A Study Of Polio Disease In Pakistan Using Gis Approach

Usman Ahmad, Sajid Rashid Ahmad, Muhammad Luqman

Abstract: Pakistan is one of the countries in the world, who is affected with polio virus. The main objective of this present study was applying spatial statistics to examine the spatiotemporal patterns and areas of hotspot detection for describing the pattern of polio disease in Pakistan. In this study, statistical data smoothing process was used to decrease noise in polio records which is registered at a district level from 2011 to 2014. Moran's I (Spatial analysis method) was applied to measure spatial association in polio disease distribution in study area and examined how districts were spread or clustered. Getis-Ord Gi* (d) statistics was utilized for the identification of cold spot and hotspot within study area and IDW technique applied for Interpolation. This predicts the trend of polio disease distribution around the study area. The incidence rate of polio disease through mapping depicted uneven distribution of poliovirus in affected districts of Pakistan. Spatial statistics are used to perform Moran's I test and it measured considerable positive spatial autocorrelation of polio disease incidences for previous four successive years. The results depicted spatially clustered and spatial pattern of polio disease in study area. The research concluded that the polio cases were increased in northwestern side of KPK province and southern part of the Sindh province of Pakistan over the past two years (2013–2014).

Keywords: Spatio-temporal, Spatial statistics, Hotspot, Moran's I, Polio disease.

1 INTRODUCTION

Polio disease is caused by a viral infections and spread primarily via the faecal-oral route. In the early 20th century, polio virus affected thousands of children every year in countries currently considered as developed. Polio was brought under control and just about eliminated as a community health crisis in these countries, when successful polio vaccines were introduced in the 1950s and 1960s. But in the third world countries, polio started causing havoc much later.[1]. In 1970, it was revealed through Lameness Surveys that in the developing countries the disease was also prevalent. Therefore, in the 1970s in all parts of the world routine immunization was introduced as part of national immunization programs, which helped in many developing countries to control the disease. The Global Polio Eradication Initiative started in 1988, when thousands of children around the world disabled in each day. In 1998 more than 125 countries in world where polio virus existed, but in 2012, this number was reduced to just three i.e. Afghanistan, Nigeria and Pakistan where polio virus still existed. Children around the globe are at danger, as long as one child remains infected with poliovirus [2].In Pakistan, April 1994 Ministry of Health (Pakistan) started a large vaccination campaigns started against polio and are still under way in Pakistan [3]. Before 2004 hundreds of Cases were reported every year in Pakistan, so intensive vaccination campaign start to reduce the number of cases. As result, the numbers of cases were reduced up to 28 in 2005-2006. This was achieved by strict surveillance and responsibility[4]. In 2008 Pakistan had its best historic opportunity to stop polio transmission forever from all over the country [1].

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Unfortunately, in 2011 reported more polio cases in Pakistan unfortunately than any other country internationally [5]. This is because in Pakistan, polio vaccination program has lot of security problems, some areas are not accessible for polio workers, front line polio staff fear of harassments, beatings and occasionally some workers were assassinated in some areas [6]. In Pakistan a number of times additional vaccination rounds repeated, but poorly protected and tough to arrive at communities has complicated the polio uprooting struggles [7]. GIS is a computerized systems capable of displaying, integrating, modeling, querying, and analyzing large quantities of spatial data[8]. In the field of health, application of GIS helps to find out spatial variation, patterns and risk factors of disease and enhanced delivery of health services [9]. Several diseases spread out within a community characterize spatial components. Spatial analysis techniques such as spatial statistics and GIS facilitate officials to deal the spatial dispersion and to guess the outbreaks of diseases more exactly [10]. For disease, it is essential to identify the spatial and temporal characteristics of disease and its transmission.GIS has a very important role in observation and control of diseases [11]. In recent times, GIS and remote sensing methods have been playing a great significance role for mapping diseases such as dengue and HIV [12].GIS cannot simply give a street to increase our understanding of the dispersion pattern of disease, but also support health officials and strategy makers about multifarious information in a simply implicit form. Therefore, in this current study, we planned to see the spatiotemporal trends of polio disease in Pakistan.

2 MATERIALS AND METHODS

2.1 Study Area

Pakistan is the second largest South Asian country which is located within latitude 24^{o} to 37^{o}N and longitude 62^{o} to75^{o}E (Figure 1). The reason for selecting this country is that, it is one of only three countries where the polio virus is still present. Pakistan covers an area of 796,095 square kilometers and its boundary share with four adjacent lands. India situated in the east, Iran on the west, Afghanistan in the north-west, China in the north and Arabian Sea in the south. Pakistan is administratively subdivided into 8 units Islamabad (capital),

Balochistan, Khyber Pakhtunkhwa, Punjab, Sindh, Federally Administered Tribal Areas, Azad Jammu and Kashmir and Gilgit Baltistan. In June 2000, the government of Pakistan's estimated population was 137.5 million which did not including about 1.5 million refugees from Afghanistan. Afghani refugee population increased in Pakistan significantly after a U.S bombing campaign against Afghanistan in the fall of 2001.

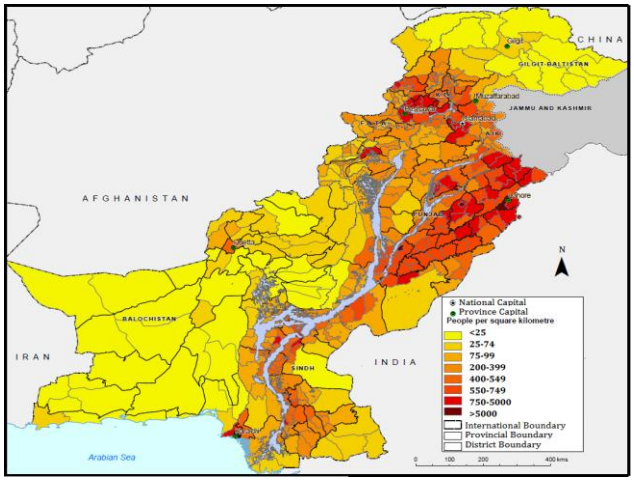

Fig1: *Location map of study area*

Due to the high growth rate in recent decades in Pakistan a large majority of Pakistanis are young. More than 41 % people of Pakistan are under the age of 14, and 55% lies between 15 and 64 years. In Pakistan infant mortality rate is very high, with 88 newborn babies died per 1,000 live births; averagely every woman in Pakistan births more than 3 babies. [13].

2.2 Data Acquisition and Management

The value of a geographical information system for preparation and managing plans relies on the availability of precise and appropriate data. Considering the scope and objectives of the study, data on Polio cases in Pakistan was acquired from 2011 to 2014 by a secondary source: web-portals of the Global Polio Eradication Initiative, the World Health Organization and the Office for the Coordination of Humanitarian Affairs (OCHA). This material was transformed to a database file for use in the GIS software. Geographic attributes, including location, districts boundaries and base map (Pakistan) was acquired from WASA (Water and Sanitation Agency) Lahore. The downloaded Polio data was transformed in Excel sheets which was further attached it with the base map to corresponding districts. Choropleth maps of the various attributes were then created. After creating maps of the different years 2011 to 2014, some patterns and trends led to the option to emphasize on years 2013 and 2014. A plot of the total sum of polio cases in Pakistan by year also showed the number of cases in 2013 and 2014 were exceptionally high. Thorough literature review also determined a number of accounts, that these years survived polio at the outbreak level. Choropleth maps of years 20013 and 2014 containing the critical period were created and then the spatial analysis technique and statistics applied to inspect their pattern.

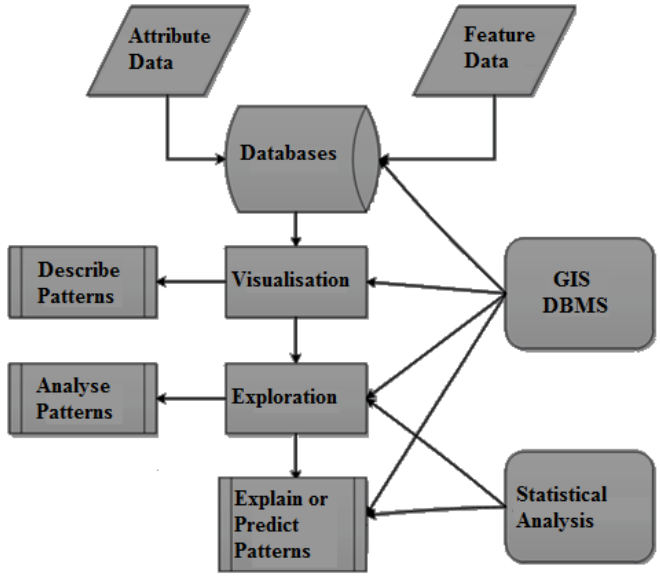

Fig 2*: Framework of spatial epidemiological data analysis activity flow chart*

2.3 Systematic Framework

In GIS record locations of all features and their corresponding attributes' information is an important part of data for making polio maps. These can then be analyzed visually. Framework of spatial epidemiological data analysis activity flow chart is shown in Figure 2. Through GIS database, we obtained further information with the help of statistical analysis which might not be clear by just looking at the map. Information such as, whether there are spatial trends in the data 'how attribute values are distributed' and whether the features form spatial patterns. Statistical analysis uses are to find out spatial patterns, cluster of feature and directional trends of disease. Whereas patterns of disease may be clear on a map, but sometime difficult to describe conclusion from a map. There are a number of tools in ArcGIS which calculate statistics and compute geographic pattern. However, in this present study, we use Hot Spot Analyses, Spatial Autocorrelation Analyses, Cluster analyses and IDW.

1. Spatial variation of polio cases was examined using choropleth maps.
2. Spatial autocorrelation analyses find out the nature and strength of interdependence between polio rates at the administrative unit level.
3. Hot spot analyses identified spatial clustering of high and low values of polio in Pakistan.
4. Cluster analyses were performed to examine levels of clustering.
5. IDW technique used for mapping the spatial distribution and potential risk regions.

2.4 Spatial Smoothening and Filtering for Data

Patients' data of polio affected cases has been geocoded using district location. Spatial filtering process was applied on data for the interest of sharpening and smoothening to decrease the random noise in the data. In data, random noise is created from the little disease case numbers or small populations [14]. For the estimation of smoothing and variation in data, Voronoi statistics technique was adopted. In the current research, the effects of spatial variability also include in

the procedure of local smoothing by using neighboring districts geographic area information. The smoothed rate was calculated in such a way, that the sum of persons affected by polio per 100,000 at every district divided by the entire population at danger inside the district, using spatial weights file. Spatial weights file is created on the basis of inverse geographical distance among the centers of the district which is affected and the district which is not affected by poliovirus. In the weight file we used '1' and '0' weight. If the neighboring district is within the specified distance then assign '1' otherwise '0'. All districts of study area were grouped in four categories: high endemic district, medium endemic area, low endemic district and non-endemic district. A smoothed map of disease incidence producing method, maintained the stability of the calculated disease incidence [15].

2.5 IDW Interpolation

For predictions' incidence rates of polio cases in present research, we used the Inverse Distance weighting method for the whole districts of Pakistan. In disease analysis, interpolation of scatter points most commonly used IDW technique in GIS field for mapping the spatial distribution and potential risk regions[16]. Through this technique we interpolate points of polio cases and predict the pattern of polio disease all over Pakistan. According to IDW technique, it gives more weight to things that are close to one another than those that are farther apart. It assumes that every measured point has a neighborhood effect that reduces with distance. It gives larger weight to points nearest to the prediction location, and the weight declines as a function of distance [17]. If in research we have trustworthy data, then inverse distance weighting interpolation technique is more appropriate and perfect, because it maintains the whole statistical distribution of polio cases occurrence [18]. Principally IDW method performs in such a way that it presumes that every calculated case value has a local influence that reduces with distance. It gives more weight to the value which is nearby to the prediction spot, and the IDW weight value decreases with distance from the measured point to the predicted point [19].

2.6 Spatial dependency analysis

In Spatial autocorrelation statistics, Moran's I is basically a parametric test, which is performed to find out the relationship between features and their locations simultaneously. The results of this test suggest level of autocorrelation by a p-value and it also indicates positive or negative relation between features. If test finds zero value during process, it means no relation between features [20]. In present study Global Moran's I test was performed using ArcGIS 10.1 on the incidence rates of polio cases in Pakistan to identify spatial disease clusters. If not, then the polio cases were scattered randomly over space.[21]. In ArcGIS 10.1 Global Moran's I test performed by a toolbox of spatial statistics, which evaluated the polio attributes and estimate the variance and mean. Then, subtracts all features value form the mean, constructing a deviation from the mean. All neighboring features whose values deviate from mean are multiplied to build a cross-product. During the calculation of test, if both the neighboring features value greater or lesser than the mean value, then the result of cross product of features value will be positive. If one feature value greater and other one lesser than the mean, then the result of cross product value will be negative. So as a result, if larger the deviation then cross product result will be larger. In datasets cluster exists, if feature high values lies close to other high values and feature low values closer to low values, so in this context Moran's Index value will be positive. In opposite situation it will be negative. In third situation, Moran's Index value will be zero, if positive cross product balances negative cross product. Range of Moran's I test lies between -1 to +1[22]. In present research Global Moran's I test was applied to find out the spatial association in polio cases and evaluates the spatial pattern of disease, either it is clustered or dispersed. Through Moran's I, we also measured z-score and p-value.

2.7 Feature clustering and outlier analysis

Whichever Moran's Index was applied (local or general) both used to identify the existence of spatial clusters of features and it also identifies spatial outliers. Through Cluster and Outlier Analysis tool, we calculated both p-value and a z-score, which represent the cluster category for features. Basically computed index values interpreted with the help of p-value and z-score, so these have statistical significance for cluster outlier analysis. In cluster analysis, if Z score has high value around the feature, in that case its neighboring features also have similar high values (H-H), or vice versa (L-L). On the other hand, in case of outlier (negative Z score), features have low values and its neighboring features have high values (L-H), or vice versa (H-L). With the help of Moran's Index test we identify, if Z score value is positive then it points out that the neighboring features also have similar values. On the other side, if Moran's Index Z score value is negative then feature and its neighboring features have different values, so that such type of feature belongs to an outlier.[22].

2.8 Hotspot detection and Analysis

Getis-Ord Gi* statistic (pronounced G-I-Star), in a dataset calculate a z-score value for every feature and use in Hotspot analysis technique for distinguishing low values cluster from high values cluster. It is also effective for finding spatial dependence among nearby observations. If a feature has a large value, generally it is interesting but in hotspot technique it may not be statistically important. In hotspot method, it is only important such that if a feature has a large value then its corresponding features also hold large values. In Gi* statistic sum of local and neighboring features were examined to all features. If difference between expected and local sum obtain largely, thus z-score shows statistically important results. In hotspot analysis, check spatial dependencies across nearby feature values and every feature returned a z-score and p-value which is computed by Gi* statistic. In this present research, Thiessen polygon continuity weight file is used for adjacency; this is created on the basis of districts location. The results of Gi* statistic depends on z-score. If the z-score value is large, it means cluster of large values (hot spot) and in other case negative z-score belongs to low values (cold spot) [23].

3 RESULTS

3.1 Spatial Analysis

Spatial heterogeneity is reflected through mapping polio cases or incidences rate of polio affected districts in Pakistan. The low and high value impacted districts are not generally spread equally in the research area; however polio is mainly clustered in a small number of parts over the Pakistan. The maximum rate of polio cases per 100,000 populations was found in

2014, whereas the minimum count was seen in 2012. The map of polio disease depicted that the polio cases appeared slightly all over the Pakistan, but more frequent polio cases were appeared in the north and northwest region of the Pakistan. Through map, we obtained a clear-cut image of polio affected regions. In 2014 the situation of polio in Pakistan was not good. It was also confirmed through map; polio cases found in northwest and south of the country. Polio disease cases in 2013 appeared in northwest and a few parcels founded in the central regions of Pakistan but in 2012 number of polio cases slightly decrease and it reported mostly in north-west of Pakistan. In 2011, polio incidence rate was high, involving north-west, south and middle regions of the country.

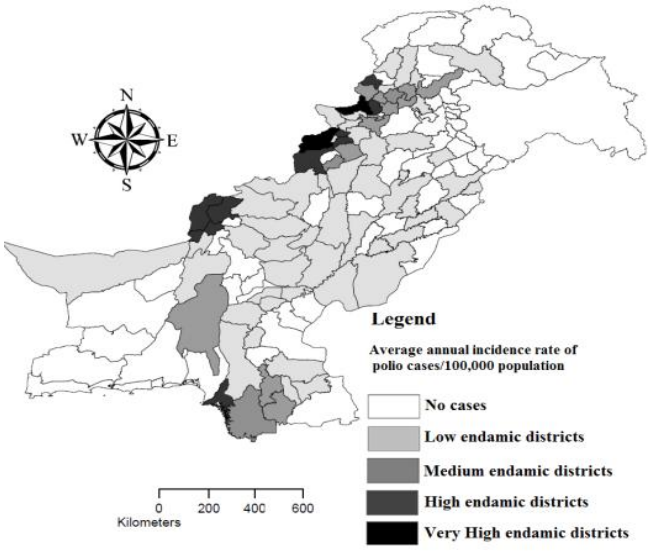

Fig 3: *Map depicting the average yearly incidence rate of polio disease for the period of 2011–2014*

In the present research, a map of polio disease events for the period 2011–2014 collectively created (Fig 3), and through analysis we found that that polio disease cases were distributed somehow all over the Pakistan. In map, the districts which are very highly affected by polio disease are represented in dark black shade, highly affected districts in light black shade, average affected districts represented in light dark grey shade, low affected districts represented in light grey shade and the empty region (no shade) represent no polio events. Spatial analysis outcome was depicted, the majority of the highly effected endemic districts were founded in south and northwest portion of the Pakistan; the central and southwest portion of the country was usually less affected by polio disease in previous 4 years. The maps for the period of 2011–2014 are shown in Figure 4. During last four consecutive years the spatial distribution of polio disease incidence interpolation were computed through IDW technique. The strength of polio disease incidence in research area is associated with color. As the color intensity increases, the risk of polio incidence also increases. It is confirmed visually that polio disease incidence frequency varied geographically over Pakistan. In 2011 (Figure 4), we found that the high-risk counts of polio cases were found in Balochistan and Fata regions of the Pakistan.

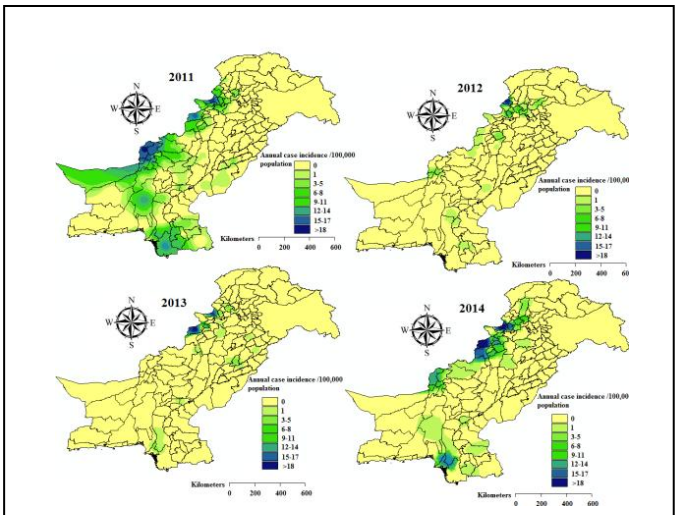

Fig 4*: Interpolated IDW maps of polio disease for the period of 2011-14*

But in 2012 and 2013, the risk decreased in the Baluchistan province, but on the other side (Fata region) there were high-risk counts reported continuously. In 2014, there was also an important year for polio disease. In this year polio intensity again increases within the whole region where previously polio incidence rate decreased in following years.

3.2 Spatial dependency analysis of polio disease distribution

Analysis of polio disease by Moran's I test for previous four years (2011–2014) indicated that the spatial dispersion of polio disease incidence rate for every 10, 0000 population was bunch and the consequences was very important (Table1). The polio disease dispersion during the year 2014 confirmed maximum value of Moran's I test 0.19. On the other hand the smallest value of Moran's I test was 0.05 produced in year 2012. These results confirmed that the adjoining districts are also facing the same situation of polio distribution which may be low or high. But low values of Moran's I test suggest that the polio distribution throughout Pakistan is not increasing in the same pattern, however distributed only in small portion of country. This information is very important to recommend health officer for further planning of polio disease: it is increasing in the form of cluster but not in a uniform manner all over the country.

3.3 High/low Clustering Analysis of Polio Distribution

Basically clustering analysis is based on inferential statistic. This method of statistics applied through ArcGIS toolbox and find out the clustering types and regions in study area.

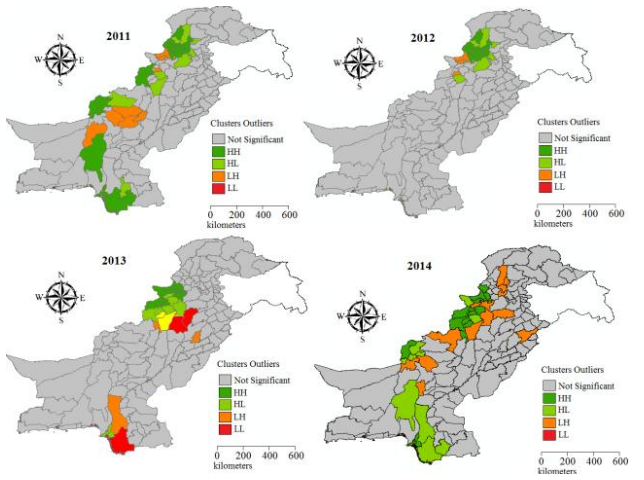

Fig 6: *Maps of polio disease depicting the hotspot and cold spot for the period of 2011–2014*

The inferential statistic results of polio disease incidence rate for every 10, 0000 populations indicates clustering pattern (Table 2).Basically high or low clustering is measured by G statistics which is based on inferential statistic. This method of statistics applied through ArcGIS toolbox and finds out the clustering types and regions in study area. The results of inferential statistic explained under the framework of null hypothesis. The G statistics results of polio disease incidence rate for every 10, 0000 populations indicate clustering pattern explained in table 2. According to results of G statistics, many parts of the country are extremely clustered. P-value has an important role in decision making. It is basically a probability, so the strength of probability is based on p value. During analysis, if p-value is small, it conveys that, the spatial pattern of polio disease is by random actions. So small p-value and large z-score in polio affected districts of Pakistan shows high values of clustering in those areas. In G statistics, z-score describes the strength of clustering which is increased in 2013 and it was calculated minimum in 2012, but its maximum value 0.019 was calculated in 2014.

Table 1: *Spatial dependency measurement for the period of 2011-14 with Moran's I test*

Year	Obs	E(I)	variance	Z	P-value	Pattern
2011	0.12528	−0.00057	0.0007	10.6496	<0.01	Clustered
2012	0.05966	−0.00057	0.000199	6.10028	<0.01	Clustered
2013	0.090901	−0.000575	0.000186	8.10137	<0.01	Clustered
2014	0.194744	−0.000575	0.000245	12.1203	<0.01	Clustered

3.4 Cluster and Outlier Analysis of Polio Distribution

With the help of cluster analysis, low or high occurrence of polio disease events are easily observed in districts of Pakistan. Considerable small clusters of polio cases were spread more or less in many districts of country (Figure 5).

Table 2: *High or low clustering analysis of polio with Gi* statistic for the period of 2011-14*

Year	Obs	E(I)	variance	Z	P-value
2011	0.01663	0.0032	6.7E-05	11.215	<0.01
2012	0.00554	0.0032	3.2E-05	5.323	<0.01
2013	0.01212	0.0032	5.3E-05	7.2524	<0.01
2014	0.01922	0.0032	9.2E-05	13.394	<0.01

However, through results of cluster and outlier analysis, no major correlation or clustering pattern of low frequency rate of polio disease cases (L-L) identified in districts of Pakistan throughout the research period of time (2011-2014). Table 3 expressed complete characteristics of every cluster during the study period according to year. In current study low p-value (0.01) obviously confirms that the sufficient numbers of clusters are recognized.

3.5 Hotspot Analysis of Polio Disease in Pakistan

In present study there were a few prominent clusters of polio disease addressing particular portion of country. Basically hotspot analysis confirms two types of clustering, one is hotspot and other one is cold spot. During analysis of polio disease through hotspot tool results expressed statistically significant hotspot (high values cluster) and cold spot (low values cluster). And results also confirm that, the type of clustering cold or hot completely relates with Z-score, higher Z-score and lower Z-score respectively confirm hotspot and cold spot. Figure 6 maps shows the hotspot analysis results with shades of color, cluster of high values(hotspot) shows with the color of rot and on the other hand cluster of low values(cold spot) express with the color of blue. Maps which are shown in figure 6 indicate the understandable patterns of polio disease incidence that were typically spread in the direction of north-west region of the Pakistan over the period of 2011–2014. A number of hotspots cluster were also depicted in the south region of the country in 2011 and 2014, but the majority of the cluster (cold spots) were observed in the northeast and central region of the country. Polio disease in 2011, analysis map indicates cluster of high values (hotspot) in the north of Balochistan and central part of FATA, and some pieces of cluster also in the south of Sindh province; but, the cluster of low values (cold spot) was detected in the central, eastern and southwest part of the Pakistan. According to the analysis, map for 2012 identified cluster of high values (hotspot) in northwest part (FATA) of Pakistan.

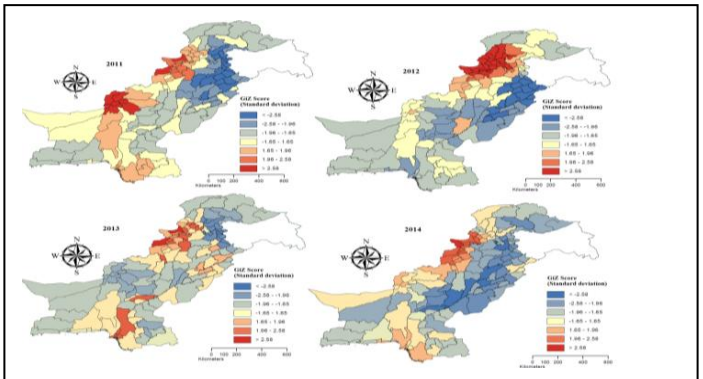

Fig 6: *Maps of polio disease depicting the hotspot and cold spot for the period of 2011–2014*

And further map for 2013 expressed the majority of high values cluster were identified in the northwest and some cluster in middle region of the Punjab province, and a few in the south region of Sindh province was noticed; but, the similar situation of polio cluster of low values (cold spot)was also found as in 2012 and 2013. Disease analysis map for 2014 indicates considerable increase of polio disease cluster (hotspot) in the direction of northwest part of FATA, northwest direction of Balochistan and in south region of the Sindh province. But the situation in 2012 were slight different in Punjab, during the period of 2012 nearby no were considerable hotspot region noticed in Punjab province, but hotspot identified in KPK and FATA regions.

TABLE 3: *FEATURE CLUSTERING AND OUTLIER ANALYSIS OF POLIO DISEASE IN PAKISTAN, 2011–2014*

Cluster-outlier type								
year	High-high				High-low			
	No. of districts	LMiIndex	LMiZScore	p-value	No. of districts	LMiIndex	LMiZScore	p-value
2011	23	19.21	11.92	0.003	9	−6.91	−2.64	<0.01
2012	11	12.73	5.8	<0.01	4	−7.47	−2.77	0.02
2013	9	9.72	5.01	0.009	5	−8.22	−3.12	0.008
2014	16	13.61	7.7	0.006	7	−10.50	−3.31	0.014
2011-14	31	38	12.11	0.008	14	−17.03	−3.78	0.015
year	Low-high				Low-low			
	No. of districts	LMiIndex	LMiZScore	p-value	No. of districts	LMiIndex	LMiZScore	p-value
2011	8	−5.54	−2.42	0.02	-	-	-	-
2012	4	−4.31	−2.39	0.02	-	-	-	-
2013	3	−6.24	−2.64	0.018	-	-	-	-
2014	6	−5.75	−2.55	0.019	-	-	-	-
2011-14	11	−14.39	−2.54	0.022	-	-	-	-

On the other hand polio disease map for 2012 was found a cluster of low values (cold spot) in the lower region of the Punjab. At the end of present study (2014) through hotspot analysis method, we concluded that cluster situation (hotspot) of polio disease in country shifted from FATA and KPK region towards (southwest direction) border area of Pakistan.

4 DISCUSSION

Through this present study, spatiotemporal characteristic of polio disease in Pakistan discloses with the help of GIS techniques. This provides opportunity for the measurement of level or intensity of clustering in study area (Pakistan). These techniques have also previously been adopted to find out the clustering pattern of sleeping sickness [24], breakbone fever [25] and human granulocytic ehrlichiosis (HGE) [10]. However, their usage for polio has been not as much general, mainly in South Asia. According to our information, we think, it is the first effort to map and examine polio disease distribution in Pakistan through GIS techniques. The current study has three main capabilities. First, it is initial step to investigate the spatial variation of polio disease incidence across Pakistan through spatial techniques of statistics. It sets a base for a next researcher to examine the factor, causes and spatiotemporal patterns of the polio disease. Secondly, the study results show that the GIS utilized as a tool to create maps and quickly present the data and information about polio disease incidence regions for making more helpful and efficient prevention plan and schemes. These maps can be used to propose and highlight the disease risk regions, where again or additional research should be applied to determine whether improved disease observation actions or existing operating actions are justified. Thirdly, the polio disease information utilized in this research is slightly general, might be applied for the local level. In present study, we planned to observe the spatiotemporal distribution patterns of polio disease at the country (Pakistan) level. The study of polio disease (2011 to 2014) identified the spatiotemporal pattern and high risk areas in endemic districts using spatial analysis with GIS tools. Spatial technique was utilized in present study to minimize the noise in data, IDW technique was applied to identify and display the districts which are affected by high polio disease to low. However, through literature review, we identified that the Kriging method of interpolation was generally better than IDW method to predict the spatial pattern of disease distribution [15]. Because IDW method has some advantages over Kriging method. When related to this study, it is efficient and spontaneously derived, and no assumption needed by record. With the help of IDW in present study, we can classify the incidence rate of polio disease in the northwest region of FATA and south region of Sindh. Moreover, the areas of Pakistan which are affected by polio disease are also affected by war and high population displaced. Also, it is economically backward. May be these reasons helped to spread polio disease in these particular regions [23] Thorough spatial analysis tool in current study applied Getis-Ord G statistic and Moran's I, which identified the distribution patterns of polio disease and classify the cluster in study area, whether it is significant or not. Spatial autocorrelation in ArcGIS is an important tool to identify the geographic patterns of polio disease over time in research. In present research of polio disease, we observed effective proof of spatial autocorrelation throughout the study area (Pakistan) by Moran's I statistics. Moran's Index positive values show that the spatial autocorrelation in polio disease distribution, pointed that the disease collected in a few particular regions of study area. But, according to the present research analysis of polio disease 0.19 is the maximum result of spatial statistics (Moran's I). In study area, analysis shows the clustering pattern of polio disease which is identified in the southwest region of FATA and in south region of the Sindh province. It could be the reason that the people of these areas have poorer economic indicators, low education levels and insurgencies, so that these factors increase polio disease rate in region. In spatial cluster analysis of polio disease incidence, whether it is low or high in districts of study area (Pakistan) are simply identified with p=<0.01. Geographic association of polio disease distribution appeared at the districts level in research area confirmed by both analysis with significant low or high infection rate. In our research, Gi * (d) statistic depict the hotspot (cluster of high values) and cold spot (cluster of low values) of polio disease which based on the occurrence rate of polio cases /100,000 people. This method given a statistically strong and reliable technique for finding hotspot and cold spot region in study area (Pakistan). Results of the present study showed that the polio disease is circulating nearby around the focal points like a cold spot and hotspot form. Polio study results displayed that the hotspots were showed mostly in insurgencies region and region effected by war. This might be due to the various reasons, migration of people or refusal of polio drops. On the other hand, religious factor, poor polio campaign and untrained staff are also issues in those regions [26]. The results of this study can be explained in another aspect. The cluster of high values (hotspot) distribution in study area might represent the poor surveillance program

conducted by health officials in those areas. We think these results could be helpful for epidemiologist and health administration to set boundaries for public which are under risk due to polio disease. Therefore the selection of districts' locations was a good idea for present study to examine the spatiotemporal trend of polio disease in last four years.

5 CONCLUSION

The exercise of GIS in polio outbreak is not a substitute for conventional descriptive epidemiological and microbiological techniques, although it should be an important addition to the public sector. However, it is significant to keep in mind that every outbreak is an exclusive event, In order to apply GIS for these purposes, it is also significant to have a clear data gathering protocols and knowledge of the technical and legal consequences about storing and handling such data (patient data).The results of this present research demonstrate that, the spatial statistically methods can be applied professionally with the help of GIS tool to recognize the affected areas (high or low) by disease professionally which help out in managing health system and reducing polio disease. The current research allows to health officials use more advanced technique to distinguish the pattern of polio outbreak applying spatial statistical techniques instead of depending on yearly accumulative incidence alone, So that through integrated spatial temporal data profiles polio high risks regions can be realized untimely. The current study with GIS based techniques explains and computes the epidemic situation of polio disease within study area epidemic regions and set a base to follow future investigations. Hotspot detection and spatiotemporal distribution may also present helpful information to epidemiologist to manage and show polio disease distribution over serious hotspot region instead for an entire region. Furthermore, the research methodology of current research is based on concepts of basic principle of spatial statistics may also utilize as a model to form a plan to manage and control polio disease by data, which is obtained through seasonally or yearly.

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