

RESEARCH ARTICLE

A SPATIAL ANALYSIS OF CHILD HEALTH IN NORTH-EAST STATES, INDIA: EVIDENCE FROM NATIONAL FAMILY HEALTH SURVEY 4 (2015-16).

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Abstract

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Received: 26 April 2017 Final Accepted: 28 May 2017 Published: June 2017 Background: The future of a nation depends on the children and it's our responsibility to ensure their healthy growth. Newborns are particularly vulnerable and children are vulnerable to malnutrition and infectious diseases, many of which can be effectively prevented or According to WHO, nearly 6.9 million children under the treated. age of five died in 2011 - nearly 800 every hour-but most could survive threats and thrive with access to simple, affordable interventions. The risk of death is highest in the first month of life. Preterm birth, birth asphyxia and infections cause most newborn deaths. This paper attempts to assess the spatial patterns of utilization of child health care services across the districts of North-East states, India and to acquire a statistical intra-assessment of relatively high and low performing areas with respect to geographically proximal areas. Data and Methods: We used National Family Health Survey-4(2015-2016) fact sheets data on child health indicators for 87 districts of North-East states. India. Applied spatial analysis: Moran's-I and LISA to assess the child health indicators across the districts. Result: All the indicators depicted striking coverage variation across the North-East states, India in this analysis. Among all the North-East states, the lowest prevalence of full immunization was observed in Arunachal Pradesh and Nagaland; Vitamin-A in Manipur, Arunachal Pradesh and Nagaland. The prevalence of stunting and wasting was observed to be very high in Meghalaya and underweighted children were observed in Tripura, Nagaland, Arunachal Pradesh, Assam and Meghalaya.

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Background

Children represent the future, and ensuring their healthy growth and development ought to be a prime concern for all societies. Children particularly newborns are vulnerable to malnutrition and infectious diseases, many of which can be effectively prevented or treated. According to WHO, nearly 6.9 million children under the age of five died in 2011 but can be saved if provided access to simple and affordable interventions^[1]. The risk of death is highest in the

Corresponding Author: Kh. Jitenkumar Singh. Address: National Institute of Medical Statistics, ICMR, New Delhi. first month of life. Preterm birth, birth asphyxia and infections cause most newborn deaths. Child health status varies by both race and ethnicity, as well as by family income and related factors including educational attainment among household members^[2,3]. Health risks to newborns are minimized by: quality care during pregnancy; safe delivery by a skilled birth attendant; and strong neonatal care: immediate attention to breathing and warmth, hygienic cord and skin care, and early initiation of exclusive breastfeeding. Globally, 30% of children under five are estimated to be stunted and 18% have low weight-for-height, and 43 million children are overweight. Optimal breastfeeding could save the lives of 1.5 million children under five every year. Nearly nine million children die every year from preventable diseases and infections. From one month to five years of age, the main causes of death are pneumonia, diarrhoea, malaria and measles. Over two million children die every year from preventable diseases in India. IMR in India is 63 deaths for every 1000 live births. Of these 47% of the deaths occur within the first week after birth. Malnutrition in childhood is also one of the biggest contributor in child mortality and estimated to contribute more than one third of all child deaths. Under-five year mortalities were 87.7% in Arunachal Pradesh, 85% in Assam and 70.5% in Meghalaya according to NFHS-3 (2005-2006)^[4]. Anaemic children perform worse on cognitive measures than non-anaemic children^[5]. Measles is the largest cause of death among children which can be prevented by a vaccine. Tetanus in newborns remains a major problem Uttar Pradesh, Madhya Pradesh, Rajasthan, West Bengal, and Assam (UNICEF India). Data shows 24.5% of new mothers initiated breastfeeding in the hour after birth, 46.4% breastfed exclusively the first six months and 56.7% nursed beyond six months with the introduction of complementary food (NFHS-3). This results in more than 50% the child population below five being underweight. 44.9% of the children under three are stunted and 22.9% of children under three are wasted. Less than 50% of children receive full immunization during infancy. This number has been dropping significantly over the years indicating a problem with the universal immunization programme. Even though there are various government programmes and schemes to address the nutritional needs of school going children in the age group of 6-14 years for e.g. Mid- Day Meal (MDM) Scheme. The Integrated Child Development Scheme (ICDS), however, there is a need to examine these for their outcomes so as to ensure greater focus on child through improvements in existing schemes and suggest new holistic interventions. Some of the indicators of child health are full immunization, BCG, DPT, polio, measles, Hepatitis B, vitamin A, public health facility, stunting, wasted, underweight and child anaemia. The North-East states of India comprised of eight small states namely Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. The region is physically isolated from the rest of the country due to mountains terrain and poor infrastructure and inhabited by numerous tribal and ethnic groups, has diverse sociocultural practices. These indigenous people live mostly in rural areas and mountainous terrain in traditional thatched roof huts without basic amenities. The lack of basic amenities and diverse sociocultural practices is directly or indirectly responsible for the child health in North-East region. Geographical variations in the child health can reveal inequities between and within states. In North East states, immunization coverage is very poor and prevalence of underweight among children is still high. The purpose of this paper is to study the spatial patterns of child health in order to understand the prevalence and patterns of the various child health indicators. Hence, the aim of the study is to visualize the spatial patterns of child health across the districts in North-East states. And to identify areas with statistically significant clustering of high values (hot-spots) or low values (cold-spots), as well as spatial outliers.

Data and Methods:-

The present study was based on a publicly available National Family Health Survey (NFHS-4), 2015-16 fact sheets data. NFHS-4, the fourth in the NFHS series, provides information on population, health and nutrition for India and each state/ Union territory. NFHS-4 was conducted under the stewardship of the Minister of Health and Family Welfare, coordinated by the International Institute for Population Sciences, Mumbai. The survey covered a range of health-related issues, including child health, maternal, fertility, malaria, reproductive health, infant and child mortality, non-communication diseases and HIV knowledge. The NFHS-4 fact sheets provide information on key indicators of all the districts. And helps to produce reliable estimates of most indicators for rural, urban and total of the districts as a whole^[6]. We obtained fact sheet data for selected child health indicators of 87 districts of 8 states in North-East states viz., 27 in Assam, 16 in Arunachal Pradesh, 9 in Manipur, 7 in Meghalaya, 8 in Mizoram, 12 in Nagaland, 4 in Sikkim and 4 in Tripura, respectively.

Spatial Analysis:-

Spatial analysis refers to "a general ability to manipulate spatial data into different forms and extract additional meaning as a result". Specifically, spatial analysis comprises a body of techniques "requiring access to both the locations and the attributes of objects" ^[7]. Spatial statistics quantify geographic variation in geographic variables,

and it can identify violations of assumptions of independence required by many epidemiological statistics; and measure how populations, their characteristics, covariates and risk factors vary in geographic space.

Spatial Autocorrelation:-

Spatial autocorrelation analysis was applied to summarise the extent to which persons with a similar health status tend to occur next to each other i.e., form spatial clusters^[8]. Spatial autocorrelation statistics depend on the definition of neighbourhood relationships through which the spatial configuration of the sampled subpopulation was defined prior to analysis. High or low values for a random variable tend to cluster in space (positive spatial autocorrelation) or location tend to be surrounded by neighbours with very dissimilar values (negative spatial autocorrelation). We used a binary weight matrix to assign weights to the neighbours. This binary weight matrix assigns a weight of unity for neighbours and zero for non-neighbours. The spatial patterns were investigated by global measures that allowed for spatial autocorrelation among districts that are spatially contiguous. The first measure used in this study is global Moran's *I*, which gives an indication of the overall spatial autocorrelation of a dataset. The second measure is a local indicator of spatial association (LISA) measure of local Moran's *I*, which indicates the "presence or absence of significant spatial clusters or outliers for each location" in a dataset.

Moran's I

Moran's statistics: Global spatial autocorrelation, measured by Moran's I, captures the extent of overall clustering or quantify the degree of spatial autocorrelation that exists in a dataset across all the districts. A Moran's I value near +1.0 indicates clustering; 0 indicates randomness; and a value near -1.0 indicates dispersion. The value of Moran's I statistics ranges from -1 to 1, where positive values indicate observations with similar values being close to each other and negative values suggest observations with high values are near those with low values, or vice-versa.

Moran's I can be depicted in a scatter plot categorized into 4 groups as-

High-high: High values surrounded by high values Low-high: Low values surrounded by high values Low-low: Low values surrounded by low values High-low: High values surrounded by low values

High-high, low-low is positive autocorrelation and high-low, low-high is negative autocorrelation. Moran's I is defined as

$$I = \frac{N}{\sum_{i} \sum_{j} w_{ij}} \frac{\sum_{i} \sum_{j} w_{ij} (X_{i} - \bar{X}) (X_{j} - \bar{X})}{\sum_{i} (X_{i} - \bar{X})^{2}}$$

where N is the number of spatial units indexed by I and j; X is the variable of interest; \overline{X} is the mean of X; and W_{ij} is an element of a matrix of spatial weights.

The expected value of Moran's I under the null hypothesis of no spatial autocorrelation is

$$E(I) = \frac{-1}{N - 1}$$

Its variance equals

$$Var(I) = \frac{NS_4 - S_3 S_5}{(N-1)(N-2)(N-3)(\sum_i \sum_j wij)^2} - (E(I))^2$$

where

$$S_{1} = \frac{1}{2} \sum_{i} \sum_{j} (w_{ij} + w_{ji})^{2}$$

$$S_{2} = \sum_{i} (\sum_{j} w_{ij} + \sum_{j} w_{ji})^{2}$$

$$S_{3} = \frac{N^{-1} \sum_{i} (x_{i} - \bar{x})^{4}}{(N^{-1} \sum_{i} (x_{i} - \bar{x})^{2})^{2}}$$

$$S_{4} = (N^{2} - 3N + 3)S_{1} - NS_{2} + 3(\sum_{i} \sum_{j} w_{ij})^{2}$$

$$S_{5} = (N^{2} - N)S_{1} - 2NS_{2} + 6(\sum_{i} \sum_{j} w_{ij})^{2}$$

Local Indicators of Spatial Association (LISA) statistics: The index used to observe spatial autocorrelation at local level is Anselin's LISA (Local Indicator of Spatial Autocorrelation), which can be seen as the local equivalent of Moran's-*I*. LISA essentially measures the statistical correlation between the value in subarea *I* and the values in nearby subareas. Univariate LISA statistics is used for the purpose which measures the extent of spatial non-stationary and clustering to its neighbourhood values.

$$I_i = Z_i \sum_j w_{ij} z_j$$

where observation z_i , z_j are in deviations from the mean from ith location to jth location and the summation over j such that only neighbouring values j ϵ J_i are included. And w_{ij} is a spatial weight measuring the nearness of subareas i and j. For ease of interpretation, the weights w_{ij} may be in row standardized form, though this not necessary and by convention, w_{ij}=0.. LISA values close to zero indicate little or no statistical association among neighbouring values.

A positive LISA statistic identifies a spatial concentration of similar values. When the LISA statistic is negative, we have a spatial cluster of dissimilar values, such as an area with a high outcomes values surrounded by areas with low outcomes values. For each location, LISA values allow for the computation of its similarity with its neighbours and also test its significance. Five scenarios may emerge: (a) location with high values with similar neighbours: high-high spatial clusters (red dot marks), also known as "Hot-Spots"; (b) location with low values with similar neighbours: low-low spatial clusters (blue dot marks), also known as "Cold spots", they represent positive spatial autocorrelation or locations surrounded by neighbours with similar values; (c) Locations with high values with low-value neighbours: high-low (light pink dot marks); (d) locations with low values with high-value neighbours: low-high (light blue dot marks), these locations are "Spatial outliers" which represent negative spatial autocorrelation or locations surrounded by neighbours with dissimilar values; and (e) locations with no significant, there is no autocorrelation. North-East states shapefile were extracted from India shapefile after downloading through DivaGIS, the final feature class had 87 polygons representing each survey district in NFHS-4. Then, selected estimates maternal health indicator from the districts factsheet were joined to the polygon dataset. We produced maps visualization, one of the first steps in exploratory spatial data analysis (ESDA) using QGIS, then, Moran's-*I* and LISA was carried out through GeoDa with 999 permutations and a pseudo p-value for cluster of <0.05 computed.

Results:-

Full Immunization:-

Figure 1.1 depicts the district wise full immunization coverage among children aged 12-23, where green colour stands for high and red colour for lowest coverage. In the coverage, lowest was observed in East Kameng and Upper Siang districts of Arunachal Pradesh and Longleng district of Nagaland and the highest in whole state Sikkim; South Garo Hills of Meghalaya and Imphal West and Bishnupur of Manipur and Changlang district of Arunachal Pradesh. There is a non-significant autocorrelation that is valued as (Moran's I = 0.327). Full immunization has high-high spatial association in Dhemaji district of Assam and Imphal East, Imphal West and Thoubal district of Manipur whereas low-low in West and South district of Sikkim.

BCG:-

Figure 2.1 depicts the district wise coverage among children aged 12-23 who had received BCG, where green color stands for the highest and red for the lowest coverage. In the coverage, the lowest percentage was observed in Upper Siang district of Arunachal Pradesh. There is a significant autocorrelation that is valued as (Moran's I = 0.290). BCG has high-high spatial association at Dhemaji and Sibsagar districts of Assam and Imphal West district of Manipur whereas low-low spatial association in West and North district of Sikkim.

DPT 3 Dose:-

Figure 3.1 depicts the district wise coverage among children aged 12-23 who had received three doses of DPT, where green color stands for high and red color for low coverage. In the coverage, lowest percentage was observed in Upper Siang district of Arunachal Pradesh and Longleng district of Nagaland. There is non-significant spatial autocorrelation seen at the regional level (Moran's I= 0.305). DPT3 has high-high spatial association in Dhemaji district of Assam and Iimphal East and Thoubal districts of Manipur whereas low-low in West and South districts of Sikkim.

Polio 3:-

Figure 4.1 depicts the district wise coverage among children aged 12-23 who had received three doses of Polio vaccine, where green color stands for highest and red for lowest coverage. In the coverage, lowest percentage was observed in Upper Siang district of Arunachal Pradesh. There is a non-significant positive spatial autocorrelation seen at the regional level (Moran's I=0.2869). Polio has high-high spatial association in Imphal East and Imphal West districts of Manipur and low-low spatial association in West and South districts of Sikkim.



Fig 1.3: Univariate LISA significant map for full immunization by districts

Fig 2.3: Univariate LISA significant map for BCG by districts

Measles:-

Figure 5.1 depicts the district wise coverage among children aged 12-23 who had received measles vaccine, where green color stands for high and red color for lowest coverage. In the coverage, the lowest percentage was observed in Upper Siang district of Arunachal Pradesh and the highest in three districts of Sikkim; four districts of Assam.

There is non-significant positive spatial autocorrelation seen at the regional level (Moran's I= 0.299). Measles has high-high spatial association at Dhemaji district of Assam and Imphal East and Thoubal of Manipur whereas low-low spatial association at West and South districts of Sikkim.



Fig 3.1: Percentage of children who received DPT3 by districts







Fig 3.3: Univariate LISA significant map for children who received DPT3 by districts











Fig 4.3: Univariate LISA significant map for children who received polio by districts

Hepatitis B:-

Figure 6.1 depicts the district wise coverage among children aged 12-23 who had received Hepatitis B vaccine, where green color stands for high and red color for lowest coverage. In the coverage, the lowest percentage was observed in East Kameng, Upper Siang and Kurung Kumey districts of Arunachal Pradesh and the highest in three districts of Sikkim and one district of Meghalaya and Manipur each. There is non-significant positive spatial autocorrelation seen at the regional level (Moran's I=0.377). Hepatitis B has high-high spatial association in

Tamenglong, Imphal west, Imphal East and Thoubal districts of Manipur. Hepatitis B has low-low spatial association in South and West districts of Sikkim.



Fig 5.1: Percentage of children who received Measles by districts



Fig 5.2: Univariate LISA cluster map for Measles by districts



Fig 5.3: Univariate LISA significant map for Measles by districts



Fig 6.1: Percentage of children who received Hepatitis B by districts



Fig 6.2: Univariate LISA cluster map for Hepatitis B by districts



Fig 6.3: Univariate LISA significant map for Hepatitis B by districts

Vitamin A:-

Figure 7.1 depicts the district wise coverage of children aged 12-23 who had received Vitamin A, where green color stands for high and red color for lowest coverage. In the coverage, the lowest percentage was observed in four districts of Arunachal Pradesh; six districts of Nagaland and five districts of Manipur and the highest in one district of Meghalaya; four districts of Assam; two districts of Tripura and six districts of Mizoram. There is non-significant positive spatial autocorrelation seen at the regional level (Moran's I=0.477). Vitamin-A has high-high spatial association in South and West districts of Sikkim and Kolasib, Aizawl, Serchhip, Champai districts of Mizoram



Fig 7.1: Percentage of children who received vitamin A



Fig 8.1: Percentage of children received from public health facility



facility

whereas low-low spatial association in Churachandpur district of Manipur, Tuensang and Zunheboto districts of Nagaland.

Vaccination in public health facility:-

Figure 8.1 depicts the district wise coverage among children aged 12-23 who had received most vaccination in public health facility, where green color stands for high and red color for lowest coverage. In the coverage, lowest percentage was observed in the Kamrup Metropolitan district of Assam and Upper Siang of Arunachal Pradesh. And



Fig 9.3: Univariate LISA significant map for children who are stunted by districts

Fig 10.3: Univariate LISA significant map children who are wasted by districts

highest in three districts of Sikkim; four districts of Manipur; whole state Tripura; seven districts of Nagaland; six districts of Mizoram; two districts of Meghalya; ten districts of Arunachal pradesh and twenty-one districts of Assam. There is a non-significant autocorrelation that is valued as (Moran's I= 0.262). Public health facility has high-high spatial association in Sonitpur district of Assam and Tuensang district of Nagaland whereas low-low in Wokha district of Nagaland.

Stunted:-

Figure 9.1 represents the district wise prevalence of stunting among children under five years, where green color stands for lowest and red color for highest coverage. In the coverage, highest percentage was observed in East Khasi



p = 0.05 (8) p = 0.01 (1) p = 0.001(0)p = 0.0001(0)Neighborless (22

Not Significant (5

Fig 11.3: Univariate LISA significant map for underweight children by districts



Fig 12.3: Univariate LISA significant map for anaemic children by districts

Hills, West Khasi Hills, Jaintia Hills and Ri Bhoi districts of Meghalaya; Dhubri, Goalpara, Chirang, Barpeta, Darrang and Karimganj districts of Assam; East Kameng district of Arunachal Pradesh, West of Sikkim and Kiphire of Nagaland. There is a non-significant positive spatial autocorrelation seen at the regional level (Moran's I=0.238). Stunted has high-high spatial association in East Khasi Hills district of Assam whereas low-low spatial association in Mokokchung district of Nagaland.

Wasted:-

Figure 10.1 represents the district wise coverage among children under five years who are wasted, where green color stands for low and red color for highest coverage. In the coverage, the highest coverage was observed in South Garo Hills district of Meghalaya; Cachar district of Assam and Upper Siang district of Arunachal Pradesh. There is a non-significant positive spatial autocorrelation seen at the regional level (Moran's I= 0.219). Wasted has high-high spatial association in East Siang district of Arunachal Pradesh. Low-low association in Serchhip, Champhai districts of Mizoram; Senapati, Imphal East districts of Manipur and Kohima, Wokha of Nagaland.

Underweight:-

Figure 11.1 depicts the district wise coverage of children under five years who are underweight, where green color stands for low and red color for high coverage. In the coverage, highest percentage was observed in five districts of Meghalaya; twelve districts of Assam and one district of Tripura and Arunachal Pradesh each. There is non-significant positive spatial autocorrelation seen at the regional level (Moran's I = 0.334). Underweight has high-high spatial association in Udalguri and Sonitpur districts of Assam and Tirap district of Arunachal Pradesh whereas low-low association in Senapati and Imphal East of Manipur, Champai and Serchhip districts of Mizoram and in Wokha district of Nagaland.

Child Anaemia:-

Figure 12.1 depicts the district wise coverage of anaemic children under five years, where green color stands for low and red color for highest coverage. In the coverage, the highest percentage was observed in South Garo Hills and East Garo Hills of Meghalaya; North and South districts of Sikkim and Changlang district of Nagaland. There is non-significant positive spatial autocorrelation seen at the regional level (Moran's I= 0.533). Child Anaemia has high-high spatial association in East Garo hills and South Garo Hills districts of Meghalaya whereas low-low in Kiphire, Zunheboto, and Wokha districts of Nagaland; Cachar district of Assam and Serchhip and Champhai districts of Mizoram.

Discussion:-

This analysis provides a quantitative assessment of child health across districts and also provides a statistical intraassessment of relativity high and low performing areas with respect to geographically proximal areas. District level exploratory spatial data analysis results for each indicator was done and were represented in maps as spatial clusters, and those clusters were further characterized in terms of the relationships among neighbouring districts, high-high values, high-low values, low-high values, and low-low values. Low-low spatial association was found in West and South district of Sikkim for full immunization; West and North district of Sikkim for BCG; West and South districts of Sikkim for DPT3, Polio3, Measles and Hepatitis B; Churachandpur district of Manipur, Tuensang and Zunheboto districts of Nagaland for Vitamin A; Wokha district of Nagaland for vaccination in public health facility; Mokokchung district of Nagaland for stunted; Serchhip, Champhai districts of Mizoram, Senapati, Imphal East districts of Manipur and Kohima, Wokha of Nagaland for wasted; Senapati and Imphal East of Manipur, Champai and Serchhip districts of Mizoram and Wokha district of Nagaland for underweight, and Kiphire, Zunheboto, and Wokha districts of Nagaland; Cachar district of Assam and Serchhip and Champhai districts of Mizoram for child anaemia.

High-high spatial association was found in Dhemaji district of Assam and Imphal East, Imphal West and Thoubal district of Manipur for full immunization; Dhemaji and Sibsagar districts of Assam and Imphal West district of Manipur for BCG; Dhemaji district of Assam and Imphal East and Thoubal districts of Manipur for DPT3; West and South districts of Sikkim; Imphal East and Imphal West districts of Manipur for Polio3; Dhemaji district of Assam and Imphal East and Thoubal of Manipur for Measles; Tamenglong, Imphal west, Imphal East and Thoubal districts of Manipur for Hepatitis B; South and West districts of Sikkim and Kolasib, Aizawl, Serchhip, Champai districts of Mizoram for Vitamin A; Sonitpur district of Assam for stunted; East Siang district of Arunachal Pradesh for wasted; Udalguri and Sonitpur districts of Assam and Tirap district of Arunachal Pradesh for underweight and East Garo hills and South Garo hills districts of Meghalaya for child anaemia.

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