JOURNAL OF CRITICAL REVIEWS

ISSN- 2394-5125 VOL 8, ISSUE 02, 2021

A Logistic Regression Analysis of the Diabetes Meletus Disease Risk: A Case Study of District NausheroFeroze, Sindh, Pakistan

Ali Akbar Pirzado[1*], Muhammad Suleman Pirzado[2], Ahsan Hayat Khanzada[3], Imran Khan Jatoi[4], Iftakhar Ahmed[5], Muhammad Sikandar Arain[6]

[1]Shaheed Mohtarma Benazir Bhutto Medical University, Larkana, Pakistan
[2]Department of Pathology/Molecular Biology and Genetic Lab, Liaquat University of Medical and Health Sciences, Jamshoro, Pakistan
[3]Department of Statistics, Sindh Agriculture University, Tandojam
[4]Department of Statistics, Shaheed Benazir Bhutto University, Shaheed Benazirabad, Pakistan
[5]Department of Economics, Lasbela University of Agriculture Water and Marine Sciences, Uthal, Balochistan, Pakistan

[6]Department of Community Medicine, Peoples University of Medical and Health Sciences for Women, Shaheed Benazirbad, Pakistan

***Corresponding:** Ali Akbar Pirzado (pirzadoaa@gmail.com)

ABSTRACT

The present study was carried out to assess the performance of logistic regression model for examining risk factors associated and diabetes mellitus. Cross sectional data was obtained from male and female age (18-60) years who visited between 3 and 5 weeks, which were classified as diabetic as well as non-diabetic patients who came for their antenatal check-ups at Civil Hospital NausheroFeroze. Results obtained from univariate and multivariate model that the risk of Diabetic Mellitus among the 45+ age group is 2.90 times higher as compared to those respondents in the ≤20 age group. This risk increased to 3.32 after controlling for income, physical activity, maternal status, and body mass index (BMI). Overweight and obese respondents whose body mass index (BMI) is greater than or equal to 45 kg are at higher risk of developing diabetic mellitus especially female with an odds ratio of 4.57. Therefore, further research should focus on primary prevention by health education in primary and secondary care settings on lifestyle factors such as food intake, smoking, physical activity, reducing obesity and early detection of lipids, blood pressure as well as early screening of those who have family history of diabetes and test the effect of different educational programme in prevention of diabetes.

Key Words: Performance, Logistic Regression,Risk Factors, Diabetes Mellitus

INTRODUCTION

Worldwide, diabetes has become one of the most prevalent disease. Globally, about 422 million persons are diabetic, a wide majority is set in low-and middle-income nations, and each year about 1.6 million lives are lost which are directly associated with diabetes. Over the past few decades both cases and number and the prevalence of diabetes have steadily been growing (World Health Organization, 2020). Many risk factors associated with diabetes due to its prevalence high rate. Diabetes is rapidly becoming one of the leading health problem in the 21st century and the socially disadvantaged in any country are the most vulnerable to that illness (Sachan et al., 2018). It is a noninfectious chronic disease caused by the inability of the pancreas

to effectively produce enough insulin or when the body in unable to properly use the insulin produced by it (Abdulaziz Al Dawish et al., 2016).

The World Health Organization (WHO, 2011) gives the main types of diabetes: Type 1 diabetes is caused by an autoimmune reaction, where the body's defense system attacks the insulin-producing beta cells in the pancreas. As a result, the body can no longer produce the insulin it needs. Why this occurs is not fully understood. The disease can affect people of any age, but usually occurs in children or young adults. People with this form of diabetes need 9 insulin every day in order to control the levels of glucose in their blood. Without insulin, a person with type 1 diabetes will die. Type 2 diabetes is the most common type of diabetes. It usually occurs in adults but is increasingly seen in children and adolescents. In type 2 diabetes, the body can produce insulin but either this is not sufficient, or the body is unable to respond to its effects (also known as insulin resistance), leading to a build-up of glucose in the blood. Many people with type 2 diabetes remain unaware of their illness for a long time because symptoms may take years to appear or be recognized, during which time the body is being damaged by excess blood glucose. They are often diagnosed only when complications of diabetes have already developed.

According to (IDF, 2013) each year the number of people with diabetes increases by 7 million in the world. By 2035, about 592 million people will have diabetes; a number which was 382 million in 2013 More than 79000 children developed type 1 diabetes 4 during 2013, diabetes killed about 5.1 million adults worldwide. Diabetes leads to complications and severe disabilities, including kidney disease, blindness, heart attack, stroke and neural damage leading to amputation and the need for chronic care. The trend in 2013 revealed that there are three new cases every 10 seconds. More than 80% of spending on medical care for diabetes is in the world's richest countries, even though 80% of the people with diabetes live in low- and middle-income countries, where 76% of the burden lies. The burden of illness caused by diabetes and the reduction in life expectancy in sub Saharan Africa will hinder the region's economic growth. Diabetes caused at least 548 billion USD in health expenditure in 2013 (it means 11% of the total health spending on adults and this amount is predicted to be 627 USD in 2035. More than 21 million live births were affected by diabetes during pregnancy in 2013. According to (Shaw et al., 2010), the world prevalence of diabetes in 2010 among adults aged 2079 years was estimated at 6.4%, affecting 285 million of adults. Between 2010 and 2030, there is an expected 70% increase in the number of adults with diabetes in developing countries and a 20% increase in developed countries. Each year, more than 231,000 people in the United states and more than 3,96 million people worldwide die from diabetes and its complications and this number is expected to increase by more than 50 percent over the next decade. Estimated global healthcare expenditures to treat and prevent diabetes and its complications is at least 376 billion US Dollar (USD) in 2010. By 2030, his number is projected to exceed some 490 billion USD.

While 4.7 percent of persons above the age of 18 around the world had diabetes in 1980, that number grew to 8.5 in 2014. In 2015, an IDF report predicted that the number of diabetes affected adults worldwide will rise from 422 million in 2017 to 642 million in 2040. The report also stated that 5 million deaths were caused by diabetes in 2015, as well as that people belonging to the 40 to 59 years age bracket were the most affected by diabetes.

ISSN- 2394-5125 VOL 8, ISSUE 02, 2021

According to Pakistan's National Diabetes Survey (Basit et al., 2018), 26 percent of Pakistanis are victims of diabetes. Statistics are widely applicable in almost every walk of life. Diabetes is ranked highest among the most rapidly spreading diseases in Pakistan (Internation Diabetes Federation, 2019). The high blood sugar levels decimate the blood vessels, heart, kidneys, nerves and eyes. Diabetes mellitus is characterized into type 1 diabetes mellitus, type 2 diabetes mellitus, gestational diabetes mellitus and other uncommon kinds of diabetes mellitus. Type 1 diabetes is a perpetual disease portrayed by the body's powerlessness to create insulin because of the immune system decimation of the beta cells in the pancreas. Type 2 diabetes represents 90% of all cases and is fundamentally connected with insulin protection and consequent lipid digestion issue. Gestational diabetes mellitus (GDM) is characterized as any level of glucose prejudice with beginning or first acknowledgment amid pregnancy.

The situation is worst in Sindh. The province has a population of 50,000,000 out of which 10,300,000 people have diabetes. On World Diabetes Day, there were so many seminars organized where experts warned that diabetic pregnant women are at risk of bearing abnormal children and can even result in stillbirths. They also informed that diabetes was now the ninth highest cause of death for women in the country.

The risk factors for Type 2 diabetes are yet being investigated. Be that as it may, having a relative with type 1 diabetes somewhat expands the danger of building up the infection. Ecological components and an introduction to some popular diseases have likewise been connected to the danger of creating Type 1 diabetes. A few risk factors like family history of diabetes, overweight, unhealthy diet, physical idleness, increasing age, high cholesterol level, high blood pressure, smoking, alcohol, history of gestational diabetes, and poor nutrition during pregnancy.

The suitable regression analysis to conduct when the dependent variable is dichotomous (binary). The logistic regression is a predictive analysis like all regression analyses. Logistic regression is generally used to define data and to elucidate the association between one dependent binary variable and ordinal, interval, or ratio-level independent, one or more nominal variables.

The key restriction of linear regression is that it does not deal with dependent variables that are categorical and dichotomous (Schneider et al., 2010). Numerous fascinating variables in business and medical world are dichotomous. For instance, consumers decide to buy or not buy, a product may pass or fail quality control; there are good or poor credit risks; an employee may be promoted or not, etc. A range of regression techniques have been developed for analyzing data with categorical dependent variables. These techniques include logistic regression analysis. Logistic regression determines the impact of multiple independent variables depicted concurrently to predict membership of one or other of the two dependent variable groups. The logistic regression is the most common multivariable technique used in health science (Shipe et al., 2019).

Objectives

The specific objectives of the present study are as follows.

1. To study the current status of prevalence of diabetes
2. To identify the risk factors for diabetes using Logistic Regression Analysis

ISSN- 2394-5125 VOL 8, ISSUE 02, 2021

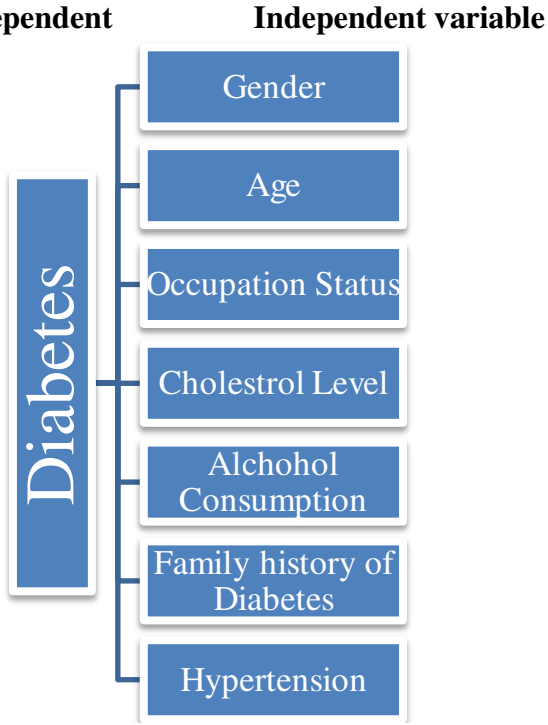
3. To evaluate the performance/strength of predictive logistic regression model

The present study is purely based on the applications of statistical model (Logistic Regression Model) in the field of medical sciences. Diabetes ranks highest among the most rapidly spreading diseases in Pakistan. Due to its high rate of prevalence, it is highly demandable to identify the risk factors associated with diabetes. The current study will contribute to respect of identification of the risk factors of diabetes using the sophisticated statistical technique such as logistic regression. The outcomes of the present study will be fruitful to create awareness among the people to keep themselves away from this disease by keeping the values of these risk factors in normal ranges.

METHODOLOGY

Conceptual framework

The following diagram illustrates the independent and depends



Target population

The target population was male and female age (18-60) years who visited between 3 and 5 weeks, which were classified as diabetic as well as non-diabetic patients who came for their antenatal check-ups at Civil Hospital NausheroFeroze.

Data collection

For data collection the study was designed hospital based for obtaining cross sectional data according to the eligibility criteria set for the study. The study was purely based on observations and quantitative. Whereas the data was only collected from one hospital. From where the necessary information was recorded on a well-structured questionnaire from the respondent. The questions were asked face to face interviews form each respondent who were visiting the hospital

for antenatal checkups. Along with respondent interviews, lab investigation reports and weight and height information were recorded by the machine present at civil hospital NausheroFeroze.

Sample Size

The estimated rate of response is 0.8 or 80%. Therefore, 86.67/0.8 =108 sample size is required. Whereas, during the study the data was collected from 200 respondents during the survey period.

Analytical process

For the analytical estimation SPSS and excel were used, where frequency distribution and descriptive statistics of socio demographic factors, family history, obstetrical history, and other variables was done.

Model description

Logistic regression is constructive for situations where the researcher wants to anticipate the presence or absence of an attribute or an effect based on values of a set of predictor variables. The basic assumptions necessary for theory testing in regression analysis are necessarily violated, especially when the dependent variable can hold just two values.

Logistic regression analysis looks like a linear regression model but is appropriate in situations where there are binary dependent variable outcomes. The probability of occurring of an effect is directly calculated by using logistic regression analysis of the next equation.

$$\left(\Pr ob\left(event\right)\right) = \frac{e^{z}}{1+e^{z}} \qquad \text{Eq. (1)}$$

Or

$$\Pr ob\left(event\right) = \frac{1}{1+e^{-z}} \qquad \text{Eq. (2)}$$

In which z is the usual linear combination, can be written as:

$$Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots\ldots + \beta_p X_p \qquad \text{Eq. (3)}$$

$\beta_0, \beta_1, \beta_2, \beta_3, \ldots\ldots\ldots, \beta_p$ are the estimated coefficients of the data, X_i are the independent variables and e is the base of the natural logarithms.

RESULTS

Table 1: Descriptive characteristic of respondents

Variables	Diabetic		Non-Diabetic		Total	
	Mean	±SD	Mean	±SD	Mean	±SD
Age in Years	46.73	4.18	45.55	4.03	45.64	4.06
Body Mass index	27.21	3.04	25.02	3.36	25.12	3.37

Table 1 shows the prevalence of Diabetic Mellitus respondents in Civil Hospital NausheroFeroze, Sindh is approximately 50%. The mean age in years of diabetic respondent was 46.73 with a standard deviation of ±4.18 and had a BMI of 27.21 with ±3.04 SD. Likewise, the mean age of non-diabetic respondent was 45.55 years with a standard deviation of ±4.0.3 and had a body mass index of 25.02 with ±3.36 SD. While the overall results indicate that the mean age of respondents (male and female) was 45.64 ± 4.06 years and an average body mass index of 25.12 ± 3.37 respectively.

Table 2: Occupation of respondent

Occupation	Diabetic		Non-Diabetic		Total
	N	%	N	%	CI
Employed (M & F)	38	19	32	16	(1.5 – 4.3)
Unemployed (M & F)	58	29	57	28.5	(0.8 – 3.1)
Students (M & F)	04	2	11	5.5	(0.03 – 1.1)
Total	100	50	100	50	

As shown in Table 2, the prevalence is higher among the unemployed male and female respondent were 29%. In relation the occurrence of diabetes mellitus among employed male and female were 19% and in the male and female student of diabetes mellitus were 2%. employed male and female with Diabetic Mellitus 95%CI (1.5-4.3). similarly, the frequency is higher among the unemployed male and female of non-diabetes mellitus respondent were 57%. In relation the occurrence of non-diabetes mellitus among employed male and female were 16% and in the male and female student of non-diabetes mellitus were 5.5%.

Table 3: Income level of respondent

Economic	Diabetic		Non-Diabetic		Total
	N	%	N	%	CI
≤ 30000	75	37.5	52	26	(1.8 – 4.8)
> 30000	25	12.5	58	29	(0.78 – 2.8)

The income level of respondent of diabetic mellitus indicated in table-3 that male and female who were earning less than or equal to Rs. 30000 had a lower prevalence 12.5% with a CI of 0.7-2.8. While the prevalence of diabetes was higher at 37.5% for male and female who were earning more than Rs.30000 with a CI of 1.8-4.8. But in the case of non-diabetic respondents a very little difference in the income level of male and female who were earning less than or equal to Rs. 30000 did not prevail diabetes were 29% while the prevalence of non-diabetes at 26% for male and female who are with earnings of more than Rs.30000.

Table 4: Educational status of respondents

Education	Diabetic		Non-Diabetic		Total
	N	%	N	%	CI
Literate	86	43	11	5.5	(2.9 – 6.4)
Illiterate	15	1.5	88	44	

As shown in the Table 4 the educational status of respondents who are literate, the prevalence of diabetic mellitus is 43% with CI of 2.9-6.4, while the educational status of respondents who are Illiterate with the prevalence of diabetic mellitus with 1.5%.And the educational status of respondents who are literate, the prevalence of non-diabetic mellitus is 5.5% with CI of 2.9-6.4,

while the educational status of respondents who are Illiterate with the prevalence of non-diabetic mellitus with 44%.

Table 5: Duration of physical activity

Physical Activity	Diabetic		Non-Diabetic		Total
	N	%	N	%	CI
≤ 5 hours	11	5.5	76	38	(1.6 – 4.6)
6 hours	17	8.5	96	48	(0.8 – 3.1)

As shown in Table 5, the duration of physical activity of diabetic mellitus male and female who do less or equal to 5 hours per day, have high prevalence of 5.5 % whereas the duration of physical activity of diabetic mellitus male and female who work for at least 6 hours have a prevalence of 8.5%.The duration of physical activity of non-diabetic mellitus male and female who do less or equal to 5 hours per day, have prevalence of 38% with CI of 1.6 - 4.6 ,whereas the duration of physical activity of non-diabetic mellitus male and female who work for at least 6 hours have a prevalence of 48% with the CI of 0.8 - 3.1 .

Table 6: Marital status

Maternal Status	Diabetic		Non-Diabetic		Total
	N	%	N	%	CI
Single	35	17.5	07	3.5	(1.3 – 3.6)
Married	125	62.5	33	16.5	(0.6 – 1.4)

Table 6 shows that the prevalence of marital status is lowest for male and female of diabetic mellitus in the single group were 17.5% and highest in the marital status of married male and female group were 62.5%. Similarly the prevalence of marital status is lowest for male and female of non-diabetic mellitus in the single group were 3.5% and highest in the marital status of married male and female of non-diabetic mellitus group were 16.5%.

Table 7: Body mass index according to age group

BMI	Diabetic		Non-Diabetic		CI
	N	%	N	%	
30 – 35	36	18	42	21	(1.1 – 3.6)
≥ 36	87	43.5	35	17.5	(0.9 – 3.3)

Table 7 shows male and female who were in the age group 36 have a prevalence of 43.5%. The estimated prevalence of diabetic mellitus for male and female with a BMI 30 - 35kg/m2 is 18% and it is quite high in male and female with BMI ≥ 36 kg/m2 (43.5%).And male and female who were in the age group 36 have a prevalence of 17.5%. The estimated prevalence of non- diabetic mellitus for male and female with a BMI 30 - 35kg/m2 is 21% and with BMI ≥ 36 kg/m2 (17.5%).

Table 8: Preference of food type

Food	Diabetic		Non-Diabetic		CI
	N	%	N	%	
Fast Food	26	13	19	9.5	(0.03 – 1.1)
Normal Food	135	67.5	20	10	(0.6 – 1.4)

Table 8 shows the prevalence of diabetes mellitus of male and female with a fast food were 13% and the prevalence of diabetic mellitus by getting normal food were 67.5% it is quite high. But in the case of non-diabetic mellitus the data show the prevalence with a fast food were 9.5% and the prevalence of non-diabetic mellitus by getting normal food were 10% it is quite low with the CI of 0.03-1.1 and 0.6-1.4 respectively.

Table 9: Status of blood pressure level

BP Level	**Diabetic**		**Non-Diabetic**		CI
	N	**%**	**N**	**%**	
Normal	33	16.5	27	13.5	(0.03 – 1.1)
High	77	38.5	18	9	(0.1 – 1.4)
Low	25	12.5	20	10	(0.6 – 6.0)

Table 9 shows the status of blood pressure level estimated prevalence of diabetes mellitus for male and female were 38.5% in high BP ,12.5% in low BP and 16.5% under normal condition. And the status of blood pressure level estimated prevalence for non-diabetes mellitus of male and female were 13.5% in high BP ,9% in low BP and 10% under normal condition.

Table 10: Diet Behavior

	Diabetic		**Non-Diabetic**		CI
	N	**%**	**N**	**%**	
Soft Drinks	135	67.5	65	32.5	(0.78 – 2.8)
Smoking	83	41.5	117	58.5	(1.8 – 4.8)
Alcohol	33	16.5	167	83.5	(1.3 – 3.6)
Sweets	77	38.5	123	61.5	(0.8 – 3.1)
Residence	87	43.5	113	56.5	(0.9 – 3.3)
Family History	26	13	174	87	(2.6 – 6.0)

Table 10 shows the estimated prevalence of diabetes mellitus for male and female with who consume soft drinks is very high 67.5%. Other factors like smoking was 41.5%, Alcohol 16.5%, Sweets 38.5%, residence at 43.5% and family history at 13% for diabetic patients. The

prevalence of non-diabetes mellitus for male and female using soft drink was 32.5%, respondents who were smoking was 58.5%, respondents who had Alcoholic behavior with highest at 83.5%, followed by respondents who consumed sweets at 61.5%, respondents having residence issues with 56.5% and respondents having family non diabetic history were 87% respectively.

Indicators of the Diabetic Mellitus Risk

Table 11: Odds ratios and their 95% CI showing the risk factors associated with Diabetic Mellitus

Covariate (rs)	**Univariate**			**Multivariate**		
	Odd Ratio	P-value	95% CI	Odd Ratio	P-value	95% CI
Ref age group: 18 – 45						
≤ 20 years	0.50	0.5	0.06 – 3.88	0.93	0.9	0.11 – 8.31
45+	2.90	0.03	1.08 – 7.79	3.32	0.03	1.07 – 10.26
Ref Occupation						
Employed	1.38	0.4	0.56 – 3.39	0.56	0.4	0.14 – 2.28
Unemployed	0.76	0.7	0.10 – 5.98	1.05	0.9	0.12 – 9.29
Students	0.23	0.73	0.02 – 5. 90	1.03	0.7	0.13 – 2.12
**Ref income: 10000 – 30000 Rs						
>30000	2.25	0.07	0.93 – 5.93	2.43	0.08	0.89 – 6.66
Time referent: less than five hours						
≥5 hours	1.88	0.1	0.77 – 4.58	2.42	0.2	0.61 – 9.59
Ref Maternal Status						
Married	1.37	0.5	0.55 – 3.44	1.04	0.9	0.37 – 2.91
Single	1.20	0.17	0.15 – 9.79	0.52	0.5	0.05 – 5.10
Ref BMI: 30 – 45						
≥45 kg	4.57	0.04	1.05 – 19.79	3.42	0.1	0.76 – 15.38

**Income in Pakistani Rupees.

Table 11 discusses the results of binary logistic regression models: univariate (unadjusted) model and multivariate (adjusted) model. The risk of Diabetic Mellitus among the 45+ age group is 2.90 times [95% CI (1.08, 7.79)] compared to those respondents in the ≤20 age group. This risk increased to 3.32 [95% CI (1.07, 10.26)] after controlling for income, physical activity, maternal status and body mass index (BMI). Overweight and obese respondents whose body mass index (BMI) is greater than or equal to 45 kg are at higher risk of developing diabetic mellitus especially female with an odds ratio of 4.57 [95% CI (1.05, 19.79)]. However, this effect

disappeared after adjusting for the other risk factors. The analysis did not reveal differences between respondents in occupation, economic status, and physical activity and material status.

Effects of diet and age on both Body Mass index (BMI) and Diabetes Mellitus (DM)

Table 12: Binary Logistic regression for the effects of diet and age on BMI and Diabetic Mellitus (DM)

	BMI			**DM**		
	Odd Ratio	P-value	95% CI	Odd Ratio	P-value	95% CI
Ref: Normal food						
Fast food	1.70	0.13	0.85-3.40	3.08	0.05	1.00-9.79
Ref: 21-45 years						
≤ 20 years	0.33	0.01	0.19-0.60	0.51	0.52	0.07-3.97
45+	2.68	0.01	1.23-5.82	2.86	0.04	1.06-7.76

The effects of diet and age on both BMI and DM are presented in Table 12. Here the risk for being obese was 70% higher among fast food compared to normal food after adjusting for age. The study also showed that fast food was 3-fold likely to develop DM as compared to normal food. With age, the risk for developing DM increased. The risk is 2.86 [95% CI (1.06-7.76)] times among the 45+ age group compared to 21-30 age groups. However, the risk of developing obesity is lower by 67% among respondents in the age group ≤ 20 compared to respondents in the age group 45+ and it is 2.68 times higher in the age group 45+.

DISCUSSION

Risk Indicators for Diabetes Mellitus

Findings of the study reveal that increasing age is a risk for diabetes mellitus whereas the age for diabetes mellitus respondents was 46.73 years and had a body mass index of 27.21. Similarly, Li et al., (2020) also indicated that the risk of gestational diabetes mellitus (GDM) indicated that pre-pregnancy BMI ≥ 30 kg/m^2 had a stronger effect on GDM in the age group of 30–34 years than those under 30 years old. Moreover, in the occupation of respondent case the prevalence is higher among the unemployed male and female respondent were 29%. In relation the occurrence of diabetes mellitus among employed male and female were 19% and in the male and female student of diabetes mellitus were 2%. Likewise Idris et al., (2017) revealed that the proportion of diabetes mellitus was higher among the unemployed respondents than among the employed ones. Further, the income level of diabetic mellitus male and female respondents who were earning less than or equal to Rs. 30000 had a lower prevalence 12.5% with a CI of 0.7-2.8. While the prevalence of diabetes was higher at 37.5% for male and female who were earning more than Rs.30000 with a CI of 1.8-4.8. Also, Correia et al., (2019) indicated that in low- and middle-income countries (LMIC) diabetes mellitus (DM) and Hypertension (HTN) are highly prevalent and are leading source of mortality and morbidity.

Furthermore, preference food of type the prevalence of diabetes mellitus of male and female taking fast food had 13% prevalence of diabetic mellitus while who were using normal food diabetes mellitus prevailed 67.5% which is quite high. Likewise, Lamyian et al., (2017) also

revealed that higher consumption of fast food was positively associated with GDM risk, compared to women who consumed < 42.6 g/week OR for those who consumed ≥175 g/week was 2.09 (95% CI 1.10–4.28; *p* for trend: 0.03), an association which remained significant after adjustment for confounding factors. Furthermore, the status of blood pressure level estimated prevalence of diabetes mellitus for male and female were 38.5% in high BP ,12.5% in low BP and 16.5% under normal condition. The prevalence of diabetes mellitus for male and female with soft drinks 67.5% is very high. Likewise Wersching et al., (2017) also stated that the relation between higher collective intake of artificially sweetened soft drinks and dementia were no longer significant after additional adjustment for vascular risk factors and diabetes mellitus. Other factors Smoking 41.5%, Alcohol 16.5%, Sweets 38.5%, residence at 43.5% and family history at 13% are also associated.

CONCLUSION

The prevalence of Diabetic Mellitus and associated risk factors was found positive for patients visiting Civil Hospital, NausheroFeroze. The risk factors of developing diabetes using logistic regression model were studied. The risk factors used are age, gender, occupation status, smoking, alcohol consumption, blood pressure level, physical activity, family history of diabetes. Univariate binary logistic regression model and multivariate logistic regression was used to examine the factors associated to diabetes. The models fitted showed that getting diabetes does not depend significantly on the gender of a person, having a family history of diabetes and smoking. Instead, there is an increased risk of getting the diabetes as a person gets older. Thus, screening tools acknowledging a wider range of risk factors need to be adopted in early detection of diabetes. It is suggested that, in addition to BMI, physical inactivity and age to incorporate smoking (as an early marker of insulin resistance) in these risk factors.

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