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Associated Risk Factors with The Prevalence of Diabetes and Prediabetes in Gopalganj District

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Abstract
People's lifestyles are changing a lot with time. Busy working life, indifference to ideal living, addiction to yummy junk food and lack of physical activity are causing many health hazards. Due to changes in lifestyle and dietary habits, the prevalence of several diseases has increased, among which diabetes can be identified as one of them. Diabetes is a chronic disease that affects people of all ages. There are several forms of diabetes. Type 2 is the most common. The number of people in Bangladesh who have type-2 diabetes has increased dramatically making it one of the country's major health problems. The rising prevalence of diabetes in Bangladesh is associated with overweight, age, family history of diabetic, physical activity, eating habit of high carbs food etc. So, we collected 320 individuals affected or take medication or checks themselves in any Diabetic Center in Gopalganj district for treatment or any suggestions. The aim of the study is to explain the status of diabetes affected peoples on average result and to find out any certain factor which relates to the disease. The variables included the age of the patient, job category, exercise time, meal plan and some other important factor that is considered to be related to diabetes. The dependent variable was chosen as the blood glucose level of the respondents. We used chi-square test and logistic regression to find any significant relation that can be described. Logistic regression analysis identified some important factors that significantly affect the blood glucose level of the respondents, namely average sleep time, rice for breakfast, diet, red meat, smoking and age.
Keywords: *Food habits, Diabetes, blood glucose level, Chi-square test, Logistic regression.*

1. Introduction

Diabetes is a chronic disease that occurs either when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces. Insulin is a hormone that regulates blood glucose. About 537 million adults

across the world have diabetes. Experts predict this number will rise to 643 million by 2030 and 783 million by 2045 (clevelandclinic.org). Prevalence has been rising more rapidly in low- and middle-income countries than in high-income countries. A healthy diet, regular physical activity, maintaining a normal body weight and avoiding tobacco use are ways to prevent or delay the onset of type 2 diabetes (WHO, 2020). A combination of treatment strategies can help manage the condition to live a healthy life and prevent complications.

Bangladesh, a country with incredible possibilities and resources, a country where every soul from their state strives to make this country better. It is a country with immense manpower. But in the last 10-12 years, the people with the workforce and their support are seriously affected by various kinds of diseases. Among them, "diabetes" is one of the first diseases. A blood sugar level less than 140 mg/dL (7.8 mmol/L) is normal. A reading of more than 200 mg/dL (11.1 mmol/L) after two hours means has diabetes. A reading between 140 and 199 mg/dL (7.8 mmol/L and 11.0 mmol/L) means has prediabetes.

Diabetes mellitus (DM), commonly known as diabetes, is a group of metabolic disorders characterized by high blood sugar levels over a long period of time. Symptoms of high blood sugar include frequent urination, increased thirst, and increased hunger. If left untreated, diabetes can cause many complications. Acute complications may include diabetic ketoacidosis, hyperosmolar, hyperglycemic states, or death. Serious long-term complications include cardiovascular disease, stroke, chronic kidney complications, leg ulcers, and vision impairment. Diabetes is caused either by the pancreas not producing enough insulin, or by body cells not responding properly to the insulin produced.

2. Objective

The objectives of this study are:

- To investigate the risk factors that are responsible for high blood glucose levels.
- To find out the association among the several factors with blood glucose level.
- To fit an appropriate model for blood glucose level among diabetic patients due to several factors.

3. Data Collection and Methodology

This was a cross sectional study where data was collected by questionnaire method. Questionnaire were designed to get information from an individual respondent's age, sex, occupation, weight, height, take drug or insulin, average exercise time, average sleeping time, types of diabetes, meal plan, smoke etc. About 320 diabetes patients were selected from the Diabetic Centre of Gopalganj from time period of May to June 2022. Data was collected by the direct interview method. Simple random sampling technique was used to select respondents. For the analysis purpose descriptive statistics, crosstabs, association measure test (chi-square test, likelihood-ratio test) and logistic regression have been conducted and for the visual presentation and better understanding of data histogram have been provided. All statistical analysis was performed using SPSS (IBM27).

3.1 Contingency Table Analysis

We represent contingency analysis, which is designed to test any association between different phenomena. In contingency studies, if 'O' denoted observed frequency and 'E' denoted expected frequency of a contingency table, then the expected frequency under any hypothesis is

$$E_{ij} = \frac{(R_i)(C_j)}{N}$$

Where,

E_{ij} = Expected frequency of the ith row and jth column.

R_i = No. of observation of the ith row the respective contingency table.

C_j = No. of data of the jth row the respective contingency table.

Null and alternative hypothesis:

H_o = There is no association between two classified variables

H_1 = There is a significant association between two classified variables

From each contingency table examine the association between variables/individuals and the different segment of the individual are made by computing Chi-square and using the test statistics is,

$$\chi^2 = \sum_{i=1}^{c}\sum_{j=1}^{c}\left(\frac{(o_{ij} - E_{ij})^2}{E_{ij}}\right)$$

Where χ^2 follows (r-1) (c-1) degrees of freedom. And O_{ij} = the observed number of observations in (ith, j th) cell.

The decision rule is if $\chi^2_{cal} > \chi^2_{tab}$ reject the null hypothesis. Where χ^2_{cal} is from the chi- squared distribution with (r-1) (c-1) degree of freedom.

Cross-tabulation and contingency analysis of different variables used in this study are given below with a related comparison table and interpretation.

3.2 Likelihood-Ratio Test

The likelihood ratio test assesses the goodness of fit of two competing statistical models, namely one found by maximizing over the entire parameter space and another found after imposing some constraint based on the ratio of their likelihoods. If the constraint (i.e., the null hypothesis) is supported by the observed data, the two likelihoods should not differ by more than the sampling error (Gary, 1989). Thus, the likelihood ratio test tests whether this ratio is significantly different from one, or equivalently, whether its natural logarithm is significantly different from zero.

Suppose that we have a statistical model with parameter space Θ. A null hypothesis is of tenstated by saying that the parameter θ is in a specified subset Θ_0 of Θ. The alternative hypothesis is thus that θ is in the complement of Θ_0, , i.e. in $\Theta \setminus \Theta_0$, which is denoted by Θ_0^c. The likelihood ratio test statistic for the null hypothesis $H_0: \theta \epsilon \Theta_0$ is given by (Koch, 1988)

$$\text{LR} = -2ln\left[\frac{sup_{\theta \epsilon \Theta_0}\mathcal{L}(\theta)}{sup_{\theta \epsilon \Theta}\mathcal{L}(\theta)}\right]$$

Where the quantity inside the brackets is called the likelihood ratio. Here, the sup notation refers to the supremum. As all likelihoods are positive, and as the constrained maximum cannot exceed the unconstrained maximum, the likelihood ratio is bounded between zero and one.

Decision rule

If *p*- value> α then fail to reject the null hypothesis at significance level α.

If *p*- value< α then reject the null hypothesis at significance level α.

4. Results and Discussion

4.1 Background Information of the Respondents

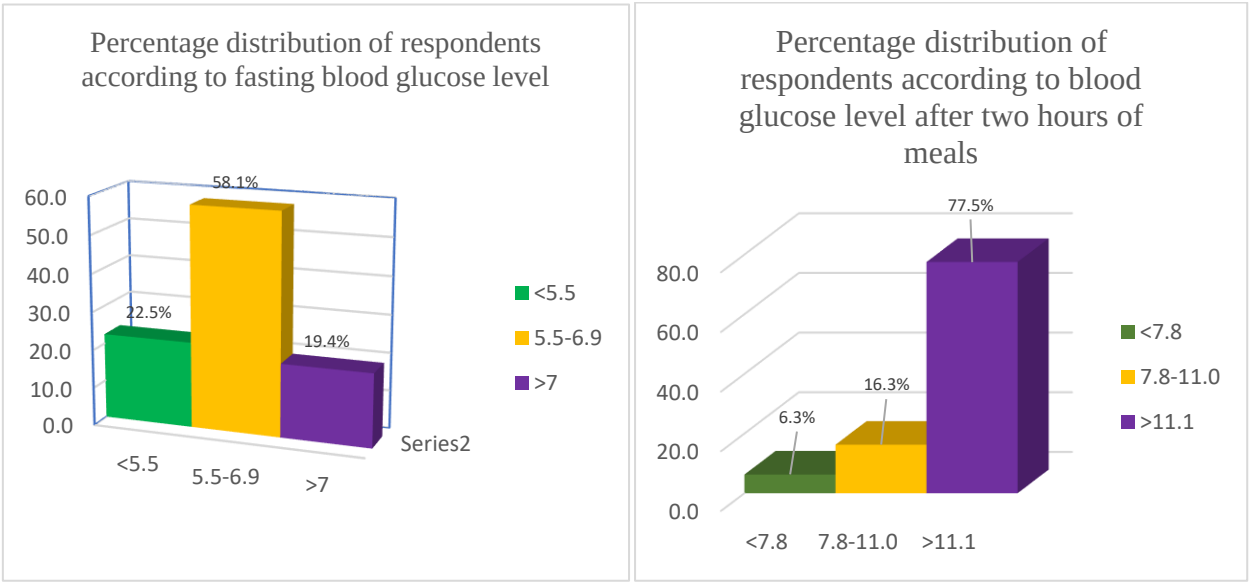
The Gender is very important demographic variables in the analysis of our study. We studied 320 respondents of whom 104 (32.5%) were females and 216 (67.5%) were males.

Table 1 Background information of the diabetic patients:

Variable	No. of respondents	Percentage
Gender		
Male	216	67.5%
Female	104	32.5%
Age		
<45	102	31.9%
45-55	82	25.7%
55-65	110	34.4%
65-75	26	8.0%
Occupation		
Teacher	55	15.3%
Farmer	16	5%
Businessman	81	23.1%
Housewife	65	18.1%
Banker	10	3.1%
Govt. job holder	38	11.9%
Private job	41	12.8%
Others	14	10.7%
Fasting blood glucose level		
<5.5	72	22.5%
5.5- 6.9	186	58.1%
≥7	62	19.4%
Blood sugar level after two hours of meals		
<7.8	20	6.3%
7.8 – 11.0	52	16.2%
≥ 11.1	248	77.5%
Types of diabetes		
Type-1	166	51.9%
Type-2	149	46.6%
Gestational	5	1.6%
TakeInsulin		
No	237	74.0%
Yes	83	26.0%
Take drugs		
No	48	15.0%
Yes	272	85.0%
Having Family history of diabetes		
No	174	54.4%
Yes	146	45.6%
Doing exercise to control diabetes		
No	62	19.4%
Yes	258	80.6%
Follow anymeal plan		
No	95	29.7%
Yes	225	70.3%

Age is a very important risk factor for attack by diabetes. It is seen from the Table 1 that about 31.9 percent of the respondents age was less than 45 years. About 26 percent of the respondents belonged to the age group (45-55) years. About 34.4 percent of them belonged to the age group (55-65) years. The average age of the respondents was 53.17 years and standard deviation was 10.39.

It is noted from the study that businessman (about 23.1%) was mostly affected by diabetes and after then housewife (about 18.1%). From the study it was showed that about 51.9 percent respondents were affected by type 1 diabetes, about 46.6 percent respondents were affected by type 2 diabetes and very few about 1.6% had gestational diabetes.



Graph 1: Histogram of percentage distribution of respondents according to blood glucose level at fasting and two hours of taking meal.

Here diabetes is tested in two ways: (i) fasting glucose test at least 8 hours after meal and (ii) blood glucose level tested two hours after breakfast. Graph1 showed that about 22.5% have fasting glucose levels below 5.5 i.e. normal and about 58.1% have fasting glucose levels between 5.5 and 6.9 mmol/L and the remaining 19.4 percent have blood glucose levels equal to or greater than 7 mmol/L, which indicates diabetes. Graph1 on blood glucose levels two hours after breakfast showed that about 6.3% of the respondents had blood glucose level below 7.8 mmol/L i.e. normal and about 16.3% of the respondents were prediabetes and about 77.5% of the respondents have blood glucose levels more than 11.1 mmol/L i.e. have diabetics. Among 320 respondents about 74.0 percent individual don't take any insulin and rest about 26.0 percent individual take insulin to control diabetes. Among them about 85 percent take drugs. It is evident from the Table that about 54.4 percent respondents who have no bloodline history and about 45.6 percent respondents have family history of diabetes. It is seen that majority of the respondents (about 80.6 %) doing exercise and about 70.3% follow meal plan to control diabetes.

4.2. Test of Association between Blood Glucose level and Some Selected Risk Factors.

Overweight, age, family history of diabetic, physical activity, eating habit of high carbs food etc. are the risk factors of having diabetic.

We tested whether there exists any association between blood glucose level and some selected risk factors. Test of association showed that there is a significant association between blood glucose level and age (LR = 150.984, $p<0.001$).

Table 2: Test of association between blood glucose level and some selected risk factors:

Variable	Subcategory	Glucose Level			χ^2 or LR	p value	Decision
		<7.8 mmol/L	7.8-11.0 mmol/L	>11.1 mmol/L			
Age (in year)	<45	20	44	38	LR= 150.984	<0.001	Significant
		100.0%	84.6%	15.3%			
	45-55	0	2	80			
		0.0%	3.8%	32.3%			
	55-65	0	2	108			
		0.0%	3.8%	43.5%			
	65-75	0	4	22			
		0.0%	7.7%	8.9%			
Gender	Male	13	36	167	χ^2 =0.131	0.937	Not Significant
		65.0%	69.2%	67.3%			
	Female	7	16	81			
		35.0%	30.8%	32.7%			
Body weight (in kg)	<50	0	4	2	LR= 68.315	<0.001	Significant
		0.0%	7.7%	0.8%			
	50-60	0	1	9			
		0.0%	1.9%	3.6%			
	60-70	20	35	83			
		100.0%	67.3%	33.5%			
	70-80	0	10	128			
		0.0%	19.2%	51.6%			
	≥ 80	0	2	26			
		0.0%	3.8%	10.5%			
Occupation	Teacher	6	6	43	LR= 46.809	<0.001	Significant
		30.0%	11.5%	17.4%			
	Farmer	0	1	15			
		0.0%	1.9%	6.0%			
	Businessman	7	12	62			
		35.0%	23.1%	25.0%			
	Housewife	7	8	50			
		35.0%	15.4%	20.2%			
	Banker	0	6	4			
		0.0%	11.5%	1.6%			
	Govt job	0	7	31			
		0.0%	13.5%	12.5%			
	Private Job	0	12	43			
		0.0%	23.1%	17.3%			
Height	$< 5'5''$	7	18	104	χ^2 = 1.208	0.547	Not Significant
		35.0%	34.6%	41.9%			
	$\geq 5'5''$	13	34	144			
		65.0%	65.4%	58.1%			

(Continued……)

Variable	Subcategory	Glucose Level			χ^2 Or LR	p value	Decision
		<7.8 mmol/L	7.8-11.0 mmol/L	>11.1 mmol/L			
Average sleep time (in hour)	4-5	0	3	103	LR= 119.855	<0.001	Significant
		0.0%	5.8%	41.5%			
	5-6	0	31	125			
		0.0%	59.6%	50.4%			
	6-7	13	15	11			
		65.0%	28.8%	4.4%			
	≥ 7	7	3	9			
		35.0%	5.8%	3.6%			
Average working time (in hour)	<3	0	3	63	LR= 67.774	<0.001	Significant
		0.0%	5.8%	25.4%			
	3-4	0	1	52			
		0.0%	1.9%	21.0%			
	4-5	7	2	35			
		35.0%	3.8%	14.1%			
	≥5	13	46	98			
		65.0%	88.5%	39.5%			
Do exercise	No	20	14	28	LR= 79.193	<0.001	Significant
		100.0%	26.9%	11.3%			
	Yes	0	38	220			
		0.0%	73.1%	88.7%			
Types of diet	No particular diet	20	41	96	LR= 59.077	<0.001	Significant
		100.0%	78.8%	38.7%			
	Exchange diet	0	9	130			
		0.0%	17.3%	52.4%			
	Avoid carbohydrate and sweet	0	2	22			
		0.0%	3.8%	8.9%			
Rice (Breakfast)	No	0	10	197	LR= 112.645	<0.001	Significant
		0.0%	19.2%	79.4%			
	Yes	20	42	51			
		100.0%	80.8%	20.6%			
Eat red meat	No	0	19	235	LR= 155.487	<0.001	Significant
		0.0%	36.5%	94.8%			
	Yes	20	33	13			
		100.0%	63.5%	5.2%			
Family history of diabetes	No	13	31	130	χ^2 = 1.868	0.393	Not Significant
		65.0%	59.6%	52.4%			
	Yes	7	21	118			
		35.0%	40.4%	47.6%			
Have smoking habit	No	7	22	213	χ^2 = 63.388	<0.001	Significant
		35.0%	42.3%	85.9%			
	Yes	13	30	35			
		65.0%	57.7%	14.1%			

The results showed a significant relationship of increasing blood glucose level with increased age. Test of association also revealed that body weight, occupation, average sleep time, average working time, physical exercise, types of diet, rice (breakfast), eat red meat and smoking habit had significant relationship with blood glucose level. Test of association did not get any significant relation of blood glucose level with respondent's gender, height and family history of diabetes.

4.3 Multivariate Analysis

In order to identify the factors, which influence on the blood glucose level of the respondents, we

used logistic regression model. The dependent variable used in the analysis is the present blood glucose level which take value 0 if blood sugar level after two hours of breakfast was less than 7.8 mmol/L and 1 otherwise. The independent variables included in the model are: age, height, weight, average working time (in hour), average sleeping time (in hour), current meal plan, rice (breakfast), bread(breakfast), bread(supper), red meat, mustard oil, smoking, having bloodline and foods with high in sugar.

Binary Logistic Regression

In a regression problem, we use binary logistic regression when the response variable is dichotomous in nature. We often observe that one or more explanatory variables could be categorical or continuous. These types of problems are generally handled by coding dichotomous variable 0 and 1 dummy variable regression.

Let us then consider logistic function is

$$Y_j = \frac{\exp\left(\beta_o + \sum_{i=1}^{n} \beta_i X_{ij}\right)}{1 + \exp\left(\beta_o + \sum_{i=1}^{n} \beta_i X_{ij}\right)}$$

$Where, i = 1, 2, 3, \ldots \ldots \ldots, n.$

$j = 1, 2, 3, \ldots \ldots \ldots, n.$

Let,

Y_{ij} = Blood glucose level (< 7.8 mmol/L =0 and≥ 7.8 mmol/L =1)

X_{ij} = Different factors.

β_j' s are regression coefficients.

Now we like to test the following hypothesis-

H_o = Covariates do not have a significant effect on blood glucose level.

H_1 = Covariates have a significant effect on blood glucose level.

Dependent Variable Encoding:

Variable	Original Value	Internal Value
Blood glucose level after two hours of breakfast	< 7.8 mmol/L	0
	≥ 7.8 mmol/L	1

Independent Variable Encoding:

Variable	Original Value	Internal Value
Height	$< 5'5''$	0
	$\geq 5'5''$	1
Weight	< 60 kg	0
	≥ 60 kg	1
Average working time (in hour)	< 5	0
	≥ 5	1
Average sleep time (in hour)	< 7	0
	≥ 7	1
Meal plan	No	0
	Yes	1
Rice(Break Fast)	No	0
	Yes	1
Bread (Break Fast)	No	0
	Yes	1
Eat red meat	No	0
	Yes	1
Have smoking habit	No	0
	Yes	1
Age (in years)	< 45	0
	≥ 45	1
Family history of diabetes	No	0
	Yes	1
Food with high carbs	No	0
	Yes	1

Table 3: Effects of selected covariates on blood glucose level of diabetic patients

Variables	*β*	S.E	Wald	*p value*	Exp(*β*)
Height(X_1)	.854	.627	1.855	.173	2.350
Weight(X_2)	-.045	.043	1.104	.293	.956
Work in hour(X_3)	-.222	.295	.565	.452	.801
Sleep in hour(X_4)	-.946	.471	4.044	**.044**	.388
Meal plan(X_5)	-1.35	.573	5.536	**.019**	.260
Rice(Break Fast)(X_6)	1.87	.654	8.190	**.004**	6.493
Bread(Break Fast)(X_7)	.785	.630	1.549	.213	2.191
Red Meat(X_8)	3.21	.708	20.48	<**.001**	24.67
Smoke(X_9)	-1.38	.601	5.242	**.022**	.252
Age(X_{10})	.774	.351	4.854	**.028**	2.168
Having bloodline(X_{11})	1.103	.580	3.618	.057	3.014
Food with high carbs (X_{12})	3.834	2.974	1.661	.197	46.225
Constant	-.447	3.824	.014	.907	.639

Binary logistic regression model having dependent variable blood glucose level of the respondents after two hours of breakfast:

$$Y=.854X_1- .045X_2- .222X_3-.946X_4-1.35X_5+ 1.87X_6+ .785X_7+ 3.21X_8- 1.38X_9+ .774X10+ 1.103X_{11}+ 3.834X_{12}$$

From the above table we get the logistic regression coefficients for different independent variables, two of which ($X_6$and X_8) are statistically significant at 1% level of significance and four of which (X_4,X_5, X_9 and X_{10})are statistically significant at 5% level of significance. The positive sign of the coefficient indicates that if the corresponding independent variable changes to 1 then the proportion on blood glucose level increases. The vice versa result is true for the negative coefficients.

The Wald criterion demonstrated that average sleeping time(in hour)(β= -0.946, *p*=0.044) and Meal plan(β=-1.35, *p*=**.019**) , Rice(Break Fast)((β=1.87, *p*=**.004**), Red Meat(β= 3.21, *p*<**.001**), Smoke (β=1.38, *p*=**.022**) and Age(β=.774, *p*=**.028**) made a significant contribution to blood glucose level, while Height, Weight, Work in hour, Bread (Break Fast), Having bloodline and Food with high carbs were not significant in influencing blood glucose level (**Table 3**). There was thus a great likelihood that a combination of the independent variables; average sleeping time, Meal plan, Rice (Break Fast), Red Meat, Smoke and Age led to influence of the respondent's blood glucose level. For example, the regression coefficient for the variable, average sleeping time (in hour)(X_4) is - 0.946, which is negatively related to the dependent variable (blood glucose level). This indicates that the blood glucose level decreases as the average sleeping time of the respondent increases. The regression coefficient for the variable, Rice(Break Fast)and Red Meat is 1.87and 3.21respectively, which is positively related with the dependent variable blood glucose level i.e. the blood glucose level increases for those respondents who had taken rice as breakfast than the respondents who had not taken rice in breakfast and the blood glucose level was increases for those respondents who had eaten red meat than those respondents who did not eat red meat.

In the current study as depicted by the model however, and contrary to the hypothesis, Food with high carbs had a positive non-significant (*p*=0.197) relationship with blood glucose level with an odds ratio of 46.225 and a log it coefficient of 3.834. The odd ratio of 1.87 is 6.493 for the variable Rice (Break Fast), means that the odds of blood glucose level of the respondents who eat rice at breakfast are 6.493 times higher for those who did not eat rice at breakfast when the other independent variables are held constant. The odd ratio of -1.35is .260for the meal plan of the respondents, means that the odds of blood

glucose level are .260 times lower for those respondents who follow a diet meal plan than the respondents who did not follow a diet meal plan.
Among the twelve variables included in the model, the Wald test results for six of these indicated that they had a statistically significant influence on blood glucose level.

Discussion and Conclusion

Diabetes or diabetes mellitus is a common-phenomenon in different ages of people. As far we can say that we do not suffer from diabetes we live with it. There are two main types, in type-1 we don't have any clues why it causes but in type-2 part of it can be lifestyle though there is a massive random element to it and some genetics too. A high blood glucose level will not kill people though a low blood glucose level can land anybody in awkward situation, by help of some others they can recover. Now insulin is only needed when blood glucose level is high. There is no specific diet for diabetic and can eat all the same things as everyone but keep in mind that they should follow a healthy balanced diet to control blood glucose level.
It is observed from the results of the study that majority of the diabetic patients (about 23.1 %) are businessman and we have found that individual age between 56-65 is mostly (about 43.5%) affected by these chronic diseases. There are about 51.9% respondents who are affected by type 1 diabetes and about 46.6% affected by type 2 diabetes. Here about 59.69% respondents didn't take insulin but taking drugs and 25.31% respondents took insulin and drugs both. The study showed that about 13.13% respondents who have diabetes but they don't follow any meal plan, and about 64.38% respondents who have diabetes and they follow meal plan. This project also provides about 45.6 percent patients have the family history of diabetes. It is noted from the results of the study that about 35.3% people like to take rice in breakfast. Logistic regression analysis result shows that age, average sleep time, meal plan, eating rice at breakfast, eating red meat and smoke have statistically significant contribution to blood glucose level of diabetes patients. We tried our best to find any predictor or anything that relates or causes diabetes. As it is a chronic disease, we couldn't point our finger directly to anything except meal plan and the food they eat. But we can observe that, people who've aged between 31 to 59 years are mostly affected by type-2 diabetes (where body is resistant to insulin). We could say that people with their earlier stressful life and who've mis-managed their daily meal has ended up with this chronic disease and living with it.

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