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A Spatial Analysis of Caesarean birth in Northeast States, India

Apoorva Nambiar
Kh. Jitenkumar Singh

Abstract

Caesarean section is the surgical intervention in case of serious delivery complications, where a normal vaginal delivery is not possible. Caesarean sections are associated with short and long term risk which can extend many years beyond the current delivery and affect the health of the woman, her child, and future pregnancies. Caesarean sections are effective in saving maternal and infant lives, but only when they are required for medically indicated reasons (WHO, 2015). According to the WHO published guidelines on caesarean rates in 1985 (revised in 1994), the proportion of caesarean births should range between 5-15%. But the scenario of the caesarean rate over the world is quite alarming and much above the WHO recommended levels. This study is aimed at identifying the scenario of Caesarean section delivery across the districts of Northeastern states of India, where maternal mortality ratio continues to be well above the national average and obstetric care facilities remain far from satisfactory and to acquire A statistical intra-assessment of relativity high and low performing areas with respect to geographically proximal areas. National Family Health Survey-2,3 and 4 (2015-16) fact sheets data on Caesarean section delivery for 87 districts of north-eastern states, India was used in this study. Spatial analysis: Moran-*I* and LISA was applied to assess the maternal health care services across the districts. Striking coverage variation for caesarean section was seen across the north-eastern states, India in this analysis. Among all the north-eastern states, high-high spatial association was found in Kamrup district of Assam, Imphal West district of Manipur and low-low spatial association in Longleng, Twensang, Kiphire districts of Nagaland.

Introduction

Caesarean section is the surgical intervention in case of serious delivery complications, where a normal vaginal delivery is not possible. Caesarean sections are effective in saving maternal and infant lives, but only when they are required for medically indicated reasons (WHO, 2015). According to the WHO published guidelines on caesarean rates in 1985 (revised in 1994), the proportion of caesarean births should range between 10-15%. A figure below 5 per cent indicates that a substantial proportion of women do not have access to surgical obstetric care; and a figure greater than 15 per cent indicates over utilization of the procedure for other than life saving reasons. But the scenario of the caesarean rate globally is quite alarming and much above the WHO recommended levels. Surgical interventions during pregnancy are usually made to ensure safety of the mother and the child under conditions of obstetric risk. In today's situation when there is access to gynaecological services and obstetric care, there has been a concern over this rising caesarean rates globally. When the reasons are studied for this increase in the rate, some studies focus purely on medical reasons, (1, 2), though there are others that show that the trend is determined by the preferences of the women, many of whom take informed decisions (3,4). Some other factors associated with this can be attributed to age, parity, multiple pregnancy, maternal weight gain, and birth weight. Some common and important indications for CS include foetal distress, prolonged labour, breech presentation, multiple gestations, previous section, and CS on demand (5). Both the developed and the developing countries are not showing a satisfactory mark for the rates and are increasing over the time. In U.S. the rate was 22.7 per cent in 1990, which increased to 27.5 per cent in 2003. These levels and trends of CS rates are even higher in case of Latin America; it ranged from 16.8 per cent to *as* high as 40 per cent in the countries of this region. It has been established that there are over 850,000 unnecessary CS performed in the region each year. The estimate for the CS rates in East Asia also shows that it is well above the 15 per cent mark (6). The caesarean section (CS) delivery rate is steadily increasing in India. There is 16.7 per cent change in the rates annually in India (Stanton, 2006), which is one of the highest among the countries. Studies conducted in various states and population are also showing prevalence rate of CS deliveries increasing over the years. Study conducted in a large tertiary care municipal hospital in Western India found the CS rate increasing from 17.2% to 28.9% (7). The rural-urban difference between C-section rates in India is quite visible. In a study conducted using data from DLHS-3(2007-

08), it is found that the rate of CS is higher in urban areas than their rural counterparts for all the states. The rural-urban gap is relatively low in the states of Haryana, Delhi, Arunachal Pradesh and Kerala (below 5 %). On the other hand, the gap is very high in the states of Jammu & Kashmir, West Bengal and Tripura (above 20%) (8).

The Northeast states, where maternal mortality ratio continues to be well above the national average and obstetric care facilities remain far from satisfactory needs special attention in the study of 'maternal and child health indicators' and 'access to' healthcare facilities in terms of institutional deliveries, availability of emergency obstetric care services. Even though government has initiated several programs and policies to improve the maternal and child health conditions in various parts of the country, the northeast region have been far away in many of these. The dearth of basic amenities and diverse socio cultural practices is directly or indirectly responsible for the utilization of maternal health care services in north eastern region. Geographical variations in the utilization of maternal health care services can reveal inequities between and within states.

The objective of this study is to explore the current trends in caesarean section delivery in the North eastern states, India. And to examine the spatial pattern of caesarean delivery across different geographical areas (districts) by identifying 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 National Family Health Survey - 2, 3 and 4 fact sheets data on Caesarean section delivery for 87 districts of north eastern states, India, 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.

The National Family Health Survey (NFHS) is a large-scale, multi-round survey conducted in a representative sample of households throughout India. The NFHS is a collaborative project of the International Institute for Population Sciences (IIPS), Mumbai, India; ORC Macro, Calverton, Maryland, USA and the East-West Centre, Honolulu, Hawaii, USA. The First National Family Health Survey (NFHS-1) was conducted in 1992-93. The survey collected extensive information on population, health, and nutrition, with an emphasis on women and young children. The Second National Family Health Survey (NFHS-2) was conducted in 1998-99 in all 26 states of India with added features on the quality of health and family planning services, domestic violence, reproductive health, anaemia, the nutrition of women, and the status of women. The 2005-2006 National Family Health Survey (NFHS-3), the third in the NFHS series of surveys, provides information on population, health and nutrition in India and each of its 29 states. The survey is based on a sample of households which is representative at the national and state levels. NFHS-3 provides trend data on key indicators and includes information on several new topics, such as HIV/AIDS-related behaviour and the health of slum populations. For the first time, NFHS-3 also provides information on men and unmarried women. The National Family Health Survey 2015-16 (NFHS-4), the fourth in the NFHS series, provides information on population, health and nutrition for India and each State / Union territory. NFHS-4, for the first time, provides district-level estimates for many important indicators. And helps to produce reliable estimates of most indicators for rural, urban and total of the districts as a whole. The scope of clinical, anthropometric, and biochemical testing (CAB) or Biomarker component has been expanded to include measurement of blood pressure and blood glucose levels. NFHS-4 sample has been designed to provide district and higher level estimates of various indicators covered in the survey.

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" (9). 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 (10,11).Spatial autocorrelation analysis was applied to summarize the extent to which persons with a similar health status tend to occur next to each other i.e., form spatial clusters (10). Spatial autocorrelation statistics depend on the definition of neighborhood 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 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 $j \varepsilon J_i$ 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 neighbors': high-high spatial clusters (red dot marks), also known as "Hot-Spots"; (b) location with low values with similar neighbors': 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.

Northeastern states shape file were extracted from India shape file 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

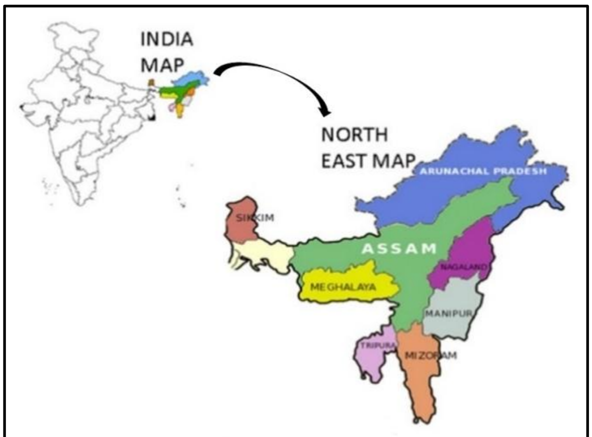

Fig 1.1 Northeast Map

Institutional delivery

Figure 1.1 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.

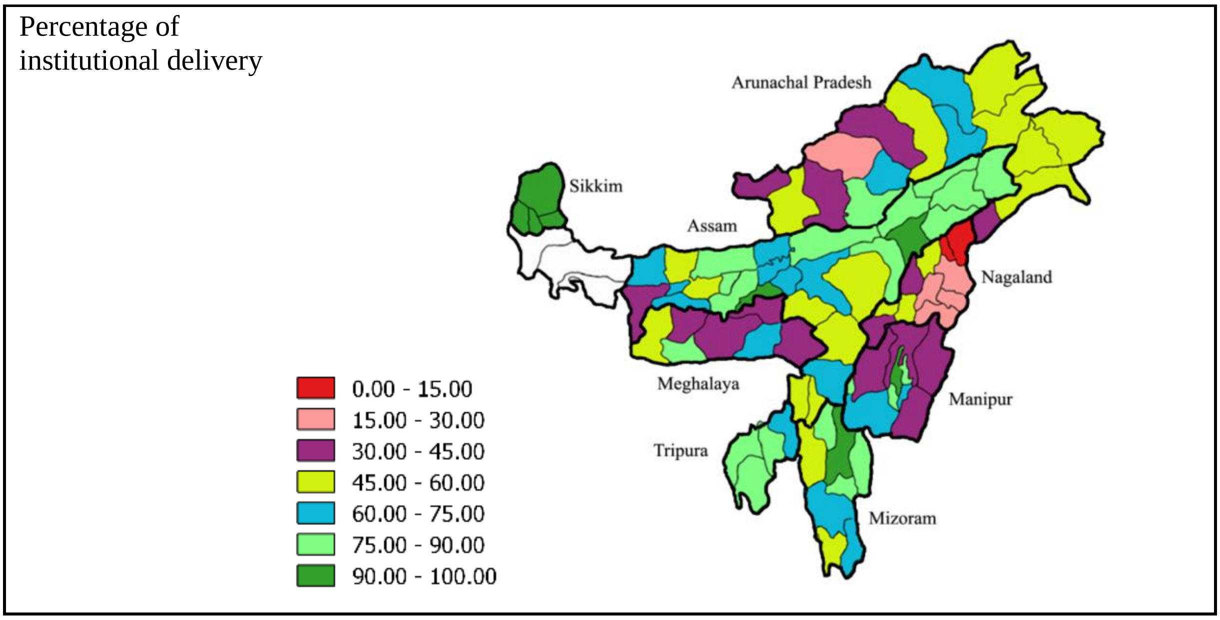

Fig 1.1 Percentage of women who received institutional delivery by districts

Caesarean section

Figure 2.1 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.

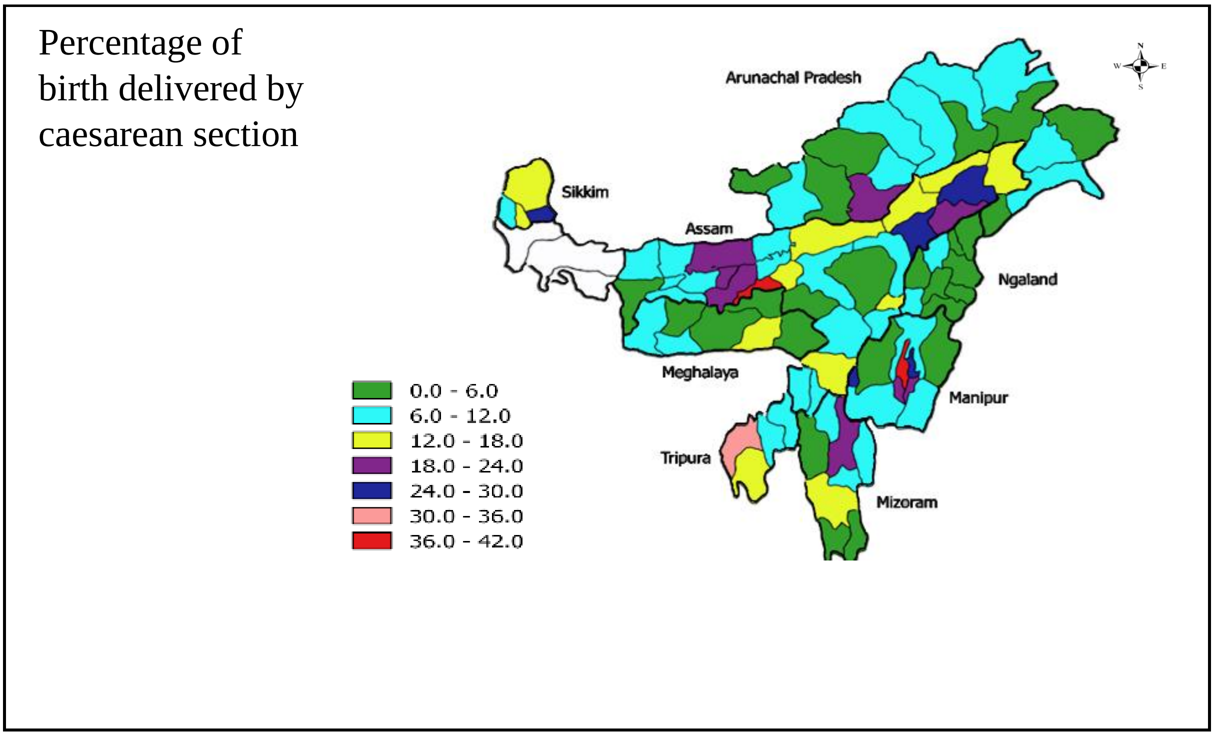

Fig 2.1 Percentage of birth delivered by caesarean section

Fig 2.2 depicts the Univariate LISA cluster map for Caesarean section delivery in the northeast states. It can be seen that 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.

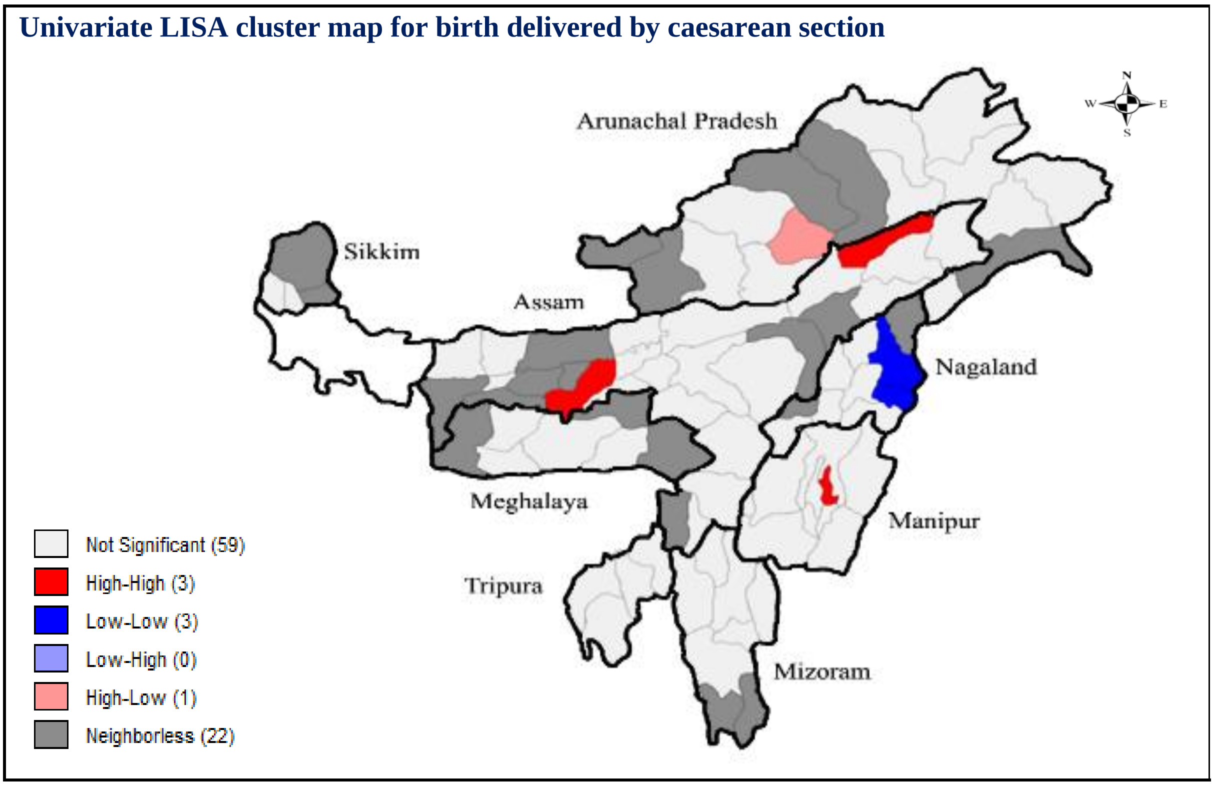

Fig 2.2 Univariate LISA cluster map for birth delivered by caesarean section by districts

Fig 2.3 depicts the Univariate LISA significance map for Caesarean section delivery in the northeast states. There is significant autocorrelation that is valued as Moran's-*I* =0.327

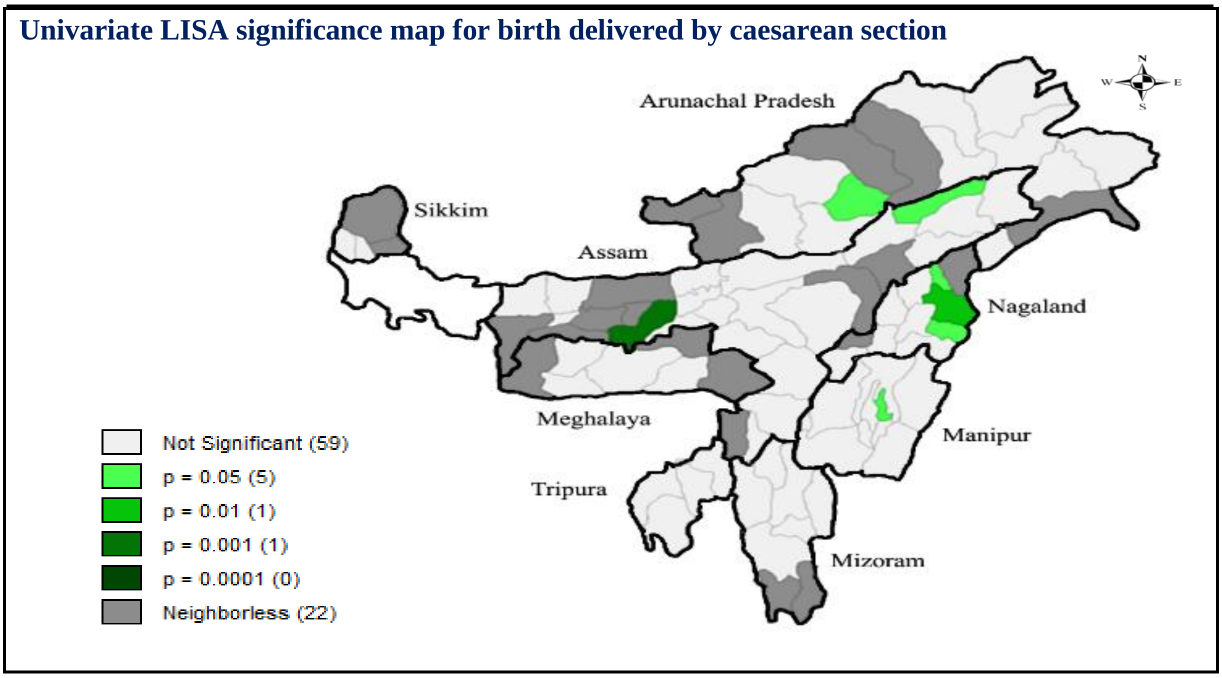

Fig 2.3 Univariate LISA significance map for birth delivered by caesarean section by districts

Fig 3 shows a comparison of the three rounds of national family health survey, i.e NFHS 2 (1998-99), NFHS 3 (2005-2006) and NFHS (2015-16). All of the states have undergone an upward trend of the caesarean section delivery from the second survey to the fourth. As per NFHS 4, Sikkim, Manipur and Tripura crossed the ideal maximum limit (15%) of caesarean section (as per the WHO guidelines). Whereas the rate of caesarean section in Nagaland is very low as compared to the other north eastern states.

Caesarean section delivery in the Northeast, India

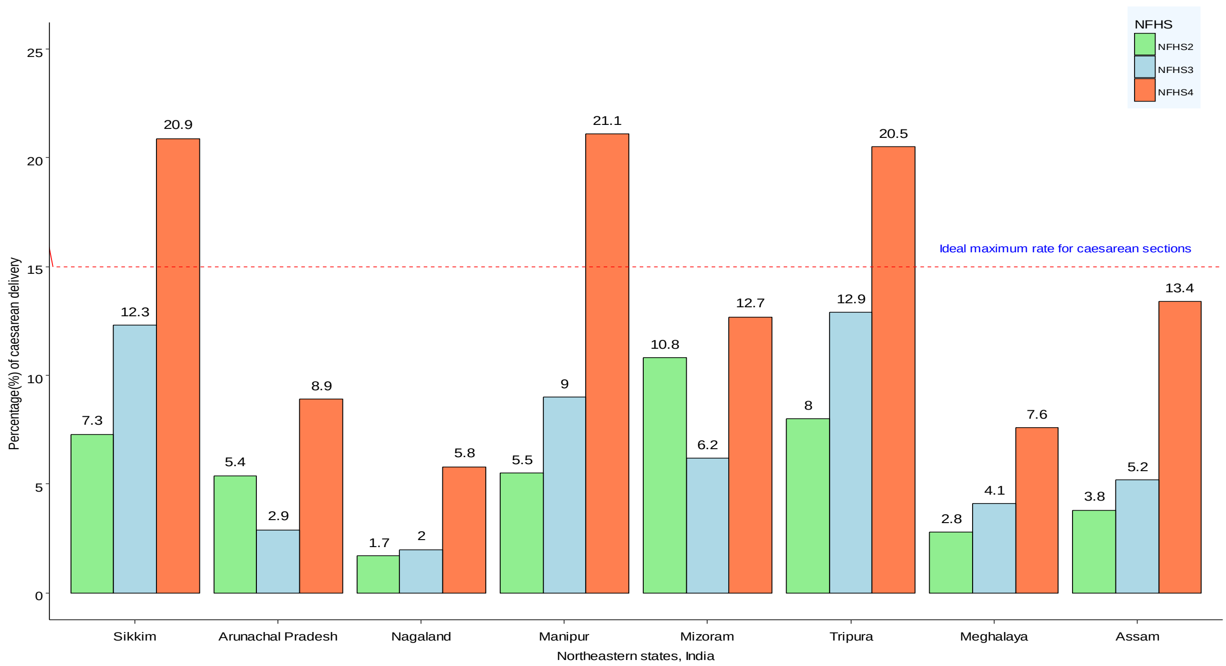

Fig 3: Trend of caesarean section delivery in the northeastern states, India

Conclusion

A large number of maternal deaths are avertable through safe deliveries and adequate maternal care. Risks of maternal deaths because of complications during delivery can be reduced by skilled attendance at all births, backed by emergency obstetric care when needed. The 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 north eastern states. Attention should be given to the states having the alarming rates to check the private practices of the doctors and the financial motive of the private institutions that could be the reason for the high caesarean rates. And to the states having low rates, the utilization of maternal health facilities should be taken into consideration and the accessibility of emergency obstetric care facilities should be increased.

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Apoorva Nambiar
M.Sc. Student, IIPS,
Mumbai,

Kh. Jiten kumar Singh
National Institute of Medical Statistics,
ICMR, New Delhi

Corresponding author: Kh. Jiten kumar Singh