

## Prevalence of Diabetic Retinopathy and Self-reported barriers to Eye Care among Patients with Diabetes in the Emergency Department

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### Abstract

**Background:** Diabetic retinopathy (DR) is a sight-threatening condition that causes progressive retina damage. Screening for DR is suboptimal, and patients with diabetes who present to the emergency department (ED) may be at particularly high risk of undiagnosed DR. Although DR screening is a basic component of diabetes care, uptake of screening programs is less than optimal. **The aim of this study is:** To determine the prevalence of DR among diabetic patients who present to the ED of our tertiary medical center using tele-ophthalmology and to assess self-reported barriers to eye care. **Methods:** A cross-sectional, single-institution study recruited clinically stable diabetic patients who presented to the ED during daytime hours over 29 total weekdays across 2 months from January to February 2022 in KSA. Participants had nonmydriatic, 45-degree, single-field digital retinal photographs taken on site (Digital Retinal System, Centervue). Following retinal imaging, participants then completed a survey about barriers to regular eye care and their acceptance of potential interventions to promote screening. Digital retinal photographs were <sup>1</sup>interpreted remotely by a board-certified ophthalmologist and communicated to participants' primary care physician and/or endocrinologist. **Results:** Over the study period, 275 ED patients had a documented diagnosis of diabetes, of which 167 were deemed clinically stable for the study and 141 were invited to participate. Sixty-four were enrolled, of whom 50 had gradable-quality fundus images (78%). Of these 50 patients, almost all had type 2 diabetes (47, 94%), with an average disease duration of 12±9 years and mean hemoglobin A1c of 8.1±2.0% (mmol/mol). Based on fundus photography, 14 patients (28%) were diagnosed with DR, which was newly diagnosed for 10 (20% of the total study population). Severity was most commonly mild or moderate (12/14, 86%), with 1 case of severe non-proliferative DR and 1 proliferative DR. The majority (26, 52%) reported at least one barrier to routine eye care in our self-administered survey, of which having too many appointments (6, 12%) and cost (5, 10%) were frequently cited as most important. The majority were receptive to interventions to promote DR

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screening, including reminder phone calls (29, 58%) and text messages (28, 56%). **Conclusions:** Digital fundus photography in the ED detected a high rate of undiagnosed DR. Half of participants reported barriers to routine care, and most were receptive to messaging interventions to schedule an eye exam. Future studies are warranted to assess scalability of ED-based screening programs and their follow-through rates.

**Keywords:** Diabetic retinopathy, Tele-ophthalmology, Telemedicine, Digital fundus photography, Screening, Barriers to eye care, Emergency department.

## Introduction

### Background

Diabetic retinopathy (DR) is a sight-threatening complication of diabetes mellitus (DM) that causes insidious and progressive damage to the retina. Global prevalence of vision-threatening DR among individuals with diabetes has been estimated at 22.27%, and the burden is only expected to increase as the prevalence of diabetes increases <sup>(1)</sup>. DR is also estimated to account for 2.6% of all blindness worldwide <sup>(2)</sup>. Regular ophthalmic screenings to identify cases of DR that require timely management are essential <sup>(3)</sup>. DR represents a major healthcare challenge, particularly in low-income populations where individuals may lack access to eye care <sup>(4)</sup>. For example, the Los Angeles Latino Eye Study found that Latinos developed visual impairment and blindness at the highest rate of any ethnic group in the country. The authors primarily attributed this to environmental factors such as access to care and socioeconomic background, and also found that lower family income was correlated with higher rates of DR and less disease awareness <sup>(5)</sup>.

Another study found that DR causes 17% of visual loss in African Americans as compared to 8% in non-Hispanic Caucasians <sup>(6)</sup>. In 2015, Saudi Arabia had the highest prevalence (17.6%) of DM in the Middle East and North Africa Region <sup>(7)</sup>. DR is the primary cause of vision loss in adults and may have a severe impact on the patient's quality of life and impose a financial burden on health systems <sup>(8-10)</sup>. The overall global prevalence of DR is estimated to be around 34.6%, accounting for 4.8% of blindness in the world <sup>(7, 8)</sup>. In Saudi Arabia, the prevalence of DR was found to be 19.7%, with 53% of them reported to have proliferative diabetic retinopathy (PDR) <sup>(10)</sup>. Other studies from different regions of Saudi Arabia have reported a high prevalence of DR ranging from 27.8% to 36% <sup>(11, 12)</sup>.

Additionally, DR is a potentially blinding complication of diabetes mellitus that affects about 28% of diabetics in the United States <sup>(13)</sup>. DR can typically be detected with annual screening, but many Americans with diabetes mellitus do not receive routine surveillance to prevent visual impairment or blindness <sup>(14, 15)</sup>. In fact, only about 60% of patients with diabetes report having had a dilated eye exam in the last year <sup>(16)</sup>. Undetected DR may be particularly prevalent in hospital settings, where we have previously found a DR prevalence of 44% among diabetic inpatients, over half of whom were previously undiagnosed <sup>(17)</sup>. Low uptake of diabetic screening exams may be mitigated by tele-ophthalmology, by which retinal images can be acquired outside of eye clinics and interpreted by ophthalmologists remotely. Offering retinal imaging outside of eye clinic settings could expand access to DR screening to patients who may otherwise go unexamined. For instance, tele-ophthalmology for DR screening in primary care offices has improved adherence to screening guidelines <sup>(18-20)</sup>.

However, little work has been done to assess the feasibility of tele-ophthalmology for DR screening in hospital settings. Emergency departments (EDs) could be a valuable setting to screen for DR. First, ED visits have been identified as a "red flag" for poor diabetes care. Specifically, diabetic patients who present to the ED are half as likely to have annual dilated fundus exams as those who do not <sup>(21)</sup>. Second, digital fundus photography

in the ED is at least as effective as direct ophthalmoscopy and is feasible to conduct in the ED setting<sup>(22, 23)</sup>. Third, diabetic patients in the ED may benefit from behavioral interventions, such as reminder messages, to promote DR screening rates<sup>(24)</sup>. However, the acceptance of these interventions in this population is largely unknown. The ED provides a high-risk diabetic patient population for screening and a setting with previously validated methods of digital fundus photography<sup>(22, 23)</sup>.

The aim of this study is to determine the prevalence of DR in the ED setting, to survey barriers to regular ophthalmic care, and to assess patient willingness to engage in behavioral interventions that promote outpatient follow up.

## Methods

A cross-sectional, single-institution study recruited clinically stable diabetic patients who presented to the ED during daytime hours over 29 total weekdays across 2 months from January to February 2022 in KSA. The study received approval from Ethical Committee of the University. Study investigators reviewed the electronic record of patients with active encounters in the ED to assess for eligibility. All patients with a documented diagnosis of type 1 or 2 diabetes mellitus who presented in stable condition were included. For patients who met inclusion criteria, study investigators contacted the emergency care providers in the ED to assess patient willingness to participate in the study.

For patients interested in participating, investigators obtained informed consent, administered a study questionnaire, and obtained fundus photographs. The questionnaire, supplemented by review of the medical record, was used to document demographic information, past medical history, duration of diabetes, and hemoglobin A1c (HbA1c) level. We also inquired about past eye exams, barriers to care, and willingness to receive interventions to improve follow up. Following administration of the study questionnaire, fundus photography was obtained in the ED by a resident physician using a portable digital fundus camera (Digital Retinal System, Centervue).

Images included a nonmydriatic, nonstereoscopic, 45-degree, single-field image of the posterior pole of each eye, which included the macula, major vascular arcades, and the optic nerve. All patients received education about DR, the potential effects of diabetes on vision, and the importance of having regular eye examinations. Retinal images were uploaded into the electronic health record and forwarded to a board-certified ophthalmologist (ELW) for interpretation. Patients found to have any level of DR by Early Treatment of Diabetic Retinopathy Study (ETDRS) criteria were advised to have a formal eye exam within about 2 weeks after review of the fundus photograph. Letters with the results of the screen were sent to the patient's primary care physician and/or endocrinologist as listed in the medical record or provided by the patient.

## Results

Electronic health records of 1,404 ED encounters were reviewed, of which 275 (20%) met inclusion criteria with a documented diagnosis of diabetes. Of these 275 patients, 108 (39%) were excluded because they were determined to be clinically unstable. An additional 26 patients were unavailable for the study due to active clinical care by emergency providers or presence at an imaging study.

Of the 141 diabetic patients approached, 34 (23%) declined because they already had an eye care provider either treating DR (15/34) or screening for it (19/34), and 7 (5%) declined to participate due to denial of diabetes diagnosis. An additional 39 (28%) wished to participate but were unable to sit at the digital fundus camera due to body habitus, medical condition, or feeling unwell, and 10 (7%) were unable to complete the study due to digital fundus camera malfunction. Of the 64 patients enrolled, 14 had fundus photos of

a quality too poor to analyze. In total, 50 patients were enrolled into the study with digital fundus photos sufficient for analysis.

### Patient characteristics

**Table (1)** shows that 50 patients in this study included 26 women (52%), had an average age of 56 (34 to 81).

**Table (2)** shows that almost all had type 2 diabetes (47, 94%), and the average duration of diabetes was 12 (2 to 47) years. The mean HbA1c was  $8.1 \pm 2.0\%$ , and half reported being insulin dependent. Patients had various comorbidities, most commonly hypertension (41, 82%) and hyperlipidemia (29, 58%). Sixteen (32%) reported having an endocrinologist. Regarding eye care, 39 (78%) indicated that they regularly see an ophthalmologist or optometrist, and most (34, 68%) reported having had a dilated fundus exam in the last year. Seven (14%) reported a known history of DR.

**Table (3)** shows patients presented to the ED for a wide range of chief complaints, most commonly chest pain (5, 17%) or dyspnea (3, 10%). Sixteen (32%) were admitted to the inpatient floor from the ED.

### Screening results

**Table (4)** shows that Of the 50 patients who completed the screening, 14 (28%) were determined to have DR, which was a new diagnosis for 10 (20% of the total). Most DR was mild (5, 10%) or moderate (7, 14%) in severity. Sixteen of the patients enrolled were subsequently admitted to the hospital, 8 (50%) of whom had diabetic retinopathy.

### Survey results

**Table (5)** shows that almost all patients (45, 90%) reported knowing that diabetes can affect their vision. Twelve (24%) reported that their vision interferes with their daily activities, and the mean self-reported vision quality score was 8 out of 10. The majority of participants reported at least one barrier to regular eye examinations (26, 52%). The barriers to care cited as most important included having too many other medical appointments (6, 12% of the total), inability to afford the exam (5, 10%), and having no perceived vision problems (4, 8%). Only three participants (6%) stated that transportation was the primary barrier to eye care. The majority of patients were receptive to receiving phone calls (29, 58%) or text message reminders (28, 56%) to schedule a routine eye appointment.

**Table (1):** Demographic characteristics of 50 patients who completed DR screening in the ED

Characteristic	n (%)
Age (years; mean $\pm$ SD)	56 $\pm$ 12 (range: 34–81)
<b>Sex</b>	
Female	26 (52)
Male	24 (48)
<b>Highest level of education</b>	
Some high school	1 (2)
High school degree	13 (26)
GED	5 (10)
Some college	8 (16)
Trade school	6 (12)
Associate's degree	4 (8)
Bachelor's degree	6 (12)
Master's degree	4 (8)

Characteristic	n (%)
Doctorate degree	3 (6)
Currently Employed	19 (38)
Health insurance	50 (100)
<b>Marital status</b>	
Single	19 (38)
Married	19 (38)
Divorced	9 (18)
Widowed	3 (6)

DR Diabetic retinopathy, ED Emergency department, GED General equivalency diploma, SD Standard deviation

**Table (2):** Clinical characteristics of 50 patients who completed DR screening in the ED

Characteristic	Completed n (%)
<b>Diabetes type</b>	
Type 1	2 (4)
Type 2	47 (94)
Other	1 (2)
Diabetes duration (years; mean $\pm$ SD)	12 $\pm$ 9 (range: 2–47)
Hemoglobin A1c (%; mean $\pm$ SD)	8.1 $\pm$ 2.0 (range: 5.4–14.5)
Mean arterial pressure recorded in ED (mmHg, mean $\pm$ SD)	102 $\pm$ 4 (range: 71–126)
Insulin dependence	25 (50)
<b>Smoking history</b>	
Current	13 (26)
Former	18 (36)
Never	19 (38)
<b>Comorbidities</b>	
Hypertension	41 (82)
Hyperlipidemia	29 (58)
Neuropathy	23 (46)
Renal disease	21 (42)
Coronary artery disease	13 (26)
<b>Medical providers</b>	
Primary care physician	49 (98)
Endocrinologist	16 (32)
Nephrologist	9 (18)
Pulmonologist	6 (12)
Cardiologist	8 (16)
Gastroenterologist	4 (8)

Characteristic	Completed n (%)
Neurologist	3 (6)
Rheumatologist	3 (6)
Vascular surgeon	2 (4)
Psychiatrist	2 (4)
Cardiothoracic surgeon	1 (2)
General surgeon	1 (2)
Infectious disease specialist	1 (2)
Report having an ophthalmologist or optometrist	39 (78)
<b>Last self-reported dilated fundus exam</b>	
Within 1 year	34 (68)
Over a year ago	9 (18)
Never	5 (10)
Known history of diabetic retinopathy	7 (14)

**Table (3):** Presenting chief complaint to the emergency department for 50 patients who completed DR screening in the ED

Complaint	Completed n (%)
Chest pain	5(17)
Dyspnea	3(10)
Eye pain	2(7)
Foot pain and/or swelling	2(7)
Abdominal pain	1(3)
Abnormal lab results	1(3)
Anemia, gastrointestinal bleed	1(3)
Cat bite	1(3)
Congestive heart failure	1(3)
COPD exacerbation	1(3)
Fever, rash	1(3)
Hyperglycemia	1(3)
Hypoglycemia	1(3)
Hypotension	1(3)
Infected fistula graft site	1(3)
Injured foot	1(3)
Leg swelling	1(3)
Nausea and vomiting	1(3)

Complaint	Completed n (%)
Nausea, vomiting, and abdominal pain	1 (3)
Shoulder pain	1 (3)
Sore throat	1 (3)
Supraventricular tachycardia	1 (3)
COPD Chronic obstructive pulmonary disease	

**Table (4):** Diabetic retinopathy screening results of 50 patients who completed DR screening in the ED

	Completed n (%)
Diabetic retinopathy, any stage	14 (28)
Mild NPDR	5 (10)
Moderate NPDR	7 (14)
With CSME	1 (2)
Severe NPDR	1 (2)
PDR	1 (2)
New diagnosis of diabetic retinopathy	10 (20)
CSME Clinically significant macular edema, NPDR Non-proliferative diabetic retinopathy, PDR Proliferative diabetic retinopathy	

**Table (5):** Self-reported barriers to regular eye examinations

Barriers	n (%) cited as most important	n (%) cited <sup>a</sup>
Too many other medical appointments	6 (12)	7 (14)
Cannot afford the exam or co-payment	5 (10)	6 (12)
My vision is fine	4 (8)	6 (12)
Transportation issues	3 (6)	4 (8)
I am too busy	2 (4)	7 (14)
Too difficult to get an appointment	2 (4)	3 (6)
I did not know it was important	2 (4)	4 (8)
Too sick to sit for several hours in the eye clinic	0 (0)	3 (6)
Mobility issues (e.g. wheelchair-bound)	0 (0)	2 (4)
My eyes were examined by my PCP	0 (0)	2 (4)
I do not trust doctors or the medical system	0 (0)	0 (0)
Other (not specified)	1 (2)	3 (6)
None	24 (48)	24 (48)
PCP Primary care physician		
<sup>a</sup> Patients could report more than one		

## Discussion

Using tele-ophthalmology, we identified a 28% prevalence of DR among diabetic patients presenting to our ED for care, most of who had not been previously diagnosed. Patients in the emergency department are more likely to have poor glycemic control and miss screening exams for DR<sup>(25, 26)</sup>. The higher likelihood of poorly controlled diabetes in this setting could make the ED a high-yield setting to detect DR and to address barriers to regular care<sup>(21)</sup>. Interestingly, our 28% prevalence of DR is more similar to the prevalence found in outpatient clinics than inpatient settings. Zhang et al., (2010)<sup>(13)</sup> detected a 29% prevalence of DR among 6797 patients in outpatient offices, with a similar proportion of vision-threatening diabetic retinopathy<sup>(13)</sup>. We had previously found a higher prevalence of DR among 113 inpatients at our hospital, of which 44% exhibited DR<sup>(17)</sup>.

Hospitalization may indicate poorer disease control and, therefore, higher risk of DR. In fact, of the 16 patients in our study who were admitted from the ED, 8 (50%) had DR. Nonetheless, our ED screening study found that most cases of DR were previously undiagnosed and that many emergency patients do not have regular eye care. The ED may serve as a valuable setting to identify barriers to outpatient care and to provide resources to address these barriers<sup>(27)</sup>. About half of participants in our study reported at least one barrier to regular eye care. The most common barriers were having too many other medical appointments and difficulty affording the costs of vision care, which were also commonly cited among diabetic inpatients at our institution<sup>(17)</sup>.

Similarly, in a separate ED-based survey on barriers to care, Tian et al., (2020)<sup>(26)</sup> found that cost and inadequate insurance predominated as reasons diabetic patients reported for not having an annual eye exam<sup>(26)</sup>. While less commonly cited in our population, transportation issues and not knowing that diabetes can affect vision are other prominent barriers to routine diabetic eye exams<sup>(26, 28, and 29)</sup>. More pervasive barriers to diabetic eye exams also exist, such as fear of negative results, distrust in physicians, forgetfulness, and low self-efficacy<sup>(24)</sup>. Interventions like educational outreach and reminder messages can help to address some of these barriers to promote diabetic eye exams<sup>(30, 31)</sup>.

We found that the majority of participants in our study were receptive to receiving phone calls or text message reminders to schedule a screening eye appointment. Follow up with mobile communication could be one potential avenue to promote eye exams for ED patients. Although, the present study has notable strengths by bringing tele-ophthalmology for DR screening to the ED setting. Similarly, future studies should also assess patient satisfaction with an ED-based screening program.

Nonmydriatic fundus photography has its own inherent limitations. Our interpretable image rate of 79%, while comparable to that of other ED-based tele-ophthalmology programs<sup>(32)</sup>, highlights the challenges of fundus photography in ED settings with uncontrolled lighting conditions and a busy clinical environment. Although commonly used for DR screening, fundus photographs of the macula may miss some cases of DR, such as those with mild peripheral disease. While nonmydriatic, single-field photographs can be taken by non-physician staff with little training<sup>(32)</sup>, the costs for implementing DR screening in the ED would require institutional investment.

Additionally, the store and forward approach of acquiring images for remote interpretation by an ophthalmologist limits real-time feedback for patient care or referral. In the future, real-time analysis and artificial intelligence to detect DR from digital photographs may allow for immediate image interpretation, which could risk-stratify urgent referrals for vision-threatening disease<sup>(33, 34)</sup>. Ultimately, implementation of an ED-based



tele-ophthalmology screening DR program would require buy-in from multiple parties (payers, ED nursing staff, interpreting ophthalmologists), and further research is warranted on its feasibility<sup>(35)</sup>. Our study suggests that tele-ophthalmology for DR screening in select patients can be a tool to diagnose previously undetected DR among ED patients.

### Conclusions

Fundus photography in the ED identified a high prevalence of previously undiagnosed DR. Over half of participants surveyed reported barriers to routine eye care. Some of these barriers, such as feeling vision is fine or feeling too busy for an eye exam, may be mitigated with reminder messages for routine screening. Future studies are warranted to assess scalability of ED-based screening programs and their follow-through rates.

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