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Research Article

Prevalence and Risk Factors of Non-proliferative Diabetic Retinopathy in Individuals with Type 2 Diabetes Mellitus Taking Oral Antidiabetic Medications

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Abstract

Background: Non-proliferative diabetic retinopathy (NPDR) is a significant complication of long-term diabetes in Sudan. This study aimed to determine the prevalence and risk factors of diabetic retinopathy among Sudanese individuals with type 2 diabetes mellitus who are taking oral antidiabetic medication.

Methods: This cross-sectional, facility-based study recruited 196 individuals with type 2 diabetes at the Jabir Abu Eliz Diabetes Health Center in Khartoum State. Data were collected through a structured questionnaire, which patients filled out after providing informed consent. The data were analyzed using the Statistical Package for the Social Sciences (SPSS). Logistic regression was performed to predict factors associated with diabetic retinopathy.

Results: The mean age of the patients was 50.1 ± 10.7 years. The prevalence of NPDR was 78 (39.8%). Bivariate analysis revealed that age, education level, and residence (P-value < 0.05) were significantly associated with diabetic retinopathy. Additional factors that were significantly associated with diabetic retinopathy included the duration of diabetes, the presence of other comorbidities, HbA1c, and fasting blood glucose in 68 (87.2%) individuals (*P*-value < 0.05).

Conclusion: The study revealed a prevalence of 39.8% for NPDR in this cohort. A longer duration of diabetes and poor control are the primary risk factors for diabetic retinopathy in Sudan. Further research is necessary to determine whether intensifying therapy or administering insulin may reduce the prevalence of retinopathy.

OPEN ACCESS

Keywords: diabetic retinopathy, diabetes, prevalence, risk factors, duration

1. Introduction

The prevalence of diabetes mellitus in Sudan and worldwide is high [1, 2]. The number of individuals with diabetes is expected to increase to more than 47 million in sub-Saharan Africa by 2045 [3]. The most significant complication of diabetes in African countries is non-proliferative diabetic retinopathy (NPDR), which is considered a common cause of blindness [4]. The worldwide prevalence of NPDR in individuals with type 2 diabetes is 22.27%, while the prevalence of diabetic retinopathy (DR) in Africa is 35.9% [5]. Risk factors for NPDR include the duration of diabetes, age, glycemic control, obesity, and dyslipidemia. Nephropathy is typically associated with this condition [6]. Regular and early screening through retinal photography remains the best, safest, and most cost-effective method for preventing DR [7–10]. Therefore, it is not surprising that the incidence of DR has significantly decreased in developed countries [11].

Risk factors and prevalence of NPDR vary significantly across countries. For instance, in Australia, factors associated with DR include HbA1c levels, duration of diabetes, and elevated systolic blood pressure [12]. In China, NPDR is linked to higher HbA1c levels and an earlier age of diabetes onset [13]. The prevalence was 57.5% in Cameroon [14], while in South Africa, it was 24.9% [15]. The risk factors included high systolic blood pressure, elevated BMI, insulin therapy, increased HbA1c, and neuropathy. In Tanzania, the prevalence was 27.9%, with high systolic blood pressure, a longer duration of diabetes, and random blood sugar levels as the main risk factors [16, 17]. Moreover, the prevalence of DR in Ethiopia was 41.4% and was significantly correlated with fasting blood glucose levels, duration of diabetes, and systemic blood pressure [18]; meanwhile, the prevalence of NPDR in Kenya was 35.9%, with DR associated with younger age, male sex, duration and control of diabetes, and treatment compliance [19].

Importantly, studies from Sudan have shown that the frequency of NPDR is increasing at an alarming rate over the years. For instance, in 1991, the prevalence was 17.2%, while in 1995, it rose to 43% and jumped to between 72.6% and 82.6% in 2017 [20–23]. Studies, including systematic reviews, have identified hypertension as another critical risk factor for NPDR [24, 25]. Additionally, the variability in fasting glucose and the rise in average overall glucose were also recognized as significant risk factors for NPDR [26, 27].

This study aims to determine the prevalence and risk factors of NPDR among type 2 diabetes mellitus patients who received oral treatment at Jabir Abu Eliz Diabetes Center in Khartoum, the capital.

2. Methods

2.1. Study setting

This prospective cross-sectional facility-based study was conducted at the Jabir Abu Eliz Diabetes Health Center in Khartoum State from June to November 2021. This center specializes in diabetes care and has a comprehensive multidisciplinary team that includes qualified ophthalmologists, endocrinologists, dentists, diabetes educators, psychologists, diabetes nurses, dietitians, and social workers.

2.2. Inclusion criteria

The study included individuals with type 2 diabetes who were on oral antidiabetic medication and were attending the study center.

2.3. Exclusion criteria

Individuals with type 2 diabetes mellitus and eye disorders unrelated to diabetes were excluded from the study. Patients with pre-existing DR were excluded at baseline to allow for the prospective measurement of prevalence.

2.4. Sample size and sampling technique

Based on the estimated population of individuals with type 2 diabetes at the Jabir Abu Eliz Center, which stood at approximately 400 patients per month with a margin of error of 5% within a 95% confidence interval (CI), we used the following equation:

$n = N/1 + N(e)^2$,

where n = the sample size to be calculated, N = population size, and e = the desired degree of accuracy or accepted margin of error, commonly set at 0.05. Thus, $n = 400/1 + 400(0.05)^2 = 200$ participants. After excluding incomplete data from the questionnaire, the sample size was adjusted to 196 participants.

The researchers employed the convenience sampling technique. They visited the center three days a week, and during each visit, they selected any patient who met the study's inclusion criteria until we reached 196 patients.

2.5. Data collection tools and methods

A pretested questionnaire was created to meet the study's objectives. It included demographic data, information about diabetes, the risk of diabetic retinopathy, investigations, and medical history. Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 23.0, applying the Chi-square test as appropriate. A *P*-value of <0.05 is considered statistically significant (CI 95%). Logistic regression was performed to identify factors associated with NPDR.

3. Results

In this study, 196 patients diagnosed with type 2 diabetes mellitus who attended the Jabir Abu Eliz Diabetes Center between June and August 2021 were enrolled to determine the frequency and risk factors of NPDR among type 2 diabetes mellitus patients receiving oral treatment (not insulin). The mean age of the patients was 50.1 ± 10.7 years. Patients aged 41–50 comprised 78 (39.8%), while those between the ages of 51 and 60 accounted for 53 (27%). Females represented 113 (57.7%) patients. Those with a university-level education or higher totaled 76 (38.8%). Patients from urban areas totaled 105 (53.6%; Table **1**).

Overall, 106 (54.1%) patients had diabetes mellitus for less than 5 years; 87 (44.4%) patients had a history of comorbidities, and among them, 62 (71.3%) had hypertension. Regarding the clinical presentations, 188 (95.9%) reported polyuria and 185 (94.4%) reported polydipsia.

The retinal grade was normal in 118 (60.2%) patients, while mild NPDR was reported in 76 (38.8%) of them. Retinal pathology indicated that retinopathy in 78 (39.8%) patients. Furthermore, 99 (50.5%) patients had uncontrolled HbA1c% levels, and fasting blood glucose was elevated in 110 (56.1%) patients (Table **2**).

The chi-square test showed that diabetic retinopathy had a statistically significant association with the participants' age, education, residence, duration since diagnosis, presence of comorbidities, and uncontrolled levels of HbA1c

and FBS (*P*-values = 0.045; <0.001; <0.001; <0.001; <0.001; <0.001, respectively; Table **3**).

When logistic regression was conducted to determine the predictors of the presence of NPDR, we found that individuals with diabetes for >10 years were eight times more likely to develop retinopathy compared to those with diabetes for <5 years (*P* = 0.002, OR = 8.2 [CI, 2.2–30.4]). Furthermore, those with comorbidities (such as hypertension, dyslipidemia, and other cardiovascular diseases) were twice as likely to develop retinopathy compared to those without, even though the result was statistically insignificant (*P* = 0.176, OR = 2.0 [CI, 0.7–5.5]). Moreover, uneducated individuals were 22 times more likely to develop retinopathy than those who graduated from university (*P* = 0.001, OR = 22.3 [CI, 2.9–170.3]). Those living in rural areas were 6.3 times more likely to develop retinopathy than those in urban areas (*P* = 0.001, OR = 6.3 [CI, 2.1–18.5]).

Regarding the effect of glycemic control on the presence of NPDR, we found that individuals with uncontrolled levels of HbA1c were eight times more likely to develop retinopathy than those with controlled levels (*P* = 0.001, OR = 8.1 [CI, 2.5–26.3]). Additionally, those with high levels of FBS were 10.6 times more likely to develop retinopathy than those with normal FBS (*P* = 0.001, OR = 10.6 [CI, 3.1–35.6]; Table **4**).

Table 1: Socio-demographic characteristics of the participants (*n* = 196).

Socio-demographic characteristics	Responses	*N*	Percentage (%)
Age groups (yrs)	30–40	33	16.9
	41–50	78	39.8
	51–60	53	27
	>60	32	16.3
Age (yrs)	Mean ± SD	50.1±10.7	
Gender	Female	113	57.7
	Male	83	42.3
Education	Not educated	27	13.8
	Primary/intermediate	26	13.3
	Secondary	67	34.2
	University/above	76	38.8
Residence	Rural	91	46.4
	Urban	105	53.6

Table 2: Characteristics of the participants' disease (*n* = 196).

	Responses	*N*	Percentage (%)
Duration since diagnosis (yrs)	<5	106	54.1
	>10	51	26.0
	5–10	39	19.9
Comorbidity	No	109	55.6
	Yes	87	44.4
Co-morbidities (*n* = 87)	Hypertension	62	71.3
	Hyperlipidemia	16	18.4
	Heart disease	12	13.8
	Renal disease	9	10.3

Table 2: Continued.

	Responses	*N*	Percentage (%)
Clinical presentations	Polyuria	188	95.9
	Polydipsia	185	94.4
	Blurred vision	85	43.4
	Visual loss	4	2.0
	Floaters	4	2.0
Retinal grade	Mild NPDR	76	38.8
	Moderate NPDR	1	0.5
	Normal	118	60.2
	Severe NPDR	1	0.5
Frequency of retinopathy	Normal	118	60.2
	Retinopathy	78	39.8
HbA1c (%)	Controlled	97	49.5
	Uncontrolled	99	50.5
HbA1c	Mean ± SD	8 ± 2.5	
FBS (mg/dl)	High	110	56.1
	Normal	86	43.9
FBS	Mean ± SD	162.5 ± 60.5	

Table 3: Crosstabulation of participants based on the frequency of diabetic retinopathy and other factors.

		Retinal photograph				*P*-value
		Retinopathy (*n* = 78)		Normal (*n* = 118)		
		N	%	*N*	%	
Age group (yrs)	30–40	10	12.8	23	19.5	0.045
	41–50	36	46.2	42	35.6	
	51–60	25	32.1	28	23.7	
	>60	7	9.0	25	21.2	
Gender	Male	35	44.9	48	40.7	0.322
	Female	43	55.1	70	59.3	
Education	Not educated	22	28.2	5	4.2	<0.001
	Primary	18	23.1	8	6.8	
	Secondary	18	23.1	49	41.5	
	University/above	20	25.6	56	47.5	
residence	Urban	27	34.6	78	66.1	<0.001
	Rural	51	65.4	40	33.9	
Duration since diagnosis (yrs)	<5	19	24.4	87	73.7	<0.001
	5–10	21	26.9	18	15.3	
	>10	38	48.7	13	11.0	
Comorbidities	Yes	56	71.8	31	26.3	<0.001
	No	22	28.2	87	73.7	
HbA1c	Controlled	12	15.4	85	72.0	<0.001
	Uncontrolled	66	84.6	33	28.0	
FBS	Normal	10	12.8	76	64.4	<0.001
	High	68	87.2	42	35.6	

Table 4: Predicting the factors that can affect the presence of diabetic retinopathy using a binary logistic regression test.

Predictors	*P*-value	OR	95% CI for OR	
			Lower	Upper
Duration since diagnosis	0.002	8.2	2.2	30.4
Comorbidities	0.176	2.0	0.7	5.5
Education	0.003	22.3	2.9	170.3
Residence	<0.001	6.3	2.1	18.5
HbA1c	<0.001	8.1	2.5	26.3
FBS	<0.001	10.6	3.1	35.6

4. Discussion

This study identified NPDR in 39.8% of both educated and uneducated male and female patients from rural and urban areas aged 30 years and older who attended the Jabir Abu Eliz Diabetes Health Center in Khartoum State. This differs from a previous study conducted in 2017, which reported a prevalence of 72.6% among individuals with type 2 diabetes living in Khartoum State [23].

The results of our study may reflect improvements in the management of NPDR in Sudan. Health education and awareness are essential weapons against DR in resource-limited countries like Sudan. Despite these improvements, the prevalence is still high compared to other countries. For instance, Olafsdottric *et al.* concluded that the frequency of NPDR ranged from 10% to 37% among individuals with diabetes mellitus [27], while in Ethiopia, the frequency of DR among individuals with type II diabetes mellitus was 16% [28]. The predominant age group in this study was 41–50 years, comprising 78 individuals (39.8%). The mean age was 50.1 ± 10.7 years. Additionally, NPDR was significantly associated with the age groups of 41–50 years (36 individuals, 46.2%) and 51–60 years (25 individuals, 32.1%; *P*-value < 0.05). Tsegaw *et al.* in Addis Ababa revealed that the mean age of the patients in their study was 50.4 ± 10.7 years, and the frequency of DR increased over time from the diagnosis of diabetes mellitus [28]. Yakob *et al.* reported a mean age of 34.8 ± 10 years in central and southern Ethiopia [29]. Al Ashoor *et al.* in Iraq reported a higher prevalence of DR occurring in the 50–59 age group [30]. Ahmed *et al.* in Saudi Arabia reported a mean age of 57.3 ± 13.1 years [31]. Wahab *et al.* in Pakistan reported a mean age of 43.2 ± 10.2 years, which was significantly associated with NPDR among diagnosed diabetic patients [32].

In this study, gender was not associated with DR, with 113 females (57.7%) and 83 males (57.7%). The female-to-male ratio was 1.4:1. Furthermore, no significant differences were reported between males and females regarding the frequency of NPDR (*P*-value > 0.05), which is consistent with Awadalla et al., who found that females comprised 50.7% and males 49.3% [23]. Ghaem *et al* showed that NPDR can be associated with hypertension and dyslipidemia. In this study, we demonstrated that NPDR was associated with hypertension and dyslipidemia (*P*-value < 0.05) [33]. High comorbidities raise the prevalence of NPDR. For example, hypertension is identified as a risk factor for DR. This aligns with the findings of previous studies conducted in Iraq, Saudi Arabia, Lebanon, Egypt, South Korea, and China [30, 31, 34–37]. Furthermore, hyperlipidemia is associated with NPDR, which is similar to previous studies conducted in Iraq, India, Pakistan, Oman, and the Netherlands [30, 38–41].

Various studies have indicated that DR correlates with higher HbA1c levels, longer diabetes duration, and cases of uncontrolled diabetes. This research demonstrated a significant link between increased HbA1c and inadequate diabetes management (*P*-value < 0.05) [28, 42].

The duration of diabetes was <5 years in 106 (54.1%), >10 years in 51 (26%), and between 5 and 10 years in 39 (19.9%) individuals in this study. On the other hand, the frequency of diabetic retinopathy was significantly higher among patients with a diabetes duration of >10 years, 38 (48.7%; *P*-value < 0.05). This finding is similar to that of Ghaem *et al.* in Iran, who found that DR was significantly associated with diabetes durations of 10–20 years and >20 years [33]. Al Ashoor *et al.*'s study in Iraq showed a strong association between a diabetes duration of 10–29 years and DR [30]. Salti *et al.* reported a significant association between retinopathy and a diabetes duration of 10 years in Lebanon [35]. Macky *et al.* in Egypt, Kizor-Akaraiwe *et al.* in Nigeria, and Ahmed *et al.* in Saudi Arabia demonstrated that the prevalence of retinopathy is significantly higher in individuals with longer diabetes duration [31, 34, 43]. Moreover, the results of our study are similar to those of a recent study conducted at Jimma University Medical Center in Ethiopia, which indicated that the development of DR is significantly associated with older age and a longer duration of diabetes [44].

Our study revealed that fasting blood glucose levels were high in 110 (56.1%) patients and normal in 86 (43.9%) patients. Moreover, the frequency of NPDR was significantly higher among patients with high levels of FBS, at 68 (87.2%; *P*-value < 0.05). Olafsdottir *et al.* showed that an increase in average FBG was also associated with an increased risk of DR in the Swedish population with type 2 diabetes. Similar to our study, previous studies in Iraq, Saudi Arabia, Lebanon, Egypt, and Jordan have demonstrated that hyperglycemia (measured by HbA1c) is a significant risk factor for the development of DR [30, 31, 34, 35, 45].

The study has some limitations. The cross-sectional design may not allow for establishing a temporal relationship. Furthermore, the results of this study do not apply to all of Sudan, as it was conducted in one center located in the capital, Khartoum. Additional research may be needed to examine the outcomes of intensive therapy with medication or the use of insulin in reducing DR.

5. Conclusion

The study showed that the frequency of DR among patients with type 2 diabetes receiving oral treatment was lower than reported by other local studies but higher than that reported by regional and international studies. Factors such as age, uncontrolled HbA1C%, high fasting blood glucose, and longer duration of diabetes mellitus were significantly associated with the development of DR. Therefore, screening and assessment for DR in individuals with type 2 diabetes should be conducted by a highly qualified and experienced visual care specialist.

Recommendations

Individuals diagnosed with type 2 diabetes should be evaluated and screened for DR by a qualified eye care practitioner (optometrist or ophthalmologist) at the time of diagnosis. The recommended follow-up period for patients showing no or minor retinopathy is 1 to 2 years. The frequency of follow-up evaluations for patients with DR should be adjusted based on the severity of their condition.

The results of eye tests, the follow-up schedule, and the treatment plan must be communicated to all members of the diabetic healthcare team to ensure optimal care.

Declarations

Acknowledgments

None.

Ethical Considerations

Ethical clearance was obtained from the SMSB Ethical Committee FM Council. The patients provided written consent. Participation was voluntary, and the confidentiality of the data collected was ensured.

Competing Interests

The authors declare that the research was conducted without any commercial or financial relationships that could potentially create a conflict of interest.

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Abbreviations and Symbols

NPDR: Non-proliferative diabetic retinopathy

SPSS: Statistical Package for the Social Sciences

DR: Diabetic retinopathy

CI: Confidence interval

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