Original Article

Visual impairment and blindness in diabetic retinopathy

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ABSTRACT

Background: Diabetic retinopathy (DR) is a major microvascular complication of diabetes mellitus (DM) and a leading cause of preventable visual impairment (VI) and blindness worldwide. The rising global prevalence of DM, particularly in low- and middle-income regions such as the Middle East, necessitates the collection of localized data on DR-related VI. Despite growing public health concerns, limited research has been conducted in the Gulf region, including Oman. This study aimed to assess the prevalence and severity of VI associated with DR and identify its key risk factors among patients with types I and II DM in Al Buraimi, Sultanate of Oman.

Methods: A retrospective cross-sectional study was conducted at Buraimi Hospital and Polyclinic in Oman between June 2023 and January 2024. Medical records of patients with type I or II DM and a confirmed diagnosis of DR were reviewed. Best-corrected distance visual acuity was assessed using a Snellen chart, and fundus examinations were performed using both direct and indirect ophthalmoscopy for DR detection and staging. VI was classified according to the WHO criteria. Relevant demographic and clinical data, including age, duration of DM, and duration of DR, were extracted. Coexisting ocular conditions were also documented.

Results: A total of 218 participants were included, with a mean age of 57.5 years; 52.3% (n = 114) were male and 47.7% (n = 104) female. Most participants had no VI (n = 131, 60.1%), whereas mild VI (n = 58, 26.6%) was the most frequent type of VI. A significant association was detected between DR severity and VI levels ($P < 0.01$); blindness occurred only in patients with severe nonproliferative DR (n = 1) and proliferative DR (n = 8). Age and DR duration were significantly associated with increasing VI severity (both $P < 0.05$), with each additional year increasing the odds by 4% and 12%, respectively. No significant association was observed between DM duration and VI severity ($P > 0.05$). Cataract (n = 131) was the most common coexisting ocular condition.

Conclusions: The frequency of VI among patients with DR was relatively high, and its severity was significantly associated with older age and longer DR duration. Blindness occurred only in more severe DR stages, reinforcing the value of early screening and immediate care in mitigating disease severity. These findings indicate the need to optimize resources for early DR management and to promote screening, even in diabetic individuals with normal vision, to prevent disease progression and reduce visual disability. Further community-based research is needed to achieve a robust, practical understanding of the preventable causes of VI, guide national eye health policies, and enhance long-term patient outcomes.

KEYWORDS

diabetic complication, diabetes mellitus, diabetic retinopathies, microaneurysms, low vision, visual impairment, logistic regression, risk factor, odds ratios

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INTRODUCTION

Diabetic retinopathy (DR) is a common microvascular complication of diabetes mellitus (DM) and remains one of the leading causes of preventable visual impairment (VI) and blindness worldwide [1-4]. Chronic hyperglycemia in patients with DM triggers a cascade of metabolic, inflammatory, and vascular changes in the retina, culminating in vision loss [3]. DR is broadly categorized into nonproliferative DR (NPDR) and proliferative DR (PDR), and its progression correlates with an increased risk of visual disability: timely screening and management are essential to mitigate its impact on vision and quality of life [3].

The global burden of DM is escalating. The International Diabetes Federation (IDF) reported 536.6 million people living with DM in 2021, with projections reaching 783.2 million by 2045 [5, 6]. The vast majority reside in low- and middle-income countries [7], where access to screening and treatment remains limited. The Middle East and North Africa (MENA) region accounts for approximately 73 million cases, a number expected to rise to 135.7 million by 2045. In Oman, the current prevalence of DM is estimated to be 11.8%, with increasing life expectancy contributing to a growing number of individuals at risk of DR [8-10].

Prevalence estimates of DR vary widely depending on the geographic region, screening method, and population characteristics. The global prevalence is approximately 34.6% of diabetic patients, with rates ranging from 19.1% in newly diagnosed patients in the UK to over 40% in the USA [10-14]. In Oman, existing studies have shown DR prevalence between 14.5% and 42.2% [15, 16]. The neighboring Gulf countries report similarly high rates, implying a shared regional public health concern [17-22].

DR remains the leading cause of VI and blindness in the working-age population. Global estimates suggest that DR-related VI affects approximately 1.4% and blindness affects 2.5% of individuals with DM [23]. Although numerous studies have addressed DR and its complications in Western populations [24, 25], there is a paucity of research focusing on DR-related VI and its associated risk factors in the Gulf Cooperation Council (GCC) region.

Given this gap, the present study aimed to assess the prevalence of DR-associated VI and to identify its related risk factors among patients with type I or II DM attending Buraimi Hospital and Polyclinic in Al Buraimi Governorate, Sultanate of Oman.

METHODS

This retrospective, cross-sectional, hospital-based study was conducted at the Ophthalmology Department of Buraimi Hospital and Polyclinic, located in the Al Buraimi Governorate, Sultanate of Oman, between June 2023 and January 2024. The study population included all patients diagnosed with type I or II DM along with DR and who attended the outpatient services at these centers during the study period.

This study was approved by the Research Ethics Committee of the University of Buraimi (Ref. No. AY22-23COHS-R11) and the Research Ethical Review and Approval Committee, Ministry of Health, Al Buraimi Governorate (Ref. No. MoH/CSR/23/26671). Written informed consent was obtained from all participants, and the study adhered to the ethical standards of the Declaration of Helsinki.

The inclusion criteria were age >18 years and a diagnosis of type I or II DM and any stage of DR. Patients with coexisting ocular pathologies such as cataracts, glaucoma, retinal detachment, or refractive errors were included based on the World Health Organization (WHO) VI classification [26]. We excluded patients aged <18 years, non-diabetic individuals, and those with cognitive or systemic conditions (e.g., Alzheimer's disease, dementia) that impeded participation.

Medical records of eligible patients were examined, and relevant demographic and clinical data were collected. All participants underwent a comprehensive ophthalmic evaluation, including best-corrected distance visual acuity (BCDVA) using a Snellen chart (Keeler Pro Chart, Keeler, UK) administered by trained optometrists. Visual acuity (VA) was recorded for each eye separately, unaided, with correction, and with a pinhole, at both distance and near.

Retinal examinations were performed using direct and indirect ophthalmoscopy. Direct ophthalmoscopy (Heine Beta 200 ophthalmoscope; Heine Optotechnik GmbH & Co., Gilching, Germany) enabled detailed visualization of the posterior pole, including the optic disc and macula. Indirect ophthalmoscopy was performed using a slit-lamp biomicroscope with a condensing lens (Haag-Streit BX 900 slit-lamp; Koeniz, Switzerland) to

assess peripheral retinal changes such as neovascularization, hemorrhage, or retinal detachment. DR staging followed the International Clinical Disease Severity Scale for DR [27, 28].

VI and blindness were classified according to the WHO criteria: VI was defined as presenting VA in the better-seeing eye between <20/60 and ≥20/400, and blindness as VA <20/400. Further, VI was subclassified as mild (20/40 to 20/60), moderate (20/80 to 20/160), and severe (≤20/200) [26]. DM duration was defined as the time elapsed from the initial diagnosis of DM by a healthcare professional until the date of the first DR screening [29].

To ensure data reliability, the data collection tools were reviewed for content validity by senior clinical experts, and a pretest was conducted on 5% of the sample. Revisions were made accordingly. The principal investigators continuously supervised the data collection to maintain consistency and accuracy.

Data were analyzed using IBM SPSS Statistics for Windows (version 27.0; IBM Corp., Armonk, NY, USA). Descriptive statistics are used to summarize the demographic and clinical characteristics. The normality of continuous data distributions was assessed using the Shapiro–Wilk test. Categorical variables are presented as frequencies and percentages, whereas continuous variables are reported as means with standard deviations (SDs). Associations between the variables were tested using the chi-square test. Ordinal logistic regression analysis was performed to examine the associations between the independent variables (age, DM duration, and DR duration) and the ordinal dependent variable (VI stratified into four levels). Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated to estimate the strength of the associations. A *P*-value less than 0.05 was considered statistically significant.

RESULTS

A total of 218 participants with a mean (SD) age of 57.5 (12.3) years (range, 26–89 years) were included, of whom 52.3% (n = 114) were male and 47.7% (n = 104) were female. The mean (SD) durations of DM and DR were 17.2 (7.0) years (range, 1–41 years) and 5.2 (3.5) years (range, 1–20 years), respectively. The distribution of DR severities among the participants was as follows: mild NPDR, 27.5% (n = 60); moderate NPDR, 13.8% (n = 30); severe NPDR, 11.9% (n = 26); and PDR, 46.8% (n = 102).

Table 1 summarizes the distribution of VI levels among the study participants with types I and II DM. Most individuals had no VI (n = 131, 60.1%), and mild VI was the most frequently observed across all participants (n = 58, 26.6%) and within each type of DM (type I, n = 4 [16.7%]; type II, n= 54 [27.8%]). Blindness was the least common condition among all participants (n = 9, 4.1%) and among those with type II DM (n = 9, 4.6%), whereas moderate VI and blindness were not observed among participants with type I DM. There was no statistically significant difference in the distribution of VI levels between individuals with type I and type II DM ($P > 0.05$) (Table 1).

Table 2 summarizes the frequencies of coexisting ocular conditions observed in the overall study sample and across different levels of VI. Among the 218 participants, 122 (56.0%) had cataract alone, 6 (2.6%) had both cataract and refractive error, 2 (0.9%) had cataract with glaucoma, 18 (8.3%) had refractive error alone, 6 (2.8%) had glaucoma alone, and 62 (28.4%) had no associated ocular conditions.

Table 3 summarizes the distribution of VI levels across different severities of DR. A statistically significant association was observed between DR severity and VI level ($P < 0.01$). Most participants within each DR stage, and across the total sample, had no VI. Mild VI was the most frequently observed level across all severities of DR and in the overall cohort. In contrast, blindness was the least common condition, occurring only in individuals with severe NPDR or PDR. However, severe VI and blindness were not observed in patients with mild or moderate NPDR (Table 3).

Table 4 summarizes the results of ordinal logistic regression analysis examining the associations of age, duration of DM, and duration of DR with VI level. Greater age was significantly associated with an increased severity of VI ($P < 0.05$), with an OR of 1.04, indicating that each additional year of age is associated with a 4% increase in the odds of progression to more severe VI. Similarly, DR duration was significantly associated with VI severity ($P < 0.05$), with an OR of 1.12, suggesting that each additional year of DR increases the odds of more severe VI by 12%. In contrast, no significant association was detected between DM duration and VI severity ($P > 0.05$) (Table 4).

Table 1. Visual impairment in participants with type I or II DM

Level of VI	Type I DM	Type II DM	*P*-value	Total
No VI, n (%)	18 (75.0)	113 (58.3)	0.343	131 (60.1)
Mild VI, n (%)	4 (16.7)	54 (27.8)		58 (26.6)
Moderate VI, n (%)	0 (0.0)	8 (4.1)		8 (3.7)
Severe VI, n (%)	2 (8.3)	10 (5.2)		12 (5.5)
Blindness, n (%)	0 (0.0)	9 (4.6)		9 (4.1)
Total, n (%)	24 (100.0)	194 (100.0)		218 (100.0)

Abbreviations: DM, diabetes mellitus; VI, visual impairment; n, number of participants; %, percentage

Table 2. Coexisting ocular conditions according to level of VI

	Level of VI					
Associated ocular condition	**No VI**	**Mild VI**	**Moderate VI**	**Severe VI**	**Blindness**	**Total**
Cataract alone, n (%)	71 (54.2)	28 (48.3)	8 (100.0)	8 (66.7)	7 (77.8)	122 (56.0)
Cataract and refractive error, n (%)	0 (0.0)	5 (8.6)	0 (0.0)	1 (8.3)	0 (0.0)	6 (2.8)
Cataract and glaucoma, n (%)	1 (0.8)	0 (0.0)	0 (0.0)	0 (0.0)	1 (11.1)	2 (0.9)
Cataract and others, n (%)	0 (0.0)	1 (1.7)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.5)
Refractive error, n (%)	12 (9.2)	5 (8.6)	0 (0.0)	1 (8.3)	0 (0.0)	18 (8.3)
Glaucoma, n (%)	5 (3.8)	1 (1.7)	0 (0.0)	0 (0.0)	0 (0.0)	6 (2.8)
Other, n (%)	1 (0.8)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.5)
None, n (%)	41 (31.3)	18 (31.0)	0 (0.0)	2 (16.7)	1 (11.1)	62 (28.4)
Total, n (%)	131 (100.0)	58 (100.0)	8 (100.0)	12 (100.0)	9 (100.0)	218 (100.0)

Abbreviations: VI, visual impairment; n, number of participants; %, percentage.

Table 3. Distribution of VI levels across the different severities of DR

		Level of VI					*P*-value	
Variable		**No VI**	**Mild VI**	**Moderate VI**	**Severe VI**	**Blindness**		**Total**
Severity of DR	**Mild NPDR**	50 (38.2)	9 (15.5)	1 (12.5)	0 (0.0)	0 (0.0)	**0.001**	60 (27.5)
	Moderate NPDR	17 (13.0)	11 (19.0)	2 (25.0)	0 (0.0)	0 (0.0)		30 (13.8)
	Severe NPDR	17 (13.0)	6 (10.3)	0 (0.0)	2 (16.7)	1 (11.1)		26 (11.9)
	PDR	47 (35.9)	32 (55.2)	5 (62.5)	10 (83.3)	8 (88.9)		102 (46.8)
Total		131 (100.0)	58 (100.0)	8 (100.0)	12 (100.0)	9 (100.0)		218 (100.0)

Abbreviations: VI, visual impairment; DR, diabetic retinopathy; NPDR, non-proliferative diabetic retinopathy; PDR, proliferative diabetic retinopathy; n, number of participants; %, percentage. Note: *P*-value < 0.05 is shown in bold.

Table 4. Associations of age, DM duration, and DR duration with VI level

Variable		OR	*P*-value	95% CI
Threshold values for different levels of VI	**No VI**	-	**< 0.001**	1.79 – 4.65
	Mild VI	-	**< 0.001**	3.28 – 6.30
	Moderate VI	-	**< 0.001**	3.64 – 6.71
	Severe VI	-	**< 0.001**	4.50 – 7.75
Impact of each independent variable on VI	**Age**	1.04	**0.003**	0.02 – 0.07
	DM Duration	0.99	0.657	- 0.06 – 0.04
	DR Duration	1.12	**0.012**	0.02 – 0.20

Abbreviations: DM, diabetes mellitus; DR, diabetic retinopathy; VI, visual impairment; OR, odds ratio; CI, confidence interval. Note: *P*-value < 0.05 are shown in bold.

DISCUSSION

This study identified significant associations of increasing age and longer DR duration with higher severity of VI in patients with DM. Most VI was mild, whereas blindness was relatively rare. No significant difference in VI severity was detected between patients with type I and type II DM, and DR severity was significantly associated with poorer visual outcomes.

Perez-Peralta et al. [30] conducted a hospital-based, cross-sectional study to estimate the prevalence of VI in patients with type II DM. Among the 840 participants, 30% had some degree of VI, and 62% had DR, including 30% with sight-threatening DR and 17% with referable diabetic macular edema. Moderate or worse VI was significantly associated with sight-threatening DR (OR = 9.02), referable diabetic macular edema (OR = 5.89), and cataract (OR = 2.51) [30]. In contrast, our study reported frequencies of 26.6% (n = 58) for mild VI, 3.7% (n = 8) for moderate VI, 5.5% (n = 12) for severe VI, and 4.1% (n = 9) for blindness. The overall VI frequency in our cohort (87 of 218 patients, 39.9%) was slightly higher than that reported by Perez-Peralta et al. [30], which may be attributed to our inclusion of patients with both type I and type II DM and the selection of individuals with DR.

Khandekar et al. [29] conducted a nationwide assessment of DR in Oman and reported a DR prevalence of 14.39% among 5564 registered patients with DM, with higher rates observed in male participants (18.46%) than in female participants (10.2%) and in individuals aged 60–69 years (22.87%). The rates of background DR, PDR, and diabetic maculopathy were 8.65%, 2.66%, and 5.12%, respectively. DR was significantly more common in patients with a longer duration of DM, poorer glycemic control (HbA1c >9%), and comorbidities such as hypertension, nephropathy, and neuropathy. Only 20% of patients for whom laser treatment was recommended had undergone the procedure, highlighting gaps in care [29]. In our study, a significant association was observed between DR duration and VI severity but not between DM duration itself and VI severity. This suggests that the duration of DR may play a more important role in vision loss than the overall duration of DM [29]. Further studies with comparable populations are required to clarify this relationship.

In this study, among individuals with type I DM, most (n = 18; 75%) exhibited no VI, 16.7% (n = 4) had mild VI, and 8.3% (n = 2) had severe VI; however, no cases of moderate VI or blindness were observed. In contrast, among those with type II DM, 58.3% (n = 113) had no VI, 27.8% (n = 54) had mild VI, 4.1% (n = 8) had moderate VI, and 5.2% (n = 10) had severe VI. Additionally, blindness was documented in 4.6% (n = 9) of participants with type II DM. VI was more common among patients with type II DM, which may reflect the rising burden of type II DM in Oman [31], necessitating proactive public health strategies to prevent type II DM and its ocular complications.

Cataract surgery may exacerbate DR progression [32, 33]. Ocular comorbidities associated with DR in this study included cataract, refractive error, glaucoma, and retinal detachment. Among these, cataract alone or coexisting with other ocular conditions was the most frequently observed comorbidity, with DR detected in 131 (60.1%) individuals. In our cohort, VI attributed solely to cataract was identified in 122 (56.0%) patients. Additionally, 6 patients (2.8%) had cataract and refractive error, 2 (0.9%) had cataract and glaucoma, 18 (8.3%) had refractive error alone, and 6 (2.8%) had glaucoma alone. The frequencies of VI in this study were as follows: mild VI in 58 patients (26.6%), moderate VI in 8 (3.7%), and severe VI in 12 (5.5%). The frequency of blindness was 4.1% (n = 9). Regarding DR severity, 60 (27.5%) participants had mild NPDR, 30 (13.8%) had moderate NPDR, 26 (11.9%) had severe NPDR, and 102 (46.8%) had PDR. Moreover, VI severity was more pronounced among patients with PDR, indicating a substantial visual burden of advanced DR in the Omani population. A retrospective study by Harb et al. [34] conducted at the Clinique du Levant in Lebanon reported that 24.6% of patients with type II DM had DR at their first ophthalmologic visit, with 8.9% presenting with PDR and 16.7% with macular edema, including 6.2% with severe forms. Moreover, 44.1% had VI based on Snellen chart testing, with 11.2% classified as severe [34], which is less than that in our study. These findings highlight the urgent need for effective screening [35], early diagnosis, and timely intervention for DR and its complications in Oman. Further longitudinal, hospital-based studies across multiple provinces in Oman are recommended to further assess the burden and progression of DR-related VI and to guide national eye health strategies.

The strengths of the current study include the well-defined clinical population and comprehensive ophthalmic assessments using standardized WHO and DR classification criteria. The findings contribute to our knowledge of DR-related VI patterns in Oman, a region with limited existing data. However, as this was a retrospective hospital-based study, selection bias and an underestimated number of undiagnosed cases may limit its generalizability. Further prospective, community-based studies with larger and more diverse participant groups are required to validate these findings and inform targeted screening and intervention strategies throughout the region.

CONCLUSIONS

We observed that VI had a considerable impact on patients with DM and DR in Al-Buraimi, Oman. Increased age and longer DR duration were significantly associated with greater VI severity, whereas blindness occurred exclusively in advanced DR stages, highlighting a vital need for early detection and timely management of DR to prevent irreversible vision loss. The predominance of cataract as a comorbid condition further emphasizes the need for integrated ocular care. Given the increasing prevalence of DM in Oman and the Gulf region, targeted screening and public health strategies are essential to mitigate the visual consequences of DR. Further community-based studies are warranted to provide a more robust, practical perspective on this preventable cause of VI, inform national eye health policies, and improve long-term outcomes.

ETHICAL DECLARATIONS

Ethical approval: This study was approved by the Research Ethics Committee of the University of Buraimi (Ref. No. AY22-23COHS-R11) and the Research Ethical Review and Approval Committee, Ministry of Health, Al Buraimi Governorate (Ref. No. MoH/CSR/23/26671). Written informed consent was obtained from all participants, and the study adhered to the ethical standards of the Declaration of Helsinki.

Conflict of interest: None.

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