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Influence of Sociodemographic, Dietary and Clinical Factors on The Risk of Diabetic Retinopathy among Type 2 Diabetic Patients

Pengaruh dari Faktor Sosiodemografi, Pola Makan, dan Klinis terhadap Risiko Retinopati Diabetik pada Pasien Diabetes Tipe 2

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Diabetic retinopathy, T2DM mellitus, Dietary pattern, Dietary intake

ABSTRACT

Background: Diabetes mellitus is one of the most frequently occurring metabolic disorders, and is associated with Diabetic Retinopathy (DR), which damages the retina and can lead to vision loss.
Objectives: The study investigated the relationship between sociodemographic, dietary, and clinical factors on the risk of DR in individuals with Type 2 Diabetes (T2DM).
Methods: The study was conducted from November 2023 to April 2024 in Coimbatore, South India. Anthropometric measurements, Demographic, clinical, and dietary details were gathered by interviewing patients. Descriptive and binomial logistic regression were used to find out the relationship between the predictors and DR.
Results: A total of 216 patients were diagnosed with T2DM for at least a year, including 41.66% of study participants with retinopathy and 58.33% without retinopathy; the majority (58%) were male, aged 40 to 59. Based on the Multivariable binomial logistic regression, indicated that Occupation (OR: 112.23, 95% CI=6.91,1820), Education (OR: 0.0753,95% CI=0.01,0.53), Monthly income (OR: 0.01,95% CI=0.01,8.27x10-04,0.25), Hypertension (OR: 1.15,95% CI=0.02,1.89), dry fruits consumption (OR: 11.41, 95% CI=1.009,128.98), sugar and jaggery (OR: 1.10, 95%CI = 0.020,1.521), the monounsaturated oils (Peanut oil, Mustard oil, Sesame oil) (OR: 0.028, 95% CI = 0.037,0.0.22) had significant associations with DR.
Conclusions: Sociodemographic, dietary, and clinical factors appear to have significant associations with the presence and severity of DR. It is important to monitor people with Type II diabetes on a healthy diet, as well as maintaining blood pressure and glycaemic status within the normal range is likely to delay the progression of the disease.

INTRODUCTION

Diabetes Mellitus (DM) is one of the most common metabolic disorders and is often associated with complications such as Diabetic Retinopathy (DR), a condition that damages the retina and can lead to vision loss. Currently, the global prevalence of diabetes has risen to an alarming 537 million cases worldwide[1]. This number is projected to rise to 700.2 million by 2045, according to the International Diabetes Federation (IDF). It is estimated that approximately 10.9% of the global population will be affected by diabetes[2,3]. This includes both Type 1 Diabetes (T1DM) and Type 2 Diabetes (T2DM). DR(DR) affects approximately 22.27% of people with diabetes worldwide[4]. With an estimated 101 million people having diabetes in 2021, it is interpreted that around 21 million individuals with diabetes will experience vision impairment in India[5]. Emerging research highlights the potential role of dietary factors in modifying the risk and progression of DR. Dietary patterns and nutrient intake can influence systemic glucose metabolism, oxidative stress levels, and inflammatory pathways, thereby impacting the microvascular complications associated with diabetes[6]. Conversely, diets high in refined carbohydrates, saturated fats, and

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excessive caloric intake have been linked to poor glycemic control and increased oxidative stress, which may exacerbate the progression of DR[6, 7].

One important question that remains to be answered is which foods are associated with the most pronounced risk reduction[8]. Furthermore, specific dietary components like omega-3 fatty acids found in fish and nuts have shown protective effects against DR through their anti-inflammatory and vascular-stabilizing properties[9,10]. Despite growing evidence suggesting a role for dietary interventions in DR prevention and management, a comprehensive understanding and clinical application remain challenging. Variability in study designs, dietary assessment methods, and patient populations contributes to the complexity of interpreting findings and establishing clear dietary recommendations for individuals with diabetes[11]. Several healthy dietary patterns emphasizing overall diet quality can be adapted for diabetes prevention[12]. Dietary modification represents a straightforward and attainable approach to the comprehensive management of diabetes and its microvascular complications among diabetic patients. There is limited research in India exploring the correlation between dietary patterns and the risk of DR. In this study, we aim to comprehensively review the connections between dietary patterns and the progression of DR. Specifically, our research investigates the impact of various food items on the development of DR in T2DM mellitus patients residing in urban settings in southern India. Our current research study aimed to summarize the associations between sociodemographic, Dietary, and clinical factors and diabetic retinopathy.

METHODS

This cross-sectional study was carried out during a six-month period between November 2023 and April 2024 on people who had visited the outpatient department with a prior history of diabetes for at least one year. The sample size was calculated using the single proportion formula (Za/ 2 p(1-p)/d2)[13] assuming a prevalence (p) of 16.3%, a standard normal distribution value at a 95% confidence level (Z) of 1.96, and a margin of error (d) of 5%. In total, the sample size required for the study was determined to be 209[13] and including 10% dropouts, accounting for 229 participants, who met the inclusion criteria. After removing incomplete data for 13 subjects, the final analysis was completed on 216 subjects (DR = 90, DWR = 126). Participants between the ages of 18 and 65 years of age receiving care from the outpatient department at the hospital, had been diagnosed with Diabetes Mellitus for at least one year before the study start date. Exclusion criteria included any patient without a diagnosis of DM for at least one year or outside the age criteria. The study protocol was reviewed by the Institutional Human Ethics Committee (IHEC) PSG IMS&R (Ref. No.: PSG/IHEC/2022/Appr/FB/010 dated 16/03/2022). The ocular examination encompassed a slit-lamp anterior segment examination and a dilated fundus examination utilizing slit-lamp bio microscopy (90D) and indirect ophthalmoscopy (20D) to assess for DR[16].

A quantifiable, interviewer-administered, easily recorded FFQ to assess nutrient intakes of individuals was created by adjusting the food list from the instrument developed to assess dietary intake in North India[14] and an adapted rating scale[15]. Dietary intake was recorded as the quantity (in grams) of food items typically consumed per day, week, or month to calculate both individual intake and consumption frequency. In the Food Frequency Questionnaire (FFQ), frequency categories were reduced from four to three levels: once a day or more often, once a week, or less often. The draft FFQ was pilot-tested, with no revisions required. Trained dietetic students carried out data collection through separately scheduled, structured interviews. Each participant completed a self-reported 24-hour dietary recall on two non-consecutive days, capturing their habitual intake of foods and drinks over the past three months. The interviews, conducted at the outpatient clinic, combined open-ended questions on usual eating patterns with structured questions to capture total intake as accurately as possible. Data were processed using the Indian Food Composition Tables (2017) to estimate nutrient intake.

Anthropometric measures, height, and weight were measured using standard measuring scales, and Blood Pressure values were taken from medical records on the day of the visit to the outpatient clinic. Height was measured using the stretch method. Body weight was assessed using calibrated electronic scales. When weighing, the participants were asked to stand in the center to avoid errors. Independent demographic variables included age, sex, family history of diabetes, duration of diabetes, occupation, presence of pharmacological treatment, presence of high blood pressure[17], Height, Weight, and BMI category (normal or overweight/obese). Independent variables for dietary patterns were created for analysis (more often or less often) for each item in the FFQ (see tables 1&2).

The data were assessed for distribution using the Shapiro-Wilk test since the sample size was smaller. Statistical analysis was conducted using Jamovi 2.3.24, an open-source statistical software, and IBM SPSS Statistics 21. Bivariate analysis was done using Chi-square or Fisher's exact test for categorical variables influencing DR. Variables that were significantly associated with the outcome (p-value<0.05) were considered for inclusion in the multivariable binomial logistic regression. A positive coefficient and OR ratio > 1 indicated a higher likelihood of DR with a specific predictor, while a negative coefficient and OR < 1 indicated protective effects against diabetic retinopathy.

RESULTS AND DISCUSSIONS

Demographic and Clinical Characteristics

The study included 216 Type II diabetes patients, 90 with retinopathy and 126 without retinopathy. The majority of study participants (73%) were between the ages of 40 and 59. A notable finding was the remarkably high prevalence of DR among individuals aged 60 years and above. Furthermore, 38% of participants aged 40–59 years were also found to have DR. However, the binary logistic regression analysis indicated that increasing age is associated with lower odds of experiencing the outcome

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studied, with statistical significance. The odds ratio and confidence interval provide a quantitative understanding of this association, indicating a negative relationship between age, as most of the affected individuals fall under the age group of 40-59 years the likelihood of the outcome. Furthermore, the majority of diabetes patients without retinopathy (65.6%) were either obese or overweight. Furthermore, the majority of (85%) in this category had completed higher education. More than 60% of diabetic individuals were hypertensive, and 17% had hypercholesterolaemia.

Table 1. Frequency distribution of sociodemographic, dietary, and clinical factors (n=216)

Categories	Presence or Absence of DR		p-value
	Diabetic without Retinopathy	Diabetic Retinopathy	
	n (%)	n (%)	
Gender			
Male	77 (53.1)	68 (46.9)	0.026*
Female	49 (69)	22 (31)	
Age			
18-39 years	23 (95.8)	1 (4.2)	0.001*
40-59 years	103 (66)	53 (34)	
Above 59 years	0 (0)	36 (100)	
Education			
Primary	13 (21.3)	48 (78.7)	0.001*
Secondary	28 (49.1)	29 (50.9)	
Post Secondary	85 (86.7)	13 (13.3	
Occupation			
Sedentary -Teachers, bank employees, IT professionals	18 (100)	0 (0)	
Home makers	32 (66.7)	16 (33.3)	0.001*
Retired	14 (56)	11 (44)	
Others	62 (49.6)	63 (50.4)	
Monthly Income			
< USD 225	58 (40.3)	86 (59.7)	<0.001*
> USD 225	68 (94.4)	4 (5.6)	
BMI Category			
Normal	46 (48.9)	48 (51.1)	0.014*
Overweight & Obese	80 (65.6)	42 (34.4)	
Pharmacological treatment			
No	71 (100)	0 (0)	0.001*
Yes	55 (37.9)	90 (62.1)	
Hypertension			
No	27 (37.5)	45 (62.5)	0.001*
Yes	99 (68.8)	45 (31.3)	
Dietary Intake mean (minimum, maximum)			
Carbohydrate	232 (136,343)	210 (113,454)	<0.001**
Protein	64 (35.2,93)	43.6 (21,65)	<0.001**
Total Fat	58.9 (16.6,99.4)	42.2 (20,98.7)	<0.001**
Calories	1794 (1086,266)	1519 (902,309)	<0.001**
Cereals preparations			
One time a day or less often	1 (100)	0 (0)	0.39b, c
Three times a day or more often	125 (58.1)	90 (41.9)	
Millet preparations			
Once a week or less often	51 (56.7)	39 (43.3)	0.675
Once a day or more often	75 (59.5)	51 (40.5)	
Pulses			
Once a week or less often	6 (66.7)	3 (33.3)	0.60b
Once a day or more often	120 (58)	87 (42)	
Legumes			
Once a week or less often	0 (0)	10 (100)	<0.001*, b
Once a day or more often	126 (61.2)	80 (38.8)	
Green leafy vegetables			
Once a week or less often	0 (0)	8 (100)	0.001*, b
Once a day or more often	126 (60.6)	82 (39.4)	
Vegetables			0.001*, b

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Categories	Presence or Absence of DR		p-value
	Diabetic without Retinopathy	Diabetic Retinopathy	
	n (%)	n (%)	
Once a week or less often	0 (0)	6 (100)	
Once a day or more often	126 (60)	84 (40)	
Fresh Fruits			
Once a week or less often	3 (10.7)	25 (89.3)	<0.001*
Once a day or more often	123 (65.4)	65 (34.6)	
Dry Fruits			
Once a week or less often	31 (45.6)	37 (54.4)	0.010*
Once a day or more often	95 (64.2)	53 (35.8)	
Milk & Yogurt			
Once a week or less often	4 (23.5)	13 (76.5)	0.002*
Once a day or more often	122 (61.3)	77 (38.7)	
Ghee & Butter			
Once a week or less often	39 (56.5)	30 (43.5)	0.711
Once a day or more often	87 (59.2)	60 (40.8)	
Cheese & Paneer			
Once a week or less often	79 (63.2)	46 (36.8)	0.089
Once a day or more often	47 (51.6)	44 (48.4)	
Red meat			
Three times a week or more often	39 (44.8)	48 (55.2)	0.001*
A few times a month or less often	87 (67.4)	42 (32.6)	
Poultry -Chicken			
Three times a week or more often	25 (42.4)	34 (57.6)	0.004*
A few times a month or less often	101 (64.3)	56 (35.7)	
Fish			
Three times a week or more often	33 (55)	27 (45)	0.538
A few times a month or less often	93 (59.6)	63 (40.4)	
Egg			
Three times a week or more often	16 (41)	23 (59)	0.015*
A few times a month or less often	110 (62.1)	67 (37.9)	
Groundnut			
Once a week or less often	11 (42.3)	15 (57.7)	0.077
Once a day or more often	115 (60.5)	75 (39.5)	
Coconut			
Once a week or less often	2 (22.2)	7 (77.8)	0.03*, b
Once a day or more often	124 (59.9)	83 (40.1)	
Almonds & Cashews			
Once a week or less often	39 (50)	39 (50)	0.062
Once a day or more often	87 (63)	51 (37)	
Sunflower oil			
One time a day or less often	21 (60)	14 (40)	0.827
Three times a day or more often	105 (58)	76 (42)	
Coconut oil			
One time a day or less often	35 (62.5)	21 (37.5)	0.462
Three times a day or more often	91 (56.9)	69 (43.1)	
Peanut oil, sesame oil, Mustard oil			
One time a day or less often	14 (18.4)	62 (81.6)	0.001*
Three times a day or more often	112 (80)	28 (20)	
Sugar &Jaggery			
Once a week or less often	17 (20.7)	65 (79.3)	<0.001*
Once a day or more often	109 (81.3)	25 (18.7)	

* The Chi-square statistic is significant at the 0.05 level.
** Data were compared by using the Mann-Whitney U test.
b. More than 20% of cells in this sub-table have expected cell counts less than 0.05. Therefore, Fisher's Exact test applied,
DR- Diabetic Retinopathy

Among DR patients, 1.11% had mild (18.88%), moderate (7.77%), and severe non-proliferative Diabetic Retinopathy, while the remaining (72.22%) had proliferative Diabetic Retinopathy. DR patients had an average diabetes duration of 16.91±8.1. And 60% of respondents reported earning less than USD 225 per

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month. There is a statistically significant and strong negative association between higher monthly income and the outcome studied. The results revealed that individuals with higher monthly income have markedly lower odds of experiencing the outcome compared to those with lower monthly income. This protective effect is emphasized by the very low odds ratio and the narrow confidence interval that does not include 1, indicating a robust association. Indicated a statistically significant and strong negative association between the study group and DR. The observation of higher rates of vision impairment and blindness among individuals from lower socioeconomic backgrounds in India. Policymakers should prioritize these vulnerable groups to mitigate healthcare disparities.

Association between Predictors and Diabetes, DR Status

The findings of the study indicated that factors such as BMI, pharmacological treatment, blood pressure, and dietary items, including milk, eggs, monounsaturated fats, cheese, fruits, vegetables, sugar, jaggery, and red meat, were also found to be significantly associated with DR (p-value<0.05). A comparative analysis of various characteristics associated with the presence or absence of DR among diabetic patients. Notably, gender differences reveal a higher prevalence of DR in males (46.9%) compared to females (31%) with a significant p-value of 0.026, indicating a potential gender-related risk factor for DR. Age is a critical determinant, with individuals aged 18-39 showing a strikingly low prevalence (4.2%), while those above 59 years exhibit a 100% prevalence, underscoring the importance of age in DR risk. Education level also plays a significant role; individuals with primary education had a high prevalence (78.7%) compared to those with more than secondary education (13.3%). Additionally, occupation and income levels significantly correlate with DR presence, while lower-income groups exhibited higher prevalence. The income is found to be associated with DR risk in our study is supported by a study done in China and in the UK showed that the individuals with higher income and social health insurance had better glycemic control and a lower risk of DR (OR: 0.88) compared to those with lower income[11]. Specifically, the data shows that the patients categorized as having a normal BMI, 46 (48.9%), were without DR, while 48 (51.1%) had DR, with a p-value of 0.014, suggesting a statistically significant association.

It was noted that all DR patients required to be under pharmacological treatment due to the underlying severity of diabetes requiring such treatment. Patients without hypertension had a lower incidence of DR (37.5%) compared to those with hypertension (68.8%). Overall, these results underscore the complex interplay between pharmacological treatment, hypertension, and the development of DR, highlighting the need for careful monitoring and management in diabetic patients. In this study hypertension is a significant risk factor for DR. this finding aligns with a study conducted[18] where the patients with T2DM found that higher Systolic Blood Pressure (SBP) levels were associated with increased DR risk, particularly when the systolic blood pressure exceeded 132 mmHg, where each 10-mmHg increase raised the risk by 28% Collectively, these findings underscore the importance of managing hypertension to mitigate the risk of DR. The study also compared the dietary intake of carbohydrate, protein, fat, and calories between DR patients and Diabetic Without Retinopathy (DWR) patients. The mean intake of DR patients was found to be lower compared to diabetic patients without retinopathy: carbohydrate (210 g vs. 232 g), protein (43.6 g vs. 64 g), fat (42.2 g vs. 58.9 g), and calorie intake (1519 kcal vs. 1794 kcal). However, the difference was statistically significant (p-value<0.05). An adequate diet can significantly reduce the risk of diabetes and Diabetic Retinopathy[19].

A significant association exists between legume consumption and f DR (p-value<0.001). Those who consume legumes more frequently are less likely to have DR. The consumption of green leafy vegetables is significantly related to a lower risk of DR (p-value<0.001*). Individuals who frequently consume these vegetables are less likely to have DR. Similar to green leafy vegetables, general vegetable consumption is also significantly associated with a lower presence of DR (p-value<0.001). Fruit consumption is highly significant in relation to DR (p-value<0.001). Individuals with less frequent fruit consumption are more likely to have DR. Increasing consumption of fruits and vegetables effectively reduces the likelihood of developing DR[20] and provides protective effects against it[21]. Fruits and leafy green vegetables contribute to delaying DR progression and mitigating visual impairment[22]. Consumption of fruits and vegetables more than twice weekly was reported by all study participants (n=219), showing a significant association (p-value<0.05). However, risk factors and the DR could not be conclusively determined from our observations. Most of the DR patients in our study were receiving antioxidant preparation in the form of multivitamin supplements. Increasing the consumption of vegetables and fruits lowers the risk of certain eye diseases[23]. Epidemiologic studies have reported that diets rich in antioxidants such as vitamin C, vitamin E, αtocopherol, or βcarotene exhibit beneficial effects on glucose metabolism and diabetes prevention[24].

There is a significant relationship between dry fruit consumption and DR (p-value<0.05). The consumption of milk and yogurt is significantly related to the presence of DR (p-value<0.05). Individuals who consume these products more frequently are less likely to have DR. A significant association exists between red meat consumption and DR (p-value<0.05). Increased consumption of red meat leads to the accumulation of Advanced Glycation End Products (AGEs) in sub-retinal membranes and micro vessels, which is implicated in DR and cataract development[25]. Those who consume red meat less frequently are more likely to have DR. Chicken consumption is significantly related to DR (p-value<0.05). Individuals who consume chicken more frequently are less likely to have DR. Egg consumption shows a significant relationship with DR (p-value<0.05). Higher

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consumption is associated with a lower presence of DR. There is a significant association between coconut consumption and DR (p-value<0.05). Frequent consumption of coconut is linked to a lower presence of DR. There is a highly significant association between Monounsaturated Fats and Oils (MUFA) and DR (p-value<0.05). Individuals who consume more MUFA are less likely to have DR. The consumption of sugar and jaggery is highly significant in relation to DR (p-value<0.05). Higher consumption of these sweeteners is associated with a lower presence of DR. This disparity might be attributed to greater awareness among DR patients regarding the risks associated with high sugar intake, possibly due to their longer duration of diabetes mellitus. High-sucrose diets can lead to elevated blood glucose levels, which are crucial in the development of vascular complications in diabetes. To prevent the vision loss associated with DR, early intervention in dietary habits, particularly reducing sugar intake, is crucial[26,27]. However, in our study, we found a statistically significant negative association between sugar and jaggery intake and Diabetic Retinopathy. The consumption of cereal, pulses, ghee and butter, cheese and paneer, fish, groundnut, almonds and cashews, Polyunsaturated Fats and Oils (PUFA), and fats and oils (SFA) were not shown to any significant association in this study. Consuming oily fish at least twice a week reduces the risk of retinopathy by nearly 60%. Consumption of 85–141 g of dark fish (such as salmon, mackerel, swordfish, sardines, and bluefish) weekly versus never was associated with almost a 70% lower likelihood of retinopathy[28]. Consumption of cheese and whole meal bread showed a reduction in the risk of DR progression among the working-aged Australian diabetic population[29].

Table 2. Multivariable binomial logistic regression investigating predictors of DR among adults

Category	Model Coefficients - DR Status	
	p-value	Odds Ratio (95% CI)
Gender		
Female	0.233	4.63 (0.37 – 57.48)
Male	Reference	–
Age		
18–39 years	0.492	118.29 (4.4×10^{-4} – 9.73×10^{7})
≥59 years	0.992	4.4×10^{-10} (0 – ∞)
40–59 years	Reference	–
Education		
Primary	0.318	0.374 (0.054 – 2.57)
Secondary	0.010*	0.075 (0.011 – 0.53)
Post Secondary	Reference	–
Occupation		
Homemaker	0.149	7.41 (0.49 – 112.8)
IT professional	0.995	2.4×10^{8} (0 – ∞)
Retired	0.001*	112.24 (6.92 – 1820.49)
Others	Reference	–
Monthly Income		
< USD 225	0.004*	0.0145 (8.3×10^{-4} – 0.25)
≥ USD 225	Reference	–
BMI Category		
Overweight/Obese	0.691	0.711 (0.13 – 3.82)
Normal	Reference	–
Hypertension		
Yes vs. No	0.037*	1.154 (0.027 – 1.89)
Fresh Fruits		
≤ Once/week	0.27	0.166 (0.007 – 4.04)
≥ Once/day	Reference	–
Dry Fruits		
≤ Once/week	0.049*	11.41 (1.009 – 128.99)

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Category	Model Coefficients - DR Status	
	p-value	Odds Ratio (95% CI)
≥ Once/day	Reference	–
Milk & Yogurt		
≤ Once/week	0.209	0.142 (0.007 – 2.99)
≥ Once/day	Reference	–
Red Meat		
≥3 times/week	0.994	0.99 (0.127 – 7.78)
A few times/month or less	Reference	–
Poultry (Chicken)		
≥3 times/week	0.789	0.671 (0.036 – 12.58)
A few times/month or less	Reference	–
Eggs		
≥3 times/week	0.713	1.92 (0.059 – 62.89)
A few times/month or less	Reference	–
Peanut/Mustard/Sesame Oil		
≤ Once/day	0.001*	0.029 (0.004 – 0.22)
≥ Three times/day	Reference	–
Sugar & Jaggery		
≤ Once/week	0.006*	1.103 (0.021 – 1.52)
≥ Once/day	Reference	–

*Significant level at the p-value<0.05, Rs.- Rupees.

The Multivariable Binomial Logistic Regression (Table 2) investigates predictors of DR, examining the relationship between various predictors and the likelihood of DR among individuals with diabetes. The odds ratio of Gender (4.6306) suggests that females have approximately 4.6 times higher odds of having DR compared to males. This means that, based on this model, being female is associated with a higher likelihood of having DR. The odds ratios for age categories are not statistically significant, and the wide confidence intervals and high odds ratios for the 18-39 age group suggest that the model's estimate is highly unstable, potentially due to limited data or other factors that may require further investigation. The patients with a normal BMI have about 0.71 times the odds (or 29% lower odds) of having DR compared to individuals who are overweight or obese. In other words, having a normal BMI might be associated with a slightly lower likelihood of DR compared to being overweight or obese. The odds ratio (OR: 112.23, 95%CI = 6.91, 1820), suggests that retired people have significantly higher odds of developing DR compared to working individuals. The wide 95% confidence interval (6.91 to 1820) indicates a high level of uncertainty about the exact risk, but it confirms a statistically significant association. Essentially, while retirees appear to face a notably increased risk of DR, and the prevalence of diabetes in retired individuals and those with DR is a significant concern globally, with older adults facing higher risks of complications and mortality[30].

In this study, Individuals with secondary level education have a significantly lower risk of developing retinopathy. The odds ratio of 0.0753, along with the 95% confidence interval and p-value, confirms that this association is statistically significant and not likely due to chance. Secondary education appears to provide a strong protective effect against retinopathy. Education (OR: 0.0753 95% CI =0.01, 0.53). The ODDs ratio related to monthly income (OR: 0.01, 95% CI =0.01, 8.27x10-04, 0.25), showed a significant association with income. Individuals with a monthly income above USD 225 have significantly lower odds (about 1% of the odds) of experiencing the outcome compared to those with an income below USD 225. The odds ratio and confidence interval confirm a statistically significant association, indicating that higher income is associated with a substantially reduced risk of the outcome. The wide confidence interval reflects some uncertainty in the exact magnitude of this protective effect but supports the general finding of reduced risk. An odds ratio (OR: 1.15, 95%CI = 0.02, 1.89) for hypertension in relation to DR indicates a 15% increased likelihood of developing DR for individuals with hypertension compared to those without hypertension.

The results suggest that there is a strong association between dry fruit consumption and an increased likelihood of the outcome being studied. The odds ratio of (OR: 11.41, 95% CI = 1.009, 128.98) indicates a much higher odds of the outcome for those who consume dry fruits more often compared to those who consume them less times. The confidence interval, which ranges from just above 1 to nearly 129, underscores the

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significance of this association, though the wide range indicates some uncertainty about the exact magnitude of the effect. An odds ratio (OR: 0.028, 95%CI =0.037, 0.22) indicates that the consumption of peanut oil, mustard oil, and sesame oil is associated with significantly lower odds (about 2.8% of the odds) of developing DR compared to those who consume coconut oil. These oils have a protective effect against Diabetic Retinopathy. In our study, the intake of peanut oil, groundnut oil, and sesame oil was associated with reduced odds of DR. There is an inverse correlation between MUFA and oleic acid and the odds of retinopathy[31,32]. MUFAs and oleic acid, including OA, may exert protective effects against the development and progression of DR by influencing insulin resistance and inflammation[33].

The negative association between consumption of nuts and seeds such as almonds, groundnuts, and chia seeds, indicates that individuals who consume these foods have lower odds of experiencing the outcome compared to those who do not consume them. The Mediterranean diet enriched with nuts was associated with a 37% reduction in the risk of Diabetic Retinopathy[34]. Groundnut consumption was less frequent among DR patients (39.5%) compared to diabetic non-retinopathy patients (60.5%). Peanuts contain resveratrol (RSV), which inhibits increased vascular leakage and loss of pericytes and regulates VEGF protein levels in mouse retinas, thereby inhibiting the development of DR[25].

Sugar and jaggery (OR: 1.10, 95%CI = 0.020,1.521). An odds ratio (OR) of 1.10 for sugar intake in relation to DR(DR) suggests a modest increase in the odds of developing DR with each unit increase in sugar consumption. Specifically, this indicates that for every additional unit of sugar, the likelihood of developing DR increases by 10%. Most study participants from both groups consume millets more frequently. Increased intake of millets (>2 times per week), though there is no significance millets contain dietary fibre, which aids in blood glucose management by slowing down glucose absorption in the small intestine and lowering the food's glycaemic index[35]. Among the study participants, 60% consumed fish (>2 times per week). There are no significant associations observed between fish meat, cheese consumption, and Diabetic Retinopathy. Many studies suggest a protective effect of fish consumption against the outcome, where individuals who regularly consume fish are less likely to experience the adverse health outcome compared to those who do not consume fish[28].

Strengths and Limitations

We have included the food items from the major food groups and assessed the macronutrient intake, which determines the strength of our study. While the study adjusted for some factors such as dietary recall bias, BMI, and pharmacological treatment, other potential confounders, such as physical activity levels and genetic predispositions, were not fully accounted for. These factors could influence both dietary choices and the development of DR. In our study, the wider confidence intervals were observed as the sample size does not provide a precise representation of the population mean interval. Future research should aim to address these limitations to provide more robust and reliable estimates.

CONCLUSIONS

A few noteworthy findings were derived, importantly the relationship between dietary habits and the risk of DR in people with T2DM. Compared to individuals without DR, patients with DR typically consumed fewer calories as well as less protein, carbohydrates, and fat. The risk of DR was shown to be strongly correlated with socioeconomic variables, Hypertension, and certain foods like sugar, Jaggery, dry fruits. The findings suggest that dietary interventions focusing on appropriate nutrient intake and food choices like low-glycaemic foods, high fibre, lean proteins, and healthy fats, while limiting sugars and refined carbs to control blood sugar and prevent complications, potentially mitigate the risk of developing DR or slowing its progression, thereby improving clinical outcomes and quality of life for diabetic patients. The health care institutions should strengthen early screening, nutrition education, and access to healthy foods to reduce diabetes complications and promote healthier aging among diabetic patients.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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AUTHOR CONTRIBUTIONS

SD: Responsible for the data collection, compilation, drafting, and coordination of manuscript submission; SN: Conceptualization of research; AS: Created questionnaire with informed consent and administered questionnaire; YV: Assisted with statistical analysis & interpretation; KA: Drafting, and submission of the manuscript; CV: Assistance in drafting the manuscript. BP: Managed the data collection, compilation MA: Manuscript writing

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