Spatial Analysis of HIV/AIDS in Pakistan
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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 autcorrelation 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.

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.

<table>
<thead>
<tr>
<th>Territory</th>
<th>Capital</th>
<th>Population</th>
<th>Land Area (sq km.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Islamabad Capital Territory</td>
<td>Islamabad</td>
<td>805235</td>
<td>906</td>
</tr>
<tr>
<td>Punjab</td>
<td>Lahore</td>
<td>73621290</td>
<td>205345</td>
</tr>
<tr>
<td>Balochistan</td>
<td>Quetta</td>
<td>6565885</td>
<td>347190</td>
</tr>
<tr>
<td>Sindh</td>
<td>Karachi</td>
<td>140914</td>
<td></td>
</tr>
<tr>
<td>Khyber Pakhtunkhwa</td>
<td>Peshawar</td>
<td>74521</td>
<td></td>
</tr>
<tr>
<td>Azad Jammu Kashmir</td>
<td>Muzafarabad</td>
<td>13297</td>
<td></td>
</tr>
</tbody>
</table>

Pakistan is on the list of HIV/AIDS high risk South Asian countries but only Iran is low risk neighbor of it¹. 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)

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

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...
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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 ArcGIS 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:

\[
I = \frac{n \sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} (z_i - \bar{z}) (z_j - \bar{z})}{S_0 \sum_{i=1}^{n} z_i^2}
\]

Where \(z\) is 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:

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

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

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

\[
A = n(n^2 - 3n + 3)S_1 - nS_2 + 3S_0^2
\]

\[
b = D[(n^2 - n)S_1 - 2nS_2 + 6S_0^2]
\]

\[
c = (n-1)(n-2)(n-3)S_0^2
\]

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

\[
S_1 = \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1, j \neq i}^{n} (w_{i,j} + w_{j,i})^2
\]

\[
S_2 = \sum_{i=1}^{n} \left( \sum_{j=1}^{n} w_{i,j} + \sum_{j=1}^{n} w_{j,i} \right)^2
\]

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 ≠ 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:

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

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:

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

Where

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

\[
\]

Additional calculations are as follows:

\[
E[G^2] = \frac{A + B}{C}
\]
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 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 0.000002 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.
center and along the longitude axis, it is perceived that it increases gradually from west and then grows towards east.

**Table 3: Gi Score**

<table>
<thead>
<tr>
<th>Counties</th>
<th>Gi Z Score</th>
<th>Gi P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sindh</td>
<td>1.461732</td>
<td>0.24554</td>
</tr>
<tr>
<td>Punjab</td>
<td>-0.340546</td>
<td>0.565946</td>
</tr>
<tr>
<td>Baluchistan</td>
<td>-0.113006</td>
<td>0.224360</td>
</tr>
<tr>
<td>KPK</td>
<td>2.048963</td>
<td>0.48229</td>
</tr>
<tr>
<td>Central Territory</td>
<td>5.428020</td>
<td>0.000000</td>
</tr>
<tr>
<td>Azad Jammu Kashmir</td>
<td>1.920055</td>
<td>0.271167</td>
</tr>
</tbody>
</table>

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<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,
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 Pakistan \(^7\). Pakistan is getting increasingly trend to HIV epidemic like some of the other Asian countries. According to report issued by The News and NACP\(^7\), 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 Refugees \(^11\).

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.
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References