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ORIGINAL RESEARCH

Prevalence and Factors Associated with Diabetic Retinopathy among Adult Diabetes Patients in Southeast Ethiopia: A Hospital-Based Cross-Sectional Study

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Background: Diabetic retinopathy (DR) is the most prevalent microvascular consequence of diabetes mellitus, and it can result in blindness that is irreversible. Due to delayed diagnosis and limited access to diabetic care, the situation is even worse in developing countries. Scientific evidence on the prevalence of DR and its associated factors among diabetes patients in low-income countries, such as Ethiopia, is limited. This study aimed to determine the prevalence of DR and associated factors among adult diabetes patients in southeast Ethiopia.

Methods: A hospital-based cross-sectional study was conducted among diabetes patients who visited Madda Walabu University Goba Referral Hospital. Fundus and slit-lamp examination were performed for screening of DR. Multivariate binary logistic regression was computed to identify factors associated with DR.

Results: A total of 256 patients (144 men, 56.2%) aged 50.15±15.71 years were included in the study. The prevalence of any DR was 19.9% (95% CI 15.4%–25.3%), mild nonproliferative diabetic retinopathy (NPDR) 10.9% (95% CI 7.6%–15.4%), moderate NPDR 5.9% (95% CI 3.5%–9.5%), severe NPDR 0.9% (95% CI 0.2%–3.9%), and proliferative DR 2.3% (95% CI 1.0%–5.1%). Duration of diabetes ≥10 years (AOR 10.22, 95% CI 1.70–61.44), central obesity (AOR 5.42, 95% CI 1.38–21.19), overweight/obese (AOR 2.65, 95% CI 1.02–6.92), lower high-density lipoprotein (HDL) cholesterol (AOR 5.82, 95% CI 1.86–18.24), moderate triglyceride:HDL cholesterol ratio (AOR 4.13, 95% CI 1.13–15.15), and urban dwelling (AOR 2.84, 95% CI 1.04–7.78) were significantly associated with DR.

Conclusion: One in every five DM patients had DR. Sociodemographic, anthropometric, and blood lipids were independently associated with DR. To reduce the burden of diabetes, strategies that focus on lifestyle modifications targeted at identified modifiable risk factors are essential.

Keywords: diabetes mellitus, diabetic retinopathy, Ethiopia

Background

Diabetes mellitus (DM) describes a group of metabolic disorders characterized by high blood sugar levels.[1] The global prevalence of DM has increased in recent decades, and this trend is expected to continue.[2,3] According to the latest estimates from the International Diabetes Federation (IDF), 463 million people are living with DM worldwide, a figure

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that is set to reach 700 million by 2045, representing a 51% increase.[2] The number of people with DM in the IDF Africa region is projected to have the highest increase of all regions by 2045.[2]

DM patients are at risk of developing a number of serious life-threatening health problems and microvascular complications, such as diabetic retinopathy (DR).[1] This is one of the serious complications of DM.[4,5] It is caused by long-term exposure to metabolic changes associated with DM, which cause damage to the retina's microvasculature.[4] The global burden of DR was estimated to be 103.12 million in 2020, and is expected to rise to 160.50 million by 2045, with low- and middle-income nations bearing a disproportionate share of the burden.[5] DM is the leading cause of blindness, atraumatic lower-limb amputation, and chronic renal failure. According to the Global Burden of Disease 2019 study, DR was the fifth-leading cause of blindness and vision impairment worldwide.[6]

DR falls into two main classes: nonproliferative (NPDR) and proliferative (PDR).[7] NPDR refers to the absence or presence of abnormal new blood vessels emanating from the retina. PDR is the more advanced form of the disease, where circulation problems deprive the retina of oxygen.[4,7] Without treatment, almost 50% of diabetic patients with PDR will become blind within 5 years.[8]

Sub-Saharan Africa faces a rampant increase in DM prevalence.[9] This will inevitably cause an increase in DM-associated complications. The predominant complications are blindness due to DR and diabetic cataracts.[8,10] In DM clinic-based surveys, the reported prevalence of DR was 7.0%–62.4%.[8] Population-based studies have also identified high DR prevalence of 35.9% in Kenya,[11] 20.5% in Nigeria,[12] and 17.9% in Egypt.[13] Despite yearly eye examinations reducing blindness by >95%, compliance with annual eye examinations remains 50% or less in African countries, including Ethiopia.[14]

Ethiopia is among the top four sub-Saharan Africa countries with the highest diabetic populations and with steadily increasing severe DM-related eye complications, such as DR.[15–17] Clinic-based studies have reported prevalence of DR of 13%–42.2%,[18–21] with pooled prevalence of 19.48%.[15] Numerous risk factors have been associated with DR, including age,[18,21] DM duration,[18,21] hypertension,[18,20,22] poor adherence to medication,[22] poor glycemic control,[22,23] and obesity.[24]

Despite the increasing prevalence of DR in Ethiopia, studies on the disease's prevalence and risk factors remain limited in different parts of the country.[15] A majority of those have been in northwest Ethiopia.[19–21,25,26] In addition, a considerable number of diabetic patients in Ethiopia have either poor knowledge about DM-related eye complications[26] or inadequate glycemic control,[27–30] which increases the risk of developing DR. As DM and DR become more prevalent in Ethiopia, it is important that strategies are developed to enable the early detection and adequate management of this emerging epidemic. Additionally, a complete understanding of the scope of DR is required to prevent vision loss and control early-DM eye complications in the study setting. The purpose of the current study was thus to determine the prevalence of DR and associated factors among DM patients in southeast Ethiopia.

Methods

Study Design and Setting

A hospital-based cross-sectional study was conducted from June 1 to July 30, 2021 in the chronic Follow-up and ophthalmology units of Madda Walabu University Goba Referral Hospital in southeast Ethiopia. Goba Referral Hospital is the only referral hospital in Bale and East Bale zones, providing service for an estimated population of 1.5 million. On average, >115,442 patients receive inpatient and outpatient service annually. At the time of data collection, on average 1,422 diabetic patients received follow-up in the hospital. The hospital also serves as the headquarters for the Bale Zone Diabetic Association.

Population and Eligibility

The source population was all diabetic patients age ≥18 years who had been diagnosed with any type of DM and receiving regular follow-up at the chronic follow-up clinic. Patients who were critically ill and consequently unable to give informed consent for participation, had no perception of light in either eye, or had media opacity that obscured the view of their retina were excluded from the study.

Sample-Size Determination and Sampling Procedure

Sample size was determined using a single population–proportion formula considering parameters of prevalence of DR of 29.9%[25] and taking into consideration a 5% margin of error, 95% CI, and a possible 10% nonresponse (p=29.9%, n=354). Since the source population was <10,000 we used a correction formula accordingly — $nf = \frac{ni}{1+\frac{ni}{N}} = \frac{352}{1+\frac{352}{1422}}$ — and the overall sample size was 283. We used consecutive sampling to include study participants following the predefined eligibility criteria. To avoid double-counting of cases, identifiers for interview participants were documented each day, and any patient arriving at the DM clinic on a specific day was cross-checked with the document before the interview.

Study Variables

Dependent Variable

Prevalence of DR.

Independent Variables

Sociodemographic variables: age, sex, education, residence, family history of DM, member of DM association.

Behavioral, clinical, and DM care–related characteristics: type of DM, duration of DM, duration of DM medication, comorbidities, blood pressure (BP), fasting plasma blood glucose level, type of antidiabetic agents taken, knowledge about DR, glaucoma, regular exercise, and history of eye examinations.

Anthropometric measurement-related variables: central obesity, waist circumference, waist:hip ratio, and body-mass index (BMI).

Lipid profile-related variables: metabolic syndrome, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol, TG:HDL cholesterol ratio, and total cholesterol (TC).

Measurements and Tools

An interviewer-administered structured questionnaire and eye-examination form were used to collect information pertaining to sociodemographic, behavioral, clinical, and DM care–related characteristics of respondents. The data-collection tools were developed by reviewing theoretical considerations and related literature. The questionnaire was first prepared in English and translated into Amharic and Afan Oromo, then translated back into English to make sure the data-collection tools were clear, understandable, and consistent.

Four senior data collectors (two optometrists and two nurses) were recruited from the ophthalmology unit. In addition, two senior health professionals were assigned to supervise the overall data-collection process along with the principal investigator. One day's training was given to all data collectors on procedures. After collection of basic sociodemographic and clinical-related variables, ophthalmological evaluation was performed.

Eye Examination

The Snellen chart, slit-lamp microscopy, a Volk 90D, and direct ophthalmoscopy were used to ascertain visual acuity and DR status of patients. Retinal examination was carried out with a 90 D Volk lens with a slit-lamp biomicroscope by a trained senior optometrist after pupillary dilation had been done using 1% tropicamide eyedrops on both eyes. The anterior segment was assessed using the slit-lamp biomicroscope. Intraocular pressure was measured by Goldman tonometry. Presenting visual acuity was measured using projection charts placed at 6 m from the patient. Depending upon the smallest line that the patient could read, vision was recorded as 6/9, 6/12, 6/18, 6/24, 6/36, and 6/60. The presence of retinopathy was assessed using slit-lamp microscopy, the Volk 90D and direct ophthalmoscopy examination after dilating the pupils. DR was clinically graded according to disease severity. We used the Early Treatment Diabetic Retinopathy Study terminology scale: no apparent retinopathy, mild, moderate, or severe NPDR, and PDR. Cleanliness of hands and sterility of eye-examination instruments was ensured before each eye examination to reduce infection transmission.

Anthropometric Measurements

Weight was measured using electronic digital scale on a firm flat surface after the participant had removed their footwear and any heavy clothes and emptied their pockets. Height was measured with a portable height-measuring board by positioning the board

on a firm surface against a wall. After the participant had removed their footwear, they stood with feet together facing data the collector with eyes level with ears. We measured height in centimeters to the nearest millimeter. Waist circumference was measured with a constant-tension tape at the end of a normal expiration with the arms relaxed at the sides at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest (hip bone). We read the measurement at the level of the tape to the nearest millimeter, making sure to keep the measuring tape snug but not tight enough to cause compression of the skin. Hip circumference was measured with the tape with arms relaxed at the sides at the maximum circumference over the buttocks to the nearest millimeter. Classifications followed WHO guidelines. Accordingly, BMI was calculated as weight in kilograms divided by height in meters squared: underweight <18.5, normal weight 18.5–24.9, overweight 25–29.99, and obese ≥30. Central obesity was classified as waist circumference >102 cm for men and >88 cm for women or waist:hip ratio of >0.9 for men and >0.85 for women.[31]

Blood Pressure

BP was measured from the right brachial artery with a standard mercury sphygmomanometer in the sitting position after 5 minutes of rest. BP measurements were performed to the nearest 2 mmHg. Three consecutive BP measurements were taken. The average of these three measurements was used in the analysis. Hypertension was defined as systolic BP (SBP) >140 mmHg, diastolic BP (DBP) >90 mmHg, or current use of antihypertensive medication.[32,33]

Blood Sugar Level and Blood Lipid Profiles

Blood samples for lipids and glucose were taken in the morning after fasting for at least 12 hours. Fasting antecubital venous blood was sampled to measure serum glucose and lipid profiles. Serum levels of fasting glucose, triglycerides (TGs), TC, HDL cholesterol, and LDL cholesterol were measured using a Hitachi 7600 automatic biochemical analyzer: raised TGs ≥150 mg/dL and reduced HDL cholesterol <40 mg/dL in men <50 mg/dL in women. A fasting blood sugar level <100 mg/dL is normal and >100 mg/dL is considered high.[34]

Metabolic Syndrome

Metabolic syndrome was determined according to the criteria of the IDF: central obesity defined as waist circumference ≥94 cm for men and ≥80 cm for women plus any two of the following four factors: raised TGs (≥150 mg/dL), reduced HDL cholesterol (for men <40 mg/dL and for women <50 mg/dL), raised BP (SBP ≥130 mmHg or DBP ≥85 mmHg, or treatment of previously diagnosed hypertension), raised fasting plasma glucose (≥100 mg/dL or previously diagnosed type 2 DM).[35]

Knowledge about DR

A composite score was constructed using six questionnaire items to compute overall knowledge score. Patients who answered all six questions correctly were considered to have good knowledge, otherwise poor.[7,24]

Member of DM Association

DM associations work to empower diabetic patients, their families, and the general public by providing current information on DM prevention, care, and treatment. They advocate for members to have access to free health care and anti-DM medications.

Operational Definitions

DR was classified into PDR and NPDR groups. NPDR was divided into mild, moderate, and severe.

No apparent retinopathy: no abnormalities.

Mild NPDR: microaneurysm only (one or more).

Moderate NPDR: more than just microaneurysms, but less than severe NPDR (microaneurysm, dot and blot hemorrhage, cotton-wool spot, venous beading, arteriolar narrowing, intraretinal microvascular abnormalities).

Severe NPDR: >20 intraretinal hemorrhages in four 4 quadrants, definite venous beading in two quadrants, prominent intraretinal microvascular abnormalities in one quadrant, or no signs of PDR.

PDR: one or both of neovascularization and vitreous/preretinal hemorrhage.

Data Processing and Analysis

After data collection, each questioner was checked manually for completeness and data were entered into EpiData Manager version 4.6.0.2 and exported to Stata version 14 for data analysis. Before data analysis, data exploration was carried out on the extent of outliers and missing values, and model fitness was checked. Primarily descriptive statistics (frequency, percentage, and mean) were computed to describe the characteristics of study participants. Both bivariate and multivariate binary logistic regression was performed. Variables in the bivariate logistic regression analysis with $p<0.25$ were included in the final model to identify factors showing significant associations with DR. Multicollinearity was checked using SE. Variables with a standard error ≥2 were dropped from the multivariate analysis. A receiver-operating characteristic curve was used to illustrate model performance. The Hosmer–Lemeshow goodness-of-fit test was used check model fitness (p=0.984). Finally, AORs with 95% CIs were calculated to indicate the direction and strength of associations.

Results

A total of 256 DM patients were included in our study, with a response rate of 90.4%. Of these, 112 (43.75%) were women. Mean age was 50.15±15.71 years, 16.41% were employed, 34.4% had attended primary education, and 68.7% were urban residents (Table 1). Table 2 indicates the behavioral, clinical, and DM care–related characteristics of respondents. Half (51.2%) of them had some form of comorbidity, and a majority (78.6%) had a history of hypertension. Half (50%) used insulin, while 43.3% took oral hypoglycemic agents for DM treatment. Close to two-thirds (57%) reported that they checked their glucose level monthly.

Blood Pressure and Anthropometric Measurement-Related Variables

Almost two-fifths (42.5%) of respondents' BMI was normal and 39.1% were overweight/obese. Regarding waist circumference, 56.3% and 82.1% of male and female study participants had ≥94 cm and ≥80 cm, respectively. Overall, 67.6% of DM patients had high waist circumference and were at risk of metabolic complications (Table 3).

Lipid Profile

Mean fasting blood glucose was 194.08±72.95 mg/dL, and 216 (84.4%) had raised TGs. A total of 81 (31.6%) were at risk with respect to HDL. More than half (54.7%) had metabolic syndrome (Table 4).

Knowledge about Diabetic Retinopathy

A composite score was constructed using the six items to compute the overall knowledge score of study participants about DR. Overall, 179 (69.9%) of had poor knowledge about DR (Table 5).

Presence of Diabetic Retinopathy

In all, 28 (10.94%), 14 (5.47%), three (1.17%), and two (0.78%) of them had mild NPDR, moderate NPDR, severe NPDR, and PDR, respectively (right eye). For the left eye, 23 (8.98%), 16 (6.25%), two (0.78%), and five (1.95%) had mild NPDR, moderate NPDR, severe NPDR, and PDR, respectively. The overall prevalence of DR among DM patients was 19.9% (95% CI 15.4%–25.3%). The prevalence of low vision among DM patients was 11.7% in right, left, or both eyes. The burden of severe visual impairment was 13.3% and 12.1% in the right and left eye, respectively (Table 6).

Factors Associated with Diabetic Retinopathy

On bivariate logistic regression analysis, presence of DR had statistically significant associations with duration of DM and duration of DM medication (Table 7). Variables with $p<0.25$ on bivariate logistic analysis and clinically significant confounders were included in the multivariate logistic regression model. Before we analyzed the multivariate model, we checked for outliers and removed any values with standardized residuals >2.58. Further, we checked for any multi-collinearity effect. Figure 1 illustrates the ability of the final model to predict diagnosed DR.

Table 1 Sociodemographic characteristics of patients (n=256)

Variables		n	%
Age, years	<40	66	25.8
	≥40	190	74.2
Sex	Male	144	56.2
	Female	112	43.8
Occupation	Unemployed	13	5.1
	Employed	42	16.4
	Merchant	27	10.5
	House servant	67	26.2
	Daily laborer	4	1.6
	Retired	52	20.3
	Farmer	34	13.3
	Other	17	6.6
Education	None	41	16.0
	Primary	88	34.4
	Secondary	60	23.4
	College and above	67	26.2
Marital status	Married	191	74.6
	Divorced	18	7.0
	Widowed	22	8.6
	Single	25	9.8
Residence	Urban	176	68.7
	Rural	80	31.3
Family history of DM	Yes	59	23.1
	No	197	76.9
Member of DM association	Yes	152	59.4
	No	104	40.6

In the final model, the odds of developing DR among urban dwellers were 2.84 times those (95% CI 1.04–7.78) those of rural dwellers. The odds of developing DR among those who had longer DM duration (≥10 years) was tenfold that (AOR 10.22, 95% CI 1.70–61.44) of their counterparts. Participants with central obesity had a higher likelihood of developing DR than their counterparts (AOR 5.42, 95% CI 1.38–21.19). The likelihood of developing DR were higher in overweight/obese diabetic patients than those with normal BMI (AOR 2.65, 95% CI 1.02–6.92). The likelihood of developing DR among patients with lower HDL was almost six times (AOR 5.82, 95% CI 1.86–18.24) that of their counterparts. The likelihood of developing DR among patients who had moderate TG:HDL ratio were four times (AOR 4.13, 95% CI 1.13–15.15) that of those with optimal ratio (Table 8).

Table 2 Behavioral, clinical, and diabetes care–related characteristics (n=256)

Variables		n	%
Duration of DM, years	<5	108	42.2
	5–10	77	30.1
	11–15	36	34.1
	>15	35	13.7
Duration of DM medication, years (n=245)	<5	106	43.3
	5–10	79	32.2
	>10	60	24.5
Medication used (n=254)	Insulin	127	50.0
	Oral hypoglycemic	110	43.3
	Both	17	6.7
Complications experienced (multiple answers possible)	Erectile dysfunction	90	35.4
	Hypoglycemia	91	35.8
	Weakness	168	66.1
	Dry mouth	121	47.6
	Other	3	1.2
Blood sugar measurement	Daily	7	2.7
	Weekly	36	14.1
	Monthly	146	57.0
	Only on follow up	56	21.9
	During experience Complications	11	4.3
Comorbidities	Yes	131	51.2
	No	125	48.8
Type of comorbidity (multiple answers possible)	High blood pressure	103	78.6
	Heart disease	17	12.9
	Kidney disease	29	22.1
	Other (asthma, back pain, HIV, and TB)	19	7.4
Have glucometer at home	Yes	76	29.7
	No	180	70.3
Check visual status at least every 6 months	Yes	60	23.4
	No	196	76.6
Take medication regularly	Yes	218	85.2
	No	38	14.8

(*Continued*)

Table 2 (Continued).

Variables		n	%
Ever smoked cigarettes	Yes	44	17.2
	No	212	82.8
Ever drunk alcohol	Yes	57	22.3
	No	199	77.7
Ever chewedkhata	Yes	44	17.2
	No	212	82.8
Use of salt in food	Yes	179	69.9
	No	77	30.1
Fruit or vegetables in meals	Yes	242	94.5
	No	14	5.5
Fruit intake (n=242)	Daily	33	13.6
	5–6 days per week	14	5.8
	3–4 days per week	100	41.3
	1–2 days per week	95	39.4
Eat animal fat	Yes	63	24.6
	No	193	75.4
Perform regular exercise	Yes	175	68.4
	No	81	31.6

Notes: [a]Khat is a flowering plant native to eastern and southern Africa. Khat contains the alkaloid cathinone, a stimulant, which is said to cause excitement, loss of appetite, and euphoria.

Discussion

The purpose of thisy was to determine the prevalence of DR and associated factors among DM patients. The overall prevalence of DR among DM patients attending Madda Walabu University Goba Referral Hospital was found to be 19.9%. We found that place of residence, longer DM duration, abdominal obesity, overweight/obesity, and lower HDL were important factors associated with DR.

The prevalence of DR was in line with other studies conducted in Ethiopia, such as in Addis Ababa (18.57%),[36] and Debre Markos (18.9%).[20] This finding is also comparable with the national pooled estimate of 19.48%[15] and a recent study from Egypt (17.9%).[13] However, it is higher than that reported in studies conducted in Ethiopia and elsewhere: 13% in Arbaminch General Hospital, south Ethiopia,[18] 13.7% in Debre Tabor General Hospital, Northwest, Ethiopia,[19] and 8.3% in Nepal.[37] The discrepancy could be attributable to differences in study settings, methods, and duration of DM. For instance, the method of data collection used in Arbaminch General Hospital was retrospective record review. However, our study used primary data collection. In the case of Debre Tabor General Hospital, a majority of the participants (53.3% vs 25%) had type 1 DM.[19] This can also be explained by the fact that type 1 is more common in younger individuals and type 2 more common in older ones, in whom microvascular complication is more common.

Additionally, our finding was lower than other related studies conducted in Ethiopia. For instance, a study conducted in Gondar Comprehensive Specialized Hospital reported a prevalence of DR was 29.9%,[25] with 41.4% in Jimma University Hospital, southwest Ethiopia,[38] 42.2% in Gondar Tertiary Eye Care and Training Center, northwest Ethiopia,[21] and 31.4% at Debre Tabor General Hospital, northwest Ethiopia.[23] Studies conducted elsewhere have also

Table 3 Blood pressure and anthropometric measurement-related variables (n=256)

Variables		n	%
Diastolic blood pressure	<90 mmHg	185	72.3
	≥90 mmHg	71	27.7
Systolic blood pressure	<140 mmHg	159	62.1
	≥140 mmHg	97	37.9
High blood pressure	Uncontrolled	51	19.9
	Controlled	205	80.1
BMI (kg/m^2)	Underweight (<18.5)	11	4.3
	Normal weight (18.5–4.9)	109	42.5
	Overweight (25–29.9)	100	39.1
	Obese ≥30	36	14.1
Waist circumference for both sexes	High	173	67.6
	Normal	83	32.4
Waist:hip ratio for both sexes	High	218	85.2
	Low	38	14.8
Waist:height ratio	≤0.5 cm	56	21.9
	>0.5 cm	200	78.1

Table 4 Lipid profiles (n=256)

Variables	Mean ± SD	Category	n	%
Triglycerides	208.49±66.91	≥150 mg/dL	216	84.4
		<150 mg/dL	40	15.6
Fasting plasma glucose	194.80±72.95	>100 mg/dL	246	96.1
		≤100 mg/dL	10	3.9
HDL cholesterol(men, n=144)	52.01±25.97	<40 mg/dL	26	18.1
		≥40 mg/dL	118	81.9
HDL cholesterol(women, n=112)	46.07±28.33	<50 mg/dL	55	49.1
		≥50 mg/dL	57	50.9
HDL cholesterol#	55.75±24.17	At risk	81	31.6
		Desirable	175	68.4
LDL cholesterol	76.01±39.56	<130 mg/dL	232	90.6
		130–159 mg/dL	9	3.5
		≥160 mg/dL	15	5.9

(*Continued*)

Table 4 (Continued).

Variables	Mean ± SD	Category	n	%
TG:HDL cholesterolratio		<3	69	26.9
		3.1–3.8	45	17.6
		>3.8	142	55.5
LDL:HDL cholesterol ratio		<2.5	219	85.5
		2.5–3.3	16	6.3
		>3.3	21	8.2
VLDL cholesterol	41.69±13.38	2–30 mg/dL	40	15.6
		>30 mg/dL	216	84.4
Total cholesterol	197.53±63.20	<200 mg/dL	203	79.3
		200–239 mg/dL	27	10.5
		≥240 mg/dL	26	10.2
Non–HDL cholesterol	117.71±43.56	<130 mg/dL	182	71.1
		130–159 mg/dL	40	15.6
		>159 mg/dL	34	13.3
Metabolic syndrome		Yes	140	54.7
		No	116	45.3

Notes: [#]<40 mg/dL in men and <50 mg/dL in women.

Table 5 Knowledge about diabetic retinopathy and history of DM-related eye examination (n=256)

Variables		n	%
Heard about DM-related eye disease	Yes	204	79.7
	No	52	20.3
Ever had DM-related eye checkup	Yes	77	30.1
	No	179	69.9
Received medical advice on DM eye complications from doctors	Always	29	11.3
	Sometimes	73	28.5
	Occasionally	79	30.8
	Not received at all	75	29.3
Do you think diabetic patients are at risk of developing diabetic eye complications?	Yes	200	78.1
	No	32	12.5
	I do not know	24	9.4

(*Continued*)

Table 5 (Continued).

Variables		n	%
Do you think uncontrolled diabetes can lead to blindness?	Yes	186	72.7
	No	25	9.8
	I do not know	45	17.5
Do you think the longer a person has diabetes, the more likely it is that they will develop DR?	Yes	181	70.1
	No	28	10.9
	I do not know	47	18.4
Do you think dietary control and lifestyle modifications, such as regular exercise, cessation of smoking, and better control of blood sugar, are important to prevent DR?	Yes	169	66.0
	No	22	8.6
	I do not know	65	25.4
Do you think regular eye checkups at least every 6 months are necessary to prevent diabetic retinopathy?	Yes	128	50.0
	No	76	29.7
	I do not know	52	20.3
Do you think one of the symptoms of diabetic eye disease is blurred vision, seeing spots or floating black dots/lines in the eye, and difficulty seeing well at night?	Yes	147	57.4
	No	43	16.8
	I do not know	66	25.8
Overall knowledge about DR	Good	77	30.1
	Poor	179	69.9

Table 6 Presences of diabetic retinopathy and other eye diseases (n=256)

Variables		n	Prevalence, %
Presence of retinopathy in one/both eyes			
	No apparent retinopathy	205	80.1 (95% CI 74.7–84.5)
	Mild NPDR	28	10.9 (95% CI 7.6–15.4)
	Moderate NPDR	15	5.9 (95% CI 3.5–9.5)
	Severe NPDR	2	0.9 (95% CI 0.2–3.9)
	PDR	6	2.3 (95% CI 1.0–5.1)
Proportion of diabetic retinopathy in one/both eyes (n=51)			
	Mild NPDR	28	54.9 (95% CI 40.7–68.3)
	Moderate NPDR	15	29.4 (95% CI 18.2–43.7)
	Severe NPDR	3	5.9 (95% CI1.8–17.3)
	PDR	5	9.8 (95% CI 4.0–22.1)

(*Continued*)

Table 6 (Continued).

Variables		n	Prevalence, %
Any diabetic retinopathy			
	Yes	51	19.9 (95% CI 15.4–25.3)
	No	205	80.1 (95% CI 74.6–84.5)
Any maculopathy			
	Yes	10	3.9 (95% CI 2.1–7.1)
	No	246	96.1 (95% CI 92.8–97.9)
Presence of glaucoma			
	Yes	14	5.5 (95% CI 1.4–9.1)
	No	242	94.5 (95% CI 90.4–96.7)
Age-related macular degeneration			
	Yes	19	7.4 (95% CI 4.7–11.4)
	No	237	92.6 (88.6–95.2)
Refractive errors			
	Yes	8	3.1 (95% CI 1.2–6.1)
	No	248	96.9 (95% CI 93.8–98.4)

Table 7 Bivariate binary logistic regression analysis of diabetic retinopathy and exposure

Variables		Diabetic retinopathy		Unadjusted OR (95% CI)	*p*
		Yes	No		
Age, years	<40	10	56	1	
	≥40	41	149	1.54 (0.72–3.28)	0.263
Sex	Male	28	116	1	
	Female	23	89	1.07 (0.58,1.98)	0.828
Education	None	6	35	0.87 (0.29,2.57)	0.805
	Primary	21	67	1.59 (0.71,3.59)	0.259
	Secondary	13	47	1.41 (0.58, 3.43)	0.452
	College and above	11	56	1	
Residence	Urban	37	139	1.33 (0.63,2.82)	0.445
	Rural	14	66	1	
Family history of DM	Yes	12	47	1	
	No	39	158	0.96 (0.47,1.99)	0.927
Member of DM association	Yes	35	117	1	
	No	16	88	0.61 (0.32,1.17)	0.135

(*Continued*)

Table 7 (Continued).

Variables		Diabetic retinopathy		Unadjusted OR (95% CI)	*p*
		Yes	No		
Type of DM	1	11	53	1	
	2	40	152	1.27 (0.61,2.65)	0.528
Duration of DM	<10 year	22	163	1	
	≥10 year	29	42	5.11 (2.67,9.79)*	<0.001
Duration of DM medication (n=245)	≤10	25	160	1	
	>10	26	34	4.89 (2.52, 9.49)*	<0.001
Central obesity	Yes	38	135	1.51 (0.76,3.03)	0.239
	No	13	70	1	
Knowledge	Good	15	36	1	
	Poor	62	143	1.04 (0.53,2.04)	0.908
Waist circumference for both sexes	High	38	135	1.51 (0.76,3.03)	0.239
	Normal	13	70	1	
Waist:hip ratio	Low	6	32	1	
	High	45	173	1.38 (0.54–3.52)	0.491
Comorbidities	Yes	29	102	1.33 (0.72,2.46)	0.364
	No	22	103	1	
BMI	Overweight/obese	23	97	0.91 (0.49, 1.69)	0.776
	Normal	28	108	1	
Metabolic syndrome	Yes	23	93	1.32 (0.68–2.57)	0.412
	No	19	107	1	
HDL cholesterol	Desirable	30	145	1	
	Lower	21	60	1.69 (0.89–3.19)	0.104
LDL cholesterol	Optimal	46	186	1	
	High	5	19	1.06 (0.38–3.00)	0.907
Ratio of TGs to HDL cholesterol	<3 mg/dL	9	60	1	
	3.1–3.8 mg/dL	13	32	2.71 (1.04–7.02)*	0.040
	>3.8 mg/dL	29	113	1.71 (0.76–3.84)	0.194
Total cholesterol	<200 mg/dL	40	163	1	
	200–239 mg/dL	7	20	1.42 (0.56–3.60)	0.228
	≥240 mg/dL	4	22	0.74 (0.24–2.27)	0.572
Glaucoma	Yes	2	12	0.80 (0.17–3.73)	0.781
	No	40	193	1	

(*Continued*)

Table 7 (Continued).

Variables		Diabetic retinopathy		Unadjusted OR (95% CI)	*p*
		Yes	No		
Regular exercise	Yes	30	138	1.21 (0.58–2.52)	0.603
	No	12	67	1	
Eye checkup every 6 months	Yes	10	49	1	
	No	31	156	1.01 (0.46–2.19)	0.990

Note: *$p<0.05$ (crude).

reported higher prevalence of DR: China 27.9%,[39] Cameroon 40.3%,[40] Zimbabwe 28.4%,[41] southern Iran 56.9%,[42] and Khartoum 82.6%.[43] Possible reasons for this inconsistency may be variations in population characteristics and design; the Khartoum study was population-based study,[43] and the one from China was multihospital-based.[39] It may also be due to differences in duration of DM, level of control of DM, age of subjects, differences in health-care facilities, and the quality of care provided to patients. The high prevalence of DR noted in our study was possibly due to longer DM duration, which is associated with DR.

In the current study, the odds of developing DR among urban-dwellers were higher than rural dwellers. This could be attributable to a lifestyle difference between the two populations, with rural residents working longer days with significantly more physical activity in the Ethiopian context. Our data also revealed that some risk factors, such as obesity, were significantly higher in urban dwellers than in rural dwellers (73.9% vs 26.01%, $p=0.009$). As a result, rural patients were less likely than urban patients to develop DR and other microvascular complications. In contrast, studies conducted in India[44] and China[45,46] reported that DM patients residing rurally were more prone to have DR than those in urban areas.

The odds of developing DR among patients who had had DM ≥10 years were higher than those of their counterparts. This finding is in line with studies conducted in Ethiopia,[18,20,21] Kenya,[11] Sudan,[43] Tanzania,[47] and Zimbabwe.[41] Cross-

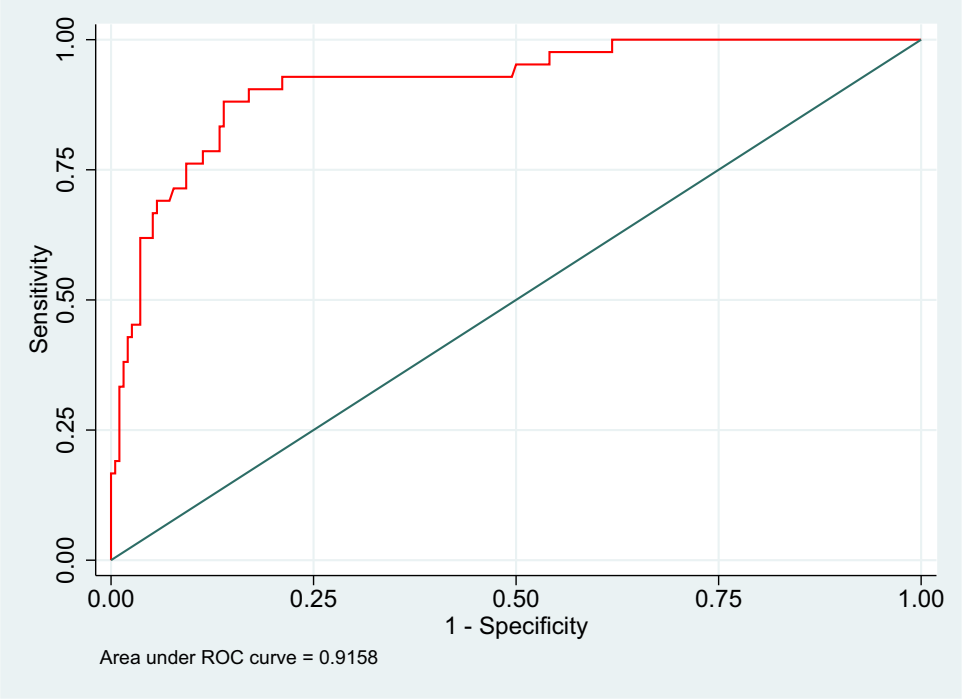

Figure 1 Receiver-operating characteristic (ROC) curve illustrating the ability of the final model to predict diagnosed DR.

Table 8 Multivariate binary logistic regression analysis of diabetic retinopathy and exposure

Variables		Diabetic retinopathy		Adjusted OR (95% CI)	*p*
		Yes	No		
Age, years	<40	10	56	1	
	≤40	41	149	1.18 (0.32–4.30)	0.789
Residence	Urban	37	139	2.84 (1.04–7.78)**	0.041
	Rural	14	66	1	
Family history of DM	Yes	12	47	1	
	No	39	158	1.47 (0.52–4.15)	0.462
Member of DM association	Yes	35	117	1	
	No	16	88	0.99 (0.41–2.42)	0.988
Type of DM	1	11	53	1	
	2	40	152	2.39 (0.63–9.08)	0.199
Duration of DM	<10 year	22	163	1	
	≥10 year	29	42	10.22 (1.70–61.44)**	0.011
Duration of DM medication	≤10	25	160	1	
	>10	26	34	2.17 (0.35–13.41)	0.404
Central obesity	Yes	38	135	5.42 (1.38–21.19)**	0.015
	No	13	70	1	
Comorbidities	Yes	29	102	1	
	No	22	103	0.95 (0.39–2.28)	0.916
BMI	Overweight/Obesity	23	97	2.65 (1.02–6.92)**	0.045
	Normal	28	108	1	
Metabolic syndrome	Yes	28	93	0.29 (0.07–1.21)	0.092
	No	23	112	1	
HDL cholesterol	Desirable	30	145	1	
	Lower	21	60	5.82 (1.86–18.24)**	0.002
Ratio of TGs to HDL cholesterol	<3 mg/dL (optimal)	9	60	1	
	3.1–3.8 mg/dL (moderate)	13	32	4.13 (1.13–15.15)**	0.032
	>3.8 mg/dL (high)	29	113	0.98 (0.26–3.65)	0.980

Notes: **$p<0.05$ (adjusted).

sectional studies conducted in Asia reported similar findings.[42,48] Long-term exposure to hyperglycemia is an established risk factor for developing DR, and the duration of DM strongly correlates with the severity of retinal damage.[40]

We also found out that the odds of developing DR among respondents with abdominal obesity were about five times those of patients with normal central obesity. In line with this finding, a study from China showed that abdominal obesity was associated with risk of DR (OR 1.07, 95% CI 1.03–1.10).[49] In accordance with our findings, studies conducted in

Ethiopia,[19] China,[48] Iran,[42] and Australia[24] reported a consistent association between obesity and risk of DR. In fact, obesity is a known risk factor for DM and may contribute to the pathogenesis of DR.[50] Being obese causes increased blood viscosity, oxidative stress, vascular growth factors, leptin, and cytokines, which leads to DR among DM patients.[51] In the current study, the likelihood of developing DR was 2.65 times in overweight/obese patients that of those with normal BMI. In line with our finding, a cohort study conducted in Europe indicated that high BMI was associated with the progression of DR,[52] and a study from South Korea established that weight reduction was a key strategy in reducing the occurrence of DR.[53] In contrast, a recent systematic review and meta-analysis of 27 studies revealed that neither being overweight nor obese was associated with an increased risk of DR.[54] A study conducted in Singapore found that those with a high BMI were significantly less likely to have DR.[55] The lack of consensus among these studies may be explained by methodological differences and differences in study participants. Further studies are needed.

We found that low HDL cholesterol were associated with DR. This indicated that those with reduced HDL had fourfold the likelihood of developing DR of DM patients who had desirable HDL levels. Nevertheless, there are conflicting reports regarding the association between blood lipid profiles, such as HDL, and the risk of developing retinopathy. For instance, Hove et al,[56] Miljanovic et al,[57] and Cui et al[48] found no significant association between DR and HDL in diabetic populations. According to recent research, patients with HDL cholesterol <41 or >60 have a significantly increased chance of negative effects, exhibiting a "U-shaped" risk pattern.[58] The explanation for this is still unclear and merits further investigation.

This study showed that the likelihood of developing DR was higher in patients with a moderate TG:HDL ratio than those with optimal ratio, but we did not found any significant association between DR and other blood lipids, such as TC (hyperlipidemia, TC >239 mg/dL), and very low-density lipoprotein cholesterol, as observed in Zhang et al's study.[59] Although some studies[36,60] have indicated that potential risk factors, such as high TGs, were independent risk factors for DR, the results of our study did not reveal any association between TGs and DR. As a result, further studies are needed on the relationship between blood lipids and DR.

Although we did not assess antioxidant status, the role of oxidative stress in the development of DM complications cannot be overstated. Oxidative stress has been identified as a critical contributor to the pathogenesis of DR. Previous research has looked into the role of oxidative stress in the progression of DR. It is also stated that oxidative stress increases as a result of duration of DM, overweight/obesity and central obesity, and lower HDL cholesterol and TG:HDL ratio, and accordingly affects the development of DR.[61–63]

Limitations

The current study had some limitations. First, there is a possibility of a selection bias because the recruited individuals were visiting the hospital for a routine follow-up. Second, the lack of data on HbA_{1c} data to measure glycemic control may affect the precision of the data. Third, behavioral factors were collected from the current data, which may not be the same as before the development of DR. Fourth, the use of self-report and review of the patient's medical records for data collection may be subject to recall bias and missing data. Fifth, the study sample was institution-based, limiting the generalizability of the results to the overall Ethiopian population. Sixth, compared with multiview fundus examination, single-view fundus examination may underestimate the prevalence of DR. Seventh, because there are few trained ophthalmologists in the area, we relied on senior and well-trained optometrists to grade the DR, and the results should be considered cautiosly. Lastly, our study design was cross-sectional, and thus we could not take account of temporal relationships between potential risk factors and outcomes.

Conclusion

In our study population, we found that one in every five DM patients had DR. Urban residence, duration of DM (≥10 years), central obesity, overweight/obesity, lower HDL cholesterol and TG:HDL ratio were independently associated with DR. There is a need for coordinated DM eye-assessment services to detect DR in the early stages. To reduce the burden of DM, strategies that focus on lifestyle modifications targeted at the identified modifiable risk factors are required.

Abbreviations

BMI, body-mass index; DM, diabetes mellitus; DR, diabetic retinopathy; FBS, fasting blood sugar; NPDR, nonproliferative DR; PDR, proliferative DR; DBP, diastolic blood pressure; SBP, systolic blood pressure; WHO, World Health Organization.

Data Sharing

Data will be available upon request of the corresponding author.

Informed Consent

The protocol for the present study was reviewed and approved by the Institutional Review Board (IRB) committee of Madda Walabu University (RDD/0098/13, approval April 16, 2021). Our study was also performed in accordance with the Declaration of Helsinki guidelines for biomedical research involving human subjects. Written informed consent was obtained from all study participants. In addition, written permission was sought from the hospital medical director. All abnormal laboratory results and implications were explained to the patients and their providers immediately upon the next clinic visit to assist them in improving diabetic care and adjust therapy. Participants who were diagnosed with retinopathy were referred to the ophthalmology clinic for further investigation, counseling, and treatment. Study participants had the right to refuse to join, ask any question, or withdraw at any time. Privacy and confidentiality were assured.

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Disclosure

The authors declare that they have no competing interests in this work.

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