable in terms of its correlation with the most important dimensions extracted by PCA is depicted in Figure 2. The contribution of variables “poor” and “edu”, for example, to the first principal component is highly significant, whereas there is no significant contribution of these variables to the second dimension. Vice versa, the proportion “hindu” appears to be highly correlated with the second dimension but is irrelevant for the first principal component. Overall, the first four principal components together explain about 60 % of the variance.

Figure 2. Contribution of different variables to first two principal components

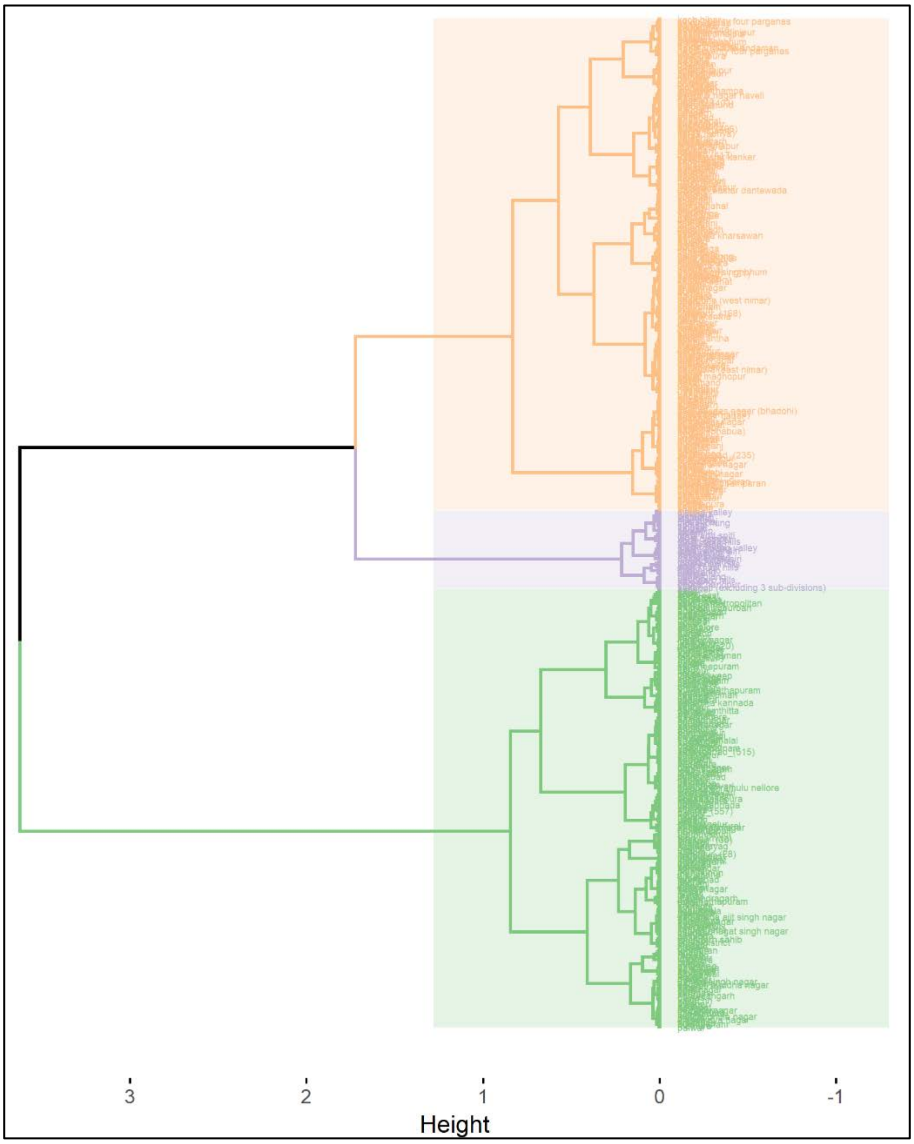


Cluster analysis techniques enjoy widespread popularity in diverse scientific disciplines (Eveleth et al., 1990; Tanner, 1962). Its first application to anthropometric data can be traced back to Mahalanobis et al. (1949). Other studies have used cluster analysis for biomedical image analysis (Wismüller et al., 2002), the study of health conditions such as diabetes (Guttula et al., 2010) or cardiac disease (Perumal and Mahalingam, 2013). More specifically for the case of India, Vasulu and Pal (1989) showed the relationship between anthropometric variation and cultural diversity among the Yanadi, a tribe in the south eastern part of Andhra Pradesh. A recent study by Rao et al. (2013) combined PCA and cluster analysis on nutritional and anthropometric data of preschool children to analyse geographical variation in child growth among the districts of Uttar Pradesh. Similar methods have been applied to classify growth profiles of children in China (Cheng-Ye et al., 1991), as well as to create patterns of overall activity and inactivity in a diverse sample of Chinese youth to evaluate their use in predicting overweight status (Monda and Popkin, 2005). A study by Tucker (2010) combined PCA and cluster analyses to study dietary patterns of different populations in the US and Ferenci et al. (2008) used the method to discuss obesity patterns observed among Hungarian children.

3. Results

Once we extracted the principal components, we can perform hierarchical cluster analysis on the reduced number of variables using Ward's criterion. The crucial question in this step relates to the number of clusters to distinguish. This can be done either through visual inspection of the dendrogram (depicted in Figure 3) or by applying a quantifiable partitioning criterion, e.g. minimizing the ratio between two successive within-group inertias (Husson et al., 2017). In our case, both of these methods suggest distinguishing three separate clusters among Indian districts, two of them very large with 271 and 313 districts, respectively, a third one with only 56 districts.

Figure 3. Dendrogram of district clusters derived from applying cluster analysis to principal components



The spatial distribution of these clusters is shown in Figure 4. The regional clustering is indeed very strong, with members of cluster 1 being concentrated in the southern and northern parts of India and cluster 3 districts being concentrated at intermediate latitudes. Of the 56 districts in cluster 2, only six are located in the western part of India at below 80 degrees longitude. The remaining 50 districts are in the East at above 90 degrees longitude. Since the quality of the data collected in Jammu & Kashmir might suffer from the ongoing conflict there, we did run the analysis without that state and the results for the rest of India are robust to this modification.

Figure 4. Clusters derived from principal components, India, 2016

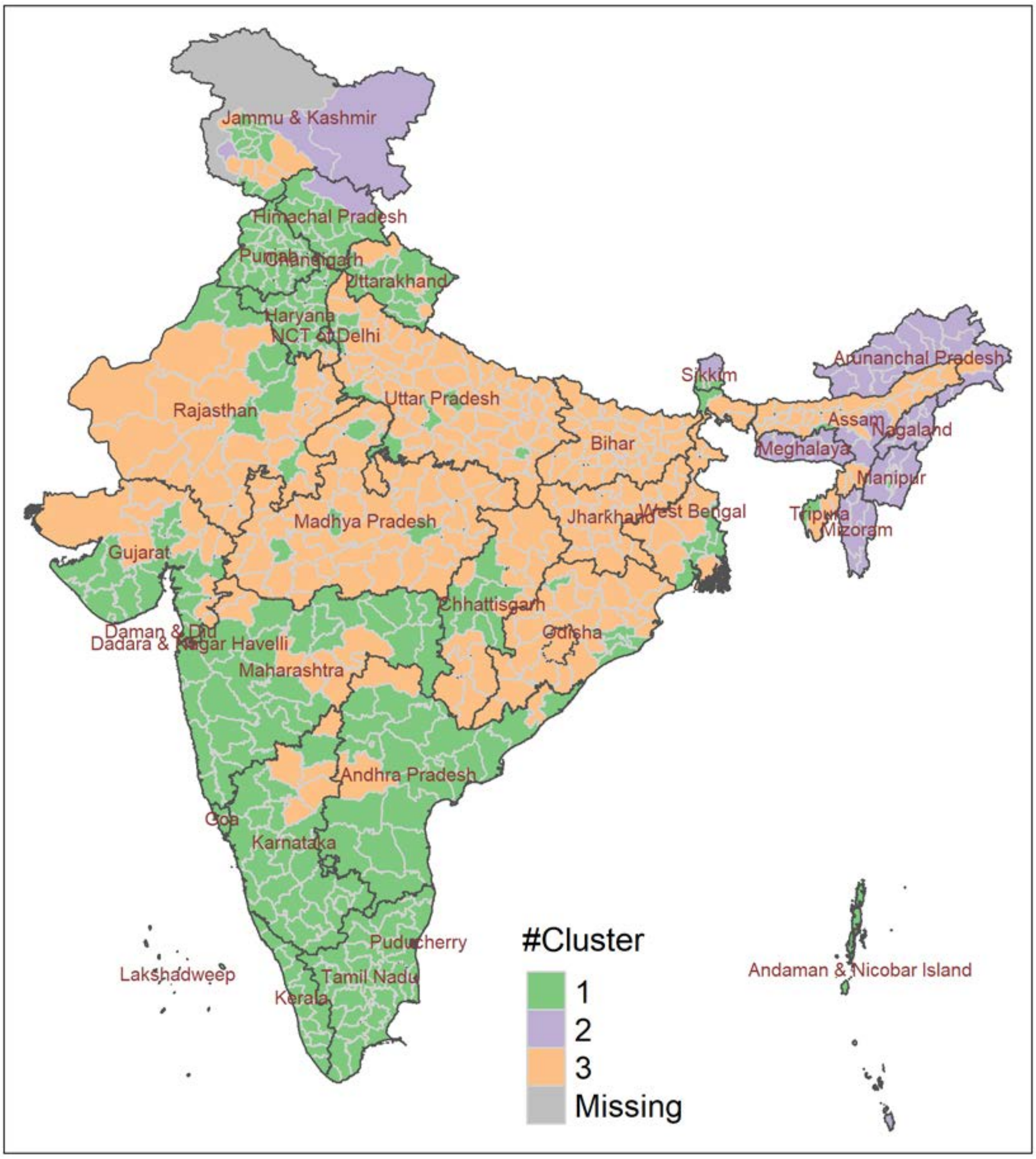


Table 2 shows the differences between district cluster 1 and the full sample of Indian districts by variable. As indicated by a positive value of the v.test statistic, districts with a high proportion of women with at least secondary education ("edu") are significantly overrepresented in cluster 1 compared to the whole of India. Whereas the mean across all 640 Indian districts in this proportion is 0.60, for the districts belonging to cluster 1 the proportion is 0.76. Districts inside cluster 1 also tend to be more "urban", children are more likely to be vaccinated ("vacc") and houses are more likely to be equipped with improved sanitation, a clean source drinking water and safe fuel for cooking is used. The negative v.test statistics in the bottom part of the table indicate an underrepresentation of districts in cluster 1 that have large proportions of "poor" people with less access to mass media (“mmedia”). Moreover, districts in cluster 1 tend to have lower fertility, as they are characterized by a smaller proportion of higher order births (“prop4pl”) and the proportion of low-BMI and otherwise deprived mothers (“SCST”) is smaller.

Table 2. Mean proportions across cluster 1 compared to proportion across all districts of India

Variable	Cluster mean	Overall mean	v.test	p.value
pcfuel	0.55	0.35	18.26	0.000
edu	0.76	0.60	17.24	0.000
ptoilet	0.72	0.53	15.18	0.000
urban	0.39	0.25	13.84	0.000
vacc	0.71	0.62	10.36	0.000
watersup	0.93	0.89	7.35	0.000
lat	21.43	23.41	-7.40	0.000
SCST	0.29	0.39	-8.72	0.000
low_bmi	0.17	0.22	-11.18	0.000
long	77.73	81.05	-11.45	0.000
prop4pl	0.06	0.13	-16.97	0.000
mmedia	0.11	0.32	-19.01	0.000
poor	0.19	0.42	-19.93	0.000

Combining the results from PCA and cluster analysis, a visual representation of the variables most important in distinguishing cluster 1 can be found in Figure 5. For the green districts that are part of cluster 1, the variables with a positive v.test in Table 2 display a strongly negative relation with the first principal component. All other variables show a positive relation with PC1 for cluster 1 districts.

Figure 5. Various risk factors and principal component #1 for different clusters

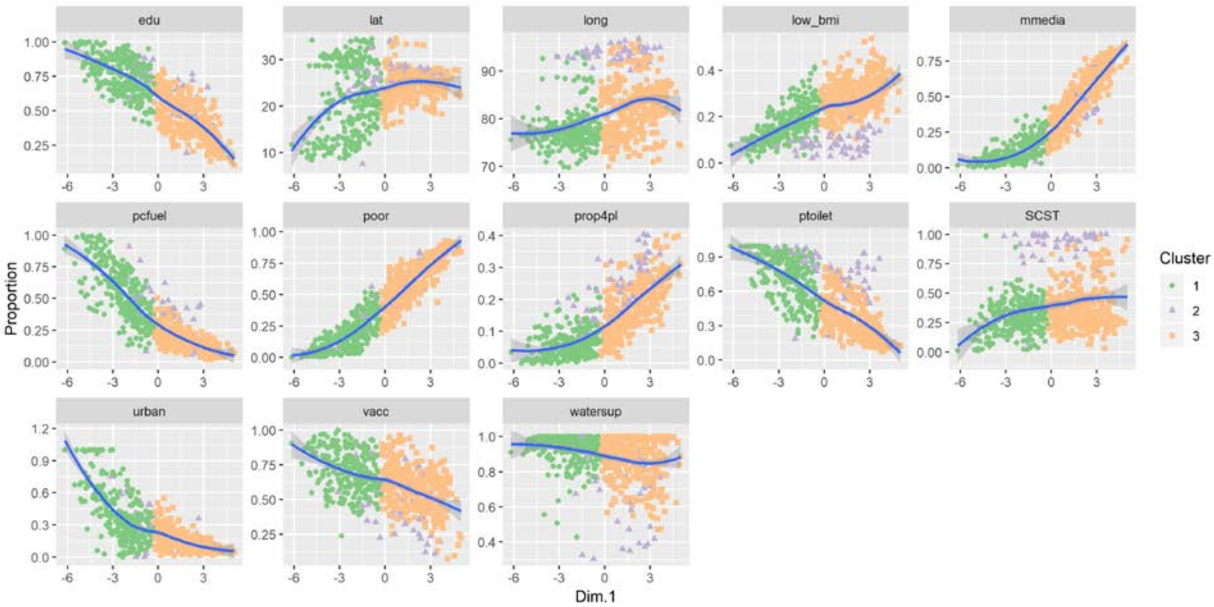


Table 3 shows the variables most distinctive for cluster 2 districts. In addition to the geographical pattern described earlier, the variables displaying the strongest positive deviation from the country overall are the proportion of population belonging to one of the scheduled castes or scheduled tribes, as well as the proportion of children ranking fourth or higher in the birth order and the proportion growing up with modern toilet facilities in the household (“ptoilet”). On the other hand, districts with low birth intervals, completed vaccination of the children, improved water supply and mothers with low BMI are underrepresented in cluster 2. In addition, with the exception of a few districts in the North of India cluster 2 is concentrated in the North-eastern part of the country. Therefore, average longitude for districts belonging to cluster 2 is significantly higher than for a central Indian district.

Table 3. Mean proportions across cluster 2 compared to proportion across all districts of India

Variable	Cluster mean	Overall mean	v.test	p.value
SCST	0.88	0.39	16.75	0.000
long	92.32	81.05	14.04	0.000
prop4pl	0.23	0.13	7.66	0.000
ptoilet	0.73	0.53	5.85	0.000
low_birthintval	0.30	0.34	-5.08	0.000
vacc	0.48	0.62	-6.65	0.000
watersup	0.76	0.89	-8.24	0.000
low_bmi	0.09	0.22	-10.39	0.000

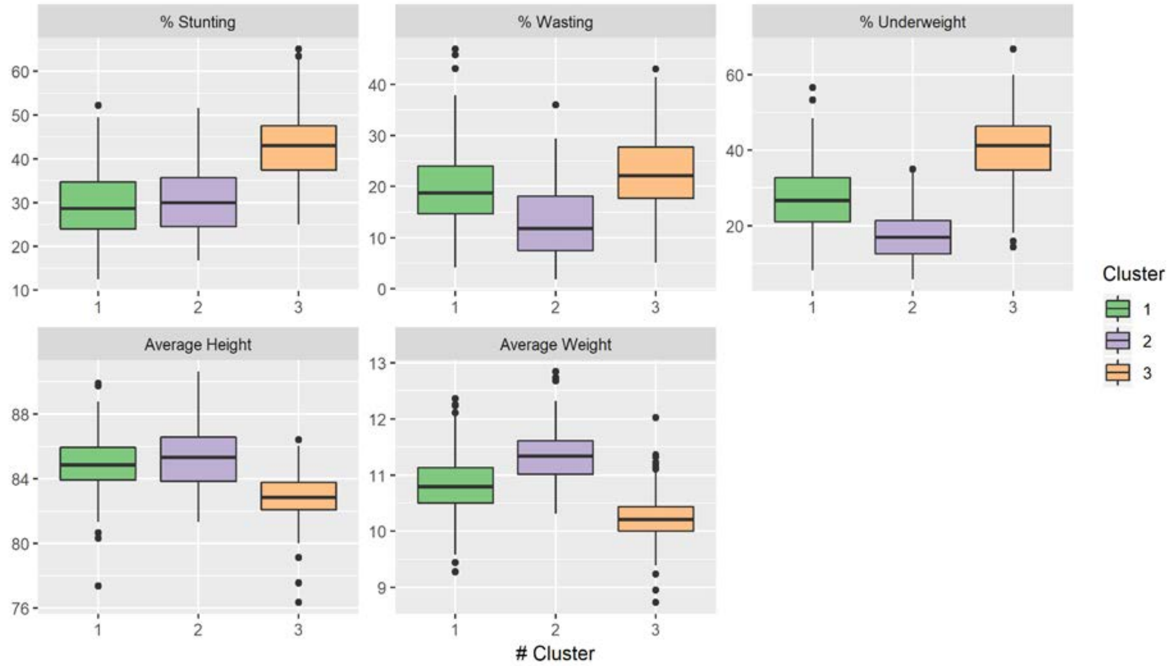
Judging from Table 4, cluster 3 appears to be the inversion of cluster 1. The same variables that were identifying districts predominantly underrepresented in cluster 1, now identify districts that are overrepresented and vice versa.

Table 4. Mean proportions across cluster 3 compared to proportion across all districts of India

Variable	Cluster mean	Overall mean	v.test	p.value
mmedia	0.49	0.32	18.48	0.000
poor	0.61	0.42	17.63	0.000
low_bmi	0.29	0.22	16.93	0.000
prop4pl	0.18	0.13	12.44	0.000
hindu	0.81	0.73	7.30	0.000
mothage_20	0.14	0.12	6.84	0.000
lat	24.64	23.41	5.22	0.000
vacc	0.58	0.62	-6.48	0.000
urban	0.14	0.25	-12.83	0.000
edu	0.45	0.60	-17.47	0.000
pcfuel	0.17	0.35	-17.81	0.000
ptoilet	0.34	0.53	-18.31	0.000

Finally, we are interested in finding out whether these clusters found by principal component and cluster analysis do indeed have explanatory power with regard to child outcomes. Figure 6 suggests that this is the case. While for cluster 1, children at under age 5 in the median district are on average 84.84 cm tall, in the median district for cluster 3 children at that age measure only 82.86 cm. The median in cluster 2 is on average higher than in cluster 1 by about half a centimetre, yet districts in cluster 2 spreading over two geographically completely separate areas of India are more heterogeneous and the difference between cluster 1 and cluster 2 cannot be said to be significant. Still, comparing height among cluster 1 and cluster 2 with cluster 3, we find no overlap in spreads indicating a clear group difference. 75 % of districts in cluster 3 lie below 75 % of districts in cluster 1 and cluster 2.

Figure 6. Distribution of wasting, stunting, underweight, as well as average height and weight across Indian districts for three different groups of counties identified by cluster analysis



Differences become clearer using the same clusters to identify differences in district level average weight of children below the age of five. Cluster 2 is now clearly very different from cluster 3 as there is almost no district in cluster 2 falling within the 75 % range of district averages in cluster 3. Looking at average weight, it is likely that cluster 1 is different from cluster 2, as the median in cluster 1 no longer reaches the spread of the box around the median for cluster 2. Moreover, districts within cluster 2 are more homogenous with respect to children's weight than with respect to their height, as indicated by the spread of the box. Similarly, children within districts belonging to cluster 3 are more likely to suffer from stunting, wasting and underweight compared to those within clusters 1 and 2. Yet the difference between cluster 1 and cluster 2 is not significant with respect to stunting.

4. Discussion

Since the National Nutritional Anemia Prophylaxis Program (NNAPP) of 1970, several ambitious programs have been implemented in India to tackle childhood malnutrition. In 1976 the government initiated the Integrated Child Development Services (ICDS) scheme, one of the world's largest programs for early childhood care and development. The scheme was implemented to provide children with health, nutrition, and education services from birth to age six, as well as nutritional and health services to pregnant and breastfeeding mothers. More recent initiatives include the National Food Security Mission (NFSM) launched in 2007, as well as the Nutri Farms scheme launched in 2013-14. Yet despite these strong efforts in the past, India continues to score very poorly on the Global Hunger Index and lags behind other developing countries.

One of the reasons for why it takes so long to fully eradicate wasting and stunting is the intergenerational transmission of risk factors. Many societies are caught in a vicious cycle where malnourished girls, lagging behind in developmental terms, grow up to become low BMI mothers whose underweight children again suffer from a larger risk of developmental deficiencies. As described by Onis and Branca (2016), this type of "growth faltering" starts already in utero and continues to affect children's further development throughout their lives leading to increased morbidity and mortality. But it would be wrong to think that the phenomenon affects only those children falling below the specified threshold for stunting and wasting. In fact, the entire length-for-age/height-for-age Z-score distribution is shifted to the left. This has dramatic consequences, most severely for the children affected and their families, but growth faltering also has to be seen from a public health standpoint and affects the development outlook of entire nations as these children will be more likely to suffer from disease and have lower productivity as adults (Sachs, 2001).

The findings present in this study are important for public health planning and for targeting the underlying factors associated with child growth and malnutrition in India. The National Health Mission (NHM) program initiated by the Government of India is continuously working on improving child and maternal health conditions across India and the National Nutritional Mission (NNM) has been set up to give a particular focus on the high priority states (Falcao et al., 2015; Murray et al., 2014). Prioritising efforts within the districts identified as most disadvantaged would help further alleviate the overall burden of malnutrition in India, while potentially increasing the efficiency and lowering the costs of such intervention programs.

Moreover, even intervention programmes that are sensitive to different types of nutritional deficiencies might be ineffective if the underlying determinants of malnutrition are not addressed (Ruel and Alderman, 2013). We therefore encourage the development of multi-sectoral plans to deal with malnutrition at district level by combining direct nutrition interventions with strategies linked to health, family planning, water supply and sanitation, and other factors that affect the risk of malnutrition (Casanovas et al., 2013). Given the scarcity of health resources, the more focused implementation of child-health inducing policy schemes in the identified geographical areas seems all the more germane. Stakeholders within government and international funding agencies should take an integrated approach coordinating efforts toward poverty reduction, increasing female education, improving sanitation, as well as care services provided to mothers and children, especially among the SC/ST communities and in the disadvantaged regions of the country.

5. Conclusion

Previous studies conducted both on India and other developing countries have demonstrated that socio-economic and demographic variables are strongly related with the nutritional status of children, affecting their weight and height (Van de Poel et al., 2008; Kanjilal et al., 2010; Biswas and Bose, 2011). Using PCA and cluster analysis on DHS survey data, in this study we are able to show strong regional clustering among 640 districts of India. Based on household-level information describing children and mothers' living conditions, we find that growing up in the central, particularly rural districts of India yields far worse child outcomes in terms of growth and nutritional development. The same is true for some scattered Northern districts, as well as a few districts in the East. But results suggest a significant advantage for children growing up in any of the districts of Southern India, particularly with respect to height. Looking at average weight, as well as the proportion of children that suffer from underweight and wasting, North-eastern districts seem to be offering living conditions more conducive to healthy child development.

With respect to the specific characteristics that distinguish regional clusters, we find that besides female education and urbanization, access to mass media and usage of clean cooking fuels, improved sanitation and drinking water are the most important determinants of child well-being. On the other hand, low BMI of mothers, household poverty levels, high fertility (as indicated by large proportions of higher order births), predominantly Hindu population, mothers' age at birth below 20 years and lack of immunization are significant determinants of lower child height and weight, as well as higher prevalence of nutritional deficiencies among under-five children.

These results confirm previous findings on the determinants of childhood malnutrition. The phenomenon is more widespread among poorer families in rural areas (Gwatkin et al., 2007; Wagstaff and Watanabe, 2000) where access to food is less secure and living conditions are more likely to lead to infectious diseases and further undernutrition. Moreover, female educational status and BMI have been found to be positively associated with nutritional indicators at the community and regional level in India (Kravdal, 2004; Khan and Mohanty, 2018). Lack of clean water supply and improved sanitation have repeatedly been identified as major drivers of infection and premature mortality (Spears et al., 2013; Rah et al., 2015; Geruso and Spears, 2018) and the possibility to make the necessary amendments to the household's infrastructure are again related to widespread economic inequalities (Pathak and Singh, 2011). One of the many seemingly paradoxical situations in contemporary India is that these observed patterns of nutritional deprivation coincide with increasing prevalence of obesity, not only among children from wealthier families but also among those from the lower social classes where underweight continues to be a major concern (Ranjani et al., 2016).

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