An Epidemiological Study of Cervical and Breast Screening in India: A District Level Spatial Analysis

Introduction

Cancer is increasingly being recognized as a major cause of mortality and morbidity with approximately 14 million new cases in 2012 (Ferlay et al. 2015). The World Health Organization (WHO) projects that cancer rates could further increase by 50% in the year 2020 (WHO 2003). Such an increase in cancer rates will result into additional 15 million cancer patients. The rising burden of the mortality from cancer is likely to be fivefold greater in the developing countries, compared to established market economies (Rastogi et al. 2004). Economic burden of cancer is significant and is rising. In 2010, the total annual economic cost of cancer was estimated at approximate US$ 1.6 trillion, threatening health budgets at all income levels, causing financial catastrophic for individuals and families (WHO, 2016).

Breast cancer and cervical cancer, the most common form of cancer in women worldwide, are too on a fast and steady rise, which account for more women deaths than any other forms of cancer in all parts of developing world (WHO 2018). Recent statistics suggest that about 527,624 and 1,671,149 new cases of cervical and breast cancer are added every year. Notice that India contributes about 122,844 cervical cancer cases and 144,937 breast cancer cases every year (Ferlay et al. 2015). India, accounts for nearly one-third of the global cervical cancer deaths and Indian women face a 2.5% cumulative lifetime risk and 1.4% cumulative death risk from cervical cancer (WHO/ICO 2017). Earlier cervical cancer was most common cancer in Indian women, but now the incidence of breast cancer has surpassed cervical cancer and is the leading cause of death (Kaarthigeyan, 2012). A point to be noted here is that breast and cervical cancer are curable if diagnosed at an early stage. These cancers are preventable with access to high-quality care, periodic screening tests and regular follow up (IARC 2018).

Cancer prevention and control in the context of an integrated approach (WHA 70.12), urges governments and WHO to accelerate action to achieve Sustainable Development Goal (SDG-3.4) to reduce premature mortality from non-communicable diseases including cancer by one third by 2030 (WHO, 2016). The strategies to reduce the high burden of cervical and breast cancers include risk factor intervention, vaccination, screening, and early diagnosis (Viens, et al. 2017). Effective screening is the first step towards reducing the burden of cervical and breast cancers. Screening has been defined as "the systematic application of a test or inquiry, to identify individuals at sufficient risk of a specific disorder to warrant further investigation or direct preventive action, among persons who have not sought medical attention on account of symptoms of that disorder (Britain, 1998). However, Screening uptake refers to the proportion of persons eligible to be screened within a population who have been both invited for screening and have received an adequate screen during a specified period (Beining, 2012). Experience from the developed world shows that effective population-based screening programmes can easily reduce the incidence of cervical and breast cancers. Also, mortality rates from cervical and breast cancers can also be reduced by such programmes (Hermann et al. 2018; Kitchener et al. 2006). Despite the clear and proven benefits of population-based screening programmes, population-based screening of cervical and breast cancers in developing countries, including India remain a challenge.

Until recently, there was no evidence on the screening of cervical- and breast- cancers in India. National Family Health Survey 2015-16 (NFHS-4), for the first time in the NFHS series, collected information on examination of the breast, cervix, and oral cavity from over 699,000 women age 15-49 (IIPS and ICF 2017). Availability of such information in NFHS-4 provided us with a great opportunity to analyze the levels and patterns in the screening of cervical and breast in India at national, state, and district levels.

Some past studies, mostly conducted in developed country settings, have identified a number of socio-economic, demographic, bio-medical, and residence-related factors that are associated with the screening of the cervix and breast. The likelihood of a woman receiving a Pap test, a clinical breast examination, depends on many aspects such as age, marital status, income level, education, and health status. Women's with more education, higher incomes, and insurance coverage are more likely to undergo cervical and breast cancer screening services (Lin 2008). Employed females are more likely to go for screening because of their higher opportunity cost, higher income and affordable out-of-pocket expenditure (Stephen 2003). Moreover, rural females are less likely than urban women to go for cervical, and breast screening (Coughlin et.al. 2008: McLafferty et.al. 2011; Beining 2012). Studies of breast and cervical screening show that women with greater access to health care, such as those with health insurance, are more likely to have recent screening tests (Selvin and Brett 2003; Stephen 2003). The risk of infection with HPV and also the risk of cervical cancer is increased by multiple sexual partners, age at first intercourse and sexual behavior of the woman's male partners (Bosch et al. 1997). Additional risk indicators for cervical cancer are the number of live births, long-term use of oral contraceptives, and cigarette smoking (Franco et al. 2001). The risk factors other than socio-economic and demographic characteristics, accountable for breast cancers are alcohol, obesity, longer use of oral contraceptives, early menstrual period, etc. (CDC 2018). Studies also suggest that neighborhood and state level characteristics including health policies and health care system influence cervical and breast cancer screening behaviors (Datta et al. 2006; Coughlin et al. 2008).

A review of cancer screening-related literature in India reveals that the spatial perspective of cancer screening is not explored yet. Cancer-related screening practices among females in India remain a neglected public health issue for Indian researchers mainly due to the scarcity of empirical data and a high focus on maternal and child health issues. Even though with an increase in the prevalence of cancer among the Indian population, most of the research on cancers in females is concentrated only on incidence rates and mortality rates of cervical, and breast cancers. The present study attempts to address some of these research gaps as it is very vital to look beyond socioeconomic risk factors, especially from a spatial perspective for a geographically diverse country like India. As India is a culturally and geographically diverse country (Singh 2017), spatial variations in cervical, and breast screening at the district level would help in capturing the real picture of screening practices. The spatial analysis would also help to depict the actual health status of females exposed to cervical and breast cancers in different geographic regions of India. Spatial effects are crucial, regression analysis ignoring the spatial correlations lead to incorrect inference on the estimated regression coefficients by narrowing confidence intervals (Huque et.al, 2014).

Data and Methodology

This study used data from the fourth round of National Family Health Survey (NFHS-4), which is a national level household survey conducted in 2015-2016. A nationally representative household-based sample was created through a stratified, multistage cluster sampling technique. For both urban and rural areas, geographic sampling units were obtained, and random household sampling was undertaken in chosen units. NFHS-4, for the first time collected information of women undergoing cervical and breast screening. This fact proved to be a desideratum to study this preventive health behavior in depth. The survey covers a representative sample of about 6,99,686 ever-married women in the age group 15-49 years, female participants at a 95% response rate and data is captured in two phases from 29 states and 7 union territories of India.

Dependent variables:

The dependent variables used in this study are, the percentage of women belonging to age group 15-49 undergoing cervical screening, and breast screening respectively at the district level, derived from the NFHS 4 data set.

Independent variables:

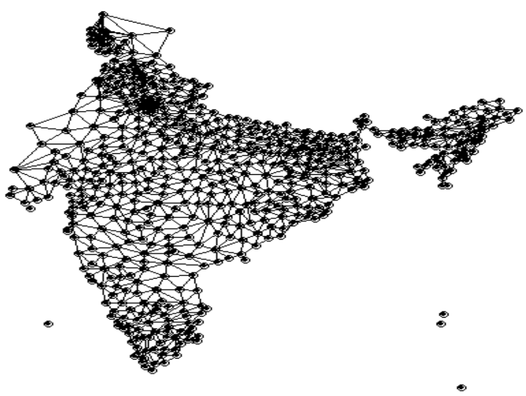
All the independent variables were constructed by selecting the percentage of women (15-49 years) at the district level. Factors affecting uptake of cervical screening such as insurance coverage, multiple partners, consumption of tobacco, usage of oral contraceptives, suffering from RTI and STI, parity greater than three. Similarly, factors influencing women undergoing breast screening include obesity, oral contraceptive usage, consumption of tobacco, insurance coverage and alcohol.

Table 1: Following is the brief description of the Districts in India by their population, sex ratio, and female literacy, data from Census 2011.

Top Five Districts by Population, Sex Ratio and Female Literacy in India (Census-2011)					
District (State)	**Population**	**District**	**Sex Ratio**	**Female Literacy %**	
Thane (Maharashtra)	1,10,60,148	**Mahe** (Puduchhery)	1184	**Aizwal** (Mizoram)	97.6
North 24 Parganas (West Bengal**)**	1,00,09,781	**Almora** (Uttarakhand)	1139	**Serchip** (Mizoram)	97.5
Bangalore (Karnataka)	96,21,551	**Kannur** (Kerala)	1136	**Mahe** (Puducherry)	97.2
Pune (Maharshtra)	94,29,408	**Pathanamthita** (Kerala)	1132	**Kottayam** (Kerala)	96.5
Mumbai Suburban (Maharashtra)	93,56,962	**Ratnagiri** (Maharashtra)	1122	**Pathanmthitta** (Kerala)	94.8
Lowest Five Districts by Population, Sex Ratio and Female Literacy in India (Census- 2011)					
District(State)	**Population**	**District**	**Sex Ratio**	**Female Literacy %**	
Dibang Valley (Arunachal Pradesh)	8,004	**Daman and Diu**	534	**Alirajpur** (Madhya Pradesh)	30.9
Nicobars (Andaman and Nicobar)	36,842	**Tawang** (Arunachal Pradesh)	714	**Bijapur** (Chhatisgarh)	31.5
Lahul and Spiti (Himachal Pradesh)	31,564	**North Sikkim** (Sikkim)	767	**Bastar** (Chhatisgarh)	32.8
Anjaw (Arunachal Pradesh)	21,167	**Dadra Nagar Haveli**	774	**Jhabua** (Madhya Pradesh)	34.3
Upper Siang (Arunachal Pradesh)	35,320	**Surat** (Gujrat)	787	**Shrawasti** (Uttar Pradesh)	37.1

There are 640 districts in India. The population size ranges between 1, 10, 60,148 (Thane) and 8,004 (Dibang valley). There is a high sex ratio (female/male) majorly in the southern districts of India. Female literacy ranges from 97.6 % to 30.9%. The table indicates a high degree of variation between different regions.

Fig 1: Neighborhood Weight Matrix Map (Queen's Style)



The spatial analysis in this paper was implemented through the R studio software Version 1.1.442 which provides a very user-friendly environment to perform Spatial Data Analysis (SDA) methods**.** The data set and shapefiles were imported to R studio, to calculate Moran's I and generate detailed Lisa maps to study spatial variations and conduct spatial analysis. "spdep" package was employed to perform spatial analysis. Firstly, "poly2nb" function has been used to create contiguity neighbors, "queens style'', which works on the principle that at least one point on the boundary of a polygon is within the snap distance of at least a point of its neighbor. This relationship is given by the argument queen=TRUE by analogy with movements on a chessboard. Once the list of sets of neighbors for our study area was established, we proceeded to assign spatial weights to each relationship. Contiguity weights matrix has been created by using the "nb2listw" function which takes a neighbors list object and converts it into a weights object. The neighbor's component of the object is the underlying "nb" object, which gives the indexing of the weights component.

In this study, we defined neighbors as the districts that share either a common border or a vertex with a given district (xi). Further, the magnitude of Moran's I was estimated by using "moran.test" function to check for the presence of spatial autocorrelation. A significance level of P-value<0.05 was used to assess spatial autocorrelation. The main idea behind spatially autocorrelated data is that values are not independent of space. This concept is based on the first law of geography proposed by Waldo Tobler: "Everything is related to everything else, but near things are more related than distant things."

Moran's I formula

$$I = \frac{N}{\sum_i \sum_j w_{ij}} \frac{\sum_i \sum_j w_{ij}(X_i - \bar{X})(X_j - \bar{X})}{\sum_i (X_i - \bar{X})^2}$$

where is the number of spatial units indexed by and; is the variable of interest; is the mean of, and is an element of a matrix of spatial weights. The Moran's I score ranges from -1 (dispersed) to 1 (clustered). A value of 0, or very close to 0, refers to random distributions.

Negative (positive) values indicate negative (positive) spatial autocorrelation. Positive autocorrelation suggests that points with similar attribute values are closely distributed in space, whereas negative spatial autocorrelation suggests that closely associated points are more dissimilar in spatial terms.

Then, LISA statistic was calculated for each observation and cluster, with the significant level at $P<0.05$

The LISA statistic gives a signal of the extent of significant spatial clustering of similar or dissimilar values around a spatial feature. It is provided by

$$I_i = \frac{n(x_i - \bar{x})\sum_{j=1}^{n} w_{ij}(x_j - \bar{x})}{\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

The parameters for the LISA statistics are same as those in Moran's I. In fact, the sum of the LISA statistics for all spatial features is proportional to the global Moran's I. A positive I_i value indicates spatial clustering of similar values around a spatial characteristic, and negative values indicate a clustering of dissimilar values around a spatial feature.
Four types of spatial associations can be derived from this statistic and plotted in Moran's scatter plot, with high-high (HH) and low-low (LL) types for spatial clustering of similar values, and high-low (HL) and low-high (LH) types for spatial clustering of dissimilar values, that is, spatial outliers [3].
Univariate Local Indicators of Spatial Association (LISA) measure the correlation of neighborhood values around a specific spatial location. It determines the extent of spatial non-stationarity and clustering present in the data. It is given by

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

Bivariate LISA measures the local correlation between a variable and weighted average of another variable in the neighborhood.

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

The univariate analysis measures the correlation of neighboring values around a district for the same variable, whereas bivariate analysis measures the correlation between the value of one variable for the observation and neighboring values of a second variable.
Further, ordinary least squares (OLS) regression was employed to explore the relationship between cervical, and breast screening and their explanatory variables respectively. Statistically, a significant association was checked for factors influencing uptake of cervical, and breast screening by their socio-demographic characteristics respectively.
The spatial error model was used to scrutinize for spatial relationship, which is accountable for a value observed in one location depends on the values found at nearby sites,i.e., there is a spatial dependence. Spatial data may show spatial dependence in the variables and error terms. When spatial dependence is present in the error term, a spatial autoregressive specification for this dependence is typically assumed.
Spatial error model—Incorporates spatial effects through error term

$Y= x\beta + \varepsilon$

$\varepsilon= \lambda W \varepsilon + \xi$

ε is the vector of error-terms, spatially weighted using the weight matrix (W)

λ is the spatial error coefficient

ξ is a vector of uncorrelated error terms

If there is no spatial correlation between the errors, then $\lambda = 0$. This model is a particular case of a regression specification with a non-spherical error variance-covariance matrix. The spatial multiplier now pertains to shocks in the unobserved variables (the errors ε) but not to the explanatory variables of the model (X). In other words, the value at any location is a function of the local characteristics but also of the omitted variables at neighboring locations. The OLS estimator remains unbiased for the regression coefficients in the spatial error model but is no longer efficient. Whereas, the spatial autoregressive parameter λ (Lambda) in the spatial error model is highly significant at 1% significance level, which also indicates that spatial autocorrelation exists in the data.

Results

Prevalence Maps:

Figure 2 Prevalence of Cervical Screening

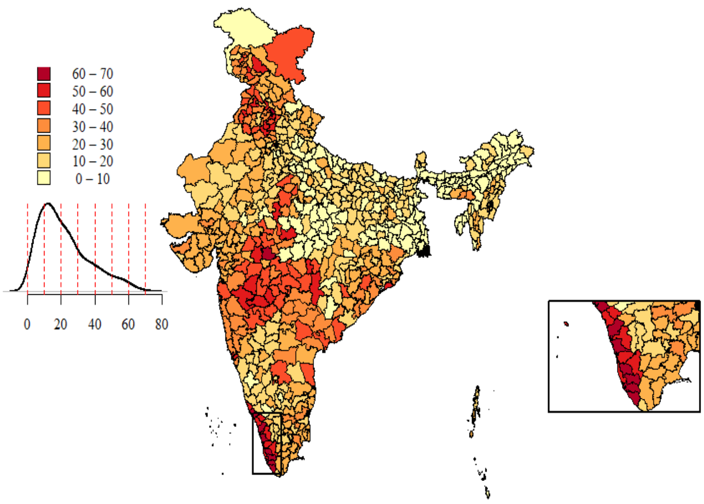


Figure 3 Prevalence of Breast Screening

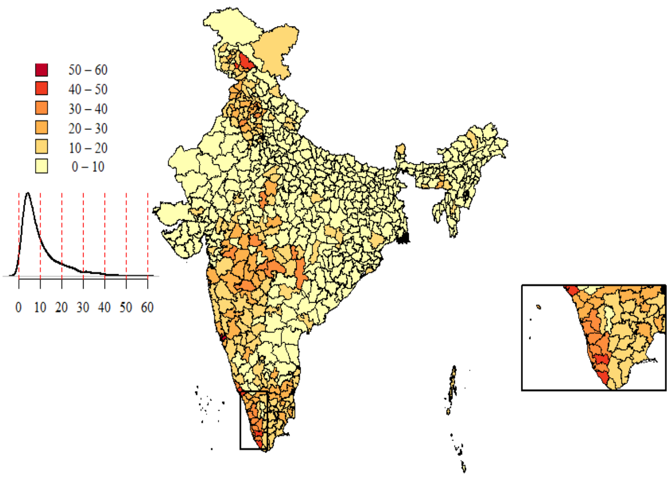


Figure 2 and 3 displays the prevalence maps of cervical, and breast screening respectively**.** Figure 2 shows that highest percentage of women going for cervical screening lies majorly in districts of southern India, precisely in Kerala. The inset zoomed map distinctively displays this finding. The distribution curve between the number of districts and their percentage of screening shows that the majority of districts are having a percentage between 10 to 20. Figure 3 manifests that North Goa have a maximum percentage of women going for breast screening, again the majority of districts of Kerala, lies under the higher percentage of breast screening. District of Jammu is among the higher scorer. The distribution curve here exhibits that majority of districts have percentage between 0 to 10.

Table 2: Moran's I for Dependent and Independent variables among Females, Indian District

Characteristics	Moran's I	Characteristics	Moran's I
Cervical Screening	0.6105	Literacy	0.6898
Breast Screening	0.5548	Employed	0.4865
Alcohol	0.5799	Currently Married	0.5696
Tobacco	0.8127	Hindu	0.7489
Parity>3	0.7532	General Caste	0.5527
Insurance		Rural	0.4182
	0.7353	Rich	0.7018

Table 2 illustrates the Moran's I values for the explanatory and independent variables incorporated in the study. If the values in the dataset tend to cluster spatially (high values cluster near other high values; low values cluster near other low values), the Moran's Index will be positive. The Moran's I for cervical and breast screening was 0.6105 and 0.5548 respectively. It stipulates high spatial autocorrelation in cervical and breast screening over the districts of India. The Moran's I range between 0.81(for a percentage of tobacco consumption) and 0.31 (for a percentage of women suffering from RTI and STI). Moran's I value is very high for oral contraceptive users (0.77), the percentage of women with parity greater than 3 (0.75), the percentage of women insured (0.73), percentage Hindus (0.75) and percentage of women belonging to the high socio-economic group.

Fig 4a: Moran Scatter Plot for Cervical

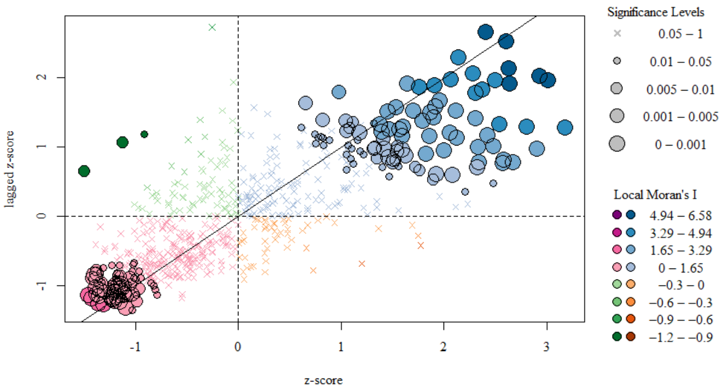
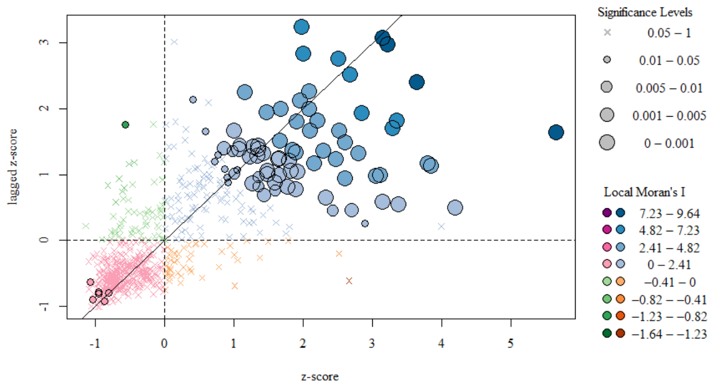


Fig 4b: Moran Scatter Plot for Breast



The scatter plot shown in figure 4a and 4b delineates the visualization of how spatially clustered or autocorrelated are the variables and the slopes indicate the positive correlation. High values clustered with high and low values clustered with low can be seen in the first and third quadrant.

UNIVARIATE LISA MAPS:

Figure 5a. Univariate LISA (Cervical)

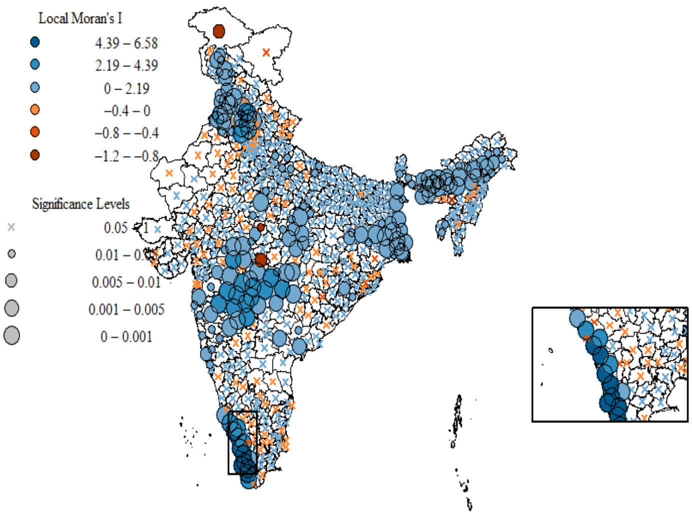
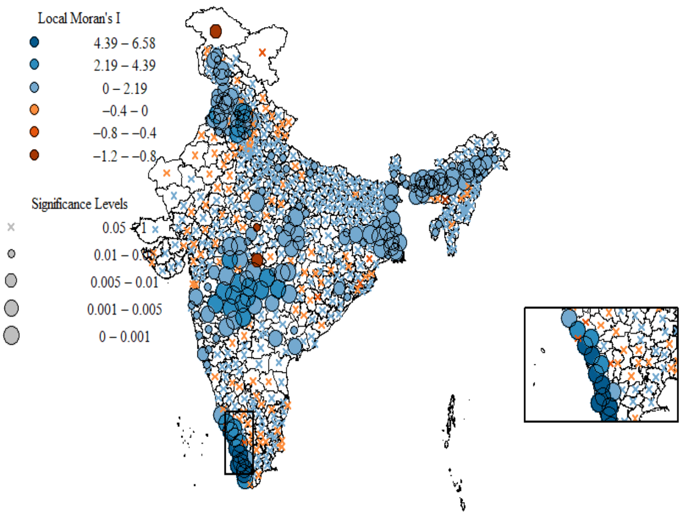


Figure 5b. Univariate LISA (Breast)



The global Moran's I do not give any information on where the clusters exist. Local Indicators of Spatial Association (LISA) provides a measure of association for each spatial unit (district) and helps to identify the type of spatial correlation. The results of LISA maps help to determine the nature of spatial autocorrelation so that they can be categorized into low adherence and high adherence groups. Inference can be based on a permutation or randomization approach. Figure 5a and 5b delineates the univariate LISA maps of cervical, and breast screening at the district level. The cluster maps display locations with a significant local Moran's statistic categorized by the type of spatial correlation. The size of the circles shows the level of statistical significance; bigger the size of the circles higher is the level of significance.

Similarly, the color of the circles depicts the LISA values. The locations on the map covered by colored cross shapes denote the non-significant LISA values. Figure 5a exhibits the clusters of cervical screening in India. High level of dense clustering can be seen in districts of Kerala, Maharashtra, Assam, Punjab, Jammu and Kashmir and West Bengal. Few clusters are also observed in districts of Madhya Pradesh and Uttar Pradesh. High dense overlapping clusters means that districts with above average cervical screening also share boundaries with neighboring districts that have above average cervical screening. Figure 5b presents the clustering of breast screening in India. Phenomenal clustering can be seen in districts of Kerala, Tamil Nadu, Karnataka, Maharashtra, and Punjab, Himachal Pradesh, Jammu, and Kashmir. Small dispersed clusters are observed in districts of West Bengal and North East.

Bivariate LISA Maps for Cervical Screening:

Figure 6 onwards represents bivariate LISA maps depicting the association between selected independent variables and cervical screening at the local level. High cervical screening clusters are statistically correlated with high female literacy; clusters can be seen in districts of Kerala, Tamil Nadu, Maharashtra, Punjab, and Himachal Pradesh. A few eastern districts of Nagaland and Mizoram and some part of Orissa also exhibit such clusters.

The map of spatial correlation between cervical screening and female work participation, distinctively reveals interesting spatial clusters, majorly covering districts of Maharashtra, Telangana and Andhra Pradesh. Districts with a high percentage of cervical screening coverage and a high percentage of women belonging to a middle class are primarily concentrated in a lower part of Deccan plateau, as the visual representation clearly depicts. Some clusters can also be seen in districts of northern and eastern districts of India. Additionally, high cervical screening is also correlated with a high-income level group of women in districts of Kerala, Punjab, and Haryana. Some clusters can also be seen in districts of Gujarat, Maharashtra and Tamil Nadu. The map of spatial correlation between screening and currently married women represents spatial clusters in districts of the northern, western and southern belt of the country. Districts with a high percentage of Hindu women and a high percentage of women up taking screening are majorly concentrated in western, central and southern districts. Few clusters can be seen in northern belt. High screening is correlated with the high percentage of women belonging to General caste; clusters can be observed in northern and southern districts. High cervical cancer screening is statistically correlated with high tobacco consumption, located mainly in eastern districts. In figure 6. Districts with a high percentage of women using oral contraceptives and a high percentage of cervical screening are primarily concentrated in districts of Orissa. Clusters can be seen in some districts of Assam as well as high cervical screening is significantly correlated with multiple high partners of women in districts of Orissa and north-east India. High women parity (>3) in some districts of U.P., Bihar, and Meghalaya share clusters concerning the high percentage of women opting for cervical screening in the said region. The map of spatial correlation between districts of high cervical screening and high insurance coverage reveals interesting spatial structures, primarily covering the districts of southern India. The spatial pattern between high cervical screening and high inflicted districts with RTI and STI can be seen in the northern and eastern belt.

Bivariate LISA Maps for Breast Screening:

Figure 7 onwards represents bivariate LISA maps depicting the association between selected independent variables and breast screening at the district level. The map of spatial correlation between breast screening and female literacy depicts interesting spatial clusters, covering southern (Kerala, TamilNadu, Maharashtra, Telangana), northern (Punjab, Uttarakhand, and Haryana) and eastern districts (Mizoram). The visual representation of high breast screening and high female work participation presents clusters in the upper part of the Deccan plateau. Some clusters can also be observed in districts of the eastern part. The map of spatial correlation between screening and currently married women represents spatial clusters primarily in the central and Deccan region. Clusters in Districts with a high percentage of Hindu women and a high percentage of women up taking screening substantially lies in the central region. Some clusters also lie in districts of the southern and northern belt. High breast screening is statistically correlated with high users of oral contraceptives, located in eastern districts only. Districts with high breast screening and a high percentage of obese women lie in upper Deccan plateau. Clusters can be seen in eastern districts, which depicts the statistical correlation between high breast screening and high tobacco users. The spatial pattern between high breast screening and high insured women can be observed in the southern belt; few clusters lie in eastern districts. (Arunachal Pradesh)

OLS regression model and spatial error model

Table 3a: Cervical Screening:

Characteristics (Percentage)	OLS Model	Spatial Error Model
Literacy	-0.0004	-0.054
Unemployed	**-0.149***	-0.074
Currently Married	**0.279***	**0.322***
Hindu	**-0.092***	**-0.083***
General Caste	**0.106***	**0.085***
Rural	**0.144***	**0.162***
Rich	**0.282***	**0.342***
Oral Contraception	**-0.472***	-0.151
RTI/STI	-0.020	0.039
Tobacco Use	-0.041	-0.024
Multiple Partner	**-0.398***	**-0.195**
Parity >3	**-0.306***	-0.035
Insurance	**0.069**	**0.081**
Multiple R squared	0.397	λ = **0.685***
Adjusted R **Squared**	0.385	
LR test value		230.17
Log-likelihood		-2351.604
AIC	4963.4	4735.2

Table 3a shows the percentage of unemployed women are negatively associated with the percentage of women opting for cervical screening. For obvious reasons, the marital status of women significantly explains the variation of 28% in our dependent variable. A positive relation can be seen for a percentage of women belonging to a general caste, percentage residing in rural areas with the cervical screening. The parallel relation is also shared by the percentage of women belonging to the higher income group. In contrast, Hindus are negatively associated with the explanatory variable. At the district level, the percentage of female oral contraceptive users are negatively associated with those undergoing cervical screening. Similar findings are obtained for a percentage of women having multiple partners and having parity above three. It is worth noting that the percentage of women availing insurance benefits have a positive correlation with that of screening. It's startling that female literacy is statistically insignificant to explain variation in screening.

We estimated spatial error regression (Model 2) to scrutinize for spatial clustering while examining the association between our dependent variables (screening) and the independent variables. The results shown in table 3a, stipulates statistically significant spatial autocorrelation (λ). The spatial autoregressive parameter $\lambda=0.68542$ (Lambda) which is statistically significant in the model, indicates that spatial autocorrelation exists in the data. It is implicit that for most of the part, the residual spatial autocorrelation in the cervical screening can be accounted for regarding unmeasured predictor variables.

Percentage of women with multiple partners are negatively associated with the percentage of women up-taking cervical screening at the district level. Same is the case for percentage Hindus. A positive association has been found for a percentage of women insured, percentage currently married and percentage of females belonging to general caste w.r.t cervical screening. Percentage residing in rural areas and percentage belonging to higher economic class also share a positive association.

Table 3b: Breast Screening:

Characteristics (Percentage)	OLS Model	Spatial Error Model
Literacy	-0.0004	-0.054
Unemployed	**-0.149*****	-0.074
Currently Married	**0.279*****	**0.322*****
Hindu	**-0.092*****	**-0.083*****
General Caste	**0.106*****	**0.085*****
Rural	**0.144*****	**0.162*****
Rich	**0.282*****	**0.342*****
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Adjusted R **Squared**	0.385	
LR test value		230.17
Log-likelihood		-2351.604
AIC	4963.4	4735.2

Table 3b shows the effect of female literacy at the district level is 0.125 on the uptake of screening and is significant, which manifests that education of women and her preventive health care seeking behavior goes hand in hand. Percentage of women unemployed are negatively associated with the percentage of women undergoing screening. Again, the percentage of married women and percentage engaged in screening shows a positive association, explaining the variation of 18% in the later. Percentage of women belonging to a general caste, percentage residing in rural areas are positively associated with the explanatory variable. Similar findings for the percentage of females being economically prosperous has been noticed. Percentage of women using oral contraceptives and consuming tobacco have a significant negative association with the percentage of women undergoing screening at the district level. Even adiposity and screening share a negative association with each other, unfolding the variation of 35% in the dependent variable. No significant association has been spotted between the percentage of women covered by insurance and percentage going for screening. Healthcare structure seems to have no impact in this case, contradictory to that of cervical screening. Similar findings obtained for a portion of women consuming alcohol.

Spatial error model employed here indicates statistically significant spatial autocorrelation with $\lambda = 0.60744$. Percentage of obese are negatively associated with percent uptake of screening. Similar outcome for a percentage of tobacco users, percent unemployed and percent Hindus. Percent of married women, percent residing in rural areas, percent belonging to general caste and percent rich are all positively associated with percentage uptake of screening.

Discussion:

The results of this study enable us to understand more thoroughly the characteristics of women who undergo a cervical, and breast screening, as well as the factors that influence uptake of screening among females in India. One of the principal findings is the significant positive association between the percentage of women insured and the percentage of women undergoing cervical screening at the district level in both the models. The spatial clusters of cervical screening and women insured coincide with each other for districts in southern India. Health care coverage may affect these decisions since those that are protected for these procedures will pay less out-of-pocket than those whose costs are not adequately covered. (Jepson, R.et al., 2000). It's worth noting that the marital status of women has a considerable role in influencing one's decision of undergoing for screening. For both the models, cervical and breast screening shows a significant positive association between the percentages of women who are currently married. Similar associations have been documented in other studies as well (Lin, S. J., 2008). Another crucial finding that emerges from our analysis is the statistically significant and positive association between the percentage of women belonging to high socio-economic status and percentage uptake for screening. The same result has been evidently established for cervical, and breast screening. This strongly resonates with the fact that the economic status of women profoundly influences her decision to undergo screening (Lin, S. J. 2008;Wu, S., 2003).

It's worth noting that the clear and distinct spatial clusters are formed in districts of Kerala, covering majorly whole state for all cervical, and breast screening (NFHS-4, 2018). The credit for such result may be attributed to the fact that adequate steps have been taken by Kerala state health department. Doctors have been sent to every home in the state to screen people above the age of thirty years for breast, and cervical screening. The Kerala Police and Swasthi Foundation in association with Aster Med city, the leading quaternary care hospital in Kerala launched 'RakshakaRaksha,' a series of free Cancer and Lifestyle diseases screening camps for the state police force. (Aster Medcity 2017). Kerala was the first state in the Indian union to formulate a cancer control programme on the guidelines of WHO as early as in 1988 (called 10-year action plan) (Nair, Mk, 2002). Even panchayaths have envisaged cancer control activities as part of their Peoples Plan Programs. These were profitably utilized for vigorous implementation of cancer control in the State of Kerala. The programme consisted primarily of the creation of awareness on risk factors and thus empowering the population to seek good lifestyles and health-related examinations to detect and diagnose the disease in early stages and undergo treatment in institutions re-oriented for this purpose. Kerala has turn out to be a paragon of virtue for other regions, obliging with the need to opt for preventive health behavior measures, i.e., screening.

Effect of spatial distribution

Spatial autocorrelation (λ) came out to be statistically significant in the spatial error model, indicating that the relationship between screening and independent variables at the macro level (districts) may be misleading if spatial clustering is ignored. Spatial regression analysis enabled us to examine spatial relationships between cervical, and breast screening and their independent variables respectively, at the district level and to identify the factors promoting the spatial pattern; factors that would help us explain why and where screening is high. Thereby, it would not be wrong to surmise that women up taking screening programs clearly indicates women's knowledge, willingness, and access to health care availability.

Conclusion:

As part of National Health Mission, the Indian government for the first time has launched population-based prevention, screening, and control programme for cancers of the cervix and breast. This analysis provides a new indication of the factors spatially affecting the utilization of preventive care among women in a developing country, which are analogous to those of other countries, and may shed further light on the issue of promoting screening and women's health. By showing geographical disparities in screening, this study highlights the importance of ensuring that the provision and uptake of screening services reach all parts of the population. This is in line with current government priorities. This document drew attention, in particular, to the lack of evidence for demonstrating and understanding existing disparities and the need to promote research to fill the gaps. This study is essential in both respects. It is imperative that we have a region-specific and organ-specific approach towards control and prevention of cancer. The findings can help formulate related policies that are directed at removing the barriers to accessing medical care and targeting those at-risk groups. Mandatory screening is need of the hour which should not be seen as a violation of reproductive rights and choice, but instead as a way of improving the health outcomes of women rapidly, instead of waiting for the benefits of health education. It may be the aptest and feasible option in transitional economies. Women's dependency on the government and the lack of agency needs to be considered within the context of their social and economic powerlessness and deprivation. Compulsory screening may, therefore, be an effective way of avoiding stigmatization of women presenting for gynecological examinations. This will also minimize the impact of social inequalities on health outcomes among women from different social backgrounds. The introduction of patient-friendly health services and adequate public health education needs to coincide with mandatory screening. The triple-A approach, i.e., accessibility, affordability, availability of health care facilities best resonates in the case of cervical, and breast screening. Modeling the cost-effectiveness of this whole affair is another critical component to deal with when there is rising global concern over the high level of out of pocket expenditure on health.
This study has some following limitations, and future research should be encouraged in that direction. Firstly, the scope of the article limits us to provide any information that whether the women undergoing for screening is the resultant of their cognizant behavior or it's driven due to external factors, i.e. - Government interventions. Secondly, women opting for screening practices include both the parties; the one who are indulged in the preventive behavior as well as those who are suffering from the disease itself. It is ambiguous to draw any surmise, due to

data limitation, which provides only the percentage of women undergone for cervical and breast health checkup.

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Figure 6a. Bivariate Map (Cervical-Literacy)

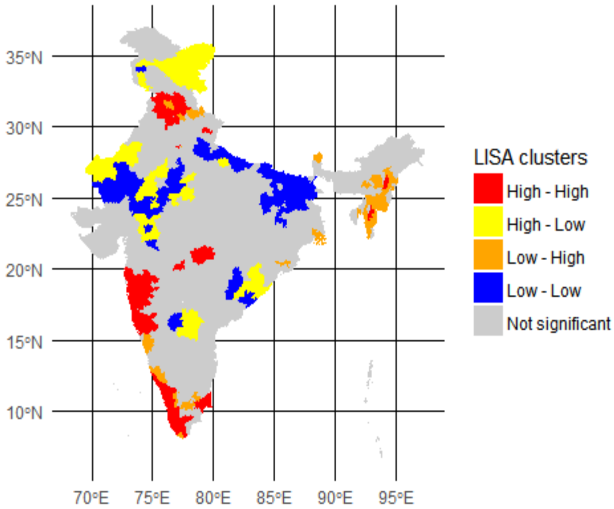


Figure 6b. Bivariate Map (Cervical-Employed)

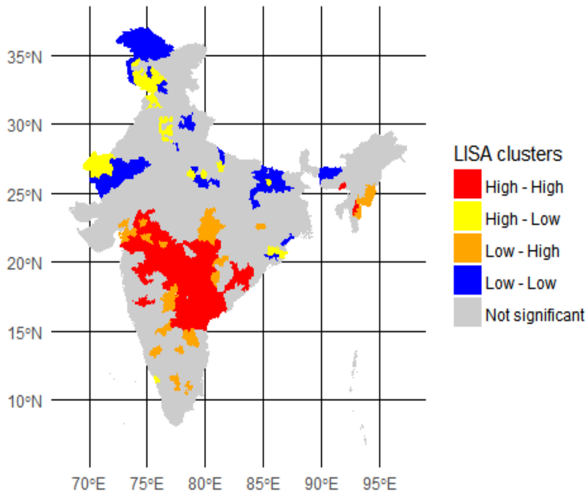


Figure 6c. Bivariate Map (Cervical-Rich)

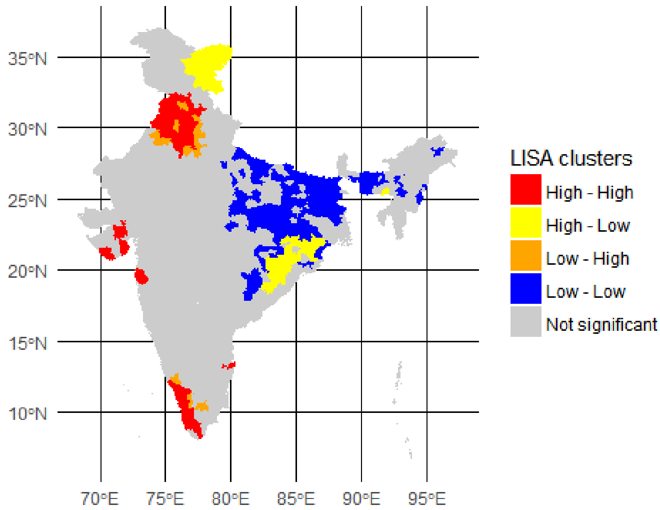


Figure 6d. Bivariate Map (Cervical-Married)

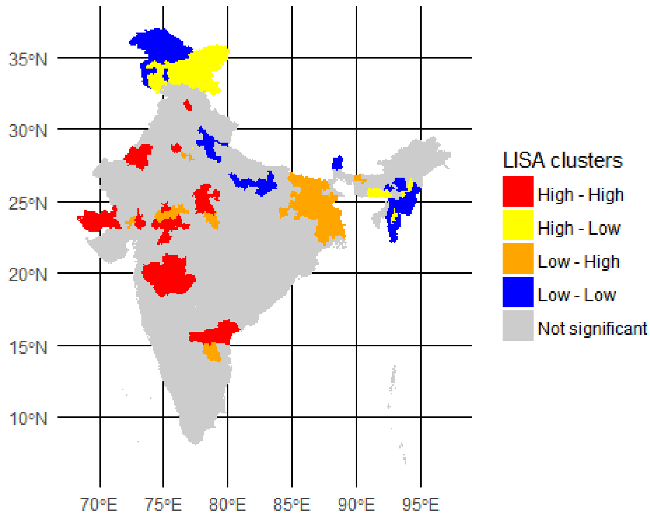
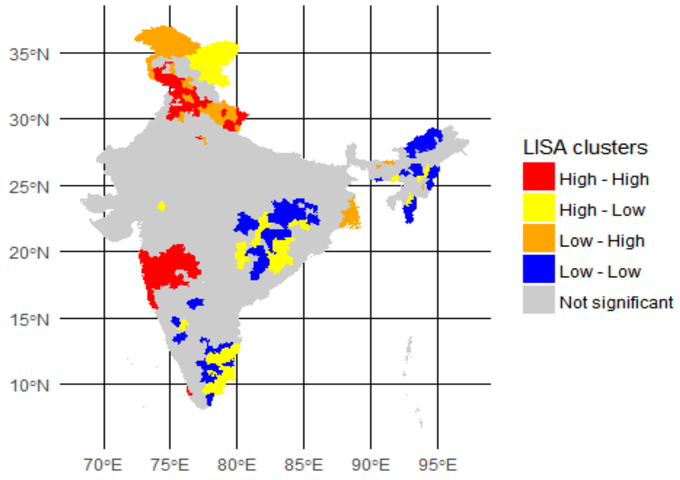


Figure 6e. Bivariate Map (Cervical-General) Figure 6f. Bivariate Map (Cervical-Tobacco)



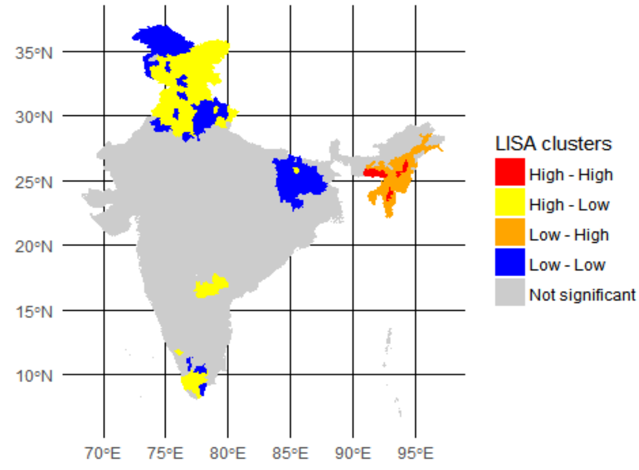
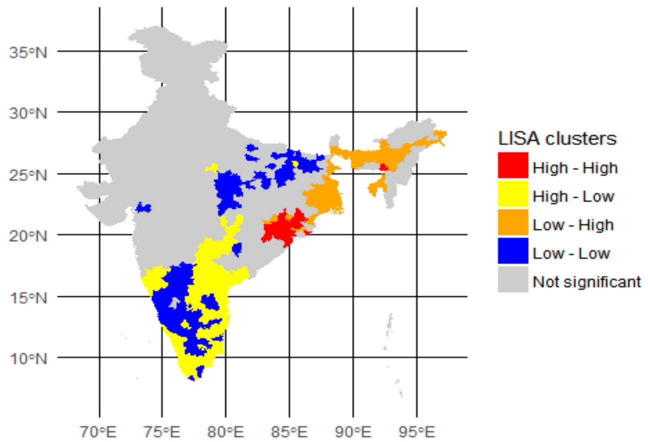


Figure 6g. Bivariate Map (Cervical-Oral) Figure 6h. Bivariate Map (Cervical-Insurance)



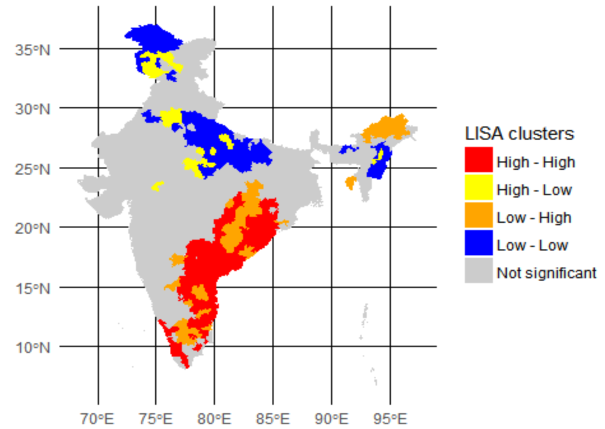
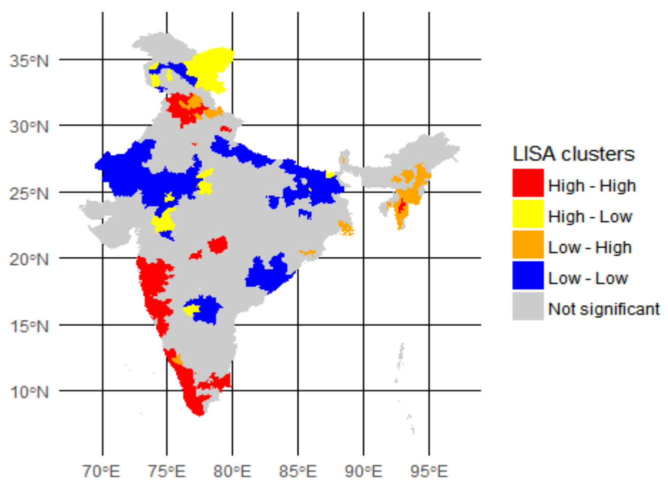


Figure 7a. Bivariate Map (Breast-Literacy) Figure 7b. Bivariate Map (Breast-Employed)



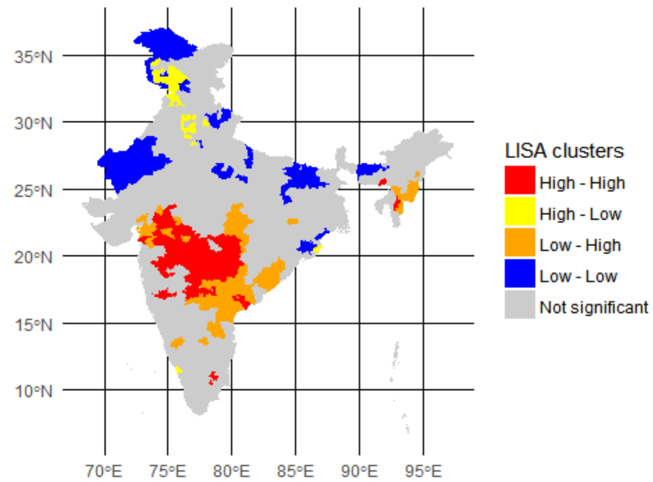


Figure 7c. Bivariate Map (Breast-Married)

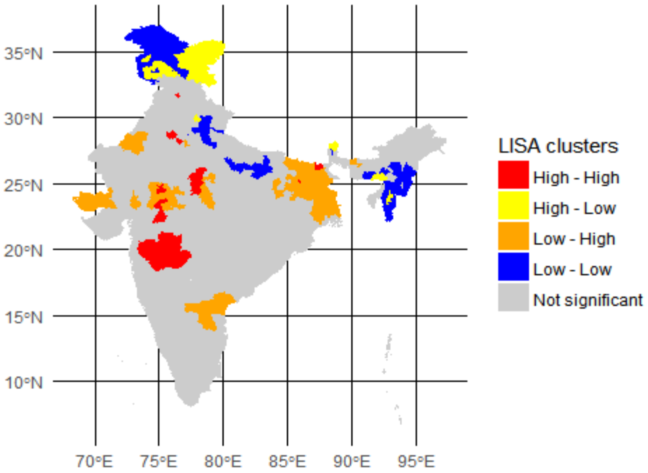


Figure 7d. Bivariate Map (Breast-Hindu)

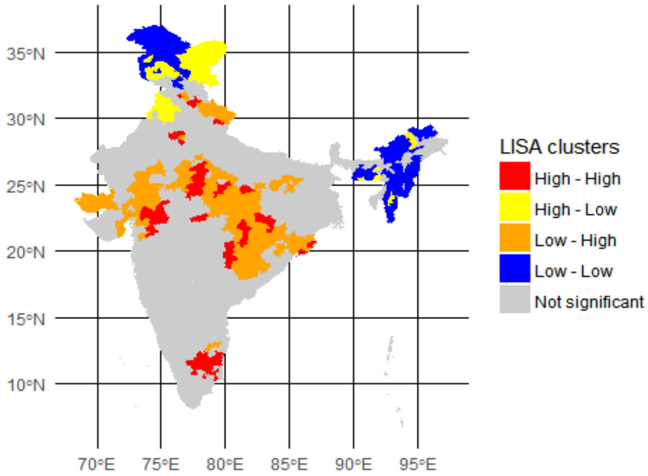


Figure 7e. Bivariate Map (Breast-Insurance)