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A SPATIAL - AUTOCORRELATION ANALYSIS OF EXTRA PULMONARY TUBERCULOSIS INCIDENCE IN MYSORE DISTRICT

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ABSTRACT

Background and objectives: Extra Pulmonary Tuberculosis (EPTB) is one of the most important bacterial diseases caused by M*ycobacterium tuberculosis.* It includes any organ of the body *viz.,* bronchus, larynx, lungs, pleura, intrathoracic bronchopulmonary lymph nodes, abdominal sites, joints, bones, CNS, pericardial cavity, kidneys, and urogenital tract. The spectrum of the EPTB ranges in different proportions at different organs and remains dormant for years at a specific site before disease expression. The directly observed treatment of short-term (DOTS) is a rapid expansion of EPTB that comes under the revised national tuberculosis control programme (RNTCP) all over India and Karnataka in the past decades. The present study aims at identifying the magnitude, incidence, hot spots and diversity of the disease with the consortium of GIS tool with the statistics of EPTB for the year 2011-16.

Methods: Some of the records show the individual reports of EPTB in DOTS centres. Identification of hotspots and extent of diversity are explored using Arc-GIS 10.2.2 software. Spatial autocorrelation analysis and spatial pattern analysis was performed to detect the geographic basis for the occurrence of the disease.

Results: Record of the RNTCP against the pulmonary and extrapulmonary disease has revealed the TB situation in Karnataka as one of the trounce in the State. Mysore is the major district of Karnataka facing incalculable problems. The number of reported EPTB in Mysore city is about 50-75 cases per month according to the district tuberculosis centre (DTC). Most of the reported cases convey males aged 45 and above showed drastic growth in EPTB in recent years. From 2011-16, EPTB in Mysore City accounts for 1,835 cases, the highest incidence in Nanjangud (642), Heggadadevanakote (508), Tirumakudalu Narasipura (538) Krishnarajanagara (415) and least in Hunsur (221) and Piriyapatna (225).

Conclusion: The spatial autocorrelation analysis was found effective for further focus on improving the socio-economic status and targeting the hot spot region with health care measures. This adds up to the existing scientific scenario and can be extrapolated to any other disease assessment of public health.

Keywords: Extra Pulmonary Tuberculosis Incidence, GIS Software, Spatial Autocorrelation, Interpolation, Temporal analysis

1. INRODUCTION

Tuberculosis is a primary disease of lungs that can affect any organ in the body. The term Extra Pulmonary Tuberculosis (EPTB) is a bacterial infectious disease caused by a bacillus, *Mycobacterium tuberculosis (M. tuberculosis*) **[1]**. Pulmonary Tuberculosis sustains and spreads to other organs of the body and referred to as EPTB. As the pathogen spreads to different organs of the body, a different proportion of the spectrum of EPTB is noticed. The revised national tuberculosis control programme (RNTCP) has been in the forefront of the battle against this scourge in our country. Data obtained from these reveals 8.4 million EPTB cases globally and 2.1 million in India in the year 2015-16 alone **[7, 8]**.

EPTB has remained a major public health problem since the dawn of civilization and continues to impose a major financial burden on the society. Despite the availability of modern techniques of diagnosis and effective drugs, India continues to bear one-fourth of the world's EPTB disease burden **[2, 3]**. It is estimated that every two minutes a person dies from TB in India. Keeping this in mind, the initiative was taken to carry out an extensive review of the current medical literature on the subject of diagnosis and treatment of various forms of EPTB. A large number of clinical specialists from different fields and experts from India and abroad have worked tirelessly for the past one and a half years to bring out an evidence-based, comprehensive guideline on the management of all forms of EPTB. In this study, we are using the Arc-GIS software for the hotspot analysis of EPTB patients in the Mysore District **[9, 10]**.

The present study uses GIS tools and statistical analysis to locate the spatial distribution, hotspots and intensity of incidence at the province **[4, 5]**. The Arc-GIS is the software that includes Arc-Map, Arc-Catalog, and Arc-Toolbox. The software provides increasing levels of functionality and favours to discover spatial sodality patterns. This tool was used to visualize and describe the spatial distribution of EPTB reported cases. The use of GIS tool aids to identify the regions at the highest risk for the EPTB outbreak at Mysore district. The dynamics and distribution of EPTB ensued from the outcome of the results that can be used as an indicator of risk in a locality **[6]**.

Arc-GIS software tools involved in this study are Arc-map, Arc-Catalog, Arc-Toolbox.

Arc-GIS Explorer is a GIS viewer that can work as a client for Arc-GIS Server, Arc-IMS, Arc-Web Services and Web Map Service (WMS). Arc-GIS Online application presents a unique searching and sharing ability of geographical locations, Arc-GIS users and other authoritative data providers **[11]**.

2. MATERIALS AND METHODS

2.1 Study design and Analysis of EPTB Data

In the present study, the calculation of risk factors among people was carried out using the pictorial epidemiological methods to tabulate the EPTB incidence data. The age and gender distribution of the patients is noted in the study, along with the HIV positive and negative correlation.

- **Inclusion Criteria:** This study includes all cases of EPTB patients of all age groups and both sexes treated at our centre by DOTS. The institutional ethical committee proved approval for performing the study.
- **Exclusion Criteria:** Excludes any case of Pulmonary TB. The statistical analysis was done using descriptive analysis.

2.2 Sources of Data and Selection Criteria

The EPTB data is collected from the District Tuberculosis Center (DTC) Mysore, DOTS, from the year 2011-16. The data consists of the overall Mysore district which includes the seven taluks (with population): *viz..,*

1. Piriyapatna (224,254)
2. Hunsur (253,926)
3. Krishnarajanagara (239,199)
4. Mysore (1,038,490)
5. Heggadadevanakote (245,930)

6. Nanjangud (360,223)
7. Tirumakudalu Narasipura (279,005)

Total No. of Population: **2,641,027**

The data which was taken from the DTC is the total number of EPTB cases in Mysore

2.3 Arc-GIS Mapping

The Arc-GIS mapping is one of the methods in overlaying the shape files for mapping. They store the data in the secondary tool and it is inputted in spatial-autocorrelation tool for outlining the structure of Map. This also includes the 2D and 3D structure of the mapping for selected data. The flat collection of all the layers are extracted and combined with ground layers, operational layers, and base map layers for generating the map. In this, there are two kinds of abstractions mapping *viz.,* Raster Images & Vector. Where our study included the Raster images. Which means bitmaps, they are a grid of individual pixels which are collectively composed and form a map or image. The raster graphics renders the images with a tiny square for each value with the data added in Arc-tool. The data represents the real objects of the EPTB cases for digitalising the map.

The collected data of EPTB is entered into a GIS form digital data collection system to find out the variations in the incidence of EPTB cases in Mysore.

2.4 Spatial Auto Correlation Analysis

The Spatial autocorrelation (Global Moran's I) tool is useful for evaluating the expressed patterns to assess if they are random, dispersed or clustered together. They are primarily based on feature values as well as its location simultaneously. The significance of the index was determined by Moran's I index value, Z-score as well as p-value.

Moran's I index is the spatial autocorrelation tool that measures the location and features of the map along with values added. The pattern expressed here is clustered classification.

Z-score refers to the standard deviation number and the values of data added in the study. It also helped in analyzing the numbers in prescribed data filed.

P-values are numerical approximations of the area under the curve for a known distribution, which is limited by statistics.

2.5 Spatial Pattern Detection

The TB spatial patterns were detected using global and local detection of the spatial patterns of SMR. Spatial clusters in the study area are identified using global detection, yet fail to provide the location of clusters. Therefore, local detection is required to obtain specific characteristics of the clusters pertaining to their size, magnitude and location **[28, 26]**. These were accomplished using Arc-GIS (10.2.2) software.

2.5.1 Moran's I

In statistics, Moran's I developed by Patrick Alfred Pierce Moran determines the spatial autocorrelation, which is the correlation of signals in space present in closest proximity [1, 2]. This is greater in terms of complexity owing to its multi-dimensional (i.e. 2 or 3 dimensions of space) and multi-directional patterns.

Moran's I is defined as:

$$I = \frac{N}{W} \frac{\sum_i \sum_j w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_i (x_i - \bar{x})^2}$$

Where N is the number of spatial units indexed by i and j; x is the variable of interest x; is a mean of spatial weights with zeroes on the diagonal (i. e. $w_{ii} = 0$) and W is the sum of all w_{ij}.

2.5.2 Getis and Ord's Local G_1 Statistics

Epidemiological data for the disease detection can be effectively represented in terms of spatial patterns. This provides information on the aggregation of cases to a particular location, detection of the presence of significant clusters, if any, to assess if any etiological factors are responsible for the disease development. Such a cluster study provides an insight into whether the occurrence of geographical aggregations is a chance factor or has statistical significance.

2.5.3 Temporal Analysis

Temporal GIS is a variant that integrates the location and other characteristics obtained by GIS with the temporal data (that facilitates analysis based on date and time). Data such as lightning, moving objects such as buses or trains, or redundant observations from traffic sensors etc **[3]**. A shift in these spatial properties can be represented as a function of temporal changes assessed by the temporal GIS that analyzes the spatio-temporal data **[4]**. The geographic movement considers the changes in spatial data with respect to time.

3. Statistical SPSS Analysis

In this study, the annual mid-year population was calculated from population statistics which was provided. The SMR was calculated using the following equation **[12, 13]**:

Standardized morbidity ratio (SMR) = N/ $\Sigma R_{si} P_i$

N = total number of cases in the observed population.
R_{si} = age-specific incidence rate in age interval i in the standard population.
P_i = population of age interval i in the observed population.

Assuming a Poisson distribution, the significance of SMRs and their confidence intervals were obtained using the formula **[14]**.

4. Incidence Rates Calculation and Adjustment

The present study primarily aimed at assessment of spatial clusters of TB incidence using SMR of EPTB data district-wise, especially the spatial cluster within Mysore district. The prominent index used for this analysis is the spatial autocorrelation for estimating the extent of similar observations falling within the same cluster **[15, 16]**. This facilitated the exploration of hot and cold spots with the help of Moran's I for prediction of disease incidence rate of a particular geographic location **[17]**.

5. RESULTS & DISCUSSION

5.1 Descriptive analysis of EPTB cases in Mysore District

There were 4,384 EPTB cases reported in Mysore District, from 2011-16. Of these 2,490 cases are males and 1,892 cases are females. The total number of cases of EPTB in Mysore district is shown by the graph represented as taluk **(Figure 1)**. All 4,382 (100%) had complete information on mapping based on their demographic data **(Figure 2)**. Annualized average incidence at the town-level ranged from 862.33 to 100.58 per 100,000 population **(Figure 3)**.

The excess hazard map showed the distribution of the excess risk, which was defined as a ratio of the observed number over the expected number of cases. Towns in blue colour had lower incidences than expected, as indicated by excess risk values less than 1. In contrast, towns in red colour had higher incidences than expected or excess risk values greater than 1.

5.2 EPTB Case distribution and Comparison in Mysore district, taluk wise:

The overall Mysore District EPTB incidence is shown in the GIS map from 2011-16, the comparison of the EPTB incidence is shown in the **(Figure 4)** (2011-A, 2012-B, 2013-C, 2014-D, 2015-E, 2016-F). There were 4,384 EPTB incidence cases reported in the Mysore District. The incidence reported in 2011 was 889 cases. It surged to a peak of 804 cases in 2012. After that, the incidences stood constant for the rest four consecutive years 2013, 2014, 2015, 2016 at 699, 690, 686 and 614 cases, respectively.

5.3 EPTB Case in Mysore District with Statistical analysis:

1,800,921 TB incidence cases were reported in Karnataka (2011-16) from that Mysore stands in 3rd position with a total number of 4,384 cases from 2011-16. The descriptive statistics include the mean, standard deviation and variance of the incidences **(Table 1)**.

5.4 Co-relation of EPTB in Genders:

The above age specificity group contained the maximum number of EPTB cases sorted as per age and gender. The study showed that male cases were higher than that of the female in all age groups **(Figure 5; Figure 6)**. All through the study period, 2,490 males and 1,894 females were registered with 60: 40 ratio of male to that of the female population **(Figure 7)**.

5.5 Co-relation of EPTB with HIV cases:

The study revealed that HIV AIDS cases were at a higher risk of encountering TB and that EPTB was observed in 15-20% of cases with active TB. Owing to greater severity of EPTB, it has elevated morbidity and mortality rates. This greater risk in case of HIV patients is likely due to the immunocompromised system that fails to fight infection.

Among 19,721 HIV cases, 19% of the cases also were EPTB **(Figure 8)** suggesting that HIV and MTB co-infection has been a common but greater challenge to the healthcare systems globally, especially the developing countries. Lymph nodes appear to be the primary site of occurrence of EPTB in about 20-40% of the cases. The lymph nodes exhibit characteristic histomorphology with irregularity in terms of shapes and sizes. In order to fight the disease and reduce mortality rates, endemic regions identified for TB should boost up proactive measures and regular clinical follow-ups.

Extra pulmonary tuberculosis is distinguished between the Urban and Rural Mysore from the year 2011-16. When compared with the urban and rural Mysore, the number of rural the cases are greater most likely due to the lack of health centre in the particular region or lack of hygiene knowledge among the population **(Figure 9)**.

Case Study Characteristics:

The socio-demographic profile of the respondents from selected urban slums of Mysore district from 2011-16 (n=4384) is summarized in the given table that suggests average percentage of males is 56.82%, and females is 43.18% **(Table 2)**.

5.6 Testing Global Measures for Spatial Autocorrelation of Predicted Extra Pulmonary Tuberculosis Incidence

The present study provides information on cluster analysis for prediction of TB incidence with the help of global measures. **Moran's I** and Gestid-Ord with the disaggregated data derived from the interpolation of Extra pulmonary tuberculosis prevalence and global measures were tested. In this case, Moran's I index has positive values 0.96204572 **(Figure 10)**. This rejects the null hypothesis of no spatial autocorrelation and accepts the inverse perfect correlation. With this disaggregated data, the situation for **Gestid-Ord G** is also different from the previous analysis. The result has shown significant clusters with the Z score of -0.71802872. It is highly unlikely that the high cluster is only a chance and not the actual incidence prediction and therefore can be considered for an effective prediction in the study **(Figure 11)**.

5.7 Testing Global Measure for Spatial Autocorrelation of Extra Pulmonary Tuberculosis Incidence

The present study was the first-ever in predicting the incidence of Extra pulmonary tuberculosis using cluster analysis. Annual values of the Moran's I indices are presented in the current study.

A negative Moran's I index describes a negative spatial autocorrelation for the incidence of TB. A further look at the p-value index of average 0.438507333 (0.10 as the lowest recorded in all categories) also reveals that the neighbouring features have dissimilar characteristics **(Table 3)**.

The presents result from the Gestid-Ord, general G as a global measure. Considering z and p-values average is 0.703291 and 0.483662333 respectively, which are the measures of statistical significance in this context, the interpretation of this result may not be uniform as in the case of Moran's I **(Table 4)**.

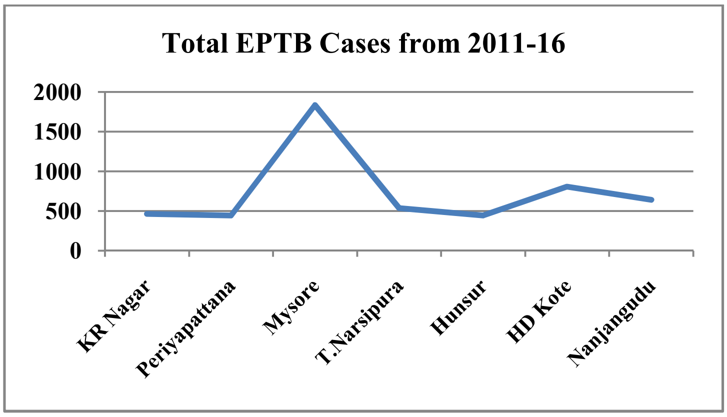

Figure 1: The curve graph of Extra Pulmonary Tuberculosis Incidence in Mysore District from 2011-16

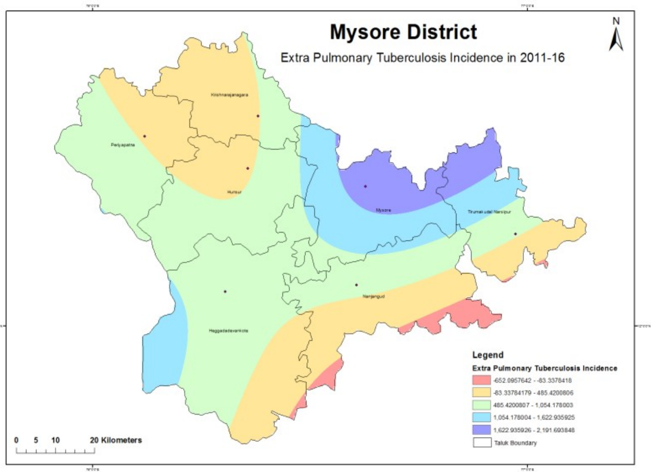

Figure 2: Extra Pulmonary Tuberculosis Incidence in Mysore District from 2011-16 by IDW interpolation pattern with a Quantile classify

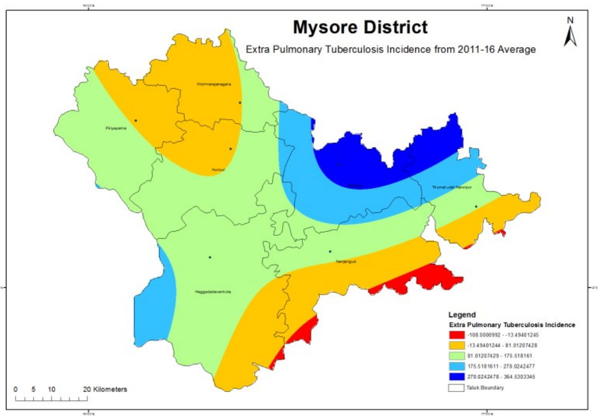

Figure 3: The average of Extra Pulmonary Tuberculosis Incidence in Mysore District from 2011-16 by IDW interpolation pattern with a Quantile classify

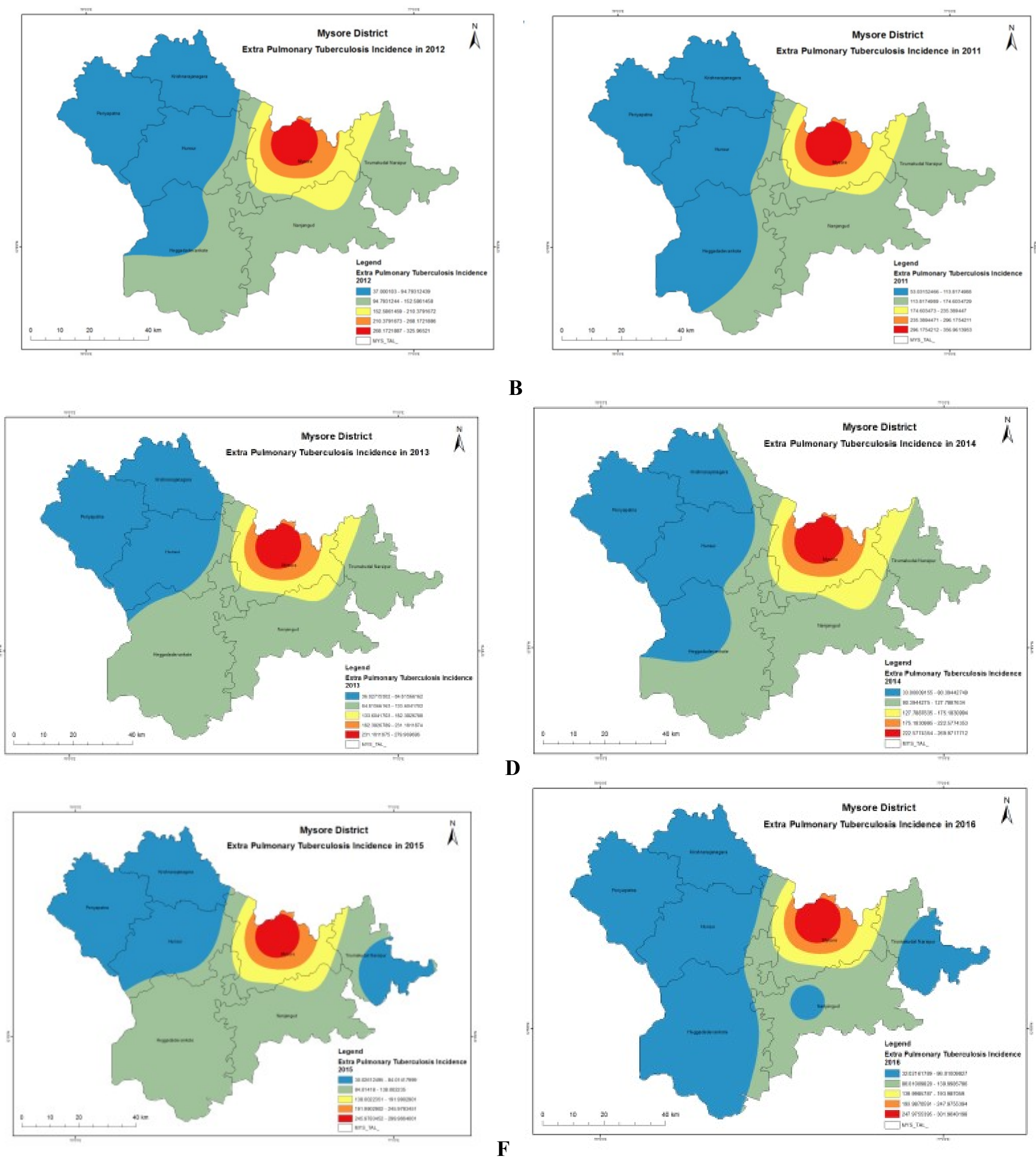

Figure 4: Extra Pulmonary Tuberculosis Incidence in Mysore District from 2011-16 by IDW interpolation pattern with a Quantile classify (2011-A, 2012-B, 2013-C, 2014-D, 2015-E, 2016-F)

Table 1: Descriptive Statistical analysis from the SPSS of the EPTB cases in the Mysore District 2011-16 year-wise and gender-wise

Descriptive Statistics									
	N	Range	Minimum	Maximum	Sum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Year	6	5	2011	2016	12081	2013.50	.764	1.871	3.500
Male	6	184	372	556	2739	456.50	27.874	68.278	4661.900
Female	6	135	305	440	2095	349.17	19.710	48.280	2330.967
Valid N (list wise)	6	-	-	-	-	-	-	-	-

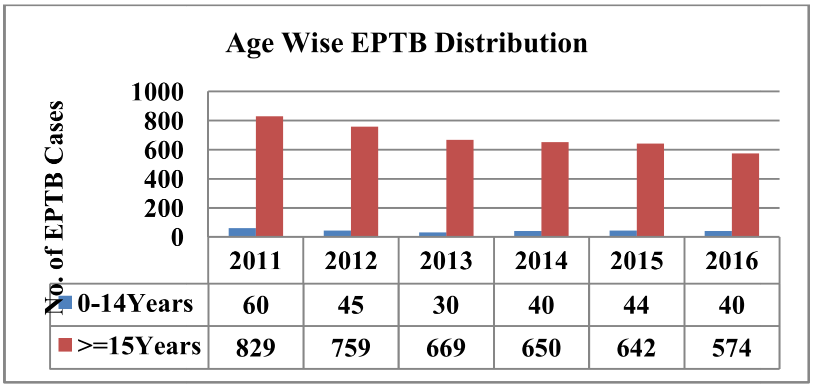

Figure 5: Age-wise Distribution of Extra Pulmonary Tuberculosis Incidence in Mysore District from 2011-16

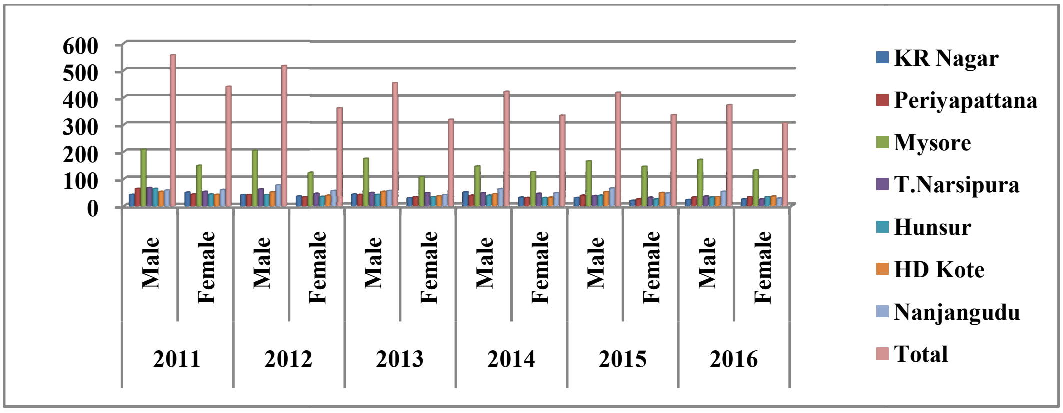

Figure 6: Extra Pulmonary Tuberculosis Incidence in Mysore District from 2011-16 with respective talukas

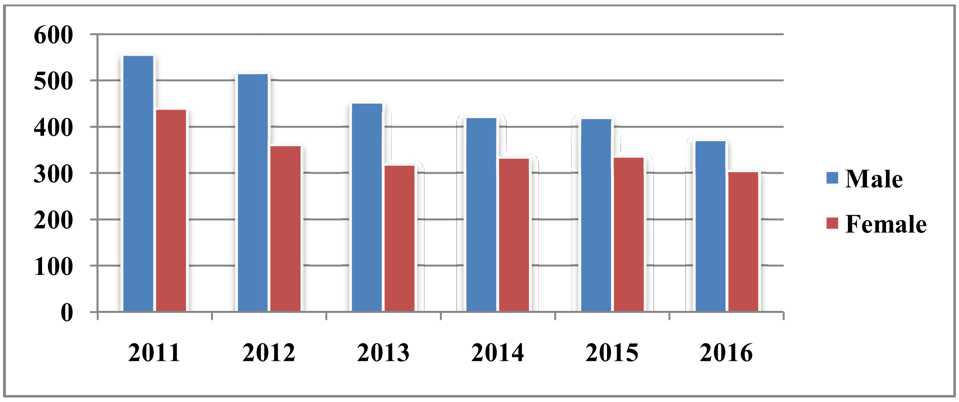

Figure 7: Extra Pulmonary Tuberculosis Incidence in Mysore District from 2011-16 is shown by the Male & Female group

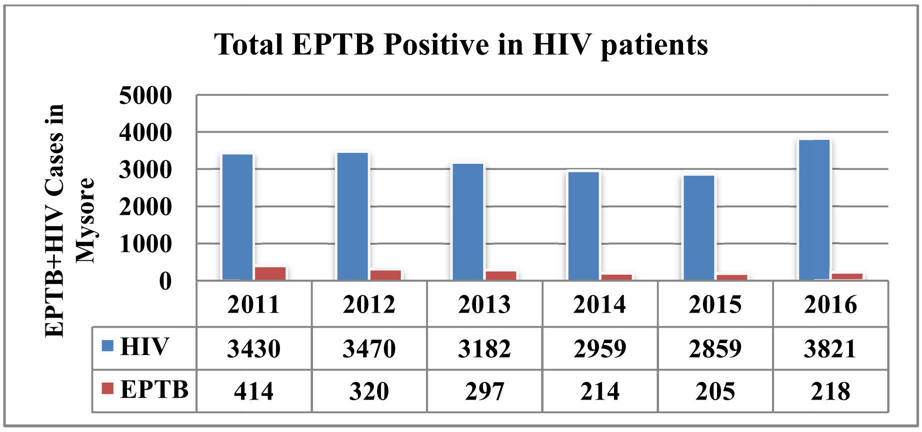

Figure 8: The Extra Pulmonary Tuberculosis positive cases in HIV patients in Mysore District from 2011-16

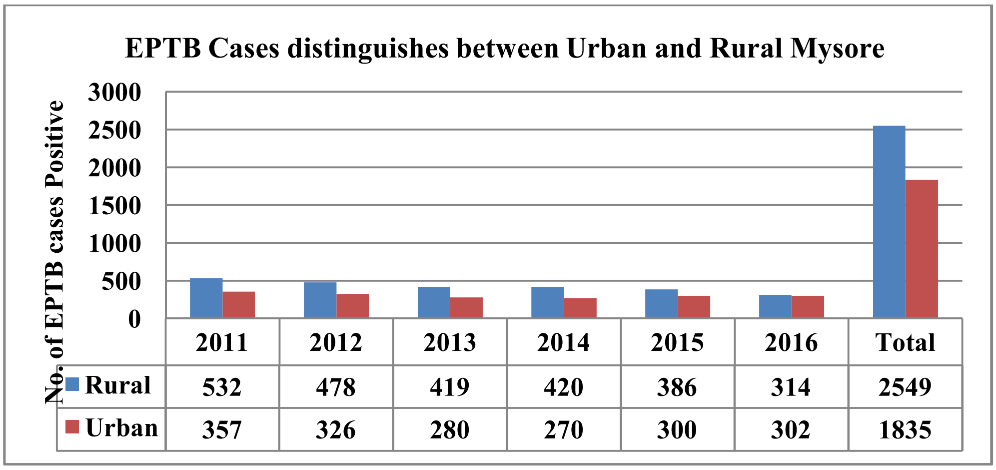

Figure 9: The Extra Pulmonary Tuberculosis positive cases in Urban and Rural Mysore District from 2011-16

Table 2: Table shows the variation and the percentage of the respective group from 2011-16 in Mysore District

Variable	n	%
Age (years)		
0-14	261	5.953%
≥ 15 & above	4123	93.95%
Sex		
Male	2490	56.82%
Female	1894	43.18%
Year of Admission		
2011	889	20.29%
2012	804	18.34%
2013	699	15.95%
2014	690	15.75%
2015	686	15.65%
2016	616	14.01%

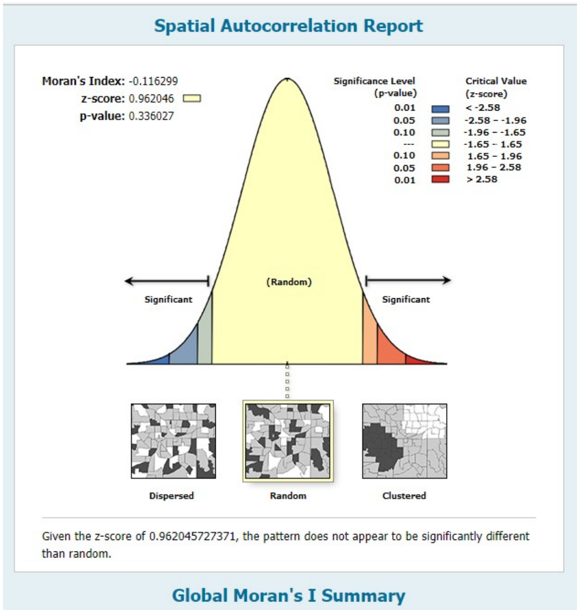

Figure 10: Global Moran's I Summary of spatial autocorrelation of Extra Pulmonary Tuberculosis Incidences in Mysuru District

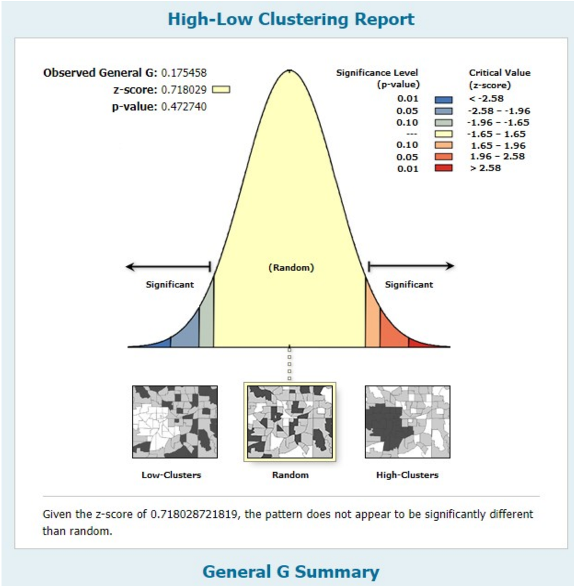

Figure 11: General G Summary-Gestid-Ord (G) test of spatial autocorrelation of Tuberculosis Incidences in Mysuru District

Table 3: Shows the result of Global Moran's I test across different periods

Morani's I	2011	2012	2013	2014	2015	2016
Moran's I	-0.122990	-0.098676	-0.117241	-0.103204	-0.116556	-0.145454
Expected Index	-0.166667	-0.166667	-0.166667	-0.166667	-0.166667	-0.166667
Variance	0.002562	0.007229	0.002846	0.003262	0.007133	0.002124
Z - Core	0.862940	0.799690	0.926491	1.111169	0.593339	0.460242
P - Core	0.388170	0.423890	0.354191	0.266496	0.552954	0.645343

Table 4: Presents the results from the Gestid-Ord, general G as a global measure

G. Ord	2011	2012	2013	2014	2015	2016
Obser. G	0.173340	0.176990	0.173179	0.175486	0.177470	0.176729
Exp. G	0.166667	0.166667	0.166667	0.166667	0.166667	0.166667
Variance	0.000123	0.000161	0.000135	0.000143	0.000199	0.000184
Signf. (z)	0.601680	0.814185	0.559795	0.737383	0.765038	0.741665
P-Value	0.547387	0.415539	0.575619	0.460889	0.444249	0.458291

6. DISCUSSION

The primary goal of this study is the assessment of efficiency of the disaggregated Extra pulmonary tuberculosis data in obtaining cluster patterns using global measures. Considering a significant number of EPTB incidence in some of the unit areas accounted as a study site, our analysis focused on the spatial interpolation of the EPTB cases in Mysore district from 2011-16. Contrastingly, our result depicted to some level the Extra pulmonary tuberculosis Quantile using the IDW/Spline/ Kriging interpolation. The IDW/Spline/Kriging tools of the Arc-GIS help in hotspot analysis of the disease spread. Similar studies have been carried out for various diseases such as: studies on cholera in Chennai **[37]**, dengue disease in Andhra Pradesh **[38]** and others. GIS is also used for studies such as temperature analysis, water analysis, air pollution, etc. In the present study, we have used the IDW tool from Arc-GIS to identify hotspots of the extra pulmonary tuberculosis diseases in Mysore District **[16]**. In epidemiological studies, the population data is utilized to compare statistics on EPTB disease magnitude across population groups and total incidences. gender and age group standardization data are currently used in identification of diversity of EPTB in Mysore district. Studies suggested that a direct method of standardization should be used in adjustment of disease incidences **[17, 18]**. In this study, age-standardization of the EPTB incidence was used. The age distribution is done according to the study of England and Wales, Hong Kong and Thailand **[19, 20]** similar to that performed for Tuberculosis disease programme.

In a study carried out by Srinath *et. al.,* female patients of Extra pulmonary tuberculosis demonstrated higher incidences in male patients when compared to that of the female patients [**21, 22]**. However, Chan-Yeung *et. al.,* showed that female cases were more than males, which can be explained to be probably owing to their food habit, hygiene, socio-economic status, climate, environment condition etc. **[30]**, and interestingly they responded to treatment much faster than men **[23]**. Whereas, some other studies showed that males were more at risk of reaching death mainly because of their smoking habits alcoholism and others **[24, 25]**.

There were also some studies such as Emch and Ali *et al*., who used the temporal patterns for the detection of cholera disease in the regions of Bangladesh **[38]**. Similarly, as per Lysien I. Zambrano *et al*., on dengue and chikungunya showed the drastic differentiation of both diseases in the area **[39]**. Srinivasa Rao *et al*., reported the Dengue cases in Andhra Pradesh which was similar to the present study in representation of hotspots using clustering analysis of GIS **[40]**. Sa'ad Ibrahim *et al*., demonstrated the clustering pattern of tuberculosis in Nigeria for 2010 which showed a high z value (1.14) and very low p-value (0.25). This corresponds well with the present findings of high z-vale (0.814) and low p-value (0.547) along with the Moran's I index of 0.86 value where it decreased the value by -0.145 to our study **[41]**. The technique used Sa'ad Ibrahim *et al*., studies were parallel to our study with IDW (inverse distance weighted method) comparison and spatial autocorrelation technique. In addition, Muhammad *et al*., presented a study with spatio-temporal analysis of tuberculosis along with TB diagnosis in Karachi centers. As per their data, there was a gradual increase in the number of cases from 2010 to 13 with a notable decrease in the number of cases in 2012 **[42]**. Relating to this, our study showed the increase in 2011-12 and stood constant from 2013 to 2016.

The study is also similar to ours because it uses distribution of patients with scattered method from the 2010-13 and is inclusive of both urban and rural population. Likewise, in our study the spatial detection of Extra pulmonary tuberculosis in Mysore shows the lower altitude areas have higher incidence. This is in agreement with the study carried out in Keny, Mexico, Vietnam, Turkey, Karachi, Nigeria, Nepal and some other countries demonstrating similar inverse relationship **[26, 30]**. The spatial autocorrelation technique helps in identifying the hotspots of disease spread and intensity of selected area that gives detailed information about the cases in a particular region. This is more elaborative study of the trend pertaining to EPTB diagnosis and treatment with the health GIS application. There is also a "Hotspot" technique in GIS, which gives the comprehensive report of the selected area for the study and represents the data with highest cases as hotspot and lowest cases as cold spot region of the disease.

In general, the present study was carried out to identify the Extra pulmonary tuberculosis incidence in Mysore with respect to specific geographical regions. Similar studies suggest that the absolute number of Extra pulmonary tuberculosis cases remained stable over the period from 2002 to 2011. Yet, under some circumstances, the incidence of pulmonary TB cases decreased which led to a corresponding increase in the proportion of Extra pulmonary tuberculosis cases **[31, 32]**. In the study carried out by Peto *et. al.,* a higher proportion of TB/HIV co-infection was observed among the extrapulmonary cases, with 7.0% of the tested Extra pulmonary tuberculosis cases reported to be HIV seropositive **[33]**. Their study also suggested 5% of HIV infected patients showing Extra pulmonary tuberculosis **[28, 29]**. The spatial distribution of the Extra pulmonary tuberculosis cases were significantly clustered and identified for the hotspot in Mysore District, taking into account both rural and urban areas. Highest hotspot was observed in Mysore city which contained the highest population as well, in comparison with that of the rural areas. However, the treatment exhibited more beneficiary in the urban areas over that of the rural population owing to the higher number of public health centers in the city limits. This study was similar to that of the study on dengue in Andhra Pradesh State with district-wise distribution, which explains that the population are in close connections, frequently migrate or rapidly urbanization is more prone to the disease **[40]**.

At regional, urban/rural, district and sub-district levels **[26, 27]**, a study conducted in

Taiwan enlisted the hotspot and spatial patterns of tuberculosis with respect to gender with the help of spatial autocorrelation indices **[17]** and spatial patterns of pulmonary tuberculosis prevalence. In addition, their relationship with the socio-economic status in Vitoria was also evaluated. Therefore, these parameters (such as age, sex, pregnancy status, income level, rural or urban, death, literacy, employment, marital status, family size, etc.) should be taken down along with the basic details of the patient in order to arrive at an accurate detection and diagnosis. Our study also showed that the variable and significant effect of Extra pulmonary tuberculosis incidence and are in line with the study of Chin *et. al.,* **[34, 35]** to classify the disease endemicity to seven clusters at the districts level and these endemic clusters were mapped using spatial tools. Apart from mapping, the study also includes Morna's I index, where a positive Morna's I index indicates tendency towards the clustering and negative towards the dispersion, Z-score and P-score are statistically significant and null hypothesis, which differently gives the overview of the input data **[36]**. Our study of the Moran's I index shows a negative tendency towards the dispersion. Similar with the study of Isah *et al*., where it shows the dispersion in Moran's I index. The Gestid-Ord (G) tool from the spatial autocorrelation measures the location and features of the values simultaneously. This evaluates the expression of pattern in clustered, dispersed or random forms along with features and associated attributes. In contrast to their study (Isah *et al*.,), local Moran's I and Gestid-Ord G* classified the clustering pattern as hot or cold spot locations **[41]**. In Kiyohiko *et al*., also showed the statistically significant Z-score and P-score results along with Global Moran's I statistic for increasing distance and to measure intensification of clustering. Their study demonstrated hotspots and coldspots detection by Getis-Ords (G) **[43]**.

The major strength of the present study is the Extra pulmonary tuberculosis data notification for the present year. This kind of information from the recent years will help in controlling the spread of the disease. Our study includes the seven taluks of Mysore District for data analysis and comparison. We have identified the hotspot areas where the Extra pulmonary tuberculosis incidence is highest by using Arc-GIS software in the public health sector. The major findings of this study are the notification data for the Extra pulmonary tuberculosis from recent years that would aid to develop precautionary measures and regulatory procedures to prevent the upcoming TB events. Secondly, reported Extra pulmonary tuberculosis cases spans all the taluks in Mysore districts for the data analysis. Finally, the novel technique of spatial distribution and cluster analysis methods were used to determine the hotspots/clusters of Extra pulmonary tuberculosis. This study enables to develop spatial and temporal maps that would aid public health officials and health centers in developing preventive measures towards Extra pulmonary tuberculosis management.

7. CONCLUSION

The study uses Arc-GIS software, which shows the hotspot of the EPTB cases in Mysore District. Within Karnataka, Mysore stands 3rd position in TB cases, with 15-20% incidence of EPTB itself. The spline and kriging proved to be a suitable tool for accurately estimating the continuous surface of EPTB prevalence in the Mysore district which includes seven taluks. When socio-economic and geographic factors were considered as co-variables, these factors had impacts on the regional differences of Extra pulmonary tuberculosis prevalence in Mysuru district. The spatial interpolation model for predicting Extra pulmonary tuberculosis disease intensity by means of Arc-GIS was the first such attempt for Mysore district. This technique significantly ensures the quality of disease prevalence that can be relied upon to develop preventive measures by health professionals. The interpolation pattern of the disease can be easily understood using Arc-GIS software tools. With the help of this study, the heterogenicity of the disease is observed through spatial autocorrelation patterns. The epidemiology study with the Arc-GIS is helpful for the implementation of preventative strategies in the TB disease control sector.

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10. REFERENCES

[1] World Health Organization. Global Tuberculosis Report 2014 [Internet]. 2014. WHO/HTM/TB/2014.08

[2] National Tuberculosis Center. Brief History of Tuberculosis. New Jersey:

New Jersey Medical School; c1996 [Updated 1996 Jul 23]; [Cited 2009 Feb 26].

[3] Anderson LF, Tamne S, Brown T, Watson JP, Mullarkey C, Zenner D, *et al*. Transmission of multidrugresistant tuberculosis in the UK: a cross-sectional molecular and epidemiological study of clustering and contact tracing. Lancet Infect Dis. 2014; 14: 406–15.

[4] World Health Organization: Highlights of activities from 1989 to 1998. World Health Forum1988; 9: 441-56

[5] Murray M, Nardell E. Molecular epidemiology of tuberculosis: Achievements and challenges to current knowledge. Bull World Health Organ. 2002; 80: 477–482.

[6] Munch Z, Van Lill SWP, Booysen CN, Zietsman HL, Enarson D, Beyers N. Tuberculosis transmission patterns in a high-incidence area: a spatial analysis. Int J Tuberc Lung Dis. 2003; 7: 271–7.

[7] Rothman, K.J.; John D. Boice, J. Epidemiologic Analysis with a Programmable Calculator; U.S. Government Printing Office: Washington, DC, USA, 1979.

[8] Breslow, N.E.; Day, N.E. Statistical Methods in Cancer Research; Oxford University Press: Oxford, UK, 1987; Volume II.

[9] Walker TM, Ip CLC, Harrell RH, Evans JT, Kapatai G, Dedicoat M, *et al*. Whole genome sequencing to delineate Mycobacterium tuberculosis outbreaks: a retrospective observational study. Lancet Infect Dis 2013; 13: 137–46.

[10] Chan-yeung M, Yeh a GO, Tam CM, Kam KM, Leung CC, Yew WW, *et al*. Socio-demographic and geographic indicators and distribution of tuberculosis in Hong Kong: a spatial analysis. Int J Tuberc Lung Dis. 2005; 9: 1320–6. Available:http://www.ncbi.nlm.nih.gov /pubmed/16466053 PMID: 16466053

[11] Julious, S.A.; Nicholl, J.; George, S. Why do we continue to use standardized mortality ratios for small area comparison? J. Public Health Med. 2001; 23: 40–46.

[12] Pickle, L.W.; White, A.A. Effects of the choice of age-adjustment method on maps of death rates. Stat. Med.1995; 14: 615–627.

[13] SouzaWV, Carvalho MS, Albuquerque MDFPM, Barcellos CC, Ximenes R A A. Tuberculosis in intraurban settings: a Bayesian approach. Trop Med Int Heal. 2007; 12: 323–30.

[14] Leung, C.C.; Yew, W.W.; Tam, C.M.; Chan, C.K.; Chang, K.C.; Law, W.S.; Wong, M.Y.; Au, K. F. Socio-economic factors and tuberculosis: A district-based ecological analysis in Hong Kong. Int. J. Tuberc. Lung Dis. 2004; 8: 958–964.

[15] Mangtani, P.; Jolley, D.J.; Watson, J.M.; Rodrigues, L.C. Socioeconomic deprivation and notification rates for tuberculosis in London during 1982–1991. BMJ 1995; 310: 963–966.

[16] Srinath S, Sharath B, Santosha K, Chadha SS, Roopa S, Chander K, *et al.* Tuberculosis 'retreatment others': Profile and treatment outcomes in the state of Andhra Pradesh, India. Int J Tuberc Lung Dis 2011; 15: 105-9.

[17] Chan-Yeung M, Noertjojo K, Chan SL, Tam CM. Sex differences in tuberculosis in Hong Kong. Int. J. Tuberculosis Lung Diseases 2002; 6: 11-8.

[18] Atif M, Sulaiman SA, Shafie AA, Ali I, Asif M, Babar ZU. Treatment outcome of new smear positive pulmonary tuberculosis patients in Penang, Malaysia. BMC Infect Dis 2014; 14: 399.

[19] Shen X, Deriemer K, Yuan Z, Shen M, Xia Z, Gui X, *et al.* Deaths among tuberculosis cases in Shanghai, China: Who is at risk? BMC Infect Dis 2009; 9: 95.

[20] Mansoer, J.R.; Kibuga, D.K.; Borgdorff, M.W. Altitude: A determinant for tuberculosis in Kenya? Int. J. Tuberc. Lung Dis. 1999, 3, 156–161.

[21] Vargas, M.H.; Furuya, M.E.Y.; Pérez-Guzmán, C. Effect of altitude on the frequency of pulmonary tuberculosis. Int. J. Tuberc. Lung Dis. 2004; 8: 1321–1324.

[22] Vree, M.; Hoa, N.B.; SY, D.N.; Co, N.V.; Cobelens, F.G.J.; Borgdorff, M.W. Low tuberculosis notification in mountainous Vietnam is not due to low case detection: A cross-sectional survey. BMC Infect. Dis. 2007; 7-8.

[23] Tanrikulu, A.C.; Acemoglu, H.; Palanci, Y.; Dagli, C.E. Tuberculosis in Turkey: High altitude and other socio-economic risk factors. Public Health 2008, 122, 613–619.

[24] Kakchapati, S.; Yotthanoo, S.; Choonpradup, C. Modeling tuberculosis incidence in Nepal. Asian Biomed. 2010; 4: 355–360.

[25] Extrapulmonary tuberculosis by nationality, The Netherlands, 1993-2001. Emerg. Infect. Dis. 2006; 12 (9): 1375-82.

[26] Peto HM, Pratt RH, Harrington TA, LoBue PA, Armstrong LR. Epidemiology of extra pulmonary tuberculosis in the United States, 1993-2006. Clinical Infectious Diseases. 2009; 49(9): 1350-7.

[27] Rieder HL, Snider DE Jr, Cauthen GM. Extrapulmonary tuberculosis in the United States. Am Rev Respir Dis. 1990; 141(2): 347-51.

[28] Anselin, L. Local indicators of association—LISA. Geogr. Anal. 1995; 27: 93–115

[29] Julious, S.A.; Nicholl, J.; George, S. Why do we continue to use standardized mortality ratios for small area comparison? J. Public Health Med. 2001; 23: 40–46.

[30] Onozuka D, Hagihara A. Geographic prediction of tuberculosis clusters in Fukuoka, Japan, using the space-time scan statistic. BMC Infect Dis. 2007; 7-10.

[31] Souza WV, Carvalho MS, Albuquerque MDFPM, Barcellos CC, Ximenes R A A. Tuberculosis in intraurban settings: a Bayesian approach. Trop Med Int Heal. 2007; 12: 323–30.

[32] Maciel ELN, PanW, Dietze R, Peres RL, Vinhas SA, Ribeiro FK, *et al*. Spatial patterns of pulmonary tuberculosis incidence and their relationship to socio-economic status in Vitoria, Brazil. Int J Tuberc Lung Dis. 2010;

[33] Alvarez-Hernández G, Lara-Valencia F, Reyes-Castro P a, Rascón-Pacheco R a. An analysis of spatial and socio-economic determinants of tuberculosis in Hermosillo, Mexico, 2000–2006. Int. Journal Tuberculosis Lung Dis. 2010; 14: 708–13.

[34] Julious, S.A.; Nicholl, J.; George, S. Why do we continue to use standardized mortality ratios for small area comparison? J. Public Health Med. 2001; 23: 40–46.

[35] Chin D P, DeRiemer K, Small P M, de Leon AP, Steinhart R, Schecter G F, *et al*. Differences in contributing factors to tuberculosis incidence in U.S. –Born and foreign born persons. Am J Respiratory Critical Care Med. 1998; 158: 1797- 803.

[36] J. T. Gleaves, G. S. Yablonsky, P. Phanawadee, Y. Schuurman, Appl. Catal. A Gen. 160 (1997) 55–88.

[37] Jayakumar K, Malarvannan S. Spatial mapping of cholera using GIS tools in Chennai, India. Arch Appl Science Res. 2013; 5 (3): 93–99.

[38] Emch M, Ali M. Spatial and temporal patterns of diarrheal disease in Matlab, Bangladesh. Environ Plan A. 2001; 33(2): 339–350.

[39] Lysien I. Zambrano, Manuel Sierra, Bredy Larae, Iván Rodríguez-Nú˜nezf, Marco T. Medinag, Carlos O. Lozada-Riascosh, Alfonso J. Rodríguez-Moralesi, Estimating and mapping the incidence of dengue and chikungunya in Honduras during 2015 using Geographic Information Systems (GIS), Journal of Infection and Public Health (2017); 10: 446—456

[40] Srinivasa Rao Mutheneni, Rajasekhar Mopuri, Suchithra Naish, Deepak Gunti, Suryanarayana Murty Upadhyayula, Spatial distribution and cluster analysis of dengue using self organizing maps in Andhra Pradesh, India, 2011–2013, Parasite Epidemiology and Control 3 (2018); 52–61.

[41] Sa'ad Ibrahim, Isah Hamisu, Usman Lawal, Spatial Pattern of Tuberculosis Prevalence in Nigeria: A Comparative Analysis of Spatial Autocorrelation Indices, American Journal of Geographic Information System 2015; 4(3): 87-94

[42] Muhammad Miandad1, Farkhunda Burke, Syed Nawaz-ul-Huda, Muhammad Azam, Tuberculosis incidence in Karachi: A spatio-temporal analysis, GEOGRAFIA OnlineTM Malaysian Journal of Society and Space 10 issue; 5 (1 - 8): 1

[43] Kiyohiko Izumi, Akihiro Ohkado, Kazuhiro Uchimura, Yoshiro Murase, Yuriko Tatsumi, Aya Kayebeta, Yu Watanabe, Nobukatsu Ishikawa, Detection of Tuberculosis Infection Hotspots Using Activity Spaces Based Spatial Approach in an Urban Tokyo, from 2003 to 2011, September 18, 2015: 1-16