Diabetes amongst women in India: A Geospatial Analysis

Rationale and Objectives: In the twenty-first century, diabetes mellitus is one of the leading threats to human health and rapidly increasing all over the world at an alarming rate. It is a chronic disease, which occurs when the body cannot effectively use the insulin or pancreas does not produce sufficient insulin; it produces. It leads to an increased concentration of glucose in the blood (hyperglycaemia). Today diabetes has become prevalent than ever before. It alters the lives of all age groups, and the age group most affected being between 35 years and above. In 2010, recent estimates showed that 285 million people live with diabetes, around the world. It corresponds to an alarming 6.4% of the world's adult population, and this number is only expected to grow to 438 million by 2030. Worldwide 3.2 million diabetes-related deaths are reported annually, a number equivalent to that of HIV/AIDS-related deaths. Recent studies by the World Health Organization (WHO) show that a considerable number of people with diabetes originate from low and middle-income countries. It contributes significantly to premature adult mortality out of all deaths of diabetic people above the age of 35; three-fourths are attributable directly to the disease.

In the existing health transition in India, resulting as a combination of demographic transition and epidemiological transition, the burden on NDCs has been projected to be double by 2030, which is primarily due to changes in dietary practices and lifestyle. As there is tremendous heterogeneity in the lifestyle of people across 640 districts in the country, which vary to a large extent by caste, class, and social groups and resulting in differential prevalence in obesity and hypertension. The major research question to be addressed in this paper is whether there is any spatial variation in the relationships between obesity and diabetes among women in India?

Data and Methods: The data used in this study has been taken from National Family Health Survey (NFHS)-4 in India conducted in 2015-2016. NFHS survey has been conducted under the stewardship of the Ministry of Health and Family Welfare (MoHFW), Government of India. The survey elicited information on demographic and health indicators at the national, regional, state and district levels from a nationally representative sample. NFHS-4 (2015-16) collected information from a nationally representative sample of 601,509 households, 699,686 women age 15-49 (NFHS-4, IIPS Mumbai). It is the first time NFHS has measured population based blood glucose levels among all the interviewed women age 15-49 and men age 15-54. The information on the emerging health issues including prevalence of diabetes for each of 640 districts in the country are available in public domain to use on (http://rchiips.org/NFHS/districtfactsheet_NFHS-4.shtml). The analysis of diabetes prevalence among women age 35-49 has used ten socio-economic and demographic variables, that have been conceptualized as exposure variables for the prevalence of diabetes, namely, age (in years), Place of residence, Caste Group, Religion, Years of Schooling, Wealth Index, Number of Children Ever Born, Current Pregnancy Status, Obesity, and Hypertension. Obesity and hypertension which are used as predictors of diabetes are computed using Body Mass Index (BMI) and measured Diastolic (DBP) and Systolic Blood Pressure (SBP) respectively. An individual falls into the category of obese if, his/her, BMI is greater than or equal to 30 kg/m^2. Also, the respondent was considered as hypertensive if the systolic blood pressure (SBP) was ≥140 mmHg and diastolic blood pressure (DPB) was ≥90 mmHg [i]. Furthermore, a respondent was considered as diabetic if the random blood sugar (RBS) level is greater than equal to 140 mg/dl. Two sets of statistical methods have been used in this paper. In the first set, age adjusted prevalence of diabetes has been used to analyze the adjusted prevalence of diabetes among women age 35-49 in India. Subsequently, for identifying the contribution of obsesity in addressing prevalence of diabetes among women age 35-49 the propensity score matching using nearest neighbourhood and counterfactual methods have been used, In the second approach, to analyze the spatial variation in the relationship between obesity and prevalence of diabetes, Moran I's and bi-variate LISA maps have been used to examine the spatial autocorrelation and OLS as well as Spatial Error Models have been used for spatial auto regression.

Results and Discussion: In order to calculate burden of diabetes unstandardized and age-standardized prevalence was calculated. For standardisation procedure, data from Census 2011, Government of India was extracted. The results suggest that the prevalence was about 11.0 percent amongst women in age-group 35-49 years. The findings suggest that the prevalence of diabetes was fund to be higher amongst respondent from urban areas [PR=13.15 (13.08-13.220)], belonging to socially- non-deprived group [PR=10.99(10.94-11.04)], non-Hindu religion [PR=11.75 (11.65-11.85)], with ten or more years of schooling [PR=13.20 (13.11-13.30)]. Furthermore, the prevalence was found to be increasing by wealth, i.e., it was least for poorest category [PR=7.01 (6.93-7.09)] and highest for richest wealth [PR=13.46 (13.37- 13.55) group. The prevalence was highest for women with at most 2 children ever born [PR=11.89 (11.82-11.95)]. The prevalence was found to be higher for women with obesity [PR=20.84 (20.68-21.00)] and hypertension [PR=18.89 (18.71-19.08)]. The comparative study between women who are obese and non-obese shows that the risk for developing diabetes. For instance, before matching, the prevalence of Diabetes among obesity group is 4.03%, and for non-obese group prevalence of Diabetes is 1.43%. After matching, the value of ATT is 0.20 in the obese group and 0.09 in non-obese group, which means that if these women would not have obesity, then prevalence of diabetes is 0.14 percent. ATU values shows that women who did not have obesity then the prevalence of Diabetes decreased to 0.27 percent. The average treatment effect (ATE) shows the difference between the Obese and non-Obese women is 0.18 percent.

The univariate LISA results for diabetes are presented in **Figure A**. The LISA cluster map yields four types of geographical clustering of the interest variable. For example, ‘‘high-high’’ means that regions with above average diabetes prevalence rates also share boundaries with neighbouring regions that have above average values of the same variables. On the other hand, ‘‘high-low’’ means that regions with above average diabetes prevalence rates are surrounded by regions with below average values. The ‘‘high-high’’ are also referred to as hot-spots, whereas the ‘‘low-low’’ are referred to as cold-spots. Findings suggest striking geographic clustering of high diabetes in the Southern and Eastern parts of the country. On the other hand, there were regions with substantially lower diabetes prevalence rates in some parts of Central India. Bivariate LISA examines the spatial relationship between the exposure and the outcome variable for the 640 districts of the country. We use bivariate models to address a closely related and pertinent question- whether the geographic regions which were privileged had a higher prevalence of diabetes? The findings form the study depicts that a spatial relationship exists between diabetes prevalence and women’s who reside in urban, years of schooling ten or more, women with CEB less than two, were obese, belonged to rich wealth quintile, and had hypertension.

Results of spatial autocorrelation with application of bi-variate LISA maps and Moran’s I demand for an analysis of spatial dependence in the prevalence of diabetes among women age 35-49 years across different districts of India. To decide the suitability of the model to analyse spatial dependence, two sets of test on Legrange’s-Multipliers (LM) and Robust LM have been used with the help of White test in OLS model .The White test produces significant LM (lag) as well as LM (error) tests. As a result, Robust LM(lag) and Robust (error) tests have been compared . Relatively larger value of LM (error) test than the LM(lag) test and relatively larger value of adjusted R^2, explaining the better model adequacy and lower values of Akaike Information Criterion (AIC) and Schwarz criterion, explaining better suitability of the model, have guided to apply LM (error) model to analyse the spatial dependence of diabetes among women age 35-49 years with various predictors was included in the spatial regression model. Results of spatial error model on spatial dependence of diabetes on proximate determinants and other meso-variables are presented in **Table A**. The autoregressive coefficient is 0.509, indicating significantly higher spatial clustering in the outcome variable diabetes accounted for geographical pattern of measured and unmeasured independent variables. The findings portray that in the prevalence of diabetes among women age 35-49 years in India, is significantly affected by space. When spatial weights are taken into consideration in the model, the spatial regression model noticeably becomes stronger in predicting the prevalence of diabetes among women aged 35-49 years. Being Obese (BMI>=30 kg/m^2), hypertensive and, having a number of children ever born<=2 were the key predictors significantly explaining the spatial dependence in the prevalence of diabetes among women age 35-49 years in India. Among all the predictors included in the spatial model the chance of suffering with diabetes is increasing with the highest pace with increasing obesity and hence creates an alarming situation, especially when there is rapid increase in obesity among women in India despite increasing women's participation in labour force. These arguments are also reinforced with the spatial dependence of diabetes on wealth quintiles of the women, which is negative though not significant. These findings indicate that increasing obesity among women age 35-49 years needs to be prioritized as part of promoting healthy life style through physical exercise and healthy dietary practices. It is worth mentioning that inclusion of spatial weights in the model has increased the predicting power of the model from 33 percent in case of OLS to 46 percent in the spatial regression model, indicating spatial clustering in the prevalence of diabetes among women age 35 and above in the country.

Moron's I =0.42, **p-value**=0.001

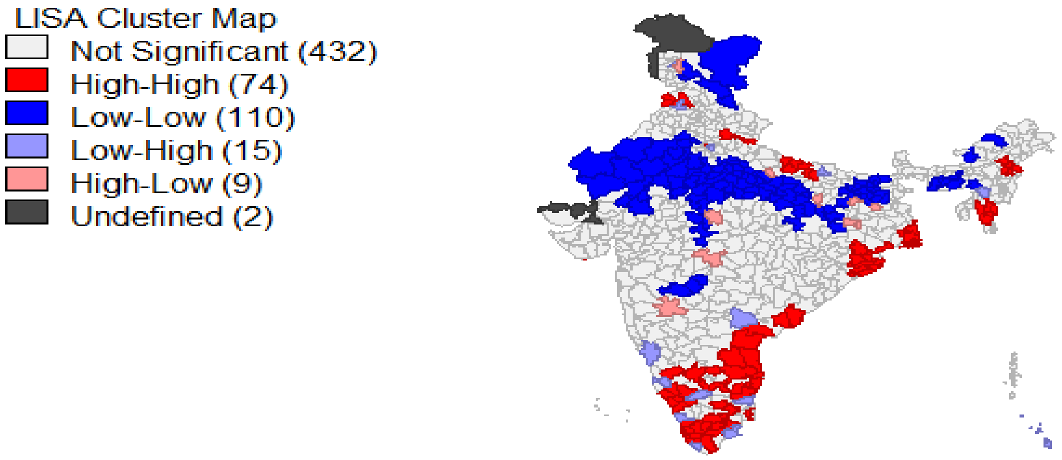

Figure A. Univariate LISA (Cluster and Significance) maps depicting spatial clustering and spatial outliers of diabetes across 640 districts of India, 2015-16. **A.** Univariate LISA Cluster map of diabetes prevalence across 640 districts in India, 2015-16. **B.** Univariate LISA Significance map of diabetes prevalence across 640 districts in India, 2015–2016.

A. **B.** **C.**

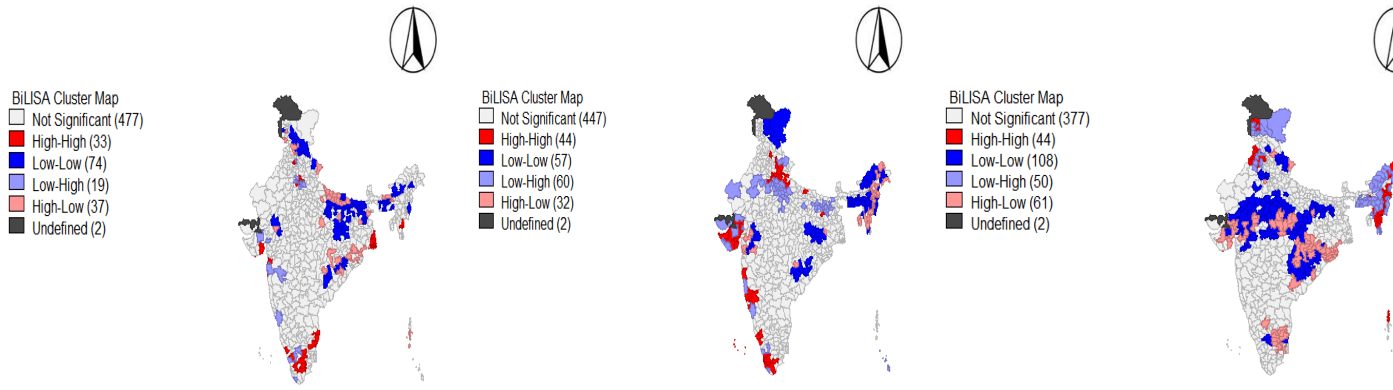

Figure B. Bivariate LISA (Cluster and Significance) maps depicting spatial clustering and spatial outliers of Diabetes Preval selected background characteristics across 640 districts of India, 2015-16. **A.** Bivariate LISA Cluster map of diabetes prevalence India, 2015-16. **B.** Bivariate LISA Cluster Map of Diabetes Prevalence and percent non-SC/ST population across 640 distric Cluster map of diabetes prevalence and percent non-Hindu population across 640 regions of India, 2015–2016. **D.** Bivar prevalence and percent population with 10 or more years of schooling across 640 districts of India, 2015-16. **E.** Bivariate LISA and percent urban across 640 districts of India, 2015-16. **F.** Bivariate LISA Significance map of Diabetes Prevalence and p districts of India, 2015-16. **G.** Bivariate LISA Significance map of diabetes prevalence and percent non-Hindu population acr Bivariate LISA Significance map of diabetes prevalence and percent population with 10 or more years of schooling across 640 di , 2015-16.

Recommendations: In view of spatial clustering in the prevalence of diabetes among women age 35-49, there is a need for diffe of obesity and life style based interventions among women.