

Spatial analysis of 'Couple Years of Protection' by district in Punjab: Percent change from 2015-2016 to 2016-2017

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Abstract

Couple Years of Protection (CYP) is a proxy indicator for birth control protection. Using data from Pakistan Bureau of Statistics, spatial distribution of CYP percent change from 2015-2016 with 2016-2017 was compared by district for Population Welfare Departments, Health departments, and Lady Health Workers in the Punjab province. Spatial profile of CYP showed discernable differences by the three service providers. Local indicators of spatial autocorrelation showed significant districts by type of spatial autocorrelation including high-high, low-low, spatial clusters, as well as spatial outliers. The three service providers had different profile of clusters for percentage change from 2016 to 2017. Cluster and significance maps depict districts where CYP percent change is statistically significantly different or same from the neighbouring districts, and as such underscoring districts where additional focus on service delivery in terms of contraceptives provision could yield improved outcomes.

Keywords: Contraception, GIS, Cluster Analysis, Pakistan

Introduction

The contraceptive prevalence, defined as percent of women aged 15-49 years using any method of contraception, was 34.2% for the year 2018 in Pakistan.¹ Against the backdrop of being globally ranked as number 5 in terms of population size, and number 40 in terms of gross domestic product.^{2,3} This brings to the fore, age old concerns about economic development and its negative relationship with growth of country's population and how to meet family planning (FP) demand and stem population growth.^{4,5} Family planning, i.e., birth control services in public sector are provided by Population Welfare Departments through Family Welfare Centres, Reproductive Health Services Centres, and Mobile Service Units. Health departments provide these services through primary, secondary, and tertiary health care facilities, in addition to Lady Health Workers in Pakistan.⁶

Pakistan Bureau of Statistics (PBS) released Contraceptive

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Performance Report (CPR) for the year 2016-2017, released in July 2018.⁶ One of the main objectives of the Report was to assess FP performance in terms of CYP (Couple Years of Protection). It also reported percentage change in CYP from 2015-16 to 2016-17, by district in the country. CYP is a proxy indicator for birth control protection based upon the volume of contraceptives sold or freely distributed in a year.

PBS calculates CYP by "... multiplying the quantity of each method distributed to clients/ service statistics by a conversion factor, which yields an estimate of the duration of contraceptive protection provided per unit of that method. The CYP for each method is then summed for all methods to obtain a total CYP figure. CYP conversion factors are based on how a method is used, failure rates, wastage, and how many units of the method are typically needed to provide one year of contraceptive protection for a couple".⁶

Spatial clustering, i.e., grouping in space of values that are similar to each other is analyzed in terms of Moran's I and 'Local Indicator of Spatial Association' (LISA). Global Moran's I "... measures spatial autocorrelation based on both feature locations and feature values simultaneously. Given a set of features and an associated attribute, it evaluates whether the pattern expressed is clustered, dispersed, or random".⁷ While, 'Local Indicator of Spatial Association' (LISA) measures local spatial autocorrelation. "The LISA for each observation gives an indication of the extent of significant spatial clustering of similar values around that observation".⁸

A previous study using Geographic Information Systems (GIS) analysed spatial distribution of CYP by district in Pakistan, for percent change in 2015-16, compared with the previous year.⁹ However, for twelve districts no CYP data were available, including two districts of Punjab province. Secondly, that study was limited to CYP data from Population Welfare Departments only. In this study, spatial distribution of CYP percent change from 2015-2016 was compared with 2016-2017 in Punjab province, by district for Population Welfare Departments, Health departments, and Lady Health Workers using Moran's I and LISA measures.

Methods

The CPR 2016-17 report includes tabular data in terms of CYP by district, and is freely downloadable from Pakistan Bureau of Statistics website (<http://www.pbs.gov.pk>). Tabular data in terms of percentage change in CYP from 2015-16 to 2016-17 report was downloaded as a PDF file and entered in the GIS programme ArcMap version 10.6. For mapping and spatial analysis, the shapefile for Punjab province was downloaded from Humanitarian Data Exchange website. Using ArcGIS and GeoDa version 1.8.16.4, spatial analysis and maps were created to analyze and visualize district-wise patterns.

Map showing all the districts in Punjab was created to identify each district individually. Three choropleth maps using quantile method were created to depict the percentage change in CYP by district in the Punjab province, for Population Welfare Departments, Health departments, and Lady Health Workers.

To check for overall spatial autocorrelation globally, i.e., at the level of entire province of Punjab, Moran's I was calculated and pseudo p-value was used to determine statistical significance. Using first order queen contiguity weights, with permutation test set at 999. While, the 'Local Indicator of Spatial Autocorrelation' (LISA) was used for district-level spatial autocorrelation. The LISA results are shown as high-high and low-low areas/districts spatial clusters, which means the value at a location (either high or low) is more similar to the value of its neighbouring districts. While the high-low or low-high districts on maps are spatial outliers. This means that there are outliers of high values near the cluster of low values and vice versa.

Calculation of Moran's I, entails the spatial matrix used, number of geographic areas, e.g. districts, proximity of each district relative to other districts, and the variable used, e.g. percent change in CYP in each district and its adjacent districts, and the mean of percent change in CYP in all districts in Punjab province. The formula numerator is derived from multiplying the number of districts by the product of deviation from mean for all pairs of adjacent districts. While the formula denominator is derived from the

product of squared deviations for mean for all pairs of adjacent districts and the sum of spatial weights used. The LISA statistic is derived from row standardized spatial weights, variable, e.g. percent change in CYP, mean and standard deviation of percent change from all districts.

Results

Figure-1 shows map of all Punjab districts with legend showing names of all 36 districts. Figure-2 shows percentage change in CYP by district for using quantile method. For LHW the percentage change ranged from -37.1 to 167.5, for HF from -31.7 to 88.8, and for PWD from -25.1 to 61.2. For LHW, 15 districts had negative percent change; for HF, 16 districts had negative percent change; for PWD, five districts had negative change, and two had no change from previous year. Spatial clustering at the level of Punjab province was determined using Global Moran's I statistic. The Moran scatter plot of CYP percent change in various districts uses standardized data so that units on the graph are expressed in standard deviations from mean. On horizontal axis standardized value of CYP percent change for district is displayed, while on vertical axis the standardized value (spatial lag) of the average CYP percent change for district's neighbours as defined by the weights matrix is displayed. The slope of regression line represents global Moran's I value. The graph has four quadrants denoting types of spatial autocorrelation; upper left and upper right quadrants represent low-high and high-high spatial autocorrelation, respectively. While, lower left and

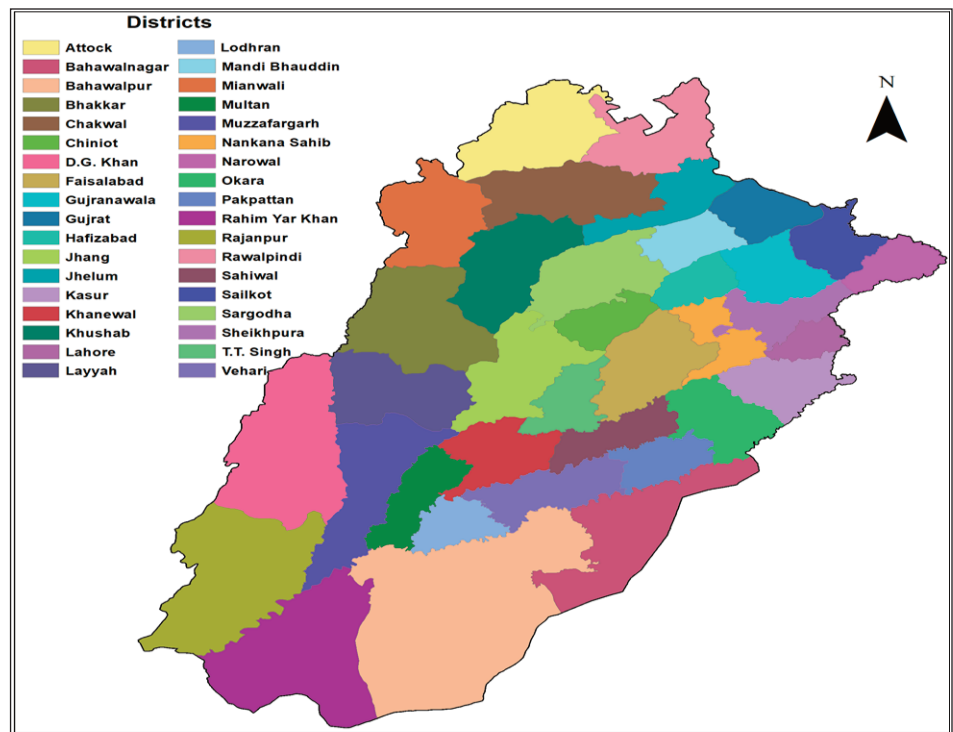


Figure-1: Map of Punjab province showing districts.

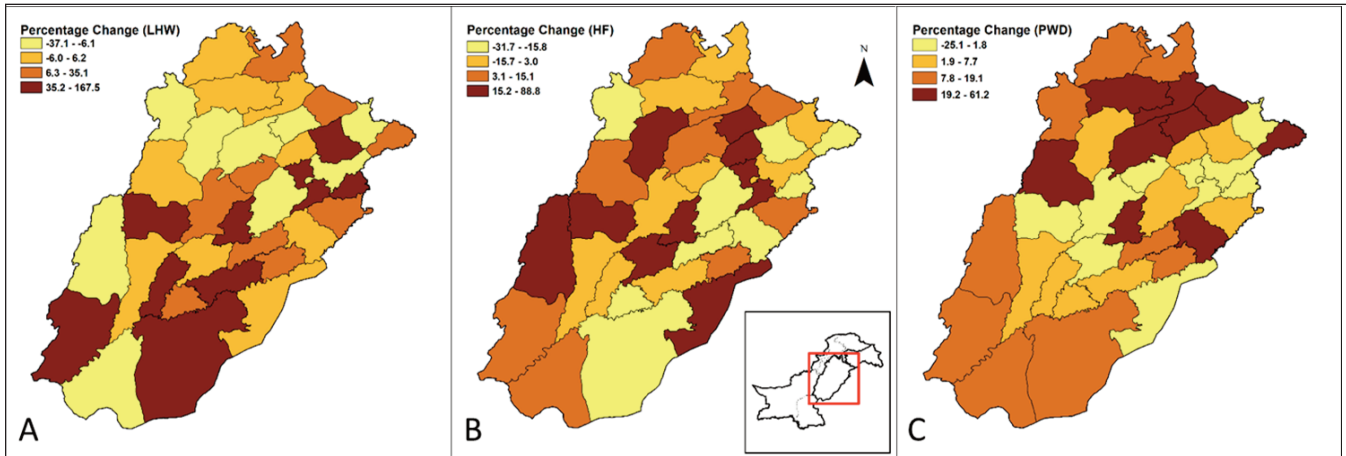


Figure-2: Map of percentage change in CYP for three family planning service providers by district using quantile method.

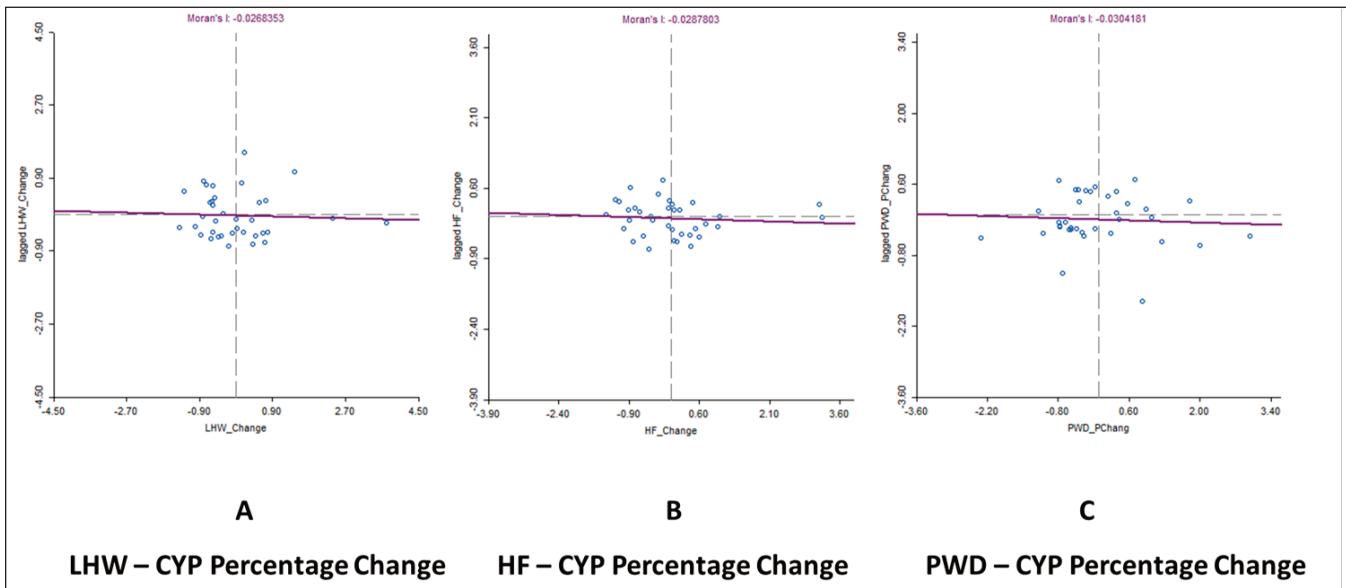


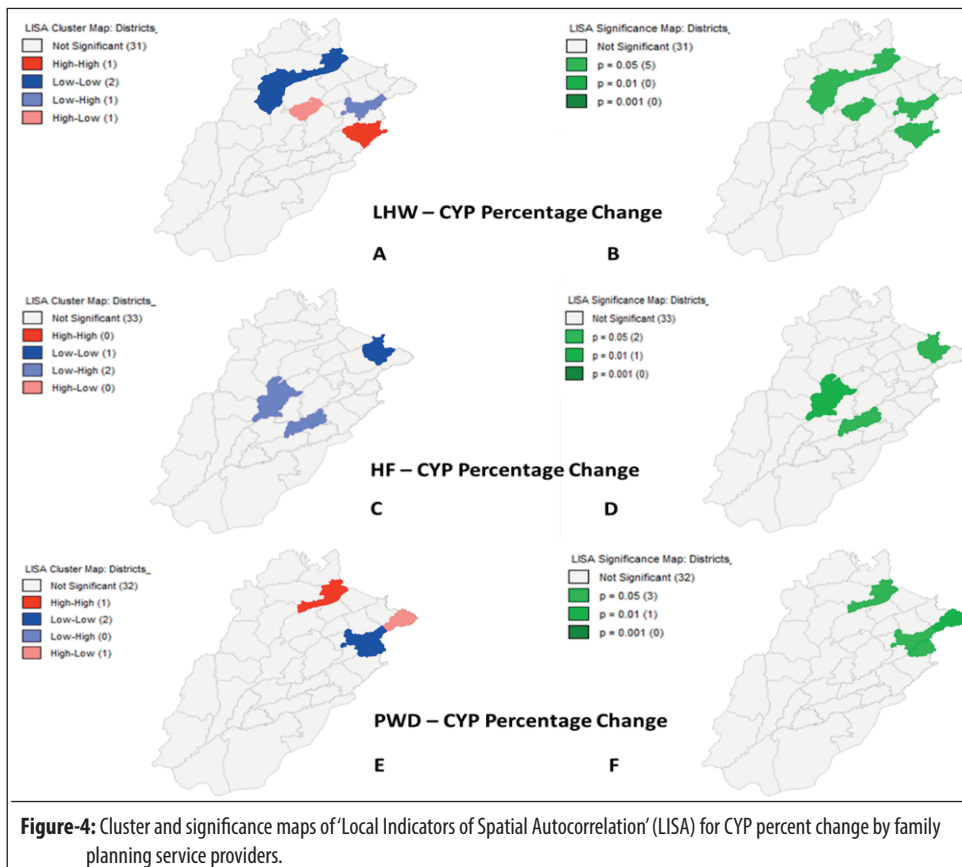
Figure-3: Moran's I graphs for three family planning service providers.

lower right represent low-low and high-low, respectively spatial autocorrelation. The high-high and low-low, both represent positive spatial autocorrelation. While the low-high and high-low, both represent negative spatial autocorrelation.

For LHWs percentage change from 2015-16 to 2016-17, there was some overall negative spatial autocorrelation globally (Moran's I = -0.0268) as shown in figure-3-A. But this was modest and not statistically significant (pseudo p-value: 0.451). The LISA cluster map and significance map also show a relatively modest scenario of autocorrelation, with just a few cluster areas, as shown in figure-4-A-B. The LISA significance map indicates 5 districts (Jhelum, Khushab, Chiniot, Sheikhpura, and Kasur) with local Moran statistics at a significance level of p value: 0.05. The LISA

cluster map shows two districts of low-low spatial autocorrelation (Jhelum and Khushab), one of high-high (Kasur), one low-high (Sheikhpura), and one of high-low (Chiniot).

For health facilities percentage change from 2015-16 to 2016-17, there was also some overall negative spatial autocorrelation globally (Moran's I = -0.0288), as shown in figure-3-B. This was also modest and not statistically significant (pseudo p-value: 0.476). The LISA cluster map and significance map also show a relatively modest scenario of autocorrelation, with just a few cluster areas, as shown in figure-4-C-D. The LISA significance map indicates 2 districts (Sialkot and Sahiwal) with local Moran statistics at a significance level of p value: 0.05, and one district (Jhang) at $p=0.01$. The LISA cluster map shows one district



of low-low spatial autocorrelation (Sialkot), and two of low-high (Jhang and Sahiwal).

For PWD facilities percentage change from 2015-16 to 2016-17 there was some overall negative spatial autocorrelation globally (Moran's I = -0.0304), as shown in figure-3-C. This was pretty modest and not statistically significant (pseudo $p=0.490$). The LISA cluster map and significance map also show a relatively modest scenario of autocorrelation, with just a few cluster areas, as shown in figure-4-E-F. The LISA significance map indicates 2 districts (Jehlum and Lahore) with local Moran statistics at a significance level of $p=0.05$, and one district (Narowal) at $p=0.001$. The LISA cluster map shows one district of high-high spatial autocorrelation (Jehlum), one of low-low (Lahore), and one of high-low (Narowal).

Discussion

Fertility levels are inextricably linked with the use of family planning services and CYP. Use of these services are impacted by myriad psychosocial and economic factors.¹⁰ A study of CYP in Kinshasa, the capital city of Democratic Republic of Congo, found that health facility type, duration of their operation, and availability of number of contraceptive methods was strongly associated with CYP.¹¹ As a proxy indicator for birth control protection based upon

the volume of contraceptives sold or freely distributed in a year, CYP equates sale/free distribution of contraceptives with their actual and correct use. Nonetheless, it does quantify process outputs for provision of birth control. A previous study used CYP data for the entire country, albeit with missing information for twelve districts. CYP is based on activities and services delivered by provincial authorities, and as such, are impacted by provincially driven policies, priorities and available funding. Hence, this study's focus was on only one and the most populous province of Punjab, in the country, in terms of spatial distribution of CYP percent change from 2015-2016, compared with 2016-2017. Population Welfare Departments, Health departments, and Lady Health Workers, all provide and distribute contraceptives every

year as part of family planning services provision in the province of Punjab.

Spatial profile of CYP painted discernible differences by three service providers. All three service providers had some districts that reported negative percent change, i.e., in the year 2016-2017, volume of services was not maintained from the previous year. Moreover, for each service provider, these districts were not the same with the exception of districts Sheikhupura and Sialkot; these two districts registered negative percent change by all three service providers and merits further investigation of the causes thereof.

For all three family planning services providers, spatial analysis revealed that there was some overall negative spatial autocorrelation globally as indicated by Moran's I, but this was modest and not statistically significant. LISA cluster map shows the significant locations by the type of spatial autocorrelation. While the LISA significance maps depict the strength or precision of the cluster determination. The LISA cluster maps and significance maps show modest scenarios, with few cluster areas. The LISA cluster maps show significant locations by the type of spatial autocorrelation. The three LISA cluster maps – for

three family planning service providers – collectively depict all four types of clusters i.e. low-low, high-high, high-low, and low-high. The three service providers had different i.e. non-overlapping profile of clusters for percentage change from 2016 to 2017. LISA cluster and significance maps depict districts where CYP percent change is statistically significantly different or same from the neighbouring districts, and as such underscoring districts where additional focus on service delivery in terms of contraceptives provision could yield improved outcomes. Increasing access to and expanding the availability of contraceptive services by improvising existing supply chain models and better understanding of local socioeconomic dynamics would increase CYP at the district level^{10, 12}. This study analysed the spatial distribution of CYP at district level in Punjab province.

Conclusion

Mapping and spatial analyses provide additional insights into CYP percent change from 2015-2016 to 2016-2017 in Punjab province by district, showing that for each of the three service provider there are distinct differences that vary by district. However, the districts of Sheikhupura and Sialkot show negative percent change by all three service providers.

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