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Spatial Pattern of Maternal Health in Northeastern States, India: Evidence from National Family Health Survey 4 (2015-16)

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ABSTRACT

Background: Maternal health refers to the health of women during pregnancy, childbirth and the postpartum period. Motherhood is not always a positive and gratifying experience, for many women around the world it is accompanied with suffering, ill-health and even death (WHO). Globally, about 800 women die every day of preventable causes related to pregnancy and childbirth; 20 per cent of these women are from India. Annually, it is estimated that 55,000 women die due to preventable pregnancy-related causes in India (UNICEF, India). This paper attempts to assess the spatial patterns of utilization of maternal health care services across the districts of northeastern states of India. And to acquire a statistical intra-assessment of relativity high and low performing areas with respect to geographically proximal areas. **Data and Methods:** We used National Family Health Survey-4 (2015-16) fact sheets data on maternal health indicators for 87 districts of northeastern states, India. Applied spatial analysis: Moran's *I* and LISA to assess the maternal health care services across the districts. **Results:** All the indicators depicted striking coverage variation across the northeastern states, India in this analysis. Among all the northeastern states, Nagaland is found to be poor in utilization of maternal health care services whereas Sikkim is found to be the better one.

Key Words: Spatial, NFHS-4, Maternal health, Autocorrelation

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Introduction

Maternal health refers to the health of women during pregnancy, childbirth and the postpartum period. While motherhood is often a positive and fulfilling experience, for many women around the world it is associated with suffering, ill-health and even death. Haemorrhage, infection, high blood pressure, unsafe abortion, and obstructed labour are some of the major direct causes of maternal morbidity and mortality. A number of initiatives were established by all the countries to galvanize efforts towards reducing maternal mortality which were not fulfilled.

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Considerable efforts have been made to ensure skilled birth attendance, with the aim of reducing morbidity and mortality among mothers and newborns baby. These efforts have substantially increased the number of women accessing health facilities for ante-natal and post-natal care, institutional deliveries, and the proportion of deliveries attended by skilled health personnel in developing countries having increased from 56% in 1990 to 68% in 2012. Despite this increased coverage, 800 women still die each day from complications during pregnancy and childbirth and in the postnatal period. India contributes one-fifth of the global burden of absolute maternal deaths; however, annual decline of 4.7% has been experienced in maternal mortality ratio (MMR) [1,2]and 3.5% annual increase in skilled birth attendance since 1990[1,3]. The state of maternal health in a nation can be characterized by numerous factors, such as maternal mortality and morbidity rates, or process indicators of service availability and use. These indicators include

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the levels of antenatal and postnatal care, coverage of tetanus toxoid (TT) vaccination, proportion of deliveries conducted in health facilities by trained birth attendants, or proportion of obstetric complications [4]. Some of the indicators used in this study agitating the maternal health were ante-natal check-up in first trimester, at least four antenatal care, full ANC (i.e. at least 3 ANC visits with 100+ IFA tablets/Syrups consumed at least 1 TT), institutional delivery, caesarean section, postnatal care, women anaemia; examination of oral, cervix, breast; blood sugar level of women and Janani Suraksha Yojana.

The northeastern 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 socio-cultural 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 utilization of maternal health care services in northeastern region. Geographical variations in the utilization of maternal health care services can reveal inequities between and within states. The purpose of this paper is to study the spatial patterns of utilization of maternal health care services in order to understand the prevalence and patterns of the various maternal health care indicators. Hence, the aim of the study is to visualize the spatial patterns of utilization of maternal health care services across the districts in northeastern states. And to identify areas with statistically significant clustering of high values (hot-spots) or low values (cold-spots), as well as spatial outliers.

Materials 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 sheet provides 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[5]. We obtained fact sheet data for selected maternal health indicators of 87 districts of 8 states in northeastern 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" [6]. 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 [7,8].

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 [7]. 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 tends 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 clustering tests. The present study used exploratory spatial data analysis (ESDA) techniques to measure the 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

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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; $\bar{X}$ 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

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

where

$$S_1 = \frac{1}{2} \sum_i \sum_j \left(w_{ij} + w_{ji}\right)^2$$
$$S_2 = \sum_i \left(\sum_j w_{ij} + \sum_j w_{ji}\right)^2$$
$$S_3 = \frac{N^{-1}\sum_i (x_i - \bar{x})^4}{(N^{-1}\sum_i (x_i - \bar{x})^2)^2}$$
$$S_4 = (N^2 - 3N + 3)S_1 - NS_2 + 3\left(\sum_i \sum_j w_{ij}\right)^2$$
$$S_5 = (N^2 - N)S_1 - 2NS_2 + 6\left(\sum_i \sum_j w_{ij}\right)^2$$

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 i^{th} location to j^{th} 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

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negative spatial autocorrelation or locations surrounded by neighbours with dissimilar values; and (e) locations with no significant, there is no autocorrelation. Northeastern 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

Ante-natal check-up in first trimester: Figure 1.1 represents the district wise proportion of women who had received first ANC in the first trimester of the pregnancy among women (15-49 years), where green colour stands for high proportion and red colour for lowest proportion. In the coverage, lowest percentage was observed in East Kameng district of Arunachal Pradesh, Mon and Longleng districts of Nagaland and the highest in North, West, South districts of Sikkim, Jorhat district of Assam and Imphal East, Imphal West and Thoubal districts of Manipur.There is non-significant autocorrelation that is valued as Moran's *I*=0.521. ANC in first trimester has high-high spatial association in West district of Sikkim and Imphal West, Thoubal and Bishnupur districts of Manipur whereas low-low spatial association in Tuensang, Zunheboto and Longleng districts of Nagaland.

Atleast Four Ante-natal Care: Figure 2.1 depicts the district wise proportion of women who had received at least four ANC during the pregnancy, where green colour stands for high proportion and red colour for lowest proportion. In the coverage, the lowest percentage was observed in East Kameng and Kurung Kumey districts of Arunachal Pradesh and Phek, Kiphire, Zunheboto, Tuensang, Mon and Longleng districts of Nagaland and the highest in North, West, South districts of Sikkim, Imphal West, Imphal East, Bishnupur and Thoubal districts of Manipur, East Khasi hills district of Meghalaya, Aizawl district of Mizoram, Jorhat and Sibsagar districts of Assam. There is non-significant autocorrelation that is valued as Moran's *I*=0.521. ANC-4 has high-high spatial association in West district of Sikkim, Champhai district of Mizoram, Imphal East district of Manipur, whereas low-low spatial association in Kiphire, Zunheboto, Tuensang and Longleng districts of Nagaland.

Full Ante-natal Care: Figure 3.1 depicts the district wise proportion of women who had received full ANC during the pregnancy, where green colour stands for high proportion and red colour for lowest proportion. In the coverage, the highest percentage was observed in three districts of Sikkim and Mizoram each and one district of Assam. There is non-significant positive spatial autocorrelation seen at the regional level (Moran's *I*=0.515). Full ANC has high-high spatial association in South and West districts of Sikkim; Lunglei, Mamit, Serchhip and Champhai districts of Mizoram. Full ANC has low-low spatial association along Zuneheboto, Phek, Kiphire in Nagaland.
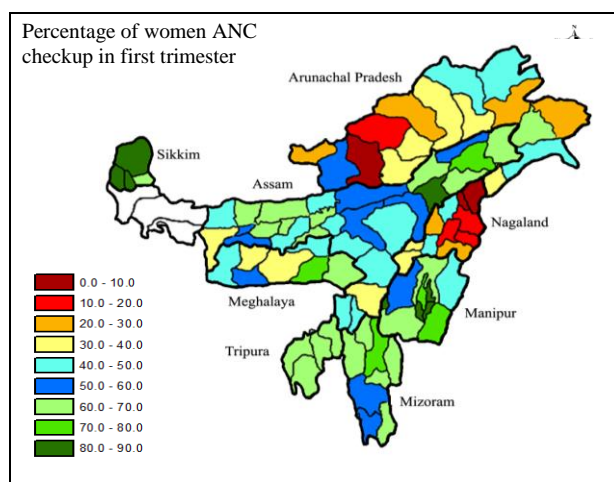

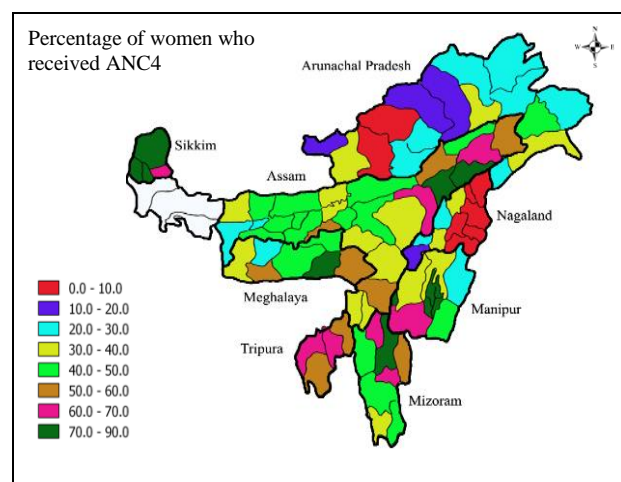**Fig 1.1 : Percentage of women ANC in first trimester by districts**

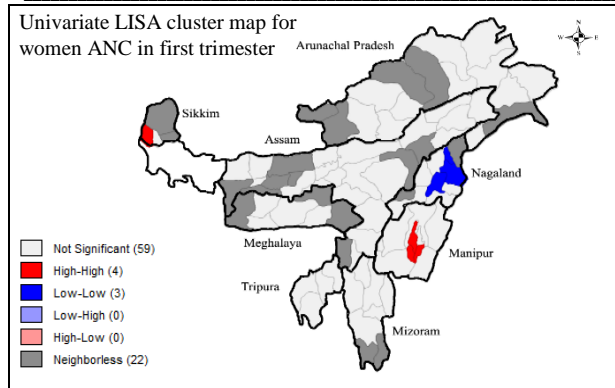**Fig 2.1: Percentage of women who received ANC4 by districts**

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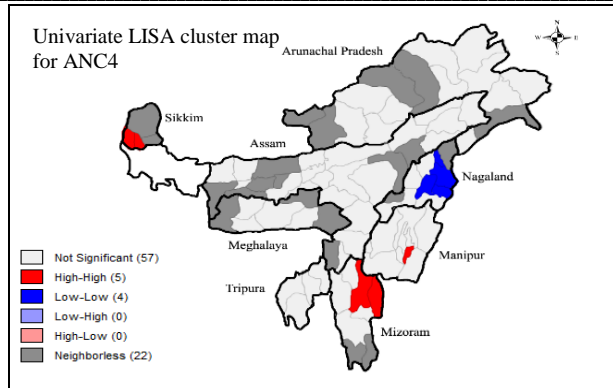**Fig 1.2: Univariate LISA cluster map for women ANC in first trimester**

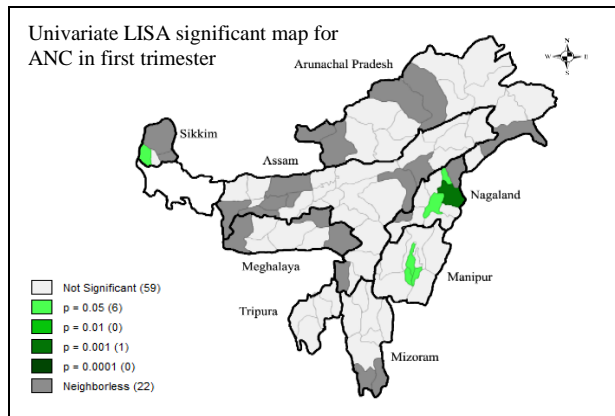**Fig 2.2: Univariate LISA cluster map for ANC4**

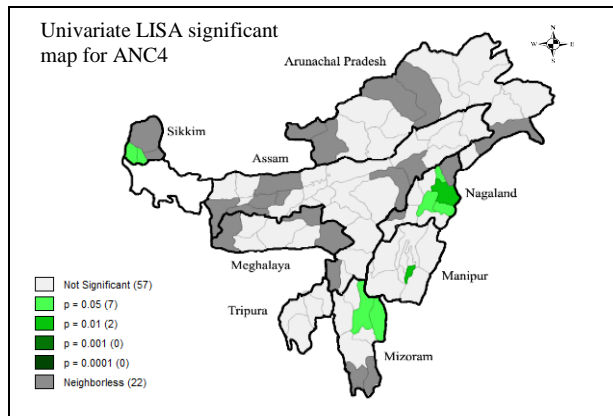**Fig 1.3: Univariate LISA significant map for women ANC in first trimester**

Fig 2.3: Univariate LISA significant map for ANC4

Institutional delivery: Figure 4.1 depicts the district wise proportion of women who had institutional delivery, where green colour stands for high proportion and red colour for lowest proportion. In the coverage, the lowest was observed in Phek, Mon and Longleng districts of Nagaland. There is non-significant autocorrelation that is valued as Moran's I=0.434. Institutional delivery has high-high spatial association at West and South districts of Sikkim, Dhemaji district of Assam and Champhai, Aizawl, Serchhip districts of Mizoram whereas low-low spatial association in Phek, Zunheboto, Wokha, Kiphire and Tuensang districts of Nagaland.
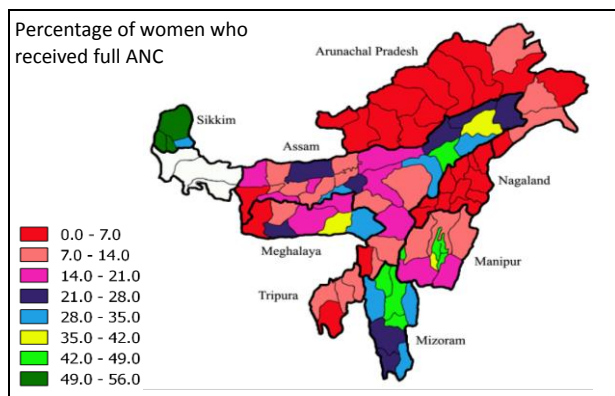
Fig 3.1: Percentage of women who received full ANC by districts
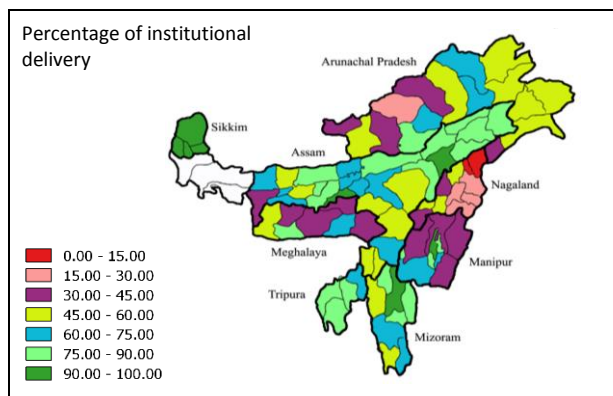
Fig 4.1: Percentage of women who received institutional delivery by districts
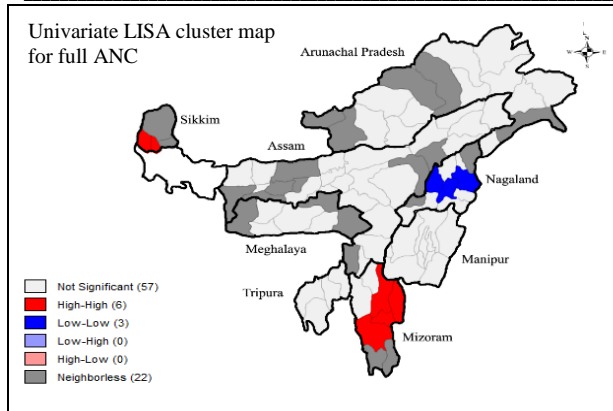
Fig 3.2: Univariate LISA cluster map for full ANC
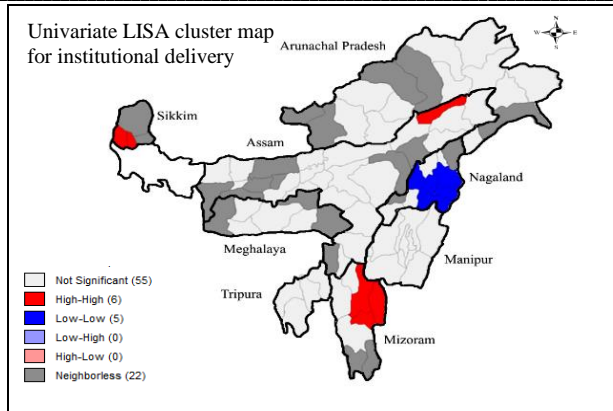
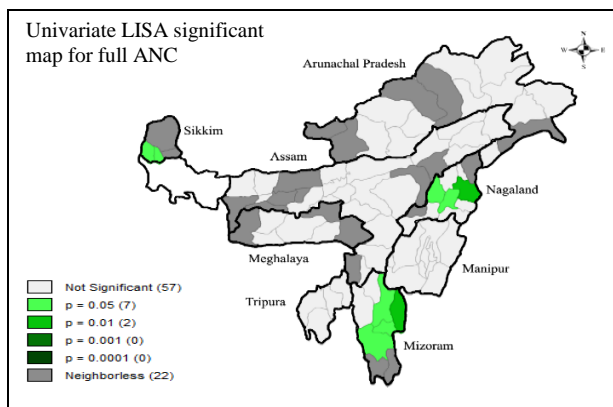**Fig 4.2: Univariate LISA cluster map for institutional delivery**

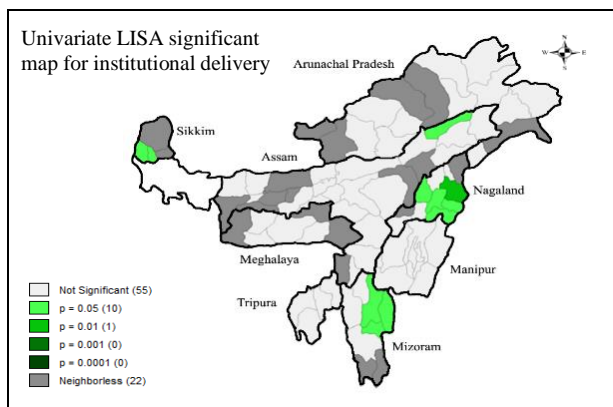**Fig 3.3: Univariate LISA significant map for any full ANC**

Fig 4.3: Univariate LISA significant map for institutional delivery

Janani Suraksha Yojana (JSY): Figure 5.1 depicts the district wise proportion of women who had received Janani Suraksha Yojana facility for births delivered in an institution, where green colour stands for high proportion and red colour for lowest proportion. In the coverage, the lowest percentage was observed in East Kamang, Papum pare and Tawang districts of Arunachal Pradesh; South Garo Hills district of Meghalaya whereas the highest in Marigaon and Dhemaji districts of Assam. There is significant autocorrelation that is valued as Moran's I=0.401. JSY has high-high spatial association in Nagoan, Sonitpur, Darrang, Udalguri, Tinsukhia, Chirang, Dibrugarh and Dhemaji districts of Assam whereas low-low spatial association in East Kameng, Phek and Tuensang districts of Nagaland.
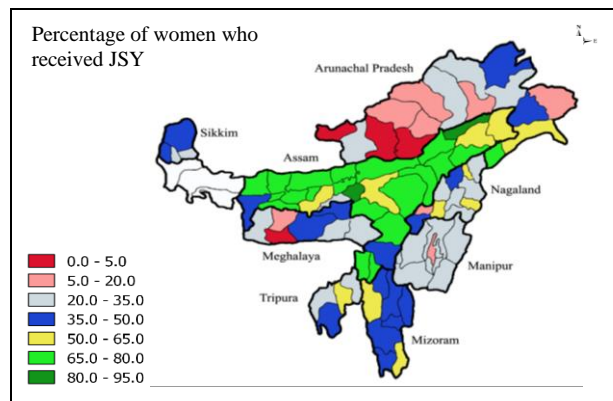

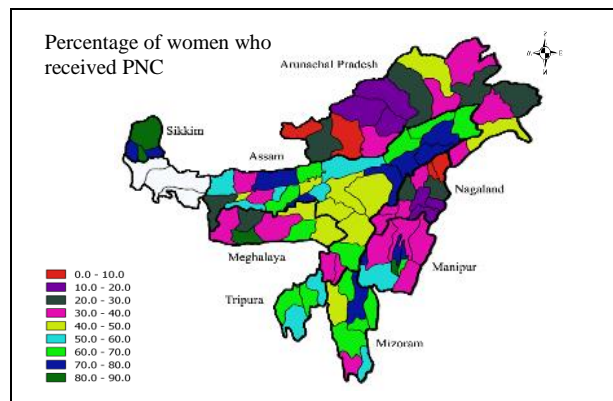**Fig 5.1: Percentage of women who received JSY by districts**

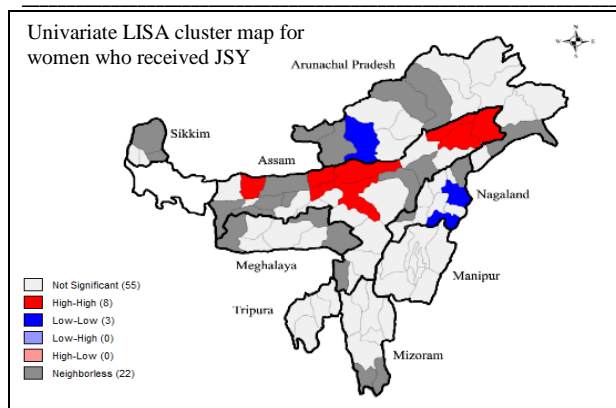**Fig 6.1: Percentage of women who received PNC by districts**

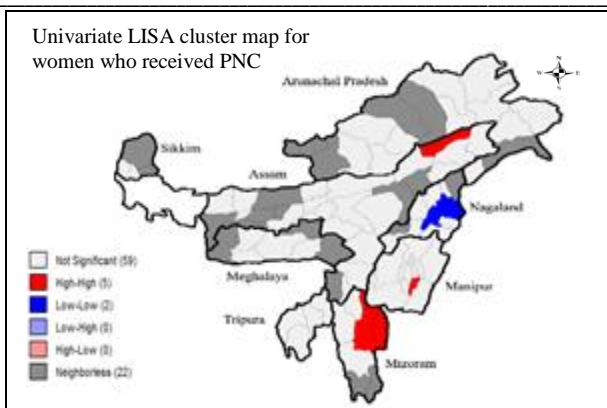**Fig 5.2: Univariate LISA cluster map for women who received JSY**

Fig 6.2: Univariate LISA cluster map for women who received PNC
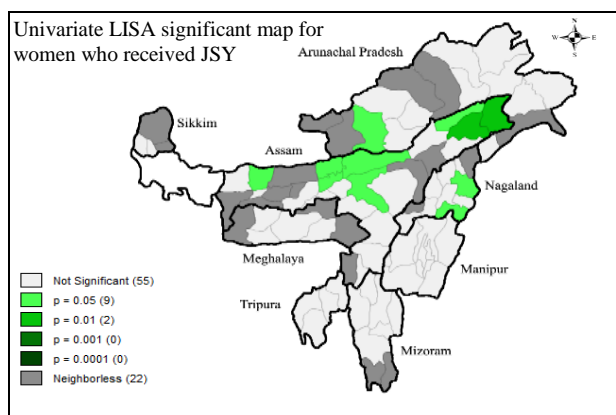

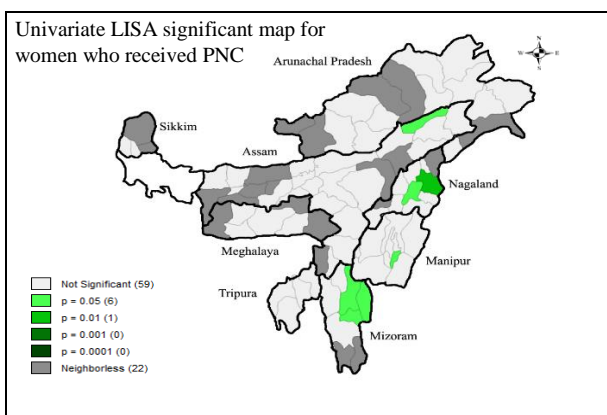**Fig 5.3: Univariate LISA significant map for women who received any JSY**

Fig 6.3: Univariate LISA significant map for women who received PNC

Post Natal Care: Figure 6.1 depicts the district wise proportion of women who had received PNC within the two days of delivery, where green colour stands for high proportion and red colour for lowest proportion. In the coverage, the lowest percentage is observed in Tawang and East Kameng districts of Arunachal Pradesh, Mon and Longleng districts of Nagaland whereas highest in Bishnupur of Manipur; North and South districts of Sikkim and South Garo hills district of Meghalaya. There is non-significant autocorrelation seen at the regional level (Moran's I= 0.431). PNC has high-high spatial association in Dhemaji district of Assam; Thoubal district of Manipur; Champai, Serchhip and Aizawl districts of Mizoram whereas low-low in Tuensang and Zunheboto districts of Nagaland.

Caesarean section: Figure 7.1 depicts the district wise proportion of women who had caesarean section delivery, where green colour stands for low proportion and red colour for high proportion. In the coverage, the percentage observed was highest in Imphal East and Imphal West districts of Manipur; Morigaon,

Dibhugarh, Kamrup districts of Assam; and West Tripura district. There is significant autocorrelation that is valued as Moran's I =0.327. Caesarean section has high-high spatial association in Kamrup district of Assam, Imphal West district of Manipur and low-low spatial association in Longleng, Twensang, Kiphire districts of Nagaland.

Women Anaemia: Prevalence of anaemia among women of age 15-49 years in figure 8.1 depicts the district wise proportion of anaemic, where green colour stands for high proportion and red colour for lowest proportion. In the coverage, lowest percentage coverage was observed in Phek district of Nagaland and the highest in West Garo Hills, East Garo Hills and Ri-bhoi districts of Meghalaya. There is non-significant autocorrelation that is valued as Moran's I=0.458. Prevalence of women anaemia has high-high spatial association at South Garo Hills and West Khasi Hills districts of Meghalaya whereas low-low spatial association in Champhai and Serchhip districts of Mizoram, Senapati district of Manipur and Tuensang, Zunheboto, Wokha and Kohima districts of Nagaland.

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Oral cavity: Figure 9.1 depicts the district wise proportion of women who have ever undergone oral cavity examination, where green colour stands for high proportion and red colour for lowest proportion. In the coverage, the highest percentage was observed in all districts of Sikkim, one district of Mizoram, Arunachal Pradesh and Meghalaya each. There is non-significant positive spatial autocorrelation seen at the regional level (Moran's I = 0.243). Oral cavity has low-low spatial association in Chirang, Marigaon, Karbi Anglong districts of Assam.

Cervix examination: Figure 10.1 depicts the district wise proportion of women who have ever undergone cervix examination, where green colour stands for high proportion and red colour for lowest proportion. In the coverage, highest percentage was observed in East Khasi Hills and Jaintia Hills districts of Meghalaya. There is non-significant positive spatial autocorrelation seen at the district level (Moran's I=0.5003).Cervix examination has high-high spatial association in

Aizawl, Serchhip and Champhai districts of Mizoram, East Khasi Hills district of Meghalaya and Paren district of Nagaland. Cervix examination has low-low spatial association in South Garo Hills district of Meghalaya; Kokrajhar, Bongaigaon, Sonitpur, Udalguri, Darrang districts of Assam and Papum Pare district of Arunachal Pradesh.

Breast examination: Figure 11.1 depicts the district wise proportion of women who have ever undergone breast examination, where green colour stands for high proportion and red colour for lowest proportion. In the coverage, the highest is observed in East Khasi Hills district of Meghalaya. There is non-significant positive spatial autocorrelation seen at the regional level (Moran's I = 0.1804). There was high-high spatial association in West Khasi Hills district of Meghalaya and low-low spatial association in South Tripura, West Tripura, Dhalai districts of Tripura and Tuensang district of Nagaland.
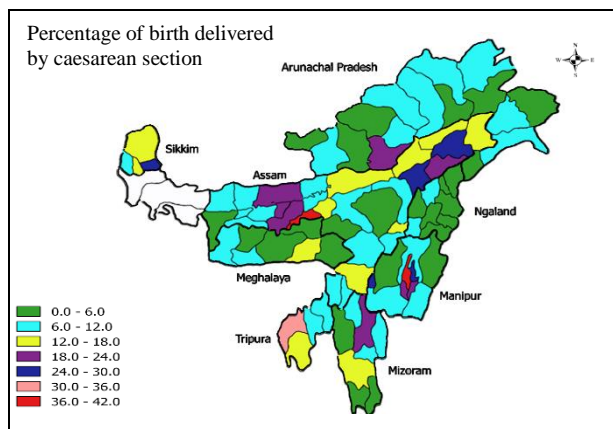

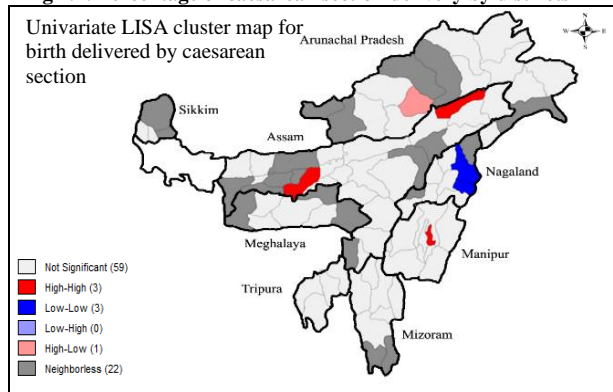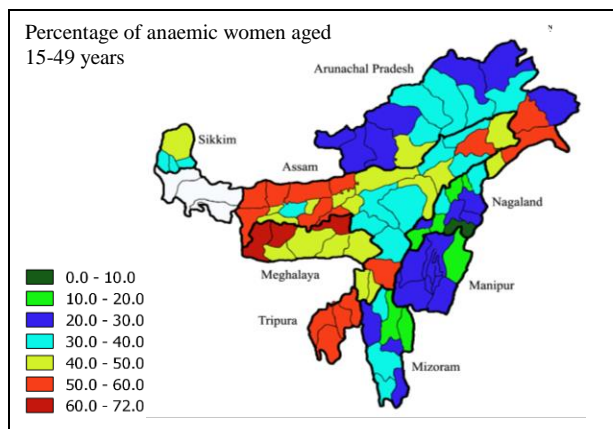**Fig 7.1: Percentage of caesarean section delivery by districts**

Fig 8.1: Percentage of anaemic women aged 15-49 by districts

Fig 7.2: Univariate LISA cluster map for caesarean section delivery

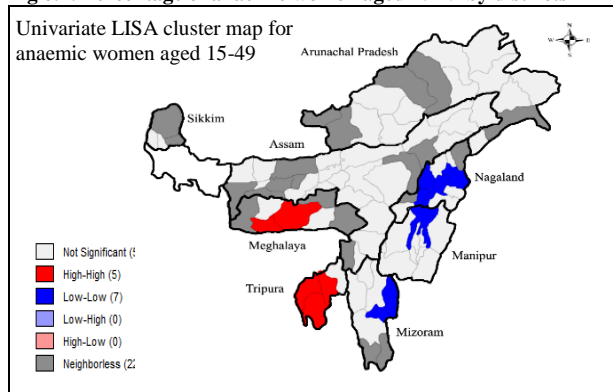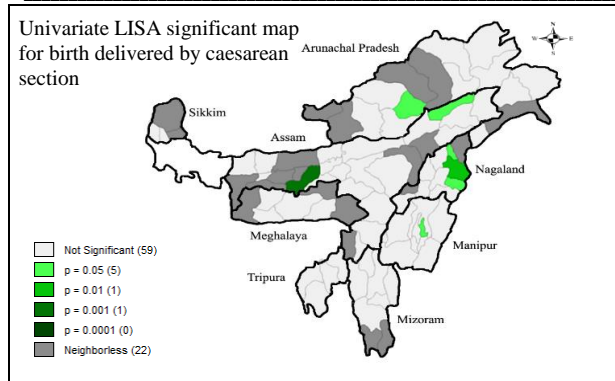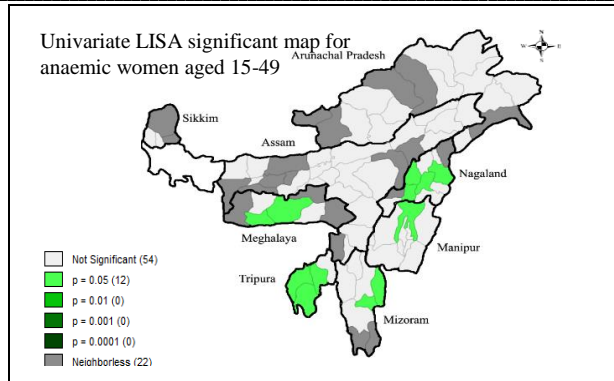**Fig 8.2 :Univariate LISA cluster map for anaemic women aged 15-49**

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**Fig 7.3: Univariate LISA significant map for caesarean section delivery**

Fig 8.3: Univariate LISA significant map for anaemic women aged 15-49

High blood sugar level: High blood sugar level among women, figure 12.1 depicts the district wise proportion of women who have high blood sugar level, where green colour stands for low proportion and red colour for high proportion. In the coverage, the highest percentage was observed in Imphal West and Churachandpur districts of Manipur; Serchhip, Aizawl and Kolasib districts of Mizoram; Mokokchung,

Wokha and Zunheboto districts of Nagaland. There is non-significant positive spatial autocorrelation seen at the regional level (Moran's I = 0.52). High sugar level has high-high spatial association in Lunglei, Aizawl, Serchhip and Champhai districts of Mizoram. Mokochungand Wokha districts of Nagaland. Chandel district of Manipur. High sugar in Women has low-low spatial association in North Cachar Hills district of Assam.
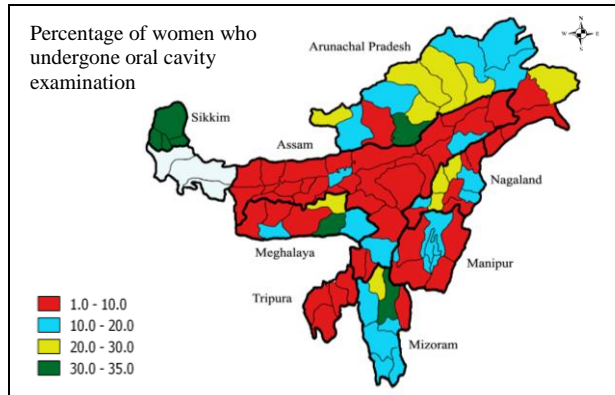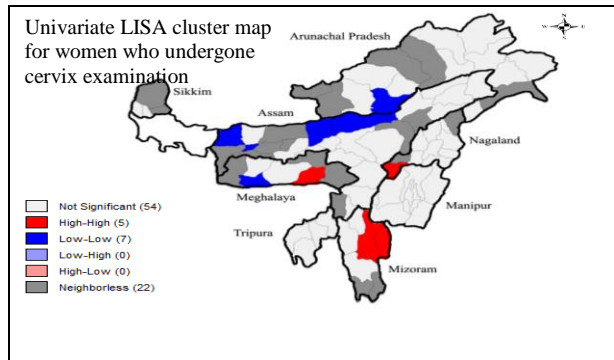

Fig 9.1: Percentage of children who undergone oral cavity examination by districts
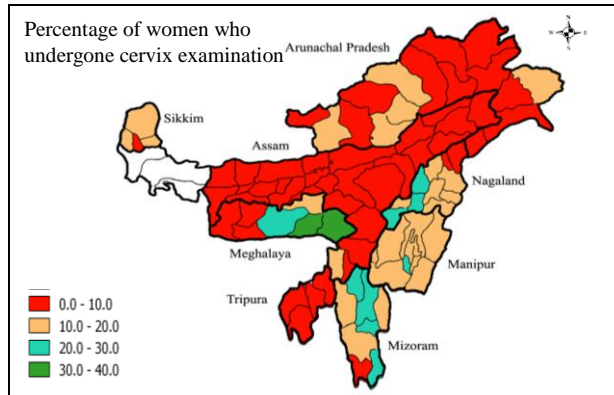
Fig 10.1: Percentage of women who undergone cervix examination by districts
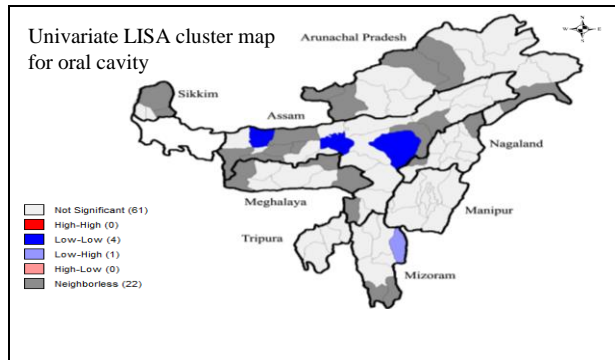
Fig 9.2 : Univariate LISA cluster map for women who undergone oral cavity examination

Fig 10.2: Univariate LISA cluster map for cervix examination

Discussion

To our knowledge, this is the first research study that has applied spatial analysis to a comprehensive set of maternal health indicators within and among northeastern states in India. This analysis provides a quantitative assessment of maternal health across districts and also provides a statistical intra-assessment of relativity high and low performing areas with respect to geographically proximal areas. District level exploratory spatial data analysis results for each indicator as well as spatial clusters were shown in maps, and characterized those clusters in terms of the relationships among neighboring districts, high-high values, high-low values, low-high values, and low-low values.Low-low spatial association was found in Tuensang, Zunheboto and Longleng for first ANC in the first trimester of the pregnancy, atleast four ANC in Kiphire, Zunheboto, Tuensang and Longleng, full ANC in Zuneheboto, Phek, Kiphire, institutional deliveries in Phek, Zunheboto, Wokha, Kiphire and Tuensang, Janani Suraksha Yojana facility in East Kameng, Phek and Tuensang, PNC in Tuensang and Zunheboto districts of Nagaland.High-high spatial association was found in Kamrup district in Assam, Imphal West district of Manipur for Caesarean section delivery. The prevalence of anaemia among women aged 15-49 years were found to be more than 40% in all the districts of Meghalaya, Tripura and few districts of Assam. Cervix and breast examination were found in higher proportion in few districts of Meghalaya and oral cavity examination in all the districts of Sikkim. Prevalence of high blood sugar level among the women was found in two districts of Manipur, three districts of Mizoram and Nagaland each. This results facilitates the identification of hotpots of low coverage and high coverage and it can be used to allocate resources effectively to reduce health inequities between and within northeastern states.

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Ethical approval

The study was approved by the Institutional Ethics Committee

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