

Original article

Spatial Analysis of HIV/AIDS in Pakistan

Tirmizi SRH¹, Tirmizi ST², Khan NU³

Abstract:

Background: HIV/AIDS has emerged as a serious worldwide health problem since 1980s and the attainment of a successful disease control program and an effective viral cure is still elusive. Currently, careful estimates put the number of HIV/AIDS affected people at 43 million all over the world. Till such time the disease remains uncured, effective policies are required for the control of HIV/AIDS. **Method:** The present study is based on the available regional data of recorded HIV/AIDS cases in different provinces of Pakistan. **Result:** To demonstrate the clustering of infected groups in the target areas we have resorted to the use of Hot Spot assessment and spatial autocorrelation techniques. **Conclusion:** We conclude that due to a number of socio-economic reasons strong clustering of infection are appearing in a predictable pattern across Pakistan.

Keywords: Spatial Analysis; Provinces of Pakistan; HIV/AIDS.

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Introduction

Pakistan is the second largest country in South Asia by population. Its borders are situated with Afghanistan on the west, China in the north, and India on the east. Pakistan has four provinces with one capital territory and seven federally administered tribal areas also. For reference, there is a table: 2 below of Pakistan's provinces and territory, arranged by land area¹.

Table:1 Pakistan's provinces and territory arranged by land area.

Territory	Capital	Population	Land Area (sq km.)
Islamabad Capital Territory	Islamabad	805235	906
Punjab	Lahore	73621290	205345
Balochistan	Quetta	6565885	347190
Sindh	Karachi		140914
Khyber Pakhtunkhwa	Peshawar		74521
Azad Jammu Kashmir	Muzafferabad		13297

Pakistan is on the list of HIV/AIDS high risk South Asian countries but only Iran is low risk neighbor of it⁷. Within the region, Pakistan stands only a few steps

behind India and Nepal in terms of HIV epidemic⁷. The data which is given in table: 1 is collected by Pakistan Demographic Health Survey, 2007-08⁶.

Table:2(Pakistan Demographic Health Survey, 2007-08)

Counties	HIV Cases	AIDS Cases	Total HIV/AIDS
Fedral Central Territory	334	37	371
Punjab	394	43	437
Sindh	490	84	574
KPK	349	53	402
Baluchistan	180	12	192
Azad Jammu Kashmir	18	4	22

The common mode of transmission of HIV/AIDS in Pakistan is heterosexuality, blood transfusions, IDU - Injecting Drug Use, mother-to-child transmission etc.¹

Pakistan is a HIV/AIDS 'at-risk' country with high levels of poverty, low levels of literacy especially in

1. Syed Rizwan Ul Haq Tirmizi, PNEC - National University of Sciences and Technology, Islamabad (Pakistan)
2. Syed Talha Tirmizi, Petroleum Department, NED University, Karachi (Pakistan)
3. Nasir Uddin Khan, Mathematics Department, Karachi University.(Pakistan)

Correspondence to: Syed Rizwan Ul Haq Tirmizi, Mailing address:B-III/006 Billy's Paradise Phase I Block 18 Gulistan Jauhar Karachi (Pakistan).Email: tirmizi50@yahoo.com

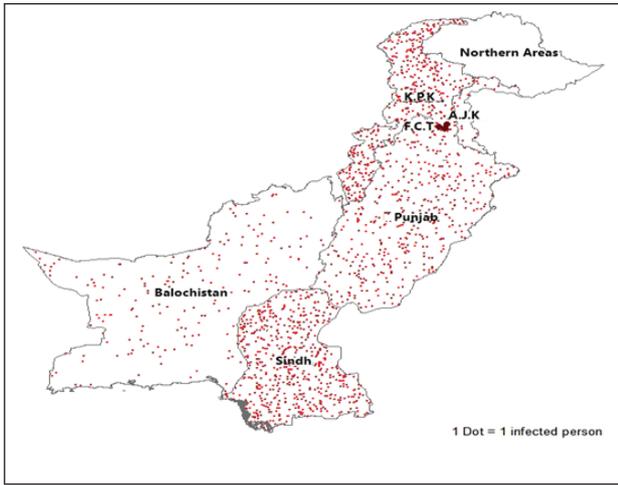


Figure 1: Reported HIV/AIDS infected population clusters in Pakistan

females, low awareness levels of knowledge among health workers, a large mobile population including refugees in border areas, long-distance truck drivers identified to connect in sexual practices therefore they are at high risk of contact HIV and sexually transmitted infections(STIs). Insufficient safety measures of blood transfusion; less access to quality STIs care; insecure medical injection and health care practices, a blooming commercial sex industry; reuse of syringes, poor awareness about HIV and avoidance measures and the stigma attached to it in the society.

Methodology

The Spatial Autocorrelation (Global Moran’s I) depends on characteristic values and phase simultaneously. For a given set of data, it evaluates whether the pattern is either clustered, dispersed, or random. The study uses Arc GIS tool to calculate a z-score, p-value and the Moran’s I Index value to assess the outcome of that Index.

The Moran’s I index statistic is given as:

$$I = \frac{n \sum_{i=1}^n \sum_{j=1}^n w_{i,j} z_i z_j}{s_0 \sum_{i=1}^n z_i^2}$$

Where z_i the deviation of an attribute for the feature I is from its mean $(x_i - \bar{x})$, $w_{i,j}$ is the spatial weight between feature i and j, n is equal to the total number of features and s_0 is the cumulative of all the spatial weights:

$$s_0 = \sum_{i=1}^n \sum_{j=1}^n w_{i,j}$$

ZI-Score for the statistic is computed as:

$$ZI = \frac{I - E[I]}{\sqrt{V[I]}}$$

Where:

$$E[I] = -1/(n - 1)$$

$$V[I] = E[I^2] - [E(I)]^2$$

$$E[I^2] = \frac{A - B}{c}$$

$$A = n(n^2 - 3n + 3)S_1 - nS_2 + 3S_0^2$$

$$B = D[(n^2 - n)S_1 - 2nS_2 + 6S_0^2$$

$$C = (n - 1)(n - 2)(n - 3)S_0^2$$

$$D = \frac{\sum_{i=1}^n z_i^4}{(\sum_{i=1}^n z_i^2)^2}$$

$$S_1 = (1/2) \sum_{i=1}^n \sum_{j=1, j \neq i}^n (w_{ij} + w_{ji})^2$$

$$S_2 = \sum_{i=1}^n (\sum_{j=1}^n w_{i,j} + \sum_{j=1}^n w_{j,i})^2$$

In case of regional level of data, the unit i and j were considered as adjacent units, then $w_{i,j} z_i z_j$ should be 1 otherwise, it should be 0. If Moran’s I $\neq 0$ and $P < 0.05$, means it has a cluster of HIV infections. Moran’s I ≥ 0 then the HIV/AIDS is considered to be positive auto correlated.

General Getis-Ord help us to measure the high or low concentration of infection in a specified study region.

The general G statistic of overall spatial association is given as:

$$G = \frac{\sum_{i=1}^n \sum_{j=1, j \neq i}^n w_{i,j} x_i x_j}{\sum_{i=1}^n \sum_{j=1}^n x_i x_j}$$

Where x_i and x_j are feature values for i and j , and $w_{i,j}$ is the spatial weight between feature i and j .

The ZG- score for the statistic is computed as:

$$ZG = \frac{G - E[G]}{\sqrt{V[G]}}$$

$$E[G] = \frac{\sum_{i=1}^n \sum_{j=1, j \neq i}^n w_{i,j}}{n(n-1)}$$

Where

$$V[G] = E[G^2] - [E(G)]^2$$

Additional calculations are as follows:

$$E[G^2] = \frac{A + B}{C}$$

$$A = D_0 \sum_{i=1}^n x_i^4 + D_1 (\sum_{i=1}^n x_i)^2 \sum_{i=1}^n x_i^4 + D_2 (\sum_{i=1}^n x_i)^2 \sum_{i=1}^n x_i^2$$

$$B = D_3 \sum_{i=1}^n x_i \sum_{i=1}^n x_i^3 + D_4 (\sum_{i=1}^n x_i)^4$$

$$C = \left[\sum_{i=1}^n x_i \right]^2 - \sum_{i=1}^n x_i^2 \times n(n-1)(n-3)$$

$$D_0 = (n^2 - 3n + 3)S_1 - nS_2 + 3w^2$$

$$D_1 = -[(n^2 - n)S_1 - 2nS_2 + 6w^2]$$

$$D_2 = -[2nS_1 - (n + 3)S_2 + 6w^2]$$

$$D_3 = 4(n-1)S_1 - 2(n+1)S_2 + 8w^2$$

$$D_4 = S_1 - S_2 + w^2$$

$$w = \sum_{i=1}^n \sum_{j=1, j \neq i}^n w_{ij}$$

$$S_1 = \left(\frac{1}{2}\right) \sum_{i=1}^n \sum_{j=1, j \neq i}^n (w_{ij} + w_{ji})^2$$

$$S_2 = \sum_{i=1}^n \left(\sum_{j=1, j \neq i}^n w_{ij} + \sum_{j=1}^n w_{ij} \right)^2$$

Moran's Index: 0.136855
 z-score: 8.062341
 p-value: 0.000000

From above calculation, it can be determined how concentration is high or low for a particular study area.

Results

As shown in Figure 2, majority of counties in Pakistan were investigated and it was observed that Sindh, Khyber Pakhtunkhwa and Federal Central Territory were shown to belong to high level of infection (shaded by dark color). From figure 2 it is also seen that the cases of HIV/AIDS infection were increased in the southern and northern parts of the country however, there is only Baluchistan territory which is still at low level of infection.

Geographically, the HIV/AIDS is found to be increasing in thickly populated areas of Pakistan.

Trend Surface Analysis provides a good picture of the geographical variation of HIV/AIDS in the different regions of Pakistan. The list of the different directions and trends for the study period is shown in table 1. Incidence generally increased vertically from North to south while the intensity rate decreased linearly from East to West. It has been observed that HIV/AIDS cases start increasing from the southern area and then moves towards to the center of the

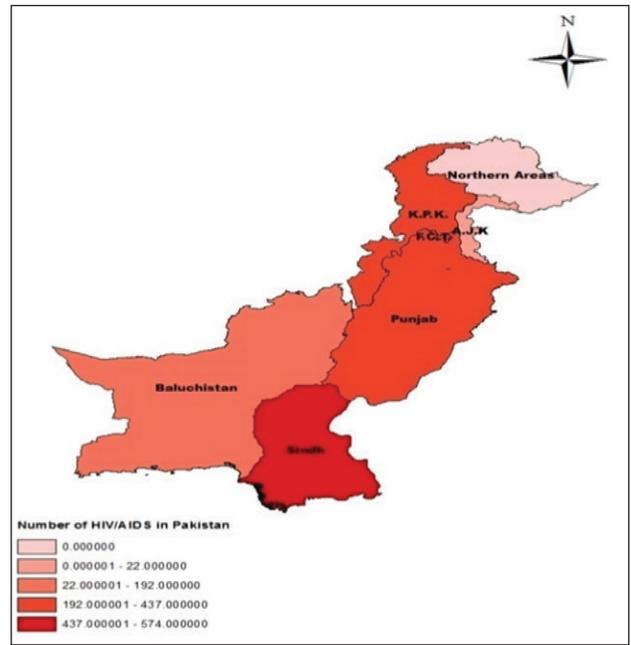


Figure 2: Number of HIV/AIDS Cases in Pakistan

region and then shows decreasing trend towards the Northern side. When it is observed along the latitudinal axis, there are more HIV/AIDS cases in the East in comparison with the West. The conclusion from the trend surface study and the Moran's Index value which is equal to 0.1368 with value of P which is equal to 0.0000002 and also the value of Getis statistics having 0.075409 with P value which is tends to 0.000000 as shown in figure 3 mention that the HIV/AIDS cases in Pakistan are very highly autocorrelated.

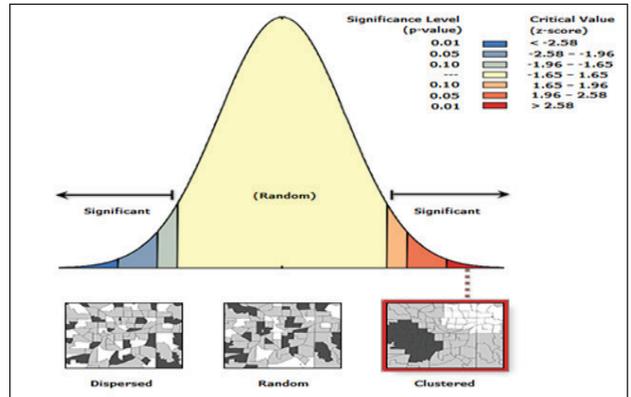


Figure 3: Spatial Autocorrelation Report

Geographically, HIV/AIDS epidemic may vary because of factors such as source of infection means of transmission and population properties. Thus, the difference between general and local autocorrelation may exist. Along with the latitudinal axis, it can be observed that HIV/AIDS cases increase on the north and south ends while it increases gradually towards

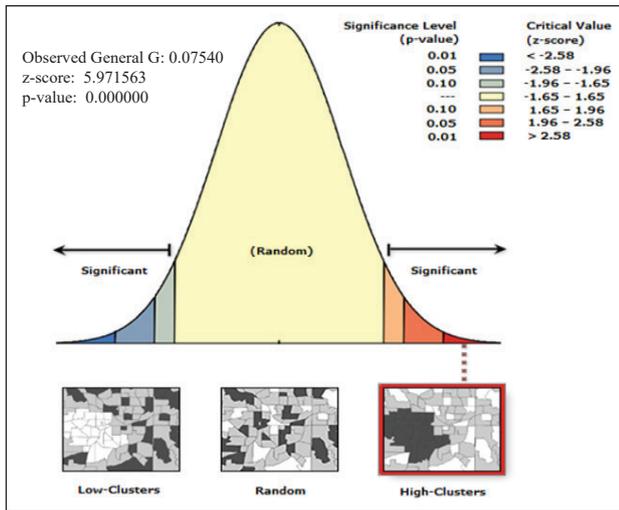


Figure 4: High-Low Clustering Report

center and along the longitude axis, it is perceived that it increases gradually from west and then grows towards east.

Table 3: Gi Score

Counties	Gi Z Score	Gi P Value
Sindh	1.461732	0.24554
Punjab	-0.340546	0.565946
Baluchistan	-0.113006	0.224360
Khyber Pakhtunkhwa	2.048963	0.48229
Central Territory	5.428020	0.000000
Azad Jammu Kashmir	1.920055	0.271167

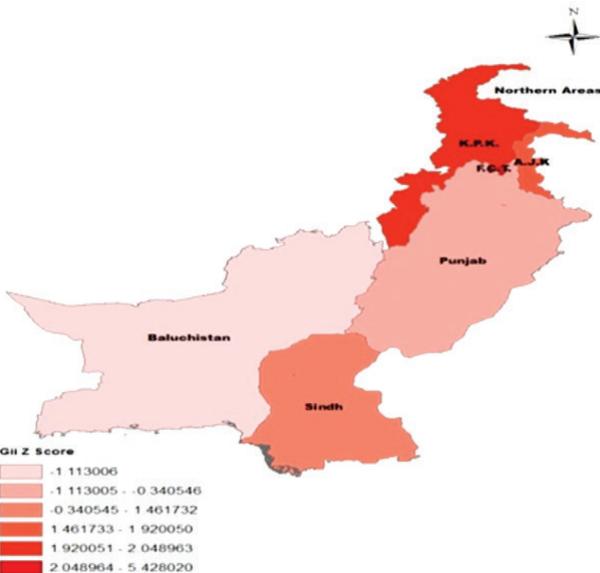


Figure 5: High-Low Cluster mapping

From figure 6 it is shown that Pakistan classified into seven levels.

Table 4. LMi Score

Counties	LMi Index	LMi Z Score	LMi P Value	Correlation
Sindh	1.388911	0.657892	0.616040	High-high
Punjab	0.110466	0.051707	0.866939	High-high
Baluchistan	1.132401	0.394629	0.691069	High-high
KPK	3.974899	1.212348	0.497605	High-high
FCT	62.132258	19.397813	0.220519	High-high
AJK	-1.516786	-0.382205	0.539838	High-low

All counties listed in table 2 are showing a statistically significant Autocorrelation

($P < 0.000000$). The central territory had the highest LMi Index with value 62.132268 also other counties Sindh, Baluchistan and Khyber Pakhtunkhwa (KPK) showed high positive correlation ($P < 0.000000$). On the other hand, although Azad Jammu Kashmir (AJK) has a large number of reported infected cases, but it is surrounded by areas of lesser infectious activity, which shows a negative auto-correlation (value -1.516786). The area of Federal Capital Territory (FCT) is highly autocorrelated and a confirmed hotspot for HIV/AIDS in this region.

The seven levels in the LMi's I map for HIV/AIDS cases in Pakistan show a considerable autocorrelation ($P < 0.0000001$). Six counties show trend of positive autocorrelated,

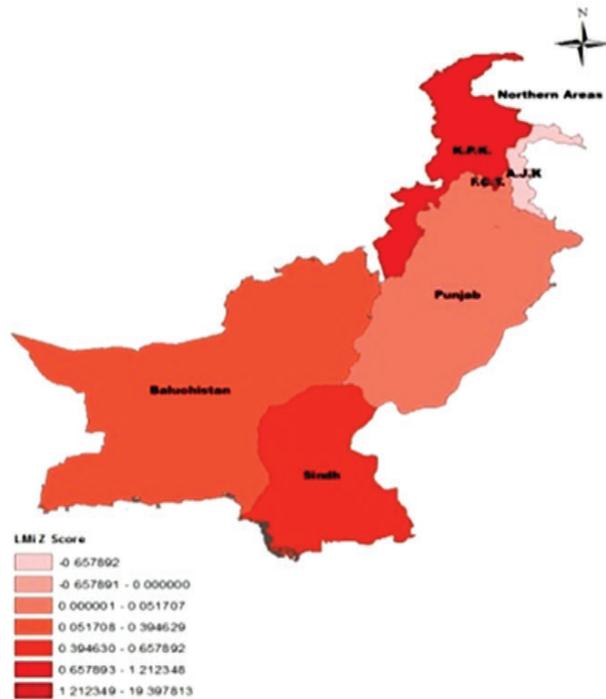


Figure 6: Spatial Autocorrelation mapping

i.e. these counties were considered as high-burden counties and were also shown to be surrounded by counties with large numbers of cases. The central territory had the highest indexes (Table 2). Other counties, i.e. Sindh and KPK also showed high positive correlations ($P < 0.00001$). However, with a local Moran's I of -0.00043

Limitations

Pakistan is ranked sixth of world population. It has population of 168.79 million residing in the provinces of Sind, Punjab, Baluchistan, Khyber Pakhtunkhwa. Pakistan is neighboring India, China, Iran and Afghanistan and its literacy rate is 54%¹. First case of HIV/AIDS was detected from Pakistan in 1987, and this ratio is increasing annually according to report issued by Pakistan⁷. Pakistan is getting increasingly trend to HIV epidemic like some of the other Asian countries. According to report issued by The News and NACP⁷, Pakistan along with few other countries is involved in the transition stage which has increased the number of victims since past five years. It is rough estimation of survey reports. The number of victims might go up to over a million if safety measures are not taken. But recently youth has been supported in terms of tackling this virus. There is lot of reasons for outbreak of HIV/AIDS epidemic. The reasons are poverty, migration of labor, lack of proper equipment and diagnosis facilities to detect the virus, blood transfusion without proper screening and drug addiction.

Discussion

Pakistan is a developing country with a population of more than 150 million. Pakistan hosts the largest number of refugees worldwide. According to a report, there are 1.6 million refugees in Pakistan as per the data published by the United Nations High Commission for Refugees¹¹.

The largest share of Pakistan's refugees comes from Afghanistan and this is the major cause for expanding the HIV/AIDS diffusion in its different regions. In addition, those counties which are attached with Afghanistan like KPK gradually develop such a society where HIV/AIDS easily flourished. By the trend surface analysis, it is seen that the epidemic has increasing trend in the north east and south west regions.

It is practically observed that of the "hot spots" are to be found in those areas where majority of refugees are settled especially in central territory, KPK and Karachi, there is another reason which is that the huge truck terminal at Mauripur in Karachi, one of the busiest rout in South Asia, sees 20,000 trucks pass through this terminal each day. There are thousands of truck drivers which is one of the group, most susceptible to HIV/AIDS, because they are engaged in such behavior like multiple sex partners and drug use but Baluchistan is a region which shows less HIV/AIDS surveillance although it is surrounded by those regions which are highly susceptible by HIV/AIDS like Sindh and very close to KPK and lot of refugees coming from Afghanistan settled here. Main reason is that their conservative customs, unawareness and less literacy rate show less incidence of HIV/AIDS otherwise figure might be entirely different.

Conclusion

Pakistan is at high risk and chances for outbreak of HIV/AIDS can be increased. It is required to implement rigorous efforts, concentrating on the northern and the southern regions which are the hot spots for HIV/AIDS in Pakistan. This epidemic is spreading persistently without knowing the borders. Further policies must be applied, otherwise there will be no solution to stop this deadly wave.

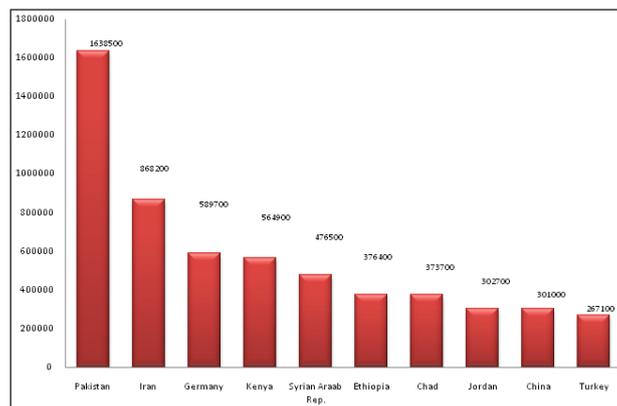


Figure 7: Major refugee-hosting countries at the end 2012

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