Exploring the Spatial Variation in Diabetes Burden among women in India: Evidence from a Cross-sectional Survey

Abstract

Background: This paper analyses the spatial variation in the prevalence of diabetes among women aged 35-49 years in India using data from the recent round of the National Family Health Survey, 2015-16.

Methods: To draw inferences from the data age-adjusted prevalence rates were calculated followed by an examination of economic inequality using the poor-rich-ratio (PRR) and Wagstaff's concentration index. To examine the spatial variation in the prevalence of diabetes, a series of quantile maps, univariate and bivariate LISA cluster maps were generated. Further to explore the district-level diabetes prevalence among women in the country OLS and Spatial Autoregressive (SAR) models were used.

Results: The findings suggest that the age-adjusted prevalence of diabetes was higher among women with obesity. The prevalence of obesity among women aged 35-49 years has made a significant contribution (13%) in enhancing the risk of diabetes. Additionally, a significant concentration of diabetes was observed among non-poor women across their place of residence, educational attainment and different regions in the country. Furthermore, there is relatively larger concentration of diabetes among women in the Southern and Eastern parts of the country. The spatial clustering of diabetes prevalence is affirmed with significantly high values of the univariate Moran's-I (I=0.42***) and auto-regressive coefficient (0.51, $p<0.01$) accounting for the geographical pattern of measured and unmeasured independent variables.

Conclusions: These findings portray that the prevalence of diabetes among women in India is significantly affected by geographic variations. Therefore, programmes and interventions to lower the intensity of community-based prevalence of diabetes, especially among women in their late reproductive ages, should adopt differential approach across different states/districts in the context of their lifestyle, dietary pattern, working pattern and other socio-cultural practices keeping levels of obesity in the central place.

Keywords: Diabetes**,** Hypertension**,** Obesity**,** Spatial Dependence

Background

In the twenty-first century, Diabetes Mellitus (DM) is one of the leading threats to human health and is increasing rapidly all over the world, at an alarming rate. It is one of the most common diseases that involves a range of metabolic disorders due to spike in blood sugar levels. It is chronic in nature, that may be caused by absence or insufficient production of insulin, or an inability of the body to properly utilise insulin. It may trigger due to genetic disposition, lifestyle or dietary habits. It leads to an increased concentration of glucose in the blood (hyperglycaemia), which is a symptom and not the cause of this disease. It is associated with numerous health conditions like obesity, hypertension and a range of heart-related ailments.

Today diabetes has become more prevalent than ever before. Though, it may affect people of any age, those over 35 years are most affected. According to the recent estimates by International Diabetes Federation (IDF), in 2016, 422 million people live with diabetes around the world and this number is projected to grow to 762 million by 2030 (World Health Organization, 2016) . DM, is divided into type 1 and type 2. Bodies of Individuals suffering with type 1 diabetes do not produce insulin, whereas, those with type-2 diabetes do not respond to insulin or do not make enough insulin (Wild, Roglic, Green, Sicree, & King, 2004). It has also been estimated that 85 to 90 percent of these diabetes cases constitute type-2 diabetes, mainly facing-out at the risk factors like, increasing longevity of life, overweight/obesity, rising level of urbanization and changes in lifestyle.

Recent studies by the World Health Organization (WHO) shows that a considerable number of people with diabetes originate from the low-and-middle-income countries. Existing literature suggests this elevation in the incidence of Diabetes in developing countries, to be contributed by the increasing urbanization, changing lifestyles which are primarily sedentary in nature and have a lower amount of physical work. Additionally, the global nutrition transition marked by increased intake of high-energy foods with poor nutritional composition, have acted as a catalyst in further accelerating the levels (Shridhar, Rajendra, Murigendra, Shridevi, & Prasad, 2015) (Mu, Xu, Hu, Wu, & Bai, 2017).

In recent years, diabetes has been identified as one of the leading causes of morbidity and mortality influencing, not just older adults but also the young and middle-aged persons. Around 2.2 million deaths worldwide were attributable to high blood glucose, and the increased risks of associated complications (e.g., heart disease, stroke, kidney failure), which often result in premature death and these complications are often listed as the underlying cause of death instead of diabetes (World Health Organization, 2016)

In the current health transition in India, resulting as a unification of demographic and epidemiological shift, the burden on Non-Communicable Diseases (NCDs) has been projected to be doubled by 2030, which is primarily due to development-oriented changes in the lifestyle and dietary pattern of the population (Stephens & Sanders, 1996) (Shridhar et al., 2015) (Mu et al., 2017). There has been a tremendous heterogeneity across the districts in the country, which has widened significantly, after the advent of economic liberalization of 1990s. Consequently, the pattern of development and lifestyle changes have not been uniform and are greatly influenced by caste, class, and social groups and resulting in differential prevalence in obesity, hypertension and other risk factors for diabetes (Singh, Pedgaonkar, Puri, & Gupta, 2018).

Moreover, existing literature points out the existence of a gap between the level of obesity for the women who have been experiencing the post-partum period at least once and those who have never undergone a conception (Khadilkar, Chiplonkar, Khadilkar, & Kajale, 2015). Studies also recommend that the effect of being in post-partum period further accelerates by the action of changes in the level of urbanization and dietary practices (Arabin & Stupin, 2014) 8]. Additionally, exploring spatial variations in the prevalence of diabetes would be helpful in suggesting ways, that are essential for strengthening policy related interventions. Thus, with the increasing prevalence of Diabetes in India, this paper attempts to answer research questions about the nature and types of mesoscale variables affecting the prevalence of diabetes among women in their late reproductive ages? How does obesity contribute to the occurrence of diabetes? And, what is the nature of spatial clustering and dispersion in ecology and appearance of obesity and diabetes among women in India? Given these research questions, the primary objective of this paper is to study the factors correlated and spatial heterogeneity in the prevalence of diabetes among women age 35-49 years across 640 districts in India.

METHODS

Data Source

The data is utilized from the fourth wave of the National Family Health Survey (NFHS)-4 in India, which is a cross-sectional survey conducted during 2015-2016. NFHS is conducted under the stewardship of the Ministry of Health and Family Welfare (MoHFW), Government of India. The survey provides 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 total of 601,509 households and 699,686 women aged between 15-49 years (International Institute for Population Sciences, 2017). It is for the first time that NFHS has measured population-based blood glucose levels among all the interviewed women aged 15-49 years and men aged 15-54 years. The information on the emerging health issues including the prevalence of diabetes for each of 640 districts in the country is available in the public domain (International Institute for Population Sciences, 2017). However, this secondary source of data does not provide any identifiable information about the respondents involved. Therefore, information regarding the patient and public involvement is not included in the article. Other relevant information regarding the study design and response rates in the NFHS-4 can be seen in Appendix 1 (International Institute for Population Sciences, 2017).

The diabetes prevalence among 235,056 women aged 35-49 years has been analysed by studying selected 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 (CEB), Current Pregnancy Status, Obesity, and Hypertension. Obesity and hypertension were used as predictors of diabetes, and were 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 higher than or equal to 30 kg/m^2 [(International Institute for Population Sciences, 2017)]. Also, the respondent was considered as hypertensive if the systolic blood pressure (SBP) was ≥140 mmHg and diastolic blood pressure (DPB) was ≥90 mmHg [(International Institute for Population Sciences, 2017)]. Furthermore, data on fasting blood sugar was not collected during the survey, and therefore, a respondent was considered as diabetic if the random blood sugar (RBS) level was ≥140 mg/dl [(International Institute for Population Sciences, 2017)]. It is worth mentioning, that all the aforementioned cut-offs, have been derived from the accepted ranges utilized by the National Family Health Survey [10].

Statistical analysis

As the study aims to explore the levels, inequalities, and spatial differentials of diabetes among women in age-group of 35-49 years in India. The entire analysis was therefore, divided into two sets of statistical methods.

In the first set of statistical tools, the age-adjusted prevalence of diabetes among selected women has been calculated. Additionally, in order to explore economic inequality in the prevalence of diabetes the poor-rich ratio (PRR) and Wagstaff's concentration index have been utilized and finally, Propensity Score Matching (PSM) using the nearest neighbourhood and counterfactual methods have been used for identifying the contribution of obesity in addressing the prevalence of diabetes among women aged 35-49 years. The Propensity Score Matching (PSM) is an effective statistical tool to analyse the effect of treatment variables in a cross-sectional data when randomized control trials are not available**.** As the objective is to make the comparison in the prevalence of diabetes among those who are obese with those who are not obese, it would have been ideal to compare these two groups when the variable understudy is randomly distributed in the population, and the selection process would have been independent of the diabetes prevalence. However, in any multistage large-scale surveys with various layers of objectives, assignment of subjects to the treatment and control groups is not random, and those included in the treatment group may be different than those included in the control groups in a systematic manner. Prevalence of diabetes among those who are obese may be significantly affected by a large number of biological and behavioural characteristics included in the age-adjusted prevalence of diabetes presented in the earlier section. Under these circumstances, the estimated effects of obesity on diabetes may be biased due to the number of confounding factors, and hence propensity score matching (PSM) provides the best solution to derive unbiased estimate of contribution of treatment in the outcome variable by comparing results of exposed (obese) and unexposed (non-obese) individuals with similar observed characteristics.

Based on the available literature on factors affecting diabetes among women, some predictors relating to biological and behavioural characteristics were included in the matching process. This was done because inclusion of a large number of predictors in the matching ensures a better chance that the propensity score matching assumptions holds true [11,12]. The details of the Propensity Score Matching utilized in the paper can be seen in Appendix 2 [12].

In the second approach, to carry out the sub-national level analysis, districts have been chosen as the unit of analysis. Data from all the 640 districts in India has been derived using standard scientific study design. Initially, Arc-GIS was used to generate the shape files and descriptive/quantile map of diabetes prevalence across 640 districts of India. These shape files were then exported to GeoDa, for conducting the exploratory spatial analysis. In the first place, spatial weight, i.e. Queen's contiguity weight matrix was generated which are essential for the computation of spatial autocorrelation indices. Queen's contiguity matrix, is a method of calculating weights based on contiguity from polygon boundary file. It was selected to explore the existence of interdependence between diabetes prevalence and the selected set of predictors in the neighbouring districts. Appropriate measures like, Moran's I indices and bi-variate LISA, and geo-spatial regression techniques have been used to examine the spatial dependence [13, 14]. A detailed description of the geo-spatial techniques utilized in the paper can be seen in Appendix 3 [13].

The entire analysis was completed using STATA Version 15.0 (StataCorp, Texas), Arc-GIS version 10.1, (Esri, California), and Geo-Da version 1.12.1.129, (Teknowledgist, New York).

Results

The present study on the spatial variation in the prevalence of diabetes among women in their late reproductive ages (35-49 years) is based on a nationally represented sample of 235,056 women from all 36 States/UT covering all the 640 districts of India.

The burden of Diabetes by Selected Background Characteristics

The burden of Diabetes by selected background characteristics is presented in table 1**.** To calculate the burden of diabetes among women in their late reproductive ages (35-49 years) unstandardized and age-standardized prevalence of diabetes was calculated, where the standardization of age was done using the weights generated from the Census of India, 2011.

The results suggest that the age-adjusted prevalence of diabetes among women aged 35-49 years in India was about 10.7 percent, which was higher from the unadjusted prevalence of 10.5 percent. The prevalence of diabetes was 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)], and those with ten or more years of schooling [PR=13.20 (13.11-13.30)] than their respective counterparts. 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 among women with two or fewer CEB [PR=11.89 (11.82-11.95)]. Women in their late reproductive ages who were obese were more likely to be diabetic than those who were non-obese [PR=20.84 (20.68-21.00)]. Also, the prevalence of diabetes was higher among women with hypertension [PR=18.89 (18.71-19.08)].

Table 1. Unstandardized and age-standardized prevalence of diabetes along with 95% C.I. among women in their late reproductive ages (35-49 years) in India, 2015-16

Covariates	Unstandardized prevalence	Age-standardized prevalence
Age (in years)		
35-39	7.76 [7.70-7.81]	
40-44	10.54 [10.47-10.61]	
45-49	13.75 [13.67-13.83]	
Place of Residence		
Rural	9.16 [9.11-9.20]	9.28 [9.24-9.33]
Urban	12.88 [12.81-12.95]	13.15 [13.08- 13.22]
Caste		
Socially Deprived	9.48 [9.41-9.55]	9.62 [9.55- 9.69]
Socially Non-Deprived	10.81 [10.76-10.86]	10.99 [10.94-11.04]
Religion		
Hindu	10.26 [10.22-10.31]	10.42 [10.38-10.46]
Non-Hindu	11.48 [11.39-11.58]	11.75 [11.65-11.85]
Years of Schooling		
0-9	10.03 [9.98-10.07]	10.08 [10.04-10.12]
10 or more	12.23 [12.13-12.32]	13.20 [13.11-13.30]

Wealth Index		
Poorest	6.85 [6.77-6.93]	7.01 [6.93-7.09]
Poorer	8.44 [8.35-8.52]	8.59 [8.51-8.68]
Middle	9.86 [9.77- 9.94]	9.97 [9.88- 10.05]
Richer	12.78 [12.69-12.87]	12.95 [12.86-13.05]
Richest	13.34 [13.25-13.44]	13.46 [13.37- 13.55]
Number of children ever born		
At most 2	11.35 [11.29-11.41]	11.89 [11.82-11.95]
More than 2	9.83 [9.78-9.88]	9.79 [9.74-9.84]
Current Pregnancy Status		
Yes	4.31 [3.95-4.71]	4.66 [4.07-5.33]
No	10.51 [10.47-10.55]	10.67 [10.63-10.71]
Obesity		
Yes	20.89 [20.73-21.05]	20.84 [20.68-21.00]
No	9.30 [9.27-9.35]	9.47 [9.43-9.51]
Hypertension		
Yes	19.64 [19.46-19.83]	18.89 [18.71-19.08]
No	9.10 [9.06-9.14]	9.34 [9.30-9.39]
Total	10.48 [10.44-10.52]	10.65 [10.62-10.69]

Age-adjusted prevalence of diabetes across different States/UTs is presented in Figure 1. Results portray that all the Southern states, along with Odisha, and West Bengal have substantially higher prevalence of diabetes. On the other hand, Haryana, Bihar, Assam, Meghalaya, Punjab, Gujarat, and Maharashtra states had a lower age-adjusted prevalence of diabetes than the national average.

[**Figure 1.** Age-adjusted prevalence of diabetes among women in their late reproductive ages (35-49 years) across different States/UT in India, 2015-16.]

Inequalities in the Diabetes Burden

In order to identify the inequalities in the burden of diabetes, two indicators, namely, poor-rich-ratio (PRR) and Wagstaff's concentration index have been utilized to draw inferences from the data. It is apparent from the results in table 2a that there is a massive gap in the prevalence of diabetes across poor and non-poor with a relatively larger concentration among non-poor, which holds even across different categories of the place of residence, educational attainment of women and various regions in the country. However, the disparity in the prevalence of diabetes is the highest in the Eastern and Southern region of the country and also among the women who have not completed ten years of schooling. These findings are also affirmed with the concentration index concerning the place of residence, years of education and region of residence. The results depict that in all sub-groups of the selected predictors a positive value of concentration index exists, which means that the prevalence of diabetes is higher for the women belonging to well-off households in all the selected sub-groups. However, the value to concentration Index was found to be higher among women from Southern and Eastern regions.

Table 2a. Poor Rich Ratio and Concentration Index in prevalence of diabetes among women in late reproductive ages (35-49 years) in India, 2015-16

Variable	Prevalence of diabetes			Concentration Index (CI)	SE (CI)
	Poor	Rich	Poor/Rich Ratio		
Residence				0.1343***	0.004
Urban	10.05	13.08	0.77	0.0509***	0.005
Rural	8.05	11.61	0.69	0.1179***	0.005
Years of Schooling				0.1343***	0.004
0-9 Years	8.24	12.79	0.64	0.144***	0.004
10 or more years	9.22	11.90	0.77	0.043***	0.007
Region				0.1343***	0.004
Northern	6.69	10.15	0.66	0.1118***	0.009
North-eastern	9.30	12.90	0.72	0.1400***	0.009
Central	7.84	12.11	0.65	0.1296***	0.007
Eastern	8.42	13.55	0.62	0.1594***	0.008
Western	7.77	11.36	0.68	0.1157***	0.012
Southern	9.76	15.65	0.62	0.1304***	0.008

*p<0.05, **p<0.01, ***p<0.001

Contribution of Obesity in the Prevalence of Diabetes among Women

The variables which affect obesity as well as diabetes, but are not influenced by the prevalence of diabetes have been included in the model and results are presented in table 2b. A comparison of the prevalence of diabetes among women who are obese and non-obese shows that the likelihood of developing diabetes was higher amongst the women who have obesity. For instance, before matching, the prevalence of Diabetes among women aged 35-49 years and had obesity was 20 percent, and for the non-obese group of women, it was 9 percent only. After using the PSM with the counter-factual approach, there is a significant reduction in the estimated prevalence of diabetes as the average treatment effect among those who were treated, i.e., ATT= 20 percent reduced to 14 percent, if they would not have been obese. Similarly, the average treatment effect among untreated (ATU) portrays that the prevalence of diabetes among those who were non-obese would have been increased from 9 percent to 22 percent if they would have been obese. The average treatment effect (ATE) shows the difference in the prevalence of diabetes among obese and non-obese women in their late reproductive ages after matching using the nearest neighbourhood method, is 13 percent.

Table 2b. Estimated effect of Obesity on Prevalence of Diabetes among women in their late reproductive ages (35-49 years) in India using Propensity Score Matching Approach, NFHS-4, 2015-16

Sample	Obese	Non-Obese	Difference	S.E.	T-Statistics
Unmatched	0.20	0.09	0.12	0.002	48.59
ATT	0.20	0.07	0.14	0.052	2.60
ATU	0.09	0.22	0.13		
ATE			0.13		

Spatial Variation in the prevalence of Diabetes

The spatial heterogeneity in the prevalence of diabetes among women in their late reproductive ages has dual evidence from quintile map as well as univariate LISA map, presented in Figure 2. It is evident from the quintile map that 254 districts in the country have a very high level of diabetes prevalence (greater than 10.7%) among women in their late reproductive ages. Another 130 districts have a moderately high prevalence of diabetes ranging from 8.7 to 10.6 percent. Most of these districts are located in the Southern and Eastern parts of the country. Findings suggest striking geographic clustering (Moran's I=0.42, p-va;ue=0.001) of higher diabetes prevalence 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.

[Figure 2. Quintile map and univariate LISA (cluster and significance) maps depicting spatial clustering and spatial outliers of diabetes across 640 districts of India, 2015-16.**]**

Bivariate LISA Results

Bivariate LISA examines the spatial relationship between the exposure and the outcome variable for the 640 districts of the country. The LISA results addressed a pertinent question- whether the geographic regions which were privileged had a higher prevalence of diabetes?

Six maps presented in Figure 3 portrays a significant spatial auto-correlation between diabetes prevalence and selected characteristics of women's background. Findings portray a significant spatial auto-correlation between diabetes prevalence and women's residing in urban areas with hotspots in 33 districts. Similarly, a total of 91 districts have emerged as the hotspots for diabetes where women had two or less CEB. Most of these districts are located in the Southern part of the country baring a few that are located in Maharashtra, Karnataka, and Odisha. Other prominent markers of higher spatial auto-correlation with the prevalence of diabetes among women are obesity (73 districts), and those belonged to rich wealth quintile (66 districts).

[Figure 3. Bivariate LISA Cluster maps depicting spatial clustering and spatial outliers of Diabetes Prevalence among women aged 35- 49 years by selected background characteristics across 640 districts of India, 2015-16.**]**

Further, the values of Moran's-I results presented in **table 3** provide quantitative evidence that the districts that had a higher proportion of urban areas were more likely to record higher prevalence rates of diabetes. However, the value of bivariate Moran's I is highest with respect to the proportion of women aged 35-49 years having two or less CEB (Moran's I =0.38, p< 0.001), having obesity (Moran's I= 0.27, p<0.001), coming from economically better-off households (Moran's I=0.22, p<0.001), living in urban areas (Moran's I =0.19, p<0.001) and had hypertension (Moran's I =0.14, p<0.001).

Table 3. Bivariate Moran's I statistics for diabetes prevalence by selected background characteristic in India, 2015-16.

Variables	Moran's I	P<0.05	P<0.01	P<0.001
Urban	0.19***	88	48	27
Non-SC/ST	0.02	96	58	39
Non-Hindu	0.14	110	79	74
Ten years of schooling or more	0.07***	87	79	42

Women having two or less CEB	0.38***	80	77	113
Obesity women	0.27***	140	85	46
Rich	0.22***	106	84	80
Hypertension	0.14***	81	64	48

*p<0.05, **p<0.01, ***p<0.001

Spatial Correlates of diabetes burden

Results of the spatial-error model on spatial dependence of diabetes on proximate determinants and other meso-variables are presented in **table 4**. The auto-regressive coefficient (lamda) is 0.51, indicating a significantly higher spatial clustering in the diabetes prevalence which is accounted for the geographical pattern of measured and unmeasured independent variables. The findings portray that in the prevalence of diabetes among women aged 35-49 years in India is significantly affected by space. Being Obese (BMI>=30 kg/m^2), hypertensive, and having two or less number of children ever born (CEB) were the key predictors significantly explaining the spatial dependence in the prevalence of diabetes among women age 35-49 years in India. It is worth emphasizing that the 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 aged 35-49 years in the country.

Table 4. OLS, Spatial Error and Spatial Lag model to assess the association between Diabetes and selected background variables among women aged 35-49 years, India, 2015-16

Variable	Spatial OLS Model	LM Spatial error
Urban	0.029***	0.019*
Non-SC/ST	0.008***	0.009
Non-Hindu	0.007	0.013
Ten or more years of schooling	0.026	0.012
Women with CEB less than two	0.056***	0.034**
Obesity	0.238***	0.221***
Rich	-0.044***	-0.014
Hypertension	0.115***	0.106***
Constant	4.441***	4.759***
Number of Observations	640	640
Log likelihood	-1606.030	-1507.03***
AIC	3230.070	3129.470
R square	0.330	0.460
Lag Coefficient(Lambda)		0.509***

Breusch-Pagen test	40.737***	62.581***
Likelihood ratio test		100.603***

*p<0.05, **p<0.01, ***p<0.001

Discussion

In the existing epidemiological transition in India, especially after the economic liberalization in the early 1990's, the burden of NCDs with the dominance of diabetes has been projected to be doubled by 2030 [15]. Development-oriented changes in the lifestyle of people, increasing urbanization, economic prosperity and dietary practices have been considered as the major correlates of the increasing prevalence of diabetes. However, the pattern of development and lifestyle changes have not been uniform across the country and vary to a large extent by caste, class, and social groups and resulting in differential prevalence in obesity, hypertension and other risk factors for diabetes [(Singh et al., 2018)].

Therefore, an attempt has been made in this study to analyse the burden, and inequality in the prevalence of diabetes which is systematically higher in specific sub-populations. This issue is vital, as the diabetes control in any population has a dual challenge of reducing the levels as well as inequalities across different sub-population. Monitoring and tackling disparities in diabetes and increased risks of associated complications like cardiovascular disease, stroke, kidney failure, etc., between socio-economic groups within countries has become an increasingly important objective for health interventions.

Additionally, the analysis in this paper has been organized to focus on the correlates and spatial heterogeneity in the prevalence of diabetes among women aged 35-49 years across 640 districts in India using a nationally representative sample of 235,056 women from all 36 States/Union Territories (UT). Socio-economic and cultural heterogeneity in different regions of the country is expected to result in differential lifestyle, which works as a catalyst in intensifying the pace of epidemiological transition with the ongoing age-structural transition.

Results portray that the prevalence of diabetes among women in their late reproductive ages was highest among those with two or fewer children ever born, who are more likely to be educated, belonging to economically prosperous households, living in urban areas and hence enjoying changing lifestyle with modernization, increased access to high energy (refined and processed) food and development. Findings clearly portray a higher prevalence of diabetes among urban women in India, who are one and a half times more likely to suffer from diabetes than their rural counterparts. These results are similar to the findings of Deshpande et al. (2008) and Ramachandran et al. (2012) based on data from South Asian countries that have pointed the increased diabetes risk was related with age, ethnicity, physical inactivity, obesity, and family history of diabetes [(Deshpande, Harris-Hayes, & Schootman, 2008)17]. The urban-rural divide in the prevalence of diabetes is narrowing as urbanization is spreading widely, and is adversely affecting the lifestyle of populations [18].

Women in their late reproductive ages who were obese were more likely to be diabetic than those who were non-obese. Application of PSM with a non-randomized community-based cross-sectional data brings out a statistically significant contribution of obesity in the prevalence of diabetes. This may be primarily because increasing obesity creates metabolic disturbances associated with insulin resistance which occurs when beta cells of the pancreas do not produce and utilize sufficient insulin, a similar finding of Park et al., 1995 on their study in South Korea. Keen et al., 1979 identified obesity as a primary risk factor for diabetes about four decades back and highlighted that among obese women, even moderate changes in pre-pregnancy weight could affect the risk of gestational diabetes. Therefore, all the programmes and services to address NCDs among women in their reproductive ages should prioritize addressing overweight and obesity among women to reduce the risk of diabetes [18]. Consistent with the theoretical premises and findings from other studies in the region [18], hypertension has been another co-morbidity of diabetes among women in India as the prevalence of diabetes was higher among women with hypertension. Imam and Hossain (2012) also observed that diabetes is more common among those persons who have sedentary lifestlye i.e. are mostly physically inactive, having high blood pressure and excess body weight. This complete picture is prominent in the urban areas compared to the rural areas [19].

Findings of this study portray relatively larger concentration of diabetes among women in the Southern and Eastern parts of the country, which are traditionally and culturally known as rice eating areas [20, 21(“Harvard Study: Eating White Rice Increases Risk Of Type 2 Diabetes | Asian Scientist Magazine | Science, technology and medical news updates from Asia,” 2012). The clustering in diabetes prevalence is also affirmed with significantly higher values of Moran’s I and auto-regressive coefficient accounting for the geographical pattern of measured and unmeasured independent variables. The findings portray that in the prevalence of diabetes among women aged 35-49 years in India, is significantly affected by space. Being Obese (BMI>=30 kg/m^2), hypertensive, and having two or less number of children ever born (CEB) were the key predictors significantly explaining the spatial dependence in the prevalence of diabetes among women aged 35-49 years in India. Among all the predictors included in the spatial model the chance of suffering from diabetes is increasing with the highest pace with increasing obesity and hence creates an startling situation.

Conclusions

These findings indicate that increasing obesity among women aged 35-49 years needs to be prioritized as part of promoting healthy lifestyle through physical exercise and a salubrious dietary practices. As a larger share of diabetes in India consists of Type-2 diabetes, which can be prevented or delayed through lifestyle interventions. Many international randomized controlled trials have confirmed that we can stop the progression from pre-diabetes to type-2 diabetes by using planned lifestyle behaviour change programs [24]. Therefore, programmes and interventions to lower the intensity of community-based prevalence of diabetes, especially among women in their late reproductive ages, should adopt differential approach across different states/ districts in the context their lifestyle, dietary pattern, working pattern and other socio-cultural practices keeping levels of obesity in the central place.

List of abbreviations

BMI: Body Mass Index

DBP: Diastolic Blood Pressure

NCD: Non-Communicable Diseases

NFHS: National Family Health Survey

PSM: Propensity Score Matching

SBP: Systolic Blood Pressure

Declarations

Ethics approval and consent to participate

The secondary data used for the study does not contain any identifiable information on the study subjects. Thus, no ethical approval was required.

Consent for publication

Not applicable

Availability of data and material

The data utilized for the study is taken from a secondary source of data, which is freely available online. In order to obtain the data, following link can be used https://www.dhsprogram.com/data/available-datasets.cfm.

Competing Interests

Authors declare no competing interest.

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Authors' Contributors

SKS conceived the idea and conceptualized the research problem, SKS and PP contributed to the statistical analysis, interpretation of the results, drafting and editing of the final manuscript. All the authors read and approved the final manuscript. Additionally, all the authors have reviewed, discussed, and agreed to their individual contributions.

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