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Sociodemographic Determinants Influencing Diabetes in Eight EAG States of India

Adity Kumari[1], Dr. Sheela Misra[2]

[1]Research Scholar, Department of Statistics, University of Lucknow, Lucknow, India.
[2]Professor, Department of Statistics, University of Lucknow, Lucknow, India.

Corresponding Author: Adity Kumari

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ABSTRACT

***Introduction*:** In India Diabetes has been on the rise over the past few decades. India is one of the top nations having the greatest percentage of adult diabetics as of 2022. Men and women are affected differently by different lifestyle diseases hence separate measurements should be used to analyse their prevalence. Diabetes is measured by the glucose level in the blood. The objective of the current study is to determine the socio-demographic and health factors that are associated with Diabetes among women of reproductive age in the eight Empowered Action Group (EAG) states of India.
***Methods*:** The prevalence of Diabetes in different EAG states was determined using the NFHS-5 dataset, where glucose level was used as a measure of diabetes. Multivariable logistic regression was then employed to find the different sociodemographic and health indicators with Glucose level as a dependent variable among the non-pregnant women of reproductive age (15 – 49).
***Results*:** The association of diabetes in women was stronger for older age group, poor women of rural areas. Smoking is also a significant factor. The risk of diabetes also increases for those women who were overweight, anaemic, had thyroid, high waist-to-hip ratio and high blood pressure. Those women who had high frequency of healthy food intake are also at risk.
***Conclusion*:** The findings reveal that the design for targeted intervention from the eight EAG State Government and other stakeholders is required for rural women of higher age groups. The detailed state-level association will enable them to create evidence-based interventions to successfully stop the progression of diabetes and manage their complications.

Keywords: Glucose Level, NFHS-5, EAG States, Reproductive Age, Lifestyle diseases, Logistic regression.

INTRODUCTION

The International Diabetes Federation (IDF) estimates that 537 million persons in the 20–79 age range will have diabetes in 2021, and if current trends continue, this figure could increase to 784 million by 2045 (1). India's diabetes epidemic is a reflection of the worldwide trend, with a substantial and rising toll. Over the past few decades, diabetes cases have sharply increased in India; the primary causes of this increase include changes in dietary patterns, a rise in sedentary lifestyles, and fast urbanization. India is one of the top nations having the greatest percentage of adult diabetics as of 2022. From 2000 to 2019, there was a 3 percent increase in diabetes mortality rates by age. In 2019, diabetes and kidney disease caused an estimated two million deaths (2). Addressing this expanding epidemic requires an understanding of the different forms of diabetes, its risk factors, complications, and the changing landscape of treatment and management approaches. Furthermore, investigating how gender, socioeconomic position, and other

demographic variables intersect with diabetes epidemiology offers important new insights for developing customized interventions and delivering healthcare in an equitable manner (3). It should be highlighted that women and men are impacted differently by non-communicable diseases, even though they affect people of all races, ages, genders, and income levels. The frequency of non-communicable diseases (NCDs) and health status varied significantly between men and women, according to research from several different nations. The variations can be linked to the varying exposure levels and susceptibilities of men and women to noncommunicable diseases (4) (5). If we talk specifically about women, in Southeast Asia, about 9% of women are diabetic. Globally, diabetes is the 9th leading cause of death among women. It is responsible for the death of 2.1 million women and about 1.8 million men every year in South Asia (6). National Family Health Survey, NFHS-4 (2015-2016) in India reveals that 42 percent of individuals with diabetes are unaware of their status, with nearly 45% having access to healthcare and geographic discrepancies across the states of India were evident (7). Diabetes raises the chance of dying from coronary heart disease (CHD) (8). It is also one of the main reasons for blindness (9). Women with diabetes have a 50% higher chance of dying from CHD than men. Women with diabetes have an increased incidence of blindness (10) (11). Due to complications associated with diabetes, hospitalization rates are also greater among female diabetics. In addition, they do not have access to health care, and experience prejudice due to their social standing (12) (13). Women of reproductive age (15 – 49), are affected by Type-2 Diabetes Mellitus (T2DM) uniquely. If a woman has T2DM and becomes pregnant, her unborn child is at high risk of developing T2DM in adulthood, thereby accelerating the inter-generational risk of T2DM (14). Interventions to prevent and control T2DM in this group are further warranted given the important contribution women make to the social and economic development of nations, the health and well-being of their children and families (15).

The study focuses on the growing prevalence of diabetes among women of reproductive age (15 – 49) in eight Empowered Action Group (EAG) States. EAG states are eight socio-economically backward states of India, namely, Uttarakhand, Rajasthan, Uttar Pradesh, Bihar, Jharkhand, Odisha, Chhattisgarh, and Madhya Pradesh, which have lagged in containing population growth to manageable levels (16). The primary objective of this study is to analyse the role of socio-economic factors, dietary patterns, lifestyle, and biological conditions (blood pressure, anaemia, and body mass index) in the incidence of diabetes among women. To estimate the associated risk factors of diabetes among women of reproductive age, data from National Family Health Survey (NFHS-5) was analysed since it collected information on different diseases across these states.

MATERIALS AND METHODS

Data source

The study used data from the fifth round of the National Family Health Survey (NFHS), which was conducted in 2019–21. NFHS-5 gathered information from 636,699 households, 724,115 women, and 101,839 men. And, for the first time, the data on Biomarkers was collected, in which blood samples were taken from the selected households and then different health indicators were measured which included measurement of waist and hip circumferences, the measurement of blood pressure, and blood glucose. The study is based on secondary data available in the public domain with no identifiable information on the participants and can be freely accessed from the Demographic and Health Surveys (DHS) program website. The survey was conducted by the Ministry of Health and Family Welfare, Government of India, with the International Institute for

Population Sciences (IIPS), Mumbai, India, being the nodal agency. The ethical approval of the survey was obtained from the ethics review board of the IIPS, and it was reviewed by the International Review Board. Informed written consent for participation in this survey is obtained from the respondent during the survey.

NFHS adopted a two-stage stratified random sampling approach by selecting primary sampling units (PSUs) with probability proportional to population size at the first stage and subsequently, picking the same number of households from each of the selected PSUs through systematic random sampling (villages in rural areas and census enumeration blocks in urban areas). Both male and female were recruited to interview the respondents. The women's file of NFHS-5 was analysed for the study. To examine the association between various demographic indicators and the risk of diabetes, we restricted the sample to only non-pregnant women of reproductive age (15–49 years) who were living in any of the eight Empowered Action Group (EAG) states of India. This resulted in a final sample size of 301,578 participants for the analysis.

STATISTICAL ANALYSIS

Descriptive statistics were calculated for all the variables using standard methods. Multiple logistic regression analysis was used to estimate the effect of several socioeconomic, health, and dietary indicators to assess the risk of diabetes. Logistic regression is mostly used to forecast the likelihood that an input falls into a specific class. It is well suited for describing and testing hypotheses about relationships between a categorical outcome variable (Y) and one or more categorical or continuous predictor variables X_i's (17) (18). The mathematical concept that underlies logistic regression is the logit: the natural logarithm (In) of odds of Y, and odds are ratios of probabilities (π) of Y happening to probabilities $(1-\pi)$ of Y not happening. The logistic regression model can be expressed mathematically as:

$$Logit\ (Y) = \ln\left(\frac{\pi\ (X)}{1-\pi(X)}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p$$

Therefore,

$$P(Y=1|X) = \pi\ (X) = \frac{e^{\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p}}{1 + e^{\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p}}$$

Where, π is the probability of the event, β_0 is the Y intercept, $\beta_1, \beta_2, \beta_3, \ldots, \beta_p$ are p regression coefficients, X = X_1, X_2….., X_p are a set of predictors. β's are typically estimated by the maximum likelihood (ML) method, which quantifies how well the model's predicted probabilities align with the actual outcomes (19) (20).

For a sample of size n, the likelihood function for logistic regression is:

$$L(\beta_1, \beta_2, \beta_3, \ldots, \beta_p) = \prod_{i=1}^{n} P(Y_i = 1|X_i)^{Y_i} . (1 - P(Y_i = 1|X_i))^{1-Y_i}$$

Or,

$$L(\beta_1, \beta_2, \beta_3, \ldots, \beta_p) = \prod_{i=1}^{n} (\pi_i)^{y_i} . (1 - \pi_i)^{1-y_i}$$

This yields the log likelihood,

$$log(L) = \sum_{i=1}^{n} [\, y_i \log(\pi_i) + (1 - y_i) \log(1 - \pi_i)]$$

The dependent variable and Covariates for the present study are given as below:

Dependent Variable (Diabetes): Biomarkers were used to determine diabetes. The presence of diabetes in individuals was confirmed by a random blood glucose (RBG) test using the finger-stick method. An individual was considered non-diabetic if RBG < 140 mg/dL and diabetic if the RBG ≥ 140 mg/dL.

Covariates: We added several sociodemographic control variables and health variables, to mitigate the impact of confounders. Waist-to-Hip ratio (WHR) was calculated by the given waist and hip circumference and abdominal obesity was taken if WHR >0.85 for women. Anaemia and Blood pressure were used as a dichotomous variable. We used the standard Asian population cut-offs for the Body Mass Index (BMI) measure, with thresholds Underweight (≤18.4 kg/m^2), Normal (=18.5–22.9 kg/m^2), Overweight (=23.0–24.9 kg/m^2) and Obese (≥25 kg/m^2). Previous studies show that smokers are more likely to develop Type-2 diabetes, show signs of insulin resistance syndrome, and are insulin resistant (21). Conversely, moderate alcohol use may lower the chance of developing Type-2 diabetes. These findings are consistent with previous research, heavy alcohol use and binge drinking may raise the risk of Type-2 diabetes (22). Yes/no questions about the participants' current usage of cigarettes, pipes, other local tobacco smoking goods, and snuff, chew, or other smokeless tobacco products were included in our controls for drinking and smoking behaviour. We constructed a dichotomous indicator for alcohol use in the present analysis. Frequency of eating healthy food, Type of cooking fuel, Source of drinking water, Read Newspapers, Listening to Radio, and having different diseases (self-reported) are some of the other covariates used for the study.

In the logistic regression model, first, we examined the unadjusted association between different covariates and diabetes risk. Then, we adjusted the model for religion, tobacco, alcohol drinking, frequency of watching TV and reading the newspaper, and for self-reported diseases like Cancer, Hypertension, Kidney, and Heart-related. To adjust for the NFHS-5 sampling design, a sample weight was also included in the final model. Results are presented as Odds Ratios (ORs) with 95% Confidence Intervals (CI) [OR (95% CI)]. P-values < 0.05 are considered statistically significant variables and p-values> 0.05 as non–significant. The estimation of CIs takes into account design effects due to clustering at the level of the primary sampling unit. All the analyses were conducted using the SPSS statistical software package V.21 (IBM SPSS Statistics, Chicago, Illinois, USA).

RESULTS

Table 1 shows the socio-demographic characteristics of the sample for glucose levels (Normal and High). The sample consisted of 301,578 women aged 15-49 years. Most of the subjects (70.2%) were married, 29.79% were unmarried. Most of them belong to rural (77.33%) areas and 22.66% to the urban area. Results show that the majority of women were educated (70.2%) and belong to Hindu religion (87.71%). Almost half of them were poor (50.93%) on the Wealth Index and of the OBC (49.30%) category. The health status of the women was determined by the BMI, WHR, Blood Pressure (BP), Anaemia, and presence of the diseases in the women.

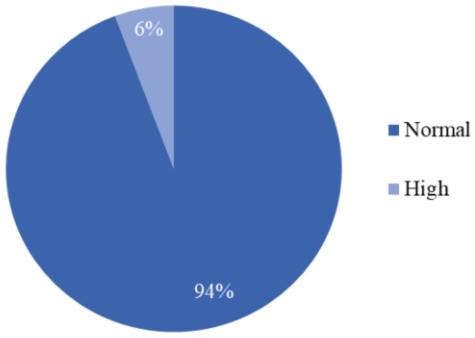
Eighty-five percent of the sample was found to have normal BP and the majority (70%) was not anaemic. More than half had normal BMI (60.7%) and 50.7% were at high risk in WHR. Only 4.3% of women smoke, 1.87% chew any kind of tobacco, and 0.6% drink alcohol. Safe cooking fuel LPG was used by 39.77% of women, 57.12% were using Tubewell as the source of water, 1.29 % had self-reported diabetes, and most of them were covered under any kind of Health insurance (71.22%).

Table 1: Socio-demographic profile of Women (15 – 49) in EAG states for Glucose Level data from NFHS-5 (2019-20)

Individual Variables	Categories	Glucose Level		Total
		Normal (<140 mg/dL)	High (≥140 mg/dL)	
		n (%)	n (%)	(N)
Age	15 – 19	59137 (97.8)	1358 (2.2)	60495
	20 – 29	94763 (96.5)	3450 (3.5)	98213
	30 – 39	73292 (93)	5488 (7)	78780
	40 – 49	56235 (87.7)	7855 (12.3)	64090
Marital Status	Not in Union	88568 (96.8)	2969 (3.2)	91537
	Married	194860 (92.8)	15181 (7.2)	210041
Education	No Education	82885 (92.2)	6974 (7.8)	89859
	Educated	200542 (94.7)	11176 (5.3)	211718
Religion	Hindu	248564 (94)	15957 (6)	264521
	Muslim	30419 (94.1)	1915 (5.9)	32334
	Others	4444 (94.1)	278 (5.9)	4722
Place of Residence	Urban	63855 (93.4)	4488 (6.6)	68343
	Rural	219572 (94.1)	13663 (5.9)	233235
Caste/ Tribe	Scheduled caste	62137 (94.4)	3700 (5.6)	65837
	Scheduled tribe	29818 (95)	1554 (5)	31372
	Other backward class	139700 (94)	8982 (6)	148682
	None of them	51773 (93)	3915 (7)	55688
Wealth Index	Poor	144915 (94.3)	8680 (5.7)	153595
	Middle	53167 (93.9)	3441 (6.1)	56608
	Rich	85346 (93.4)	6029 (6.6)	91375
EAG States	Uttarakhand	4955 (93.8)	326 (6.2)	5282
	Rajasthan	39731 (96.5)	1453 (3.5)	41184
	Uttar Pradesh	100897 (94.2)	6209 (5.8)	107107
	Bihar	51118 (92.3)	4269 (7.7)	55387
	Jharkhand	15887 (94)	1008 (6)	16896
	Odisha	20590 (91.1)	2016 (8.9)	22607
	Chhattisgarh	15149 (94.7)	848 (5.3)	15997
	Madhya Pradesh	35100 (94.6)	2020 (5.4)	37119
BMI	Under-Weight	62046 (96.3)	2375 (3.7)	64421
	Normal	174010 (95.1)	9061 (4.9)	183071
	Over Weight	46650 (87.5)	6663 (12.5)	53313
Waist-to-Hip Ratio	Normal	141700 (95.3)	6923 (4.7)	148624
	High Risk	141687 (92.7)	11219 (7.3)	152906
Anaemia Status	Not Anaemic	198253 (94.1)	12331 (5.9)	210584
	Anaemic	84806 (93.6)	5780 (6.4)	90586
Blood Pressure Level	Normal	244572 (94.8)	13427 (5.2)	257999
	High	31757 (87.8)	4408 (12.2)	36164
Frequency of Healthy Food Intake	Low	16875 (94.4)	998 (5.6)	17873
	Normal	157256 (94.1)	9934 (5.9)	167190
	High	109294 (93.8)	7219 (6.2)	116513
Smokes	No	271479 (94.1)	17073 (5.9)	288552
	Yes	11948 (91.7)	1077 (8.3)	13026
Chew Tobacco	No	278249 (94)	17674 (6)	295923
	Yes	5179 (91.6)	477 (8.4)	5655
Drink Alcohol	No	281724 (94)	18032 (6)	299756
	Yes	1704 (93.5)	118 (6.5)	1822
Source of Water	Piped Water	85769 (94.3)	5153 (5.7)	90923
	Tubewell	161341 (93.7)	10923 (6.3)	172264
	Other	36317 (94.6)	2074 (5.4)	38391
Type of Cooking Fuel	LPG	111985 (93.4)	7970 (6.6)	119955

	Wood	117976 (94.6)	6747 (5.4)	124723
	Other	53467 (94)	3433 (6)	56900
Toilet facility	Flush Type	166597 (93.7)	11220 (6.3)	177817
	Other	46719 (94.3)	2810 (5.7)	49530
	No Facility	70111 (94.4)	4120 (5.6)	74231
Having Diabetes	No	280873 (94.4)	16788 (5.6)	297661
	Yes	2554 (65.2)	1362 (34.8)	3917
Having Respiratory Disease	No	280465 (94)	17851 (6)	298316
	Yes	2962 (90.8)	299 (9.2)	3262
Having Kidney Disease	No	282482 (94)	18074 (6)	300556
	Yes	946 (92.6)	76 (7.4)	1022
Having Heart Disease	No	281687 (94)	17936 (6)	299623
	Yes	1740 (89)	214 (11)	1955
Having Hypertension	No	271694 (94.3)	16507 (5.7)	288201
	Yes	11734 (87.7)	1643 (12.3)	13377
Having Thyroid Disease	No	279511 (94.1)	17544 (5.9)	297056
	Yes	3916 (86.6)	606 (13.4)	4522
Having Cancer	No	283094 (94)	18129 (6)	301223
	Yes	334 (94.1)	21 (5.9)	355
Health Insurance	No	201549 (93.8)	13255 (6.2)	214804
	Yes	81878 (94.4)	4896 (5.6)	86774
Read Newspaper	No	203183 (93.7)	13593 (6.3)	216776
	Yes	80245 (94.6)	4558 (5.4)	84802
Listen Radio	No	251372 (93.9)	16344 (6.1)	267716
	Yes	32056 (94.7)	1806 (5.3)	33862
Watch Television	No	102314 (94)	6567 (6)	108882
	Yes	181113 (94)	11583 (6)	192696

Fig. 1. Diabetes status among Women of EAG States



The overall prevalence of Diabetes among sampled women and states-wise prevalence is given in **Fig.1** and **Fig. 2** respectively. Ninety-four percent of women had normal glucose levels. From Fig. 2, it can be seen that Odisha (20.7%) and Bihar (18%) have a maximum percentage of diabetic women among all EAG states while Rajasthan (8.8%) has a minimum percentage.

In **Table 2**, for Binary Logistic Regression analysis, 286,266 observations were used. The likelihood ratio (Omnibus) test was statistically significant and the Hosmer & Lemeshow Test predicted that the model was good fitted. Overall correct prediction of the model is 94 percent. The final adjusted model shows that as the age of women increases the risk of diabetes increases i.e. for age group 40 – 49 (OR 3.964; 95% CI 3.663 to 4.289). Women who were married, educated, and living in rural areas had higher chances of diabetes. Overweight (OR 1.99; 95% CI 1.88 to 2.10) women had a higher prevalence of diabetes than those who were underweight and of normal weight (OR 1.04; 95% CI 0.99 to 1.09). Women who were anaemic, with high WHR and high BP had a higher prevalence

of diabetes than those who lay in the normal range. Those who reported having diabetes were 5 times more prevalent and having Thyroid also had a significant effect. Those who had any kind of health insurance, respiratory disease, and listen to the radio were at less risk. All the other covariates were not significant (p-value more than 0.05) for Diabetes.

Table 2: Logistic Regression for Women of Reproductive Age

Covariates	Categories	Weighted Model (Odds Ratio with 95% CI)	p-value
Age	15 – 19 (Ref)		< 0.0001
	20 – 29	1.384 (1.285, 1.49)	< 0.0001
	30 – 39	2.397 (2.216, 2.593)	< 0.0001
	40 – 49	3.964 (3.663, 4.289)	< 0.0001
Marital Status	Not in Union (Ref)		
	Married	1.061 (1.006, 1.118)	0.028
Education Level	No Education (Ref)		
	Educated	1.074 (1.034, 1.116)	< 0.0001
Place of Residence	Urban (Ref)		
	Rural	1.074 (1.029, 1.122)	0.001
Caste/ Tribe	Scheduled caste (Ref)		< 0.0001
	Scheduled tribe	0.918 (0.861, 0.979)	0.009
	Other backward class	1.027 (0.986, 1.071)	0.202
	None of them	1.068 (1.015, 1.123)	0.012
Wealth Index	Poor (Ref)		0.012
	Middle	0.975 (0.931, 1.02)	0.270
	Rich	0.927 (0.882, 0.975)	0.003
Body Mass Index	Under-Weight (Ref)		< 0.0001
	Normal	1.041 (0.992, 1.093)	0.106
	Over Weight	1.99 (1.883, 2.103)	< 0.0001
Waist-to-Hip Ratio	Normal (Ref)		
	High Risk	1.221 (1.182, 1.262)	< 0.0001
Anaemia	Not Anaemic (Ref)		
	Anaemic	1.199 (1.159, 1.24)	< 0.0001
Blood Pressure	Normal (Ref)		
	High	1.498 (1.44, 1.557)	< 0.0001
Frequency of Healthy Food Intake	Low (Ref)		< 0.0001
	Normal	1.131 (1.054, 1.213)	0.001
	High	1.247 (1.16, 1.341)	< 0.0001
Smokes	No (Ref)		
	Yes	1.091 (1.019, 1.168)	0.013
Source of Water	Safe (Ref)		
	Unsafe	0.944 (0.898, 0.992)	0.022
Type of Cooking Fuel	LPG (Ref)		< 0.0001
	Wood	0.948 (0.907, 0.99)	0.017
	Other	1.096 (1.043, 1.152)	< 0.0001
Having Diabetes	No (Ref)		
	Yes	5.591 (5.195, 6.018)	< 0.0001
Having Respiratory Disease	No (Ref)		
	Yes	0.829 (0.727, 0.944)	0.005
Having Thyroid Disease	No (Ref)		
	Yes	1.221 (1.111, 1.342)	< 0.0001
Health Insurance	No (Ref)		
	Yes	0.871 (0.84, 0.902)	< 0.0001
Listen Radio	No (Ref)		
	Yes	0.885 (0.84, 0.933)	< 0.0001

DISCUSSION

Compared to earlier estimates, diabetes prevalence in India is significantly greater. The country's most developed states are seeing a stabilization of the diabetes epidemic, but most other states are still seeing increases in the disease (23). There is significant country-wide variation in diabetes prevalence in India Therefore, in order to stop the fast-spreading epidemic of diabetes in India, state-specific policies and interventions are urgently needed. The eight EAG states considered in the study were already backward in most of the health indicators, hence they must need special attention for diabetes also.

In India, nearly 25 million are pre-diabetes (2) (at higher risk of developing diabetes). It

is the most prevalent among other non-communicable diseases (NCDs) and more than 50 percent of people are unaware of their diabetes status. In our study, we found that the prevalence and likelihood of suffering from diabetes increase with the increase in age of women in these EAG states. Also, the risk of diabetes is strongly associated with the anaemia status, blood pressure, BMI, and Waist-to-hip ratio of women. As previous studies show in comparison to males, females were physically more inactive (24) (25), and our study also emphasizes that overweight women should focus more on fitness to avoid the risk of diabetes. These findings are important for a country that is already tackling the burden of diabetes in the population (26). The positive association of diabetes with the education of women reveals that despite being educated women were at higher risk.

Our study also observed that rural women are more likely to suffer from diabetes than urban women. The reason could be a changed lifestyle in terms of eating habits and patterns of occupation in urban areas. The poor awareness about lifestyle diseases adds to the problem. The lack of awareness is more in rural areas. Studies have also shown that more household responsibilities and unpaid household work among women may cause feelings of conflict, contributing to high-stress level diabetes (27). For prevention of diabetes, government agencies should focus on obesity and target specific socio-economic groups in India.

Given the large health and economic costs associated with diabetes, our findings have important policy implications, since those women who do not have Health insurance were at higher risk of diabetes. As we know, over 53% of all healthcare costs in India are paid for out-of-pocket by households, and the financial burden of diabetes may have a severe negative influence on household finances (28). Hence, the government must emphasize an increase in the enrolment of women in any sort of health insurance in these EAG states.

Future research may examine the effects of overnutrition on diabetes because in our study it is revealed that the higher the intake of healthy food, more the risk of diabetes. These findings contribute to our understanding of causal associations between overnutrition and diabetes. In a country like India, where malnutrition among women is very prevalent, evidence for this result should be needed.

The lifestyle of a large section of the population has become more sedentary than before and thus the burden of metabolic diseases is growing. The planning and delivery of healthcare in these eight EAG states of India will be impacted in several ways by the findings of our study. The detailed state-level association will enable them to create evidence-based interventions to successfully stop the progression of diabetes and manage their complications. Especially, the State governments of these EAG states, who are primarily responsible for providing healthcare in their respective regions, will be benefitted more. A population-based initiative for prevention, control, and screening for diabetes has to be rolled out in these states as a part of ‘Comprehensive Primary Health Care”.

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