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Original Research Article

Burden and clustering of anaemia among children aged 6-59 months in Uttar Pradesh, India: a district-level spatial analysis

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ABSTRACT

Background: In the previous decade, India held the position of being the foremost contributor to childhood anemia among developing nations. In India, 89 million children aged 6-59 months suffer from anaemia. The study attempts to examine the spatial prevalence and detect the clustering of anaemia in Uttar Pradesh and also tries to identify the determinants of anaemia among children aged 6-59 months.
Methods: The study utilized secondary data from the national family health survey-5 conducted in 2019-2021. It employed spatial analysis software, including ArcGIS 10.8 and GeoDa 1.22, incorporating Moran's index. The assessment of factors predicting the prevalence of anemia among children involved the application of a logistic regression model using STATA-17, considering socio-economic, demographic, maternal, and child characteristics.
Results: The anaemia prevalence is highest in Kanshiram Nagar and lowest in Allahabad districts. A total of 38 districts of Uttar Pradesh have more than national level average (67.1%-NFHS-5) of anaemia. Results also shows that 66.7% and 65.3% children 6-59 months age group were anaemic in urban and rural areas respectively. Around 70.7 % of children belonging to poorest wealth status and 69.4% of children who lived in rural areas were anaemic. Increase of mothers age, education, receipt of full ANC and richer wealth status reduce the risk of childhood anaemia.
Conclusions: The correlation between anemia in preschool-aged children and various socioeconomic factors was significant. The research proposes directing efforts towards districts in Uttar Pradesh identified as hot-spots with a higher prevalence of anemia.

Keywords: Anaemia, Children, Uttar Pradesh, India

INTRODUCTION

Approximately 1.92 billion people, constituting roughly 24.3% of the global population, were living with the burden of anaemia in 2021 (haemoglobin level <11.0 gm/dL) and more than 89% of this burden attributed to the developing countries.[1,2] Globally, it is estimated that 40% of all children aged 6-59 months are affected by anaemia.[3] In 2019, approximately 50 million years of healthy life were lost due to disability, primarily stemming from dietary iron deficiency, thalassaemia, sickle cell trait, and malaria as the leading causes.[4] The global nutrition report has identified 125 countries grappling with the burden of anaemia, with 52 countries experiencing both anaemia and overweight issues. Additionally, 38 countries are contending with the dual challenge of stunting and anaemia.[5]

One of the dominant causes of anaemia, accounting for less than 50% of cases, is iron deficiency.[6] As per WHO report, around 90,000 maternal and neonatal deaths in developing regions were attributed to iron deficiency anaemia in 2013.[7] Such type of anaemia is still a very common problem in South Asian countries, including India, Bangladesh and Pakistan. It causes major serious problems, especially among pregnant and lactating women, children and adolescents.[8] While iron deficiency remains the primary cause of anaemia, other factors such as deficiencies in vitamin A and B12, and infections like hookworm and malaria, also contribute to anaemia among pre-school children.[9] Previous studies on anaemia in low-income and middle income countries have focused on women of reproductive age group and their children because of significant adverse effects associated with anaemia during pregnancy and early childhood including low birth weight, poor cognitive function and maternal mortality.[10-12] Anaemia among children has also been indirectly correlated with developmental stage of a region, as evidenced by region-specific data.[13]

India emerged as the leading contributor to childhood anaemia among developing nations over the past decade and economic action group (EAG) states account for roughly 70% of anaemic children across the nation.[9,13,14] Anaemia among preschool children is caused by insufficient consumption of iron, folates, vitamin A, B12, and micronutrients, in addition to malaria infections.[9,15] According to world bank, the prevalence of anaemia among under 5 children, in India was 59% in 2011 while the national family health survey (NFHS-5) reported it as 67%.[6,16] Similarly, it shows rising trend in Uttar Pradesh (one of the EAG states of India), the prevalence of anaemia in the pre-school children increased from 63% (NFHS-4) to 66% (NFHS-5).[16,17] The literature indicates that increased prevalence of anaemia among children in India is linked to factors such as low household income, lower maternal education, and the mother's anaemic status.[18] Moreover, special attention should be given to children residing in rural areas, as they face an elevated risk of anaemia. The risk of anaemia among children may be mitigated through factors such as maternal education, nutrition, and implementation of birth control measures.[19]

To the best of our knowledge, very few studies are available in literature on anaemia among children (6-59 months) in Uttar Pradesh. A geospatial analysis along with the risk factors of childhood anaemia in India will help to reduce the burden of anaemia in highly vulnerable districts of Uttar Pradesh. In view of this present study has attempted to determine the prevalence and detect the spatial clustering of anaemia in this age-group of children. The study also seeks to investigate the risk factors associated with childhood anaemia in state of Uttar Pradesh. Thus, this study tries to identify the higher prevalence and hot-spot districts along with factors which may help in decline of this morbid condition among children in India. This study enabled early identification of anaemia in these children, enabling development of targeted interventions tailored to specific regions.

METHODS

Data source

The present study is based on the data from NFHS-5 conducted in the year 2019-21 by the international institute for population sciences (IIPS), Mumbai. The NFHS-5 was a nationwide representative sample survey of 636,699 households, 724,115 women in the age group 15-49 years. Multistage stratified sampling design has been used for the survey and it provides the estimation of clinical, anthropometric and biochemical (CAB) components along with the prevalence of diabetes, hypertension, malnutrition and HIV through the biometric measurements.

In NFHS, 2019-21 haemoglobin testing was performed on all children aged 6-59 months in the sample households using capillary blood method. As per the standards of NFHS, children were considered as anaemic when their haemoglobin level was below 11.0 g/dL; as mildly anaemic with 10.0-10.9 g/dL, moderately anaemic with 7.0-9.9 g/dL and as severely anaemic with less than 7.0 g/dL. As, the study is focused on Uttar Pradesh, hence total sample size utilised for the study was of 18,351 last born children aged 6-59 months.

Outcome variables

The study has used prevalence of anaemia among children as the dependent variable. This study variable is dichotomous with 1 considered as "anaemic" and 0 considered as "not anaemic".

Independent variables

A set of background characteristics of the households along with factors associated with child and mother have been used based on existing literature and availability of data. Residence, religion, caste, wealth quintile, regions have been taken as key background characteristics having implications for the variation in the prevalence of anaemia among children. Similarly, age of mother (less than 25 years, 25-35 years and 36 years and above), education of mother, mother's anaemia status (haemoglobin level below 12.0 g/dL considered as anaemic and a level equal to or more than 12.0 g/dL as not anaemic), mother's nutritional status/BMI (Body mass index), IFA (Iron folic acid) tablet intake (yes, no) and number of ANC (Antenatal care) visit during pregnancy have been used as maternal factors in the study. Factors related to children included age of the child, sex of the child, experience of diarrhoea (in last 2 weeks), birth order, birth order, low birth weight (<2.5 kilograms).

Statistical analysis

We have chosen individual and district as the unit of analysis for bivariate and spatial analysis respectively. The analysis of this study has been completed in two parts. Firstly, bivariate analysis has been carried out to establish the relationship between anaemia prevalence and its contextual determinants. Incorporating insights from the aforementioned literature review and previous research, this study has utilized explanatory variables.

After checking for multi-collinearity, four binary logistic regression models have been applied to test the effect of confounding factors associated with the occurrence of anaemia. Multi-collinearity occurs when independent variables in a regression model are correlated with each other. If the degree of correlation between variables is high enough, it can cause problems when researcher tries to fit the model and interpret the results. In this analysis, the variance inflation factor (VIF) has been used to check for multi-collinearity. Here first a normal linear regression is first run and then after obtaining the normal R squared value the VIF is calculates as: $VIF= 1/(1-R^2)$

The analysis assessed the statistical significance of variation in anaemia prevalence, utilizing adjusted odds ratios along with 95% confidence intervals across three models of predictor variables. The entire analysis has been carried out using STATA 17.

Secondly, the research employed spatial analysis software including ArcGIS 10.8 and GeoDa 1.22 to examine geographical disparities and identify spatial clusters of child anaemia across India's districts. By conducting exploratory spatial data analysis (ESDA), the study aimed to detect clustering patterns, spatial heterogeneity, and spatial correlation in the prevalence of anaemia. The geographical information system (GIS) and spatial statistical technique based on ESDA are useful in terms of describing and representing spatial distribution, detecting hot-spot and cold-spot areas and suggesting spatial regimes or other forms of spatial heterogeneity.[20] The computation of spatial auto-correlation requires the construction on the bases of weight matrix known as spatial weight matrix (W). First order queen contiguity matrix has been used as the weight for the analysis purpose. The dependent variable for the analysis is the district wise percentage of anaemia among children aged 6-59 months. The independent variables include district wise percentage of first order birth, percentage of educated mothers, percentage of women with no ANC visit, percentage of women taking IFA tablets during pregnancy, percentage of anaemic women, percentage of women living in urban area, percentage of women belonging to poorest wealth quintile, percentage of currently mother's less than 20 years age, percentage of underweight mothers, percentage of low-birth-weight children. The percentage distributions of above-mentioned independent variables have been estimated for all 75 districts of Uttar Pradesh.

This study has used Moran's I (spatial autocorrelation) and local indicators of spatial autocorrelation (LISA) to measure the extent of autocorrelation among the neighbourhood districts in the state. Moran's I help in measuring the intensity of clustering (z-score) with increasing distance. Furthermore, LISA statistics has been applied to detect the hot-spot areas across a district considering the percentage of children suffering from anaemia. The LISA values consent the computation of its similarity with its neighbouring districts and also test the level of significance (p values) for each location. LISA map portrays results in five scenarios-cluster with high values (high-high or hot spot), cluster with low values (low-low or cold spot), outlier in which a high value is surrounded by a low value (high-low), outliers wherein a low value is surrounded by a high value (low-high) and lastly no significant local autocorrelation.

The analysis employed the spatial error model within GeoDa to explore the spatial relationship between the dependent variable and independent variables.[21] This model assess the clustering of an outcome variable that is not explained by the independent variables. Spatial clustering is explained with reference to clustering of the error terms. This model can be mathematically expressed as: $Y=Xb + u$, with, $u= m.W.u+e$

Where, u=the model prediction error; e are the residues (spatially uncorrelated); m=the spatial auto regressive parameter; and W is the spatial weights matrix (queen contiguity weight matrix).

RESULTS

Prevalence of anaemia among children aged (6-59 months) with geographical variation

Figure 1 illustrates the spatial prevalence of anaemia across the districts (total 75) of Uttar Pradesh. About half of the districts i.e., 36 out of the 75 districts of the state have reported more than the national average of prevalence of childhood anaemia (67.1%). Looking to spatial variance, the map (Figure 1) shows that 16 districts have reported <60% prevalence level of anaemia and 37 districts reported the level of anaemia ranging from 60% to 72%; the remaining 22 districts reported >72% prevalence of anaemia in the year 2019-21. The high prevalence districts come from central and east parts of Uttar Pradesh mostly from Central (Avadh) region.

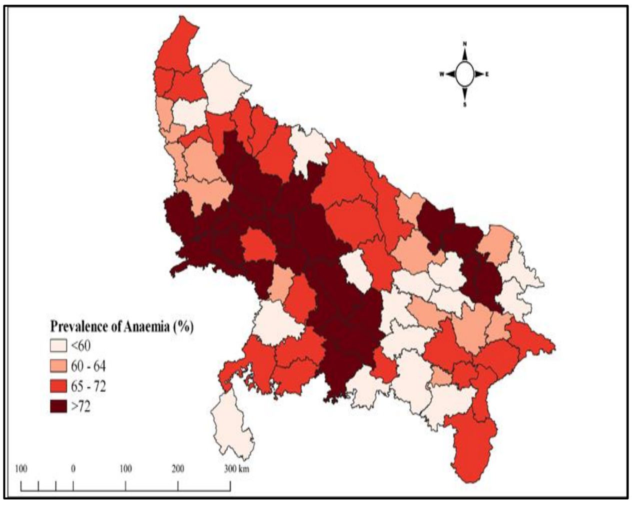

Figure 1: Spatial prevalence of anaemia among children (6-59 months) in Uttar Pradesh (2019-21): a district level map.

Spatial clustering of anaemia in districts of Uttar Pradesh

Moran's index statistics of spatial autocorrelation illustrations that prevalence of anaemia in the districts of Uttar Pradesh as a cluster (Moran's Index is 0.23) and the results are also highly significant (p<0.001) (Figure 2).

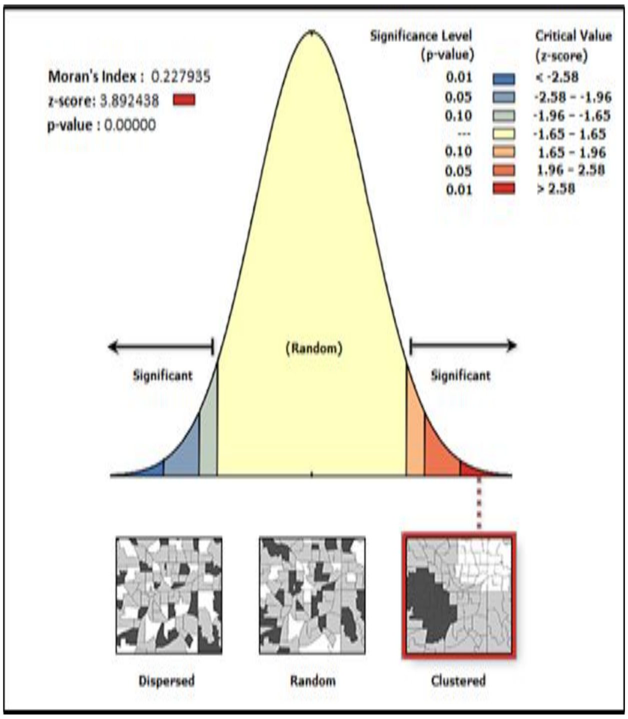

Figure 2: Graphical presentation of the result of spatial autocorrelation of anaemia prevalence among children (6-59 months) in districts of Uttar Pradesh, 2019-21.

Based on this result, the LISA map has identified the probable hot-spot areas of anaemia prevalence among children at district level in Uttar Pradesh (illustrated in Figure 3). In Figure 3, map (A) represents the clustering levels in the clustering levels in the prevalence of childhood anaemia, and map (B) depicts the significance levels of clustering. The hotspots (high to high) are shown in the red in colour depicting that districts with a higher prevalence of anaemia are surrounded by neighbouring districts with greater levels of anaemia among children. On the other side, cold spots (low to low), given in blue colour are the districts with lower levels of anaemia prevalence which also have neighbouring districts with lower levels of anaemia.

A total of 11 districts belong to the hotspot (cluster with high anaemia prevalence) areas which are mostly from central and western parts of the state. While, 7 districts are from cold spot areas from southern part of Uttar Pradesh. The level of significance map shows that around 19 districts are reported in cluster with less than 5% of significance level.

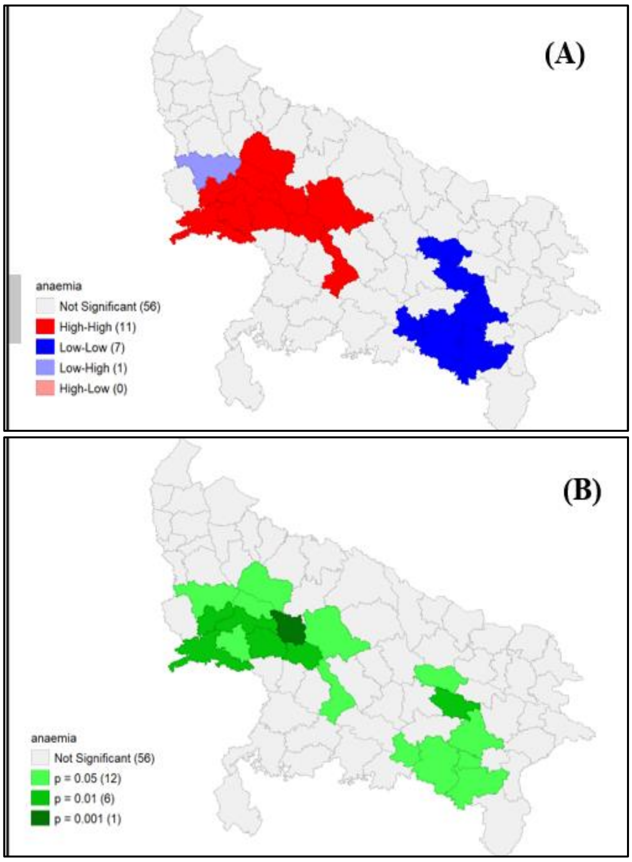

Figure 3 (A and B): Univariate LISA cluster and LISA significance map of anaemia disease in districts of Uttar Pradesh, 2019-21.

Prevalence of childhood anaemia (6-59 months) with background characteristics

As showed in Table 1, the prevalence of anaemia among children aged 6-59 months was relatively higher among the rural residents (69.4%) as compared to the urban counterpart. It was the lowest among Hindus (68%). The SC group showed the highest percentage of such children (69.8%). The economic factor showed the results in the expected way with highest prevalence of anaemia among children belonging to the poorest class (70.7%). The regional variations ranged from the lowest i.e., 66.3% of anaemic children reported in the Bundelkhand region to the highest i. e., 72.33% of anaemic children reported in the central (Avadh) region of Uttar Pradesh.

Furthermore, anaemia prevalence was the highest among the children of very young mothers i. e., whose current age was <25 years (73.5%) and illiterate mothers (70.7%). Additionally, mothers who were anaemic also had a much higher percentage of anaemic children (73.1%) as compared to those children (63.4%) whose mothers were not anaemic. Similarly, the study also reveals that prevalence of anaemia is relatively higher among children whose mothers are underweight (72.3%), mothers who did not received ANC (74.6%), and did not take IFA tablets (69.8%) during pregnancy.

The anaemic condition of children is the lowest among the age-group 36 to 59 months (56.2%), which depicts the anaemic condition of children improved with the advancement in age. Anaemia also shows relation with diarrhoea as it is higher (73.6%) among children who also had diarrhoea. Similarly, anaemia prevalence is more among the children born with low weight (<2.5 kg) (71.2%) and is the highest among the children who belonged to the third and above birth order (69.5%).

Childhood anaemia among children (6-59 months) and its contextual determinants in India

Table 2 presents the logistic regression results for prevalence of anaemia among children after controlling for all the background characteristics. Among socio-economic variables, (Table 2) the adjusted odds of children suffering from anaemia is 1.12 times more likely among Muslims as compared to Hindus. The children from OBC (OR:0.89; CI:0.83, 0.96) than Others social groups. Children of rich quintile household are markedly less likely to experience anaemia (OR: 0.89; CI:0.78, 1.03) as compared to poor household children. Children from Central region (OR: 1.18; CI:1.05, 1.32) of Uttar Pradesh is more likely to suffer from anaemia as compared to those from Western region.

Among the maternal characteristics, (Table 2) with increasing age of the mother, the likelihood of suffering from anaemia gets reduced. Primary (OR:0.94; CI: 0.86, 1.02) and higher level (OR:0.79; CI:0.70, 0.88) educated mothers are less likely to be associated with childhood anaemia for their children as compared to illiterate mothers. Anaemic mothers increased the chances of anaemia among their children by 1.50 times. Four times visit to ANC (OR:0.76; CI:0.65, 0.89) during pregnancy reduces the risk of childhood anaemia.

In case of children's characteristics, (Table 2) children aged 12-23 months (OR: 1.25; CI: 1.11, 1.40) were more vulnerable and those with 24-35 months (OR:0.82; CI:0.73, 0.93) and 36-59 months (OR:0.43, CI: 0.39, 0.48) were less likely to be associated with anaemia as compared to 6-11 months aged children. In case birth weight, children born with less than 2.5 kilograms of weight (OR:1.10; CI:1.00,1.20) were at higher risk of suffering from anaemia. An increasing birth order increases the risk of anaemia among children.

Spatial autocorrelation

Table 3 represents the Moran's Index values for the dependent and independent variables included in the analysis. The Moran's I for anaemia is 0.228. It indicates moderate spatial autocorrelation in anaemia among children over the districts of Uttar Pradesh. Spatial autocorrelation is positive when similar values occur neighbourhood of one another in space. Moran's I highest for poorest wealth quintile (0.598) and lowest for the No ANC visit (0.194). Some of the independent variables have a Moran's I value more than 0.50. These include percentage of educated mothers (0.565), poorest (0.598), and underweight women (0.572), followed by percent of anaemic mothers (0.436) and percent of children with low birth weight (0.379).

Spatial error model

In order to examine whether a value observed in one location depends on the values observed at neighbouring location such as spatial dependency, for this spatial error model has been used which is showed in Table 4. The model shows spatial clustering while examining association between childhood anaemia and independent variables. It is seen from the model that first order birth had positive relation with anaemia. Women not received any ANC during their pregnancy also had a positive relation with anaemia among children. Underweight mothers had a positive relation while, intake of IFA tablet showed a negative relation. Educated mothers had a negative relation with anaemia among their children, while anaemia mother showed a highly positive relation with childhood anaemia. The spatial autocorrelation is indicated by the lambda value of 0.492 which indicates that there is spatial dependence among variables.

Bivariate LISA maps

Figure 4 presents bivariate maps illustrating the association between childhood anaemia and various independent variables in Uttar Pradesh. Among these variables are the percentage of educated women, first-order births, women with no ANC visit during pregnancy, women taking IFA tablets during pregnancy, underweight women, those from the poorest wealth quintile, mothers under 20 years, urban residents, and children born with low birth weight. In Figure 4 (A), a high-high association between birth order and anaemia is evident in four western districts, with lower first-order birth percentages associated with higher anaemia rates in eight districts and vice versa in four southern districts. Figure 4 (B) reveals that lower percentages of educated mothers are linked to higher childhood anaemia rates in seven western districts, while higher education rates correlate with lower anaemia rates in five southern districts. Figure 4 (C) shows a high-high association between no ANC visit and anaemia in seven western and central districts, while five southern districts exhibit lower rates of both variables. In Figure 4 (D), a higher percentage of anaemic mothers corresponds to higher childhood anaemia rates in 12 central districts, while lower rates of both variables are seen in four southern districts. Figure 4 (E) indicates that higher urban population percentages are associated with higher childhood anaemia rates in four western districts, while lower urban population percentages correlate with higher anaemia rates in eight western districts. Figure 4 (F) displays a high percentage of mothers under 20 years and childhood anaemia in ten west-central districts, while lower rates of both are observed in seven districts. Figure 4 (G) shows six districts with a high percentage of mothers belonging to poorest wealth status and high childhood anaemia rates. In Figure 4 (H), a high-high association between underweight mothers and childhood anaemia is found in 5 districts, while low-low association is observed in four southern districts. Figure 4 (I) demonstrates low-high association between IFA intake by mothers and childhood anaemia in ten western and central districts. Figure 4 (J) illustrates the association between low birth weight and childhood anaemia, with higher low birth weight percentages correlating with higher anaemia rates in 10 districts, and lower percentages associated with lower anaemia rates mainly in southern districts.

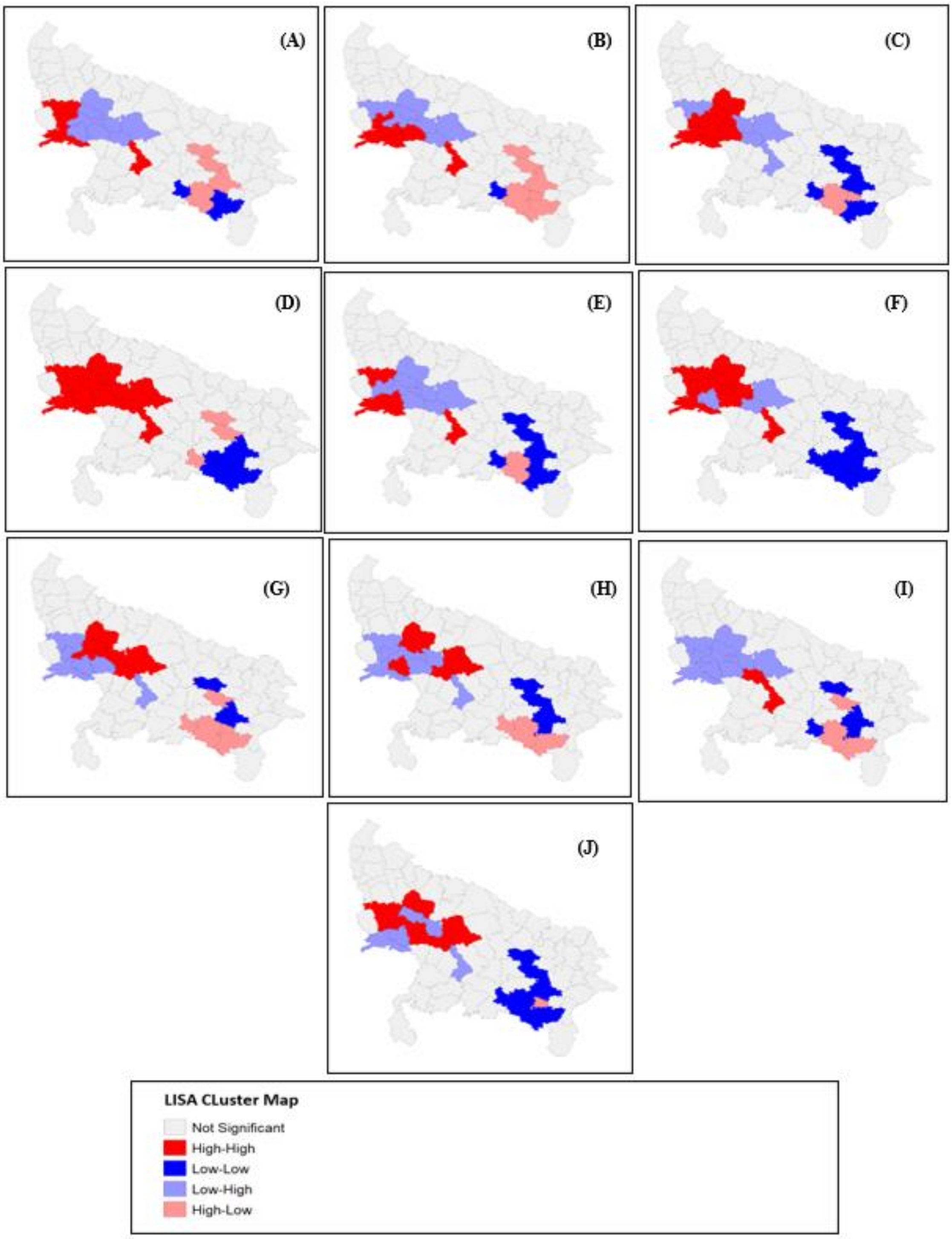

Figure 4 (A-J): Bivariate LISA cluster maps depicting spatial clustering ans spatial outliers of anaemia by different determinants: Birth order and anaemia, educated mothers and anaemia, no ANC visits and anaemia, anaemic status of mothers and anaemia, residing in urban area and anaemia, mother's age less than 20 years and anaemia, poverty and anaemia, underweight status of mothers and anaemia, IFA tablet intake and anaemia, low birth weight and anaemia across 75 districts of Uttar Pradesh, 2019-21.

Table 1: Percent distribution of last-born children (6-59 months) with anaemia by some selected background characteristics in Uttar Pradesh, 2019-21.

Background characteristics	Prevalence of anaemia (%)	N	Chi2-p value
Socio-economic characteristics			
Place of residence			
Urban	66.63	3893	0.178
Rural	69.40	14458	
Religion			
Hindu	68.24	15289	<0.001
Muslim	71.63	2997	
Others	74.39	65	
Caste			
SC	69.78	5048	0.019
ST	66.44	351	
OBC	68.03	9557	
Others	69.81	3395	
Wealth index			
Poorest	70.68	4604	<0.001
Poor	69.87	4483	
Middle	69.05	3363	
Richer	68.74	2989	
Richest	64.02	2912	
Region			
Western region	69.61	4547	<0.001
Central (Avadh) region	72.33	3009	
Bundelkhand	66.62	893	
Eastern region	67.58	9902	
Maternal characteristics			
Age of mother (in years)			
Less than 25	73.46	4279	<0.001
25-35	67.5	12526	
36 and above	66.58	1546	
Mother's education level			
No education	70.7	5288	<0.001
Primary	69.11	445	
Secondary	69.68	9382	
Higher	63.18	3236	
Mother's anaemic status			
No	63.38	8068	<0.001
Yes	73.11	10283	
BMI of mother (kg/m^2)			
Underweight	72.29	3031	<0.001
Normal	69.22	11631	
Overweight	64.6	3689	
No. of ANC visits			
No visit	74.57	1012	<0.001
Up to 4 visits	68.54	13307	
More than 4 visits	68.26	4032	
IFA tablet			
No	69.8	2823	0.163
Yes	68.6	15528	
Children characteristics			
Sex of child			
Male	68.78	9998	0.643
Female	68.84	8353	

Continued.

Background characteristics	Prevalence of anaemia (%)	N	Chi2-p value
Age of child (months)			
6 to 11	74.41	2493	<0.001
12 to 23	79.15	5292	
24 to 35	71.19	4322	
36 to 59	56.17	6244	
Diarrhoea[a]			
No	68.48	17164	<0.001
Yes	73.59	1187	
Birth order			
First	67.02	4790	0.081
Second	69.02	5901	
Third and above	69.54	7660	
Birth weight (kg)			
Less than 2.5	71.16	3101	<0.001
More than 2.5	68.34	15250	

SC: Scheduled caste, ST: Scheduled tribe, OBC: Other backward classes; [a]Children had diarrhoea within last 2 weeks from survey date.

Table 2: Regression models show odds of having anaemia among children (6-59 months) with background characteristics in Uttar Pradesh, India, 2019-21.

Background characteristics	uOR		aOR	
	OR	95% CI	OR	95% CI
Socio-economic characteristics				
Place of residence				
Urban®				
Rural	1.02	[0.95, 1.09]	1.06	[0.96, 1.17]
Religion				
Hindu®				
Muslim	1.10**	[1.02, 1.17]	1.11*	[1.01, 1.23]
Others	1.39	[0.85, 2.29]	1.73	[0.92, 3.24]
Caste				
SC	1	[0.92, 1.08]	0.89*	[0.80, 0.99]
ST	0.93	[0.77, 1.13]	0.87	[0.68, 1.12]
OBC	0.91**	[0.85, 0.98]	0.84***	[0.77, 0.92]
Others®				
Wealth index				
Poorest®				
Poor	0.95	[0.89, 1.02]	0.99	[0.90, 1.09]
Middle	0.94	[0.87, 1.02]	0.99	[0.89, 1.10]
Richer	0.94	[0.87, 1.02]	0.97	[0.86, 1.10]
Richest	0.81***	[0.75, 0.89]	0.89	[0.78, 1.03]
Region				
Western region ®				
Central (Avadh) region	1.13**	[1.03, 1.24]	1.18**	[1.05, 1.32]
Bundelkhand	0.84***	[0.76, 0.93]	0.86*	[0.76, 0.98]
Eastern region	0.91**	[0.86, 0.98]	0.95	[0.87, 1.04]
Maternal characteristics				
Age of mother (in years)				
Less than 25®				
25-35	0.79***	[0.74, 0.84]	0.98	[0.89, 1.08]
36 and above	0.78***	[0.70, 0.87]	1.01	[0.87, 1.18]
Mother's education level				
No education®				
Primary	0.93	[0.79, 1.10]	0.9	[0.72, 1.11]
Secondary	0.93*	[0.88, 0.99]	0.94	[0.86, 1.02]
Higher	0.78***	[0.72, 0.85]	0.79***	[0.70, 0.88]

Continued.

Background characteristics	uOR		aOR	
	OR	95% CI	OR	95% CI
Mother's anaemic status				
No ®				
Yes	1.59***	[1.51, 1.68]	1.50***	[1.41, 1.61]
BMI of mother (kg/m^2)				
Underweight ®				
Normal	0.90**	[0.84, 0.97]	0.94	[0.86, 1.04]
Overweight	0.78***	[0.71, 0.85]	0.9	[0.80, 1.00]
No. of ANC visits				
No visit ®				
Up to 4 visits	0.77***	[0.66, 0.89]	0.76***	[0.65, 0.89]
More than 4 visits	0.74***	[0.64, 0.87]	0.76**	[0.65, 0.90]
IFA tablet				
No ®				
Yes	0.94	[0.86, 1.03]	0.95	[0.87, 1.05]
Children characteristics				
Sex of child				
Male®				
Female	0.97	[0.92, 1.02]	0.92**	[0.86, 0.98]
Age of child (months)				
6 to 11®				
12 to 23	1.25***	[1.12, 1.39]	1.25***	[1.11, 1.40]
24 to 35	0.82***	[0.74, 0.92]	0.82**	[0.73, 0.93]
36 to 59	0.43***	[0.39, 0.48]	0.43***	[0.39, 0.48]
Diarrhoea [a]				
No ®				
Yes	1.38***	[1.23,1.56]	1.19*	[1.03, 1.36]
Birth order				
First®				
Second	1.06	[0.99, 1.13]	1.03	[0.94, 1.13]
Third and above	1.14***	[1.07, 1.21]	1.1	[0.99, 1.22]
Birth weight				
Less than 2.5 kg	1.16***	[1.08, 1.24]	1.10*	[1.00, 1.20]
More than 2.5 kg ®				

uOR: Unadjusted odds ratio; aOR: Adjusted odds ratio; CI: Confidence interval; aChildren had diarrhoea within last 2 weeks from the survey date; Exponentiated coefficients; 95% confidence intervals in brackets; *p<0.05, **p<0.01, ***p<0.001.

Table 3: Moran's I of the dependent and independent variables.

Selected variables	Moran's I
Anaemia	0.228
Birth order	0.156
Educated mothers	0.565
No ANC visit	0.194
Anaemic mothers	0.436
Urban	0.277
Mother's age less than 20 years	0.251
Poorest	0.598
Underweight mothers	0.572
IFA tablet	0.229
Low birth weight	0.379

Table 4: Results of spatial error model.

Selected variables	Spatial error regression coefficient (SER)	Probability
Birth order	0.159094	0.52201
Educated mothers	-0.346538	0.00117

Continued.

Selected variables	Spatial error regression coefficient (SER)	Probability
No ANC visit	0.236262	0.16044
Anaemic mothers	0.325895	0.00247
Urban	-0.0174243	0.80051
Mother's age less than 20 years	-0.024171	0.31209
Poorest	-0.0793789	0.38201
Underweight mothers	0.0173838	0.93314
IFA tablet	-0.166221	0.35609
Low birth weight	0.0185159	0.92816
Constant	55.3586	0.00251
Spatial Autocorrelation	0.492232	
R2/pseudo R2	0.411875	
No. of observations	75	

DISCUSSION

In Uttar Pradesh 66.7% of children less than 5 years are living with anaemia in 2019-21 and girl child are suffering more from anaemia. The prevalence is highest in the Kanshiram Nagar and Etah districts. The reason for this is not clear, but it might be due to an improper diet, childhood illness such as diarrhoea, worm infections or lack of nutritious food and iron supplementation.[22-25] The present study reveals a remarkable geographical variation in the risk of childhood anaemia in the districts of Uttar Pradesh. Higher prevalence rates are observed in districts like Kanshiram Nagar, Firozabad, Agra, and Bareilly in Uttar Pradesh. On the other hand, Mirzapur (58.6 %) and Lucknow (54 %) districts show a low level of anaemia among 6-59 months of children.

The study finds that the prevalence of anaemia is the highest in the central (Avadh) region of Uttar Pradesh. Around 50% of the total districts of Uttar Pradesh are having more than the national level of anaemia disease in children. The study also finds the medium level of clustering of anaemia in the districts with 0.228 Moran's Index, which means spatial auto-correlation exists between neighbourhood districts in Uttar Pradesh. Total 11 districts have been identified as the hot-spot areas from central and western parts of the state and 19 districts out of 75 districts show <0.05% level of significance.

Among socio-economic variables, children from a Muslim religious background are more likely to suffer from anaemia compared to Hindus, consistent with a previous study.[26] Regarding the household wealth index children from poorest households were more likely to suffer from this morbid condition as compared to those from rich households.[27] Children from central districts of Uttar Pradesh at the higher risk of anaemia than other regions. This discrepancy may stem from socioeconomic factors, including limited access to nutritious food and healthcare services. Dietary habits in these areas may lack diversity and sufficient intake of iron-rich foods.[28]

As regards the maternal characteristics, the increase in age of mother, education level of mother, and receipt of all of the ANC visits reduce the prevalence of anaemia among children.[19,26,29-31] Contrarily, mothers who are anaemic and underweight are more likely to have children with anaemia.[14,26,27,32] Children aged 12-23 months are more vulnerable to suffer from anaemia as compared to other age groups, this finding also in line with some previous studies.[26,29]Additionally, underweight children and a higher birth order elevate the risk of childhood anaemia.[19,26,29,33]

The present research is based on the certain assumption while applying the GIS tool. The study suggests targeting the hot-spot districts with a high prevalence of anaemia in Uttar Pradesh. Additionally, the highlighted determinants of childhood anaemia in this study offer valuable insights for the formulation of targeted policy interventions at a systematic level. Such analysis can provide region-specific spatial information which can help in decision making, policy formulation and effective assessment of anaemia prevention and control among children.

CONCLUSION

The current research not only sheds light on significant geographical disparities concerning anaemia in Uttar Pradesh but also delves into the contextual factors influencing its prevalence. It emphasizes the necessity for comprehensive intervention plans aimed at educating mothers about the detrimental effects of anaemia. As per the results, the study suggests that public health programs should focus on districts identified as hot spots with a high prevalence of anaemia .Moreover, the study underscores that the objectives of national programs like the national nutritional anaemia programme (1970), integrated child development schemes (1975), and anaemia mukt bharat programme (2018) could yield improved outcomes by implementing targeted strategies specifically tailored for regions identified as underperforming districts in this study.

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