A PRACTICAL GUIDE TO

Diabetes-Related Eye Care

CONTRIBUTING AUTHORS

THOMAS W. GARDNER, MD, MS
Professor of Ophthalmology & Visual Sciences, Molecular & Integrative Physiology, and Internal Medicine
University of Michigan Medical School, Kellogg Eye Center
Ann Arbor, MI

BLAKE A. COOPER, MD, MPH
Vitreo-Retinal Surgeon, Partner
Retina Associates, LLC
Lenexa, KS

MICHAEL HUVARD, MD
Clinical Assistant Professor of Ophthalmology & Visual Sciences
University of Michigan Medical School, Kellogg Eye Center
Ann Arbor, MI

SHERROL A. REYNOLDS, OD, FAAO
Associate Professor
Nova Southeastern University College of Optometry
Ft. Lauderdale, FL

ANJALI R. SHAH, MD
Clinical Assistant Professor
Department of Ophthalmology and Visual Sciences
University of Michigan Medical School, Kellogg Eye Center
Ann Arbor, MI

REBECCA A. WU, MD
Clinical Assistant Professor
Department of Ophthalmology and Visual Sciences
University of Michigan Medical School, Kellogg Eye Center
Ann Arbor, MI

This publication has been supported by unrestricted educational grants to the American Diabetes Association from VSP Vision Care and Regeneron.
This compendium, “A Practical Guide to Diabetes-Related Eye Care,” follows a 2019 compendium titled “Prevention and Management of Diabetes-Related Eye Disease” (1). The first publication focused on the medical and ocular features of diabetes-related eye disease and its diagnosis and treatment. The current publication builds on that foundation to address pragmatic approaches to improving bidirectional communication between eye care professionals (ECPs) and primary and specialty diabetes health care professionals (HCPs) and reducing barriers to diabetes-related eye care.

In this compendium, we have chosen to use the term “diabetes-related retinal disease” (DRD) to reflect the involvement of the entire retina, including both vascular and neural elements. The principles set forth in the first compendium remain the basis for the clinical practice of ECPs when treating people with diabetes. Here, we describe the health status information ECPs need from HCPs, and the eye examination reports HCPs need from ECPs to improve diabetes and eye health outcomes for the patients they share. We also discuss the challenges of and opportunities to improve the detection and timely treatment of DRD in all people with diabetes, with a particular emphasis on individuals who are socioeconomically disadvantaged or face other significant impediments to obtaining recommended eye care services.

Vision loss from DRD is preventable, as was demonstrated in the Diabetes Control and Complications Trial (DCCT) and its ongoing follow-up Epidemiology of Diabetes Interventions and Complications (EDIC) study. After 18 years of follow-up, DRD categorized as mild nonproliferative disease or less was maintained without further progression in 68% of people in the DCCT’s intensive therapy cohort and 49% of those in the conventional treatment cohort (2,3). Thus, the technical means to maintain good vision are available now. Analogous long-term benefits also persist for diabetes-related kidney disease (4). Nevertheless, DRD remains a leading cause of vision impairment and blindness worldwide (5), and, crucially, is a major concern of people with diabetes and their families.

The alarming increase in diabetes prevalence worldwide has resulted in large part from the growing prevalence of obesity, although prevalence rates of both type 1 diabetes and type 2 diabetes have increased, suggesting that other causes are also at play. The International Diabetes Federation (6) estimates that the total number of people with diabetes globally will increase from 536.6 million (10.5% of the world’s population) in 2021 to 783.2 million by 2045. Approximately one in five people with diabetes worldwide have some degree of DRD—an estimated 103.12 million individuals—of whom ~28.5 million have vision-threatening DRD. The challenges presented by diabetes are illustrated by the fact that youth and young adults with the disease in the United States have mean A1C levels of 8.8% for those with type 1 diabetes and 8.6% for those with type 2 diabetes (7). It is not surprising, then, that youth with type 1 or type 2 diabetes already have mild DRD, peripheral neuropathy, and nephropathy (8,9) and thus the predicate conditions for development of vision-threatening DRD in early adulthood.

The United Kingdom, Denmark, Sweden, Ireland, Thailand, and Iceland have uniform, government-funded screening and treatment programs. Because of the success of the United Kingdom program, DRD in 2010 ceased being the leading cause of blindness in working-age adults there (10). The United States does not yet have widespread DRD screening programs, but telemedicine initiatives are expanding, and one system that uses artificial intelligence to interpret diagnostic imaging has been approved by the U.S. Food and Drug Administration (11). The economic costs of DRD and diabetes-related macular edema (DME) are substantial for people with diabetes and their employers (12).

The ocular manifestations of diabetes are readily detected by standard ophthalmic exams conducted by optometrists and ophthalmologists and include primarily cataracts and DRD. The scopes of practice of ophthalmologists and optometrists overlap considerably. Ophthalmologists are physicians with M.D. (doctor of medicine) or D.O. (doctor of osteopathic medicine) credentials who have completed medical school, an internship, and a 3-year residency in ophthalmology. Slightly fewer than 500 physicians complete ophthalmology training per year in the United States (13), and about half of them complete additional fellowship training in specialty areas such as glaucoma, corneal diseases, and retinal diseases. Surgery is an intrinsic aspect of ophthalmology but not optometric training. Retinal specialists are ophthalmologists whose practice focuses on medical and surgical diseases of the retina and vitreous. They typically perform intravitreal (intraocular) injections of medications, laser surgery for retinal diseases, and...
In our third chapter, Michael Huvard, MD, looks at communications in the opposite direction and how the information from HCPs’ records can be interpreted by ECPs to guide diagnoses and treatment decisions. Specifically, he discusses the advantages of electronic medical record (EMR) systems to facilitate communication among the various professionals who care for people with multifaceted, chronic conditions such as diabetes. EMR systems can provide reminders for periodic screening exams, transmit information to both patients and other ECPs or HCPs via secure messaging, enable quantitative monitoring of care quality, and facilitate the collection and analysis of data for research to improve care. Dr. Huvard cites three important references (21–23) that emphasize the value of secure messaging, decision-support tools, and metrics of care available within EMR systems.

Finally, Anjali R. Shah, MD, and Rebecca A. Wu, MD, provide a thought-provoking discussion of disparities in rates of both DRD and diabetes-related eye screening. They describe existing disparities among racial/ethnic groups, including the higher diabetes prevalence rates among Blacks, Hispanics, and Native Americans and their higher rates of DME, proliferative diabetes-related retinal disease (PDR), and visual impairment. Moreover, they note that people living in distressed counties of the Appalachian “diabetes belt” (24) have substantially higher rates of both diabetes and DRD and that socioeconomically disadvantaged people are less likely to undergo recommended DRD screening and more likely to be unaware of their risk of DRD. Drs. Shah and Wu propose a focus on improving system-level factors, including expanding access to DRD screening through telemedicine. For now, however, the challenges of minimal reimbursement for remote disease detection and monitoring continue to limit widespread implementation of this beneficial technology.

Preparing People with Diabetes for DRD Treatment

In his chapter, Dr. Cooper provides tips for preparing people with diabetes for routine diabetes-related eye exams. Here, we add some brief information to help prepare people for ensuing DRD treatment, if needed.

Intraocular injection of anti-vascular endothelial growth factor (VEGF) drugs (i.e., bevacizumab, ranibizumab, and aflibercept) and corticosteroids is now the most common form of treatment for advanced DRD. People with this condition are understandably apprehensive about undergoing this therapy, but most tolerate it well once they learn what to expect. Thus, providing a clear explanation of the process can alleviate some of their fear and reluctance.
A person receiving intraocular injections is placed in a comfortable seated or reclining position, and the eye is anesthetized by installation of eyedrops (proparacaine) and topical or subconjunctival application of lidocaine or a similar agent. A povidone-iodine solution is applied, although soap solutions can be substituted for people with iodine allergies. Some ophthalmologists insert an eyelid speculum, and they may or may not wear sterile gloves. The person is asked to look to the side, and the very small needle (usually 30-gauge or smaller) is inserted, which may cause a brief pressure sensation but little pain. The medication injection lasts only a couple of seconds, and then the speculum is removed and saline solution is used to irrigate the eye. Most people do not receive topical antibiotics or need an eye patch. Rarely, a person’s vision may temporarily dim if the intraocular pressure exceeds the retinal perfusion pressure. If vision does not recover within a few minutes, aqueous fluid from the anterior chamber can be removed. Most people describe some irritation and blurred vision throughout the day of the procedure. The greatest risk of this procedure is endophthalmitis, which is quite rare, occurring with fewer than 1 in 1,000 injections.

Panretinal photocoagulation is also still used widely to treat PDR because it creates a more durable regression of neovascularization than does anti-VEGF therapy. The procedure requires pupil dilation. Topical or subconjunctival anesthesia usually suffices to minimize pain from the contact lens that focuses the laser light and the stimulation of ocular sensory nerves by the laser energy. However, a minority of people receiving this treatment require retrobulbar anesthetic injection or even systemic sedation for the procedure. Vision is often blurred for a day or two after the procedure.

Vitrectomy to remove blood and/or scar tissue in the eye can be very effective in restoring vision in people with PDR. This procedure takes place in an operating room under intravenous or general anesthesia, and patients wear an eye patch for a day or more and usually apply steroid and/or antibiotic eyedrops for about 2 weeks. Postoperative pain is usually mild.

We hope this compendium will facilitate better communication between ECPs and HCPs, improving both the quality of and their satisfaction with the care they provide and—most importantly—the eye health of people with diabetes.
Ten Key Elements of a Diabetes-Related Eye Examination

Blake A. Cooper MD, MPH, Retina Associates, LLC, Lenexa, KS

Diabetes-related eye examinations focus on detecting the impact of diabetes on ocular health, including diabetes-related retinal disease (DRD), diabetes-related macular edema (DME), glaucoma, and cataracts. Screening and early treatment can often halt or reverse the level of DRD and protect eyesight. This chapter reviews the 10 key elements of a diabetes-related eye exam: history, visual acuity, intraocular pressure, pupils, extraocular motility, visual field, external examination, slit-lamp examination, dilated funduscopic examination, and diagnostic testing. By its conclusion, readers should understand the basics of a diabetes-related eye exam and how to prepare people for their visits to an eye care professional (ECP).

1. History
Arguably, the most important aspect of any medical examination is the history that is obtained, and this holds true for ocular evaluations of people with diabetes. Understanding a person’s duration of diabetes, current use of medications, glycemic stability and variability, and A1C and/or time-in-range targets will give the examiner an idea of the person’s potential for developing DRD.

In addition, establishing a timeline of any visual changes will help direct the exam, timing of treatment, and schedule for return appointments. It is important to understand that DRD is often asymptomatic until later stages of disease, and obtaining regular eye exams will aid in early diagnosis and help to protect eyesight. Depending on the findings of initial eye exams, ECPs may recommend more frequent exams or may refer people to a retinal specialist. American Diabetes Association guidelines for the timing of diabetes-related eye exams are shown in Table 1. (16)

<table>
<thead>
<tr>
<th>Table 1: American Diabetes Association Eye Exam Recommendations (16)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>For adult type 1 diabetes</strong></td>
</tr>
<tr>
<td><strong>For pediatric type 1 diabetes</strong></td>
</tr>
<tr>
<td><strong>For type 2 diabetes</strong></td>
</tr>
<tr>
<td><strong>Around pregnancy</strong></td>
</tr>
</tbody>
</table>

*If there is no evidence of DRD and glycemia is well controlled, screening every 1–2 years may be considered. If existing DRD is progressing or sight-threatening, exams will be needed more frequently. †Women who develop gestational diabetes do not require eye exams during pregnancy and do not appear to be at increased risk of developing DRD during pregnancy.

2. Visual Acuity
The best uncorrected and corrected vision in each eye is typically measured at distance and up close in a dark-adapted room using a high-contrast test object known as an eye chart. Pinholes or more formal refraction can determine whether there is a refractive error limiting vision and the best possible visual acuity with new lenses.

A determination that a person has 20/20 vision means the person sees the same optotypes at 20 feet that a person with ideal vision would see at 20 feet. For people with decreased visual acuity—for example, to 20/80—what they can see at 20 feet is the same as what a person with ideal vision could see at 80 feet. People who are unable to see the largest (20/400) optotype are checked for their ability to count fingers, determine hand motion, or detect the presence or absence of light.

Dramatic fluctuations in blood glucose levels may cause a person’s vision to change and are one of the ways ECPs can determine that a person has diabetes.

3. Pupils
Pupils are evaluated in dark- and light-adapted states for reactivity, size, and symmetry of shape. A significant difference is >0.4 mm between the two pupils and is known as anisocoria. The etiology of anisocoria includes Horner syndrome, in which the smaller pupil is found on the affected side, oculomotor nerve (cranial nerve [CN] III) palsy on the side of the larger pupil, or simply physiologic anisocoria (25).

Analysis for a relative afferent pupillary defect is performed by using the swinging flashlight test. When a light is shined in the normal eye, both eyes briskly constrict.
With unilateral optic nerve dysfunction, when the light is "swung" to the affected eye, the pupils “escape,” or dilate, because there is relatively decreased perceived light signal intensity. When the pupillary response is asymmetrical, a determination of whether the defect results from an abnormality of the afferent (optic nerve) or efferent (oculomotor nerve) pathway is necessary (26).

Pupil abnormalities are common among people living with diabetes because of diabetes-related autonomic neuropathy and ocular ischemia, which may cause pupils to dilate poorly and not properly react to light.

4. Extraocular Motility
Extraocular motility (EOM) is checked by having the person maintain fixation on a test object and evaluating how the eyes move in the six cardinal directions of gaze, while looking for any difference between the two eyes. Over- or under-actions of ocular movement are recorded on a scale of 1–4 and are documented in each direction.

In people with diabetes, a benign cause of abnormal EOM may be a rare and often temporary CN palsy resulting from hyperglycemia, neuronal ischemia, and inflammation. Understanding the innervation of the EOM can help to identify which CN is responsible for abnormalities in EOM function. CN IV innervates the contralateral superior oblique muscle, which is responsible for intorsion and depression. CN VI innervates the ipsilateral lateral rectus muscle, which is responsible for abduction. CN III innervates the remaining ipsilateral extraocular muscles, including the inferior rectus, medial rectus, superior rectus, and inferior oblique, as well as the levator palpebrae, the main muscle that elevates the upper eyelid (27).

5. Intraocular Pressure
Intraocular pressure (IOP) is the fluid pressure inside the eye and is measured by instilling a drop of topical anesthetic (proparacaine) into the person's eye and placing the applanator against the center of the cornea. The internal pressure of the eye will resist and can be recorded in millimeters of mercury (mmHg). Normal pressure is between 12 and 22 mmHg.

Elevation of IOP is a potential sign of glaucoma, and diabetes and DRD modestly increase the risk for glaucoma. For this reason, a detailed examination of the optic nerve during ophthalmoscopy (described below) and additional testing may be required.

6. Visual Fields
Visual fields are tested individually for each eye and represent the entire field of view that is seen with the person looking straight ahead. The simplest method of evaluating the areas of vision that are present or absent is confrontation visual field testing, which grossly determines peripheral vision. While maintaining central fixation, the person is asked to identify individual fingers that are presented in the periphery of each quadrant. If acuity is particularly poor, the person is asked to note the presence or absence of hand movement or a light that is presented in each quadrant. It should be noted that the documentation of visual field testing is recorded from the person's perspective, and areas of decreased or lost vision are represented as darkened areas.

Aside from the confrontational visual field testing, automated testing randomly evaluates points that can be used to document the central 10°, 24°, or 30° visual field. For individuals who are poorly attentive or have decreased vision <20/200, a Goldmann visual field allows an examiner to use test objects to map and record the visual field while ensuring the person's attention and fixation.

For individuals living with diabetes, visual field testing is useful for evaluating central macular and optic nerve function and monitoring for glaucoma, and repeat testing helps to determine stability or progression of the disease.

7. External Examination
The external exam is an important evaluation in people with diabetes. Abnormalities of the position and symmetry of the eyelids and ocular alignment may be the first indication of CN dysfunction.

The lower position of the eyelid, known as ptosis, along with a deviation of the eye, could indicate a CN III palsy. In addition to eyelid symmetry and ocular alignment, a gross inspection of the sclera, conjunctiva, and iris can give insight into diabetes-related eye disease. Conjunctiva that are red and appear inflamed may be related to diabetes-related keratopathy (corneal disease) resulting from a decrease in corneal sensitivity. This condition may be an early or late sign of diabetes and is characterized by impaired innervation of the cornea that leads to decreased sensitivity difficulties with nonhealing corneal ulcers. A close inspection of the iris may reveal neovascularization of the iris (NVI), which occurs when new blood vessels grow in response to retinal ischemia. NVI is associated with more advanced disease known as proliferative diabetes-related retinal disease (PDR) and may cause spontaneous hyphema and neovascular glaucoma.
8. Slit-Lamp Examination

A sophisticated microscope known as a slit lamp allows the use of light at different angles, thicknesses, and intensities to magnify and evaluate three-dimensional ocular structures during the exam. When evaluating a person with diabetes, careful examination should be made of particular areas of interest, including the lids, lashes, and lacrimal system to detect any abnormal anatomy, lesions at the lid margin, and loss of eyelashes. As mentioned earlier, it is important to evaluate the conjunctiva, sclera, and cornea for inflammation, masses, and foreign objects, as well as epithelial stroma or endothelial defects.

With the use of higher magnification and a narrow, oblique light, it is possible to see deeper structures of the eye, including the anterior chamber, iris, lens, and anterior vitreous. Red or white blood cells may be found in the anterior or posterior chambers, along with NVI and opacifications in the lens of people with DRD.

9. Ophthalmoscopy (Fundoscopy)

Fundoscopy is the most important method of determining the presence and level of DRD. Typically, once pupils are dilated, use of a direct ophthalmoscope, indirect ophthalmoscope, or slit-lamp microscope will allow a highly magnified view of the posterior chamber, including the macula, retina, retinal blood vessels, and optic nerve.

When evaluating the optic nerve, special attention is given to looking for neovascularization, in addition to pallor, thinning, and the degree of symmetry in the optic cup-to-disc ratio. Close evaluation of the macula, retinal vasculature, and periphery in people with diabetes may reveal retinal hemorrhages, microaneurysms, hard exudates, DME, retinal ischemia (possibly seen as cotton wool spots), neovascularization, vitreous hemorrhage, and traction retinal detachment. Depending on the appearance of the retina, levels or stages of DRD can be determined.

10. Ocular Imaging

ECPs use multiple imaging modalities to evaluate ocular function and anatomy. Apart from the physical examination, the additional tests described below may be required to guide classification and treatment options for DRD.

Fundus Photography

Fundus photography (Figure 1A) involves a wide-angle, high-resolution photograph taken of the structures in the posterior chamber of the eye, including the macula, optic nerve, retinal vasculature, and peripheral retina. Images can be recorded and used for patient education, and grading of ultra-widefield retinal imaging is often used to stage and follow DRD. Comparing photos over time allows ECPs to determine disease severity and monitor progression.

Fluorescein Angiography

Fluorescein angiography (Figure 1B) is a procedure used to diagnose and monitor the severity of DRD and usually takes place after fundus photography. During fluorescein angiography, a nurse injects a vegetable-based dye known as fluorescein into a vein in the person's hand or arm, where it enters the circulation. As the fluorescein passes through the retinal and choroidal vasculature, a series of timed photographs are taken to document and evaluate the circulation in the retina, optic nerve, and choroid.

In eyes with DRD, the vasculature is abnormal and may show areas of nonperfusion, leakage, or staining of fluorescein dye from blood vessels; with more advanced disease (i.e., PDR), new blood vessels may be detected. Thus, the results of this study are used to determine whether additional monitoring, intravitreal injections, or laser procedures may be needed.

Some individuals may experience nausea and, occasionally, vomiting during this procedure. Localized skin irritation and yellowing may occur if the dye leaks around the injection site. For several hours after fluorescein is injected, the skin may turn yellow, but this effect disappears as the fluorescein is renally cleared. Urine may be orange/yellow for a day or two after the test as well.

It should be noted that fluorescein is safe for people with renal impairment. Allergic reactions to fluorescein are rare and may include a rash or hives that respond to antihistamines. Rarely, anaphylaxis can occur and can be life-threatening.

Optical Coherence Tomography

Optical coherence tomography (OCT), as shown in Figure 1C, uses light waves and a computerized camera to take cross-sectional images of the retina. This procedure allows for interpretations of retinal thickness, which is important for documenting the presence or absence of DME.

OCT angiography (OCTA) uses motion contrast instead of fluorescein and creates volumetric scans that can be segmented to specific depths. In eyes with advanced DRD, OCTA images may demonstrate abnormalities in the choriocapillaris and retinal vasculature. This study can also provide valuable insight into the presence of microaneurysms, capillary tortuosity and dilation, enlargement of the foveal avascular zone, and vascular remodeling.
FIGURE 1. Ocular images of DRD. A: Color fundus photograph of a right eye with moderate to severe nonproliferative DRD and DME. B: Ultra-widefield fluorescein angiography of a right eye with PDR. C: OCT of a right eye with DME. D: B-scan ultrasonography demonstrating a dense vitreous hemorrhage.

B-Scan Ultrasonography
In eyes with advanced DRD, when direct visualization of the posterior segment is limited, it is possible with B-scan ultrasonography (Figure 1D) to determine the presence of blood in the vitreous cavity, fibrosis, and retinal traction, in addition to a detached retina. Recorded images help to document these conditions and can be used for patient education.

Preparing People for a Diabetes-Related Eye Exam
Although diabetes-related eye evaluations are safe and noninvasive, it is helpful to prepare people regarding what to expect before, during, and after their screening eye exams. Health care professionals are encouraged to share the following tips with their patients with diabetes.

Before the exam:
• Bring all glasses and/or contact lenses you wear, along with sunglasses for afterward.
• Expect to have a dilated exam that will cause blurred vision for a few hours.

During the eye exam:
• Expect to have periods of waiting during the exam. Dilation and testing can often take several hours.
• Bring a source of quick-acting carbohydrates to correct any episodes of hypoglycemia that may occur during the exam.
• Although near vision may be difficult after dilation, bringing a book or magazine may help to pass the wait time before dilation.

After the exam:
• Make a list of any questions you have about diabetes and your vision.
• Ask for a report of the exam to be sent to your primary care provider and/or endocrinologist, and keep a copy for your own records.
• Schedule a return visit based on the absence or presence and stage of DRD found during the exam.
• It is best to ask someone to drive you after the exam or to wait until the dilation has worn off before driving yourself.
How to Interpret a Diabetes-Related Eye Examination Report

Sherrol A. Reynolds, OD, FAAO, Nova Southeastern University College of Optometry, Ft. Lauderdale, FL

The prevalence of diabetes is expanding at an alarming rate. More than 133 million Americans are now living with diabetes or prediabetes—an increase of 11 million in the past 2 years (28). More concerning is that millions of these individuals are unaware of their diabetes or prediabetes status (28).

Given the sharp increase in diabetes, it is expected that the prevalence of diabetes-related eye disease—diabetes-related retinal disease (DRD) as well as glaucoma, cataracts, and other ocular disorders—will also continue to rise. DRD and its associated pathology, including diabetes-related macular edema (DME), is the leading cause of visual impairment and vision loss in adults between the ages of 20 and 74 years (16,18). DRD affects >7 million Americans, and the National Eye Institute projects an increase to >11 million people by 2030 (29).

Preventing or delaying the onset and slowing the progression of DRD is the goal of all eye care professionals (ECPs) and other health care professionals (HCPs) who participate in the care of people with diabetes. A crucial component of successfully meeting this goal is communication between ECPs and other diabetes HCPs to properly coordinate care. This chapter explains how to interpret eye examination reports for people with diabetes and reviews the latest information regarding diagnostic technologies, patient education, treatments, and telemedicine-based DRD screening. This information is necessary to facilitate collaborative care among ECPs and HCPs and ensure the best outcomes for their shared patients with diabetes.

Diabetes-Related Eye Disease Risks

It is estimated that ≥20% of people with diabetes first learn of their diabetes status through an eye exam (30). Thus, a diabetes-related eye exam record should include information about the person’s diabetes status, ethnicity, age, duration of diabetes if present, and modifiable risk factors. These risk factors include the “ABCs of diabetes” (A1C, Blood pressure, Cholesterol, and Smoking status), as well as BMI/obesity status and nutritional concerns.

As observed in major diabetes clinical trials (19,20,31), lowering A1C to ≤7% is key to reducing the risk or slowing the progression of DRD and other diabetes complications (Table 1). Small reductions add up; even a 1% reduction in A1C can reduce microvascular and macrovascular complications. In addition, for people with diabetes who use continuous glucose monitoring (CGM), time in range and related CGM-derived parameters (32) should also be noted during eye exams.

Comorbidities such as hypertension and dyslipidemia should be addressed (33). The benefits of blood pressure and lipid-lowering medications in slowing the progression of DRD have been established for people with type 2 diabetes in clinical trials such as the FIELD (Fenofibrate Intervention and Event) study (34) and the ACCORD (Action to Control Cardiovascular Risk in Diabetes) Eye study (35).

Additionally, eye examination records should include information about medication use—particularly diabetes medications—to assess medication-taking consistency and engagement with the diabetes treatment plan.

### TABLE 1 Reductions in Complication Rates with A1C Lowering in Major Clinical Trials (19,20)

<table>
<thead>
<tr>
<th>Complication</th>
<th>Diabtes Control and Complications Trial*</th>
<th>UK Prospective Diabetes Study†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retinopathy</td>
<td>63</td>
<td>17–21</td>
</tr>
<tr>
<td>Nephropathy</td>
<td>54</td>
<td>24–33</td>
</tr>
<tr>
<td>Neuropathy</td>
<td>60</td>
<td>—</td>
</tr>
<tr>
<td>Macrovascular disease (stroke and myocardial infarction)</td>
<td>41</td>
<td>16</td>
</tr>
</tbody>
</table>

*Percentage reduction in prevalence of complications from lowering mean A1C from 9 to 7%. †Percentage reduction in prevalence of complications from lowering mean A1C from 8 to 7%.
Timing of Diabetes-Related Eye Exams

All people with diabetes should have regular dilated retinal exams to identify the presence of any diabetes-related eye diseases and ensure prompt treatment if they develop. However, many people with diabetes are unaware that they have the disease, making it unlikely that they will receive these exams. Additionally, many people with significant vision-threatening DRD remain asymptomatic and may therefore be unaware that they are even at risk for serious ocular complications. According to one recent study (36), ~60% of Americans with diabetes do not receive eye exams as recommended. For this reason, it is crucial for all diabetes care professionals to consistently reinforce the importance of getting regular dilated retinal exams.

A diabetes-related eye exam report will include symptoms that might indicate undiagnosed diabetes, including refractive changes, early-onset cataracts (especially posterior subcapsular cataracts), ocular surface disease (i.e., dry eyes), and other diabetes-related findings (Table 2).

As mentioned earlier in this compendium (p. 4), people with type 2 diabetes should have an initial dilated retinal exam near the time of diagnosis and generally annually thereafter. By the time a person is diagnosed with type 2 diabetes, the disease often has been present for several years; indeed, 33% of individuals who are newly diagnosed will already have some degree of DRD (37). The screening interval can be extended to 2 or 3 years in individuals with type 2 diabetes who reliably follow up, whose diabetes is well controlled, and who have had a normal dilated retinal exam previously (38). Individuals with DRD may require more frequent follow-up, depending on its severity.

DRD can progress rapidly during pregnancy. Therefore, all women with type 1 or type 2 diabetes who become pregnant should have a dilated retinal exam in the first trimester of pregnancy, with additional monitoring every trimester and for 1 year postpartum as indicated by the degree of DRD present.

Eye Exam Reports: What HCPs Need to Know

After a diabetes-related eye exam, the ECP should share a report with the person’s HCP. This report will include information about the person's stage of DRD (Table 3) and presence of DME, if applicable; a summary of retinal imaging results, telemedicine screening, and/or other diagnostic tests; and treatment and follow-up recommendations, including the need for referral to a retinal specialist, if appropriate. Table 4 defines some of the common abbreviations ECPs often use in reporting findings of diabetes-related eye exams.

Retinal fundus photography (Figure 1) is considered the gold standard for DRD imaging, and recent advances in imaging technologies have significantly improved the ability to detect and treat DRD and maculopathy. Ultra-widefield imaging (Figure 2) provides a larger field of view, allowing ECPs to see more of the retina and detect peripheral changes, which in turn facilitates early detection of DRD and enhances patient education regarding the importance of screening and follow-up care.

The American Diabetes Association recognizes the potential of HCP clinic–based retinal photography with remote (telemedicine) review and interpretation by eye care experts as a way to overcome barriers to screening services.

### TABLE 2 Components of a Comprehensive Diabetes-Related Eye Exam

<table>
<thead>
<tr>
<th>Complications</th>
<th>Symptoms/Signs</th>
<th>Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refractive errors</td>
<td>Fluctuating or blurry vision related to glycemic variability</td>
<td>Best corrected visual acuity test</td>
</tr>
<tr>
<td>Abnormal visual function</td>
<td>Abnormal color vision or visual function deficits</td>
<td>Tests to detect decreased color perception, contrast sensitivity, and abnormal electrophysiology of the retina</td>
</tr>
<tr>
<td>Neurological disorders</td>
<td>Optic nerve issues (e.g., cranial nerve palsies, neovascularization, or glaucoma)</td>
<td>Checks of pupils, extraocular motility, tonometry, and visual field</td>
</tr>
<tr>
<td>Anterior segment disorders</td>
<td>Dry eyes, corneal erosion, reduced corneal sensitivity, iris neovascularization, and cataracts</td>
<td>Slit-lamp examination</td>
</tr>
<tr>
<td>Retinal conditions (e.g., DRD, DME, vitreomacular traction, retinal vascular occlusion, vitreous hemorrhage, and tractional retinal detachment)</td>
<td>Decreased vision, metamorphopsia, or sudden loss of vision</td>
<td>Dilated retinal exam, retinal photography/widefield imaging, optical coherence tomography, and optical coherence tomography angiography, and ultrasonography</td>
</tr>
</tbody>
</table>
in locations where qualified ECPs are not readily available (16). However, in-person exams are still necessary if retinal photos are of unacceptable quality and for follow-up if abnormalities are detected. Retinal photos are not a substitute for dilated comprehensive eye exams, which should be performed at least initially and at intervals thereafter as recommended by an ECP (16). U.S. Food and Drug Administration-approved artificial intelligence systems that detect more than mild DRD and DME are an alternative to traditional screening approaches. However, their benefits and optimal use have not yet been determined (16,40).

Optical coherence tomography (OCT) (Figure 3) has dramatically improved early detection and care of DRD and maculopathy. OCT allows for the early identification and management of DME. Based on OCT, DME is categorized as center-involved or non–center-involved. Center-involved

<table>
<thead>
<tr>
<th>Severity Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>No apparent DRD</td>
<td>No abnormalities</td>
</tr>
<tr>
<td>Mild NPDR</td>
<td>Microaneurysms only</td>
</tr>
<tr>
<td>Moderate NPDR</td>
<td>Hemorrhages, exudates, and/or microaneurysms; cotton wool spots; venous beading; intraretinal microvascular abnormalities</td>
</tr>
<tr>
<td>Severe NPDR</td>
<td>Classified using the 4-2-1 rule:</td>
</tr>
<tr>
<td></td>
<td>‣ Hemorrhages in all 4 quadrants</td>
</tr>
<tr>
<td></td>
<td>‣ Venous beading in at least 2 quadrants</td>
</tr>
<tr>
<td></td>
<td>‣ Intraretinal microvascular abnormalities in at least 1 quadrant</td>
</tr>
<tr>
<td>PDR</td>
<td>Neovascularization; vitreous or pre-retinal hemorrhage</td>
</tr>
</tbody>
</table>

**FIGURE 1** Fundus photographs of eyes with nonproliferative DRD (A), proliferative DRD (B), and DME (C).

**FIGURE 2** Ultrawide-field imaging of NPDR.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCVA</td>
<td>Best corrected visual acuity</td>
</tr>
<tr>
<td>CN</td>
<td>Cranial nerve; various CN palsies can hinder extraocular motility in specific ways.</td>
</tr>
<tr>
<td>CWS</td>
<td>Cotton wool spot; also known as soft exudates, these are infarcts within the retinal nerve fiber layer that appear white and feathery.</td>
</tr>
<tr>
<td>DME</td>
<td>Diabetes-related macular edema; an ocular complication of diabetes characterized by fluid build-up in the macula—the part of the eye responsible for clear straight-ahead vision.</td>
</tr>
<tr>
<td>DMI</td>
<td>Diabetes-related macular ischemia; DMI refers to the presence of occlusion, atrophy, or loss of retinal capillaries in the macula, with narrowing or obliteration of precapillary arterioles.</td>
</tr>
<tr>
<td>DR/DRD</td>
<td>Diabetes-related retinopathy or diabetes-related retinal disease; the most common and serious type of diabetes-related ocular complication, DR or DRD refers to mild to severe damage to retinal blood vessels caused by high blood glucose.</td>
</tr>
<tr>
<td>EOM</td>
<td>Extraocular motility; movement of the six muscles that, when functioning properly, allow the eyes to move and focus together in various directions.</td>
</tr>
<tr>
<td>FAZ</td>
<td>Foveal avascular zone; an area at the center of the retina that is devoid of blood vessels.</td>
</tr>
<tr>
<td>HE</td>
<td>Hard exudates; HEs are distinct white/yellow cholesterol deposits resulting from active or resolved DME.</td>
</tr>
<tr>
<td>IOP</td>
<td>Intraocular pressure; fluid pressure inside the eye that, if elevated, could be a sign of glaucoma.</td>
</tr>
<tr>
<td>IRMA</td>
<td>Intraretinal microvascular abnormality; one of the defining features of severe NPDR (see definition below), IRMAs are abnormal branching or widened retinal blood vessels that supply areas of nonperfusion in DRD.</td>
</tr>
<tr>
<td>MA</td>
<td>Microaneurysm; an early sign of DRD, MAs are small-vessel aneurysms resulting from weakening of capillary walls.</td>
</tr>
<tr>
<td>NPDR</td>
<td>Nonproliferative diabetes-related retinal disease; the more common form of DRD, NPDR is a condition in which the walls of retinal blood vessels weaken and sometimes leak fluid and blood into the retina, but new blood vessels are not yet growing (proliferating) in response to this damage. It is subclassified as mild, moderate, and severe and can also cause DME (see definition above).</td>
</tr>
<tr>
<td>NVI</td>
<td>Neovascularization of the iris; NVI occurs when new blood vessels grow in response to retinal ischemia, is associated with PDR (see definition below), and may cause spontaneous hyphema and neovascular glaucoma.</td>
</tr>
<tr>
<td>NVD/NVE</td>
<td>Neovascularization of the disk or elsewhere in the retina; NVD/NVE occurs when new blood vessels grow in response to retinal ischemia, is associated with PDR (see definition below), and may cause spontaneous vitreous hemorrhage.</td>
</tr>
<tr>
<td>OCT</td>
<td>Optical coherence tomography; an imaging test that uses light waves to take cross-section pictures of the retina. OCT allows ECPs to see and measure the distinctive layers of the retina to diagnose and guide treatment of DRD and glaucoma.</td>
</tr>
<tr>
<td>OCTA</td>
<td>Optical coherence tomography angiography; OCTA is an imaging technique that uses laser light reflectance of the surface of moving red blood cells to accurately depict retinal vessels without the use of dye.</td>
</tr>
<tr>
<td>PDR</td>
<td>Proliferative diabetes-related retinal disease; PDR is the most advanced stage of DRD, characterized by the growth of new, fragile blood vessels in the retina (neovascularization).</td>
</tr>
<tr>
<td>TRD</td>
<td>Tractional retinal detachment; TRD is the separation of the neurosensory retina from the retinal pigment epithelium resulting from the traction caused by proliferative membranes present over the retinal surface or vitreous.</td>
</tr>
<tr>
<td>UWF</td>
<td>Ultra-widefield; UWF imaging provides a 200° panoramic image of the retina, allowing ECPs to better visualize and evaluate retinal abnormalities.</td>
</tr>
<tr>
<td>VB</td>
<td>Venous beading; a late-stage finding in NPDR that represents weakened walls of major retinal vessels, VB is one of the strongest predictors for progression to PDR.</td>
</tr>
<tr>
<td>VH</td>
<td>Vitreous hemorrhage; VHs are caused by bleeding from fine neovascular blood vessels in the eye.</td>
</tr>
</tbody>
</table>
DME is characterized by loss of foveal contour, cystoid macular edema involving the center of the fovea, neurosensory detachment involving the center of the fovea, and increased central subfield thickness. Non–center-involved DME is characterized by retinal thickening and/or cystic spaces not directly involving the center of the macula.

OCT angiography (OCTA) (Figure 4) is another modern imaging test that can detect other vascular anomalies such as vascular loops, tortuosity, and dilations of the vessels, as well as intraretinal microvascular abnormalities and superficial neovascularization. It also detects diabetes-related macular ischemia, with clinical signs of paramacular areas of capillary nonperfusion, impairment of the choriocapillaris flow, and enlargement of the foveal avascular zone (FAZ). Abnormalities in the structure or perfusion of the FAZ not only result in vision impairment, but also signify a poor prognosis because the condition cannot be treated.

**Next Steps: What to Do After the Eye Exam**

All people with severe nonproliferative diabetes-related retinal disease (NPDR), proliferative diabetes-related retinal disease (PDR), or DME should be referred to an ophthalmologist experienced in the management of DRD—even those with 20/20 vision and no visual complaints (16–18). Anti-vascular endothelial growth factor (VEGF) medications are the first-line treatment for most people with center-involved DME and PDR (41,42). In some cases of persistent edema after three to six injections, the retinal specialist may elect to switch anti-VEGF agents, add laser therapy, or initiate steroid treatment. For individuals with non–center-involved DME, the specialist may start treatment with focal laser therapy or anti-VEGF agents or decide on further observation if the vision is not compromised.

**Conclusion**

Reports of diabetes-related eye exams are an essential component of interprofessional communication between ECPs and HCPs who share patients with diabetes or prediabetes. These reports can be handwritten notes, forms developed and completed via an electronic medical record system, or based on templates obtained from various resources such as professional organizations. In addition to merely reporting their findings, ECPs should use these reports to alert HCPs if additional care such as a referral to a retinal specialist is warranted. Even when people have no notable ocular manifestations of diabetes upon examination, the ECP should still share a report to that effect in a timely manner.

Confronting the emerging epidemic of DRD and ensuring better ocular outcomes requires collaboration from all ECPs and HCPs involved in the care of people with diabetes. Bidirectional interprofessional communication is particularly important, and both ECPs and HCPs should be aware of their shared patients’ overall medical status, individualized glycemic targets, and evolving eye health. Effective team care and ongoing communication can decrease the risk of sight-threatening DRD, reduce systemic complications, improve clinical outcomes, and enhance quality of life for people with diabetes.
How to Review and Incorporate Primary Care Records into Eye Care

Michael Huvard, MD, University of Michigan Medical School, Kellogg Eye Center, Ann Arbor, MI

Diabetes affects 37.3 million individuals (11.3% of the U.S. population) and impacts all organ systems (28). Diabetes-related retinal disease (DRD) is a neurovascular complication of type 1 and type 2 diabetes and a leading cause of vision loss and blindness (5). Approximately 35% of individuals with diabetes will develop some form of DRD, and 10% of those individuals will develop vision-threatening complications (43). As understanding of DRD has evolved in recent decades, the rate of vision impairment resulting from it has significantly declined (44,45). The primary reasons for this improvement are advances in systemic management of diabetes combined with improved screening and the advent of new therapeutic options for vision-threatening DRD. A multidisciplinary approach involving diabetes health care professionals (HCPs) and eye care professionals (ECPs) is essential in optimizing outcomes.

Adoption of electronic medical record (EMR) systems has transformed health care delivery. Although much has been written about the challenges of EMR design and implementation, the ability of these systems to improve access to information and enhance collaboration may improve diabetes care (21,22,46). This chapter reviews the systemic components of diabetes that are associated with vision outcomes. It describes the usual routes of information flow via EMR systems and explains how EMR systems can enhance interprofessional communication between HCPs and ECPs. Finally, it explores how ECPs may benefit from reviewing HCPs’ medical records for the patients they share.

Systemic Components of Diabetes and Their Relationship to DRD

Several systemic components of diabetes are related to the development and progression of DRD. It is important for HCPs to recognize that A1C is not the only correlate to DRD and to actively treat all of the conditions and processes that may lead to DRD progression (Table 1) (1).

Hyperglycemia is the most widely recognized risk factor for DRD. Diabetes duration and, to a lesser extent, the degree of hyperglycemia, are well established as the leading risk factors for the development of DRD, and once DRD is present, the degree of glycemic control better predicts its progression (1,18,47,48). Worsening of DRD is slowed by achieving glycemic targets (2,19,20,49–51). In fact, lowering A1C by 1 percentage point reduces the risk of DRD by 35% and the risk of its progression by ~20% (52). Improved glycemic control also reduces the risk of cataract formation and the need for cataract surgery (53,54). However, rapid correction of elevated A1C levels is associated with a transient worsening of DRD (55,56). There is no consensus on the optimal rate at which A1C should be reduced. However, implementing intensive glycemic control has been shown to result in significant reduction in DRD progression in the long term (19).

TABLE 1 Key Components of Diabetes That Are Related to the Progression of DRD

<table>
<thead>
<tr>
<th>Component</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperglycemia</td>
<td>▶ Glycemia has the strongest link to DRD progression.</td>
</tr>
<tr>
<td></td>
<td>▶ Its degree and duration correlate with DRD.</td>
</tr>
<tr>
<td></td>
<td>▶ DRD progression is slowed by achieving glycemic targets.</td>
</tr>
<tr>
<td>Hypertension</td>
<td>▶ DRD progression is slowed by achieving a systolic blood pressure &lt;130 mmHg.</td>
</tr>
<tr>
<td></td>
<td>▶ There may be reduced need for intravitreal anti-VEGF injections when blood pressure targets are achieved.</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>▶ Treatment with statin therapy, when appropriate, may reduce the risk of DME.</td>
</tr>
<tr>
<td></td>
<td>▶ Treatment of hypertriglyceridemia with fenofibrate, when appropriate, may reduce DRD progression.</td>
</tr>
<tr>
<td>Diabetes-related nephropathy</td>
<td>▶ The presence of renal insufficiency may be a risk factor for DRD progression.</td>
</tr>
<tr>
<td></td>
<td>▶ Initiation of dialysis may improve DME.</td>
</tr>
<tr>
<td>Diabetes-related neuropathy</td>
<td>▶ The presence of neuropathy may be a risk factor for DRD progression.</td>
</tr>
<tr>
<td>Pregnancy</td>
<td>▶ Pregnancy is associated with transient but rapid worsening of DRD.</td>
</tr>
<tr>
<td></td>
<td>▶ Increase surveillance to occur in each trimester of pregnancy and for 1 year postpartum based on the degree of DRD.</td>
</tr>
</tbody>
</table>

Adapted from ref. 1.
Hypertension is another important risk factor for DRD. Treating hypertension reduces its progression and the likelihood of vision-threatening complications such as diabetes-related macular edema (DME), the most common cause of reduced vision in people with DRD (57,58). More recently, hypertension was identified as a risk factor for the need to receive intravitreal anti-vascular endothelial growth factor (VEGF) medication for DRD (59). No specific antihypertensive regimen has been shown to be superior in reducing DRD progression.

Complications of diabetes affect small blood vessels and include nephropathy, neuropathy, and DRD. In the United States, 57.9% of people with diabetes have at least one of these complications, and 14.3% have three or more (60). The presence of nephropathy and neuropathy are risk factors for DRD (61). DME has been shown to improve with the initiation of dialysis in people with renal insufficiency (62–64), and statin therapy for dyslipidemia is associated with reduced DME risk, although there is no clear evidence about its effect on DRD progression (65). Similarly, treatment of hypertriglyceridemia with fenofibrate reduced retinopathy in several trials (49,66). There are no specific guidelines for lipid therapy as it relates to DRD.

Pregnancy is also a risk factor for DRD progression (67–69) and can temporarily accelerate the rate of progression, with the highest risk occurring in the second trimester (56). This increased risk of DRD progression can persist for up to 12 months postpartum. Factors associated with DRD progression during pregnancy include diabetes duration, DRD severity at conception, and the previously discussed general risk factors for DRD progression. The American Academy of Ophthalmology’s Preferred Practice Pattern for DRD (18) recommends that pregnant women with type 1 or type 2 diabetes receive screening in the first trimester, with subsequent follow-up determined by DRD severity. Similarly, as reviewed earlier in this compendium (p. 4), the American Diabetes Association recommends an eye exam within the first trimester and continued monitoring every trimester and for 1 year postpartum as indicated by the degree of DRD (16).

As our understanding of diabetes as a systemic disease has evolved, we have come to better appreciate new risk factors for DRD progression. Traditionally, ECPs have relied on A1C as the primary marker of glycemic control. As noted earlier, hyperglycemia has the strongest link to DRD, but taking stock of other conditions such as hypertension and nephropathy is important to more fully understand a person’s overall health status. Some of these new relationships, such as the link between hypertension and the need for intravitreal anti-VEGF injections, arose in part because of the ability of EMR systems to capture large amounts of data for analysis (59).

There is a great need for ongoing collaboration between ECPs and HCPs who share patients—for ECPs to communicate their findings after eye exams and for HCPs to treat and communicate pertinent information regarding hyperglycemia, hypertension, dyslipidemia, and other conditions linked to DRD progression. It is important for ECPs to know the status of these other diabetes-related factors, which will enable them to better stratify risk of DRD progression than when relying on A1C data alone. EMR systems may help to facilitate this crucial bidirectional communication.

**Use of EMR Systems for Diabetes Care**

The adoption of EMR systems in the United States was founded on the idea that their implementation would lead to numerous benefits, including enhanced patient care, increased efficiency, and improved safety, all while reducing health care costs (21,46). Despite concerns such as a possible loss of information integrity with EMR systems, there is great potential for EMRs to facilitate interprofessional collaboration and ultimately improve patient care.

Early detection of vision-threatening complications of DRD and prompt intervention can result in a 90% reduction in vision impairment. However, less than two-thirds of people with diabetes in the United States receive appropriate screening—a statistic that underscores the importance of improving access to diabetes-related eye examinations and fostering interprofessional communication (2,70,71).

Before the widespread adoption of EMR systems, studies looking at the relationship between HCPs and ECPs reported that adoption of an EMR system was the number one suggestion for improving the rate of referrals for diabetes-related eye exams (72). Even today, some of the main barriers to DRD screenings are a lack of their integration with other processes of diabetes care and challenges accessing ECPs (73,74). In practice settings in which clinics are unified by a single EMR system, such as academic hospitals or large health care networks, the system can assist in both scheduling screening appointments and acquiring information. Eye care reports can be made easily accessible to HCPs, while ECPs can just as easily access data on their patients’ overall health status. However, practitioners who are not part of these networks and whose EMR systems, if any, cannot interface with others may be at a disadvantage (75).
EMR systems can be overly complex and both costly and challenging to maintain. Despite these drawbacks, their adoption has been shown to improve diabetes care outcomes (21–23). Their advantageous features include drug interaction identification, laboratory test reminders, clinical intervention tools, and data-driven decision-support mechanisms. EMR systems may also serve as data repositories for clinical research. Thus, modern EMR systems offer much more than merely a digital simulacrum of a paper chart.

Finally, although EMR systems have been shown to be an asset in improving interprofessional collaboration on and access to diabetes-related eye care, it is important to mention that other barriers to receiving both diabetes care and related eye care exist. As described elsewhere in this compendium (p. 16–19), these include the inequitable distribution of social determinants of health that can lead to food insecurity, financial strain, poor housing conditions, and lack of social support (76). The importance of these factors cannot be overstated.

**ECPs’ Review of HCPs’ Records**

When people are referred for an eye exam, ECPs should carefully review their medical chart, if possible. The availability of a shared EMR system may help ECPs ascertain the reason for the referral and more easily collect key information about patients’ overall health status. It is particularly important to review the factors beyond A1C that may affect a person’s DRD progression and risk of developing vision-threatening complications, as listed in Table 1.

Understanding a patient’s overall health will allow an ECP to make better decisions and identify optimal treatment recommendations based on individual factors.

This information may be readily available when both clinics are part of the same system and document patient care in the same EMR system, but if a person is referred from a clinic outside of the local network, the necessary data may be fragmented and more challenging to acquire. However, emerging EMR tools such as the Care Everywhere Network in Epic (Epic Systems, Verona, WI), are helping to alleviate this challenge by integrating similar electronic data from different institutions into a unified record (77). Clinical decision-support tools that help to collate relevant data may be embedded in EMR systems.

Because of the complexities and variations among EMR systems, it is impossible to describe in detail an exact protocol for locating information of interest. ECPs and HCPs should familiarize themselves with the features of their own EMR systems that facilitate access to essential patient health information. It may be prudent for referring HCPs to collate and emphasize the risk factors for and status of DRD progression in their documentation, especially if communication between ECPs and HCPs is occurring across different records systems.

Understanding patients’ overall health status is also important in that it may allow ECPs to recognize potential barriers to receiving eye care. These barriers may affect the ECPs’ treatment recommendations or ability to provide timely care. For example, a person with diabetes-related nephropathy who is receiving hemodialysis several days per week may be a poor candidate for monthly intravitreal anti-VEGF injections to mitigate proliferative diabetes-related retinopathy. Studies have shown that people with DRD are subject to significant lapses in follow-up caused by illness or other social factors and that these lapses may result in irreversible vision loss if their DRD is being managed with anti-VEGF injections alone (78,79).

Finally, a thorough review of patients’ HCP records may help to identify confounding diagnoses that mimic DRD. Classic findings of DRD such as intraretinal hemorrhages or retinal neovascularization may also be found in other conditions such as ocular ischemic syndrome (a sequela of carotid artery disease), radiation retinopathy, or sickle cell retinopathy.

**Conclusion**

DRD is a leading cause of vision impairment, but progress in understanding systemic components of diabetes that are risk factors for its progression, in combination with improved collaboration between ECPs and HCPs, has helped to reduce the risk of vision loss. EMRs aid in placing referrals for screening exams and may improve data availability and acquisition by both ECPs and HCPs. Careful review of HCPs’ records may improve the ECPs’ understanding of their patients’ medical status and thereby allow for more informed treatment decisions.
According to the Centers for Disease Control and Prevention, an estimated 37.3 million people (11.3% of the U.S. population) have diabetes, and an additional 96 million people >18 years of age (38% of the U.S. adult population) have prediabetes (28). Sociodemographic factors such as race, ethnicity, income, education level, and insurance status have all been shown to affect diabetes prevalence rates (80–83). Ecological studies of diabetes prevalence have recently identified a “diabetes belt”: a region of the United States that encompasses 644 counties in mostly southern states in which diabetes prevalence is ≥11% (24). Research on these geographical disparities has shown that community factors such as racial/ethnic mix, income, and food environment all contribute to rates of diabetes. Diabetes-related retinal disease (DRD), the most common ocular complication of diabetes and a leading cause of blindness in the United States (84), also disproportionately affects certain populations.

Disparities in Prevalence
Correlations between race/ethnicity and rates of DRD in the United States have been well established in multiple studies. Harris et al. published several studies in the 1990s that found that Blacks had significantly higher rates of DRD than non-Hispanic Whites. One study (85) reported that Black men were ~23% more likely to develop DRD than other race-sex groups, and another study (86) found that Blacks were more likely to develop DRD than Whites, with a calculated odds ratio (OR) of 2.96 after adjusting for glycemic control, blood pressure, and diabetes treatment. A third report by Harris et al. (87) showed that non-Hispanic Blacks and Mexican Americans not only have a higher prevalence of DRD compared to their White counterparts (46% and 84%, respectively), but also have higher rates of moderate and severe stages of DRD. This report concluded that, for Blacks, much of the difference in DRD rates could be attributed to higher levels of risk factors in that population.

Prevalence rates of diabetes in the Hispanic population are generally reported to be about twice that of non–Hispanic Whites (88). DRD is also noted to develop at higher rates in this population. The National Eye Institute reports that, in 2010, Hispanic Americans ≥50 years of age had the highest prevalence of DRD (8%) of any racial/ethnic group (84). Almost half of Latino people with diabetes have DRD, with reported rates of 46.9 and 48% in two large epidemiological studies (88,89). In addition, while the number of Americans with DRD is expected to nearly double between 2010 and 2050, Hispanic Americans are expected to experience the greatest rise in cases, with a nearly three-fold increase in that time frame (84). Figure 1 illustrates projected increases in DRD cases in the United States by race/ethnicity.

Native Americans/Alaska Natives also have a prevalence of diagnosed diabetes that is about twice that of non–Hispanic Whites (1). Studies conducted in the 1980s and 1990s reported rates of DRD in these populations as high as 35–49%, but in a more recent study published in 2018, Bursell et al. (90) reported prevalence rates of DRD that were approximately half of those reported in earlier studies. They hypothesize that improvements in rates of DRD are associated with improvements in diabetes management.

Diabetes-related macular edema (DME), a vision-threatening stage of DRD, also disproportionately affects communities along racial/ethnic lines. Wong et al. (91) showed that the prevalence of DRD and DME was significantly higher in Blacks and Hispanics than in White and Chinese cohorts; however, despite the differences...
in rates of disease, their analysis found that race was not an independent predictor of the development of DRD. Another study (92) reported that the prevalence of DME was approximately threefold higher in non-Hispanic Blacks than in the non-Hispanic White population.

Proliferative diabetes-related retinal disease (PDR) is an advanced, vision-threatening stage of DRD. In a large database study, Malhotra et al. (93) reported that Black and Hispanic individuals had higher rates of PDR compared to their White and non-Hispanic counterparts. They also noted that Black and Hispanic people had worse visual acuity at initiation of treatment for vision-threatening disease compared to White and non-Hispanic people. Blacks and Hispanics had ORs of 1.23 and 1.71, respectively, for presenting with one level of DRD severity worse than White or non-Hispanic people. Black individuals presented with not only more severe DRD, but also significantly worse visual acuity.

Given the significant disparities in the rates of DRD, DME, and PDR, as well as differences in severity of disease at presentation, it is not surprising that visual impairment from DRD also disproportionately affects certain populations. Data from the Salisbury Eye Evaluation, reported two decades ago, showed that African Americans were four times more likely than Whites to suffer visual impairment from DRD (94).

In addition to race and ethnicity, there are significant correlations between other socioeconomic factors and prevalence of diabetes and DRD. A 2010 study (95) looked at prevalence of diabetes in Appalachian counties within the diabetes belt based on 3-year unemployment rate, per-capita income, and poverty rate. Counties were deemed “distressed” if they were in the bottom 10% of all counties in the country on these measures. The researchers found that residents of distressed Appalachian counties had 33% higher odds of having diabetes than those in non-Appalachian counties. The reasons for this disparity are likely complex and multifactorial, including higher rates of obesity, less physical activity, food insecurity, poor health literacy, and lack of access to care. A study of people with diabetes in North Carolina (96) reported that, in addition to increased prevalence in Blacks and individuals with a longer duration of diabetes, self-reported DRD was more common in adults who were not married or living with a partner, those with less than a high school education, those without health insurance, and adults with an annual household income <$25,000; these findings underscore the impact of socioeconomic status on rates of DRD.

Disparities in Rates of DRD Screening
Most people are asymptomatic in the early stages of diabetes-related eye disease. Nwanyanwu et al. (97) found that nearly 11% of people with type 2 diabetes were unaware of their DRD diagnosis, which represents an estimated 9.8 million individuals. Screening for DRD is a cost-effective way of identifying it early and providing opportunities for both systemic and vision-preserving interventions (98). Early detection and treatment of DRD can reduce severe vision loss by 94% (99), and up to 21% of people with type 2 diabetes may already have some degree of DRD at the time of their diabetes diagnosis (100). Despite these statistics, adherence to DRD screening guidelines is low, with one study demonstrating that 35% of its cohort with diabetes did not receive appropriate screening (99). Other estimates suggest that nearly half of all people with diabetes do not receive eye health screenings as recommended in guidelines. 2020 data from the National Committee of Quality Assurance (NCQA) show that less than 50% of individuals with commercial insurance, 50.6% of those with Medicaid, and less than 69% of those with Medicare underwent DRD screening as recommended (101).

Racial minority groups have lower rates of eye screening than non-Hispanic Whites. One study demonstrated that, from 2002 to 2009, while the screening rate for Whites increased from 56 to 59%, the screening rate in minorities decreased from 56 to 49% (102). Although not specific to people with diabetes, another study reported that African Americans were less likely than non-Hispanic Whites to receive any eye care examinations (103). In the Los Angeles Latino Eye Study (104), 65% of participants had not had guideline-recommended eye care for people with type 2 diabetes.

In addition to race and ethnicity, household income, education level, health literacy, and geographical location have all been shown to be significant barriers to meeting eye health screening guidelines. Lower income and education levels, rural residence, and lack of health insurance have all been linked to fewer visits to eye care professionals and fewer dilated eye exams, and all of these factors also contribute to the lower screening rates noted in minority populations (103–105).

Screening in youth is important because 20.1 and 7.2% of youth with newly diagnosed type 1 and type 2 diabetes, respectively, in a large U.S. managed-care network developed DRD during 3 years of follow-up (8). Disparities in DRD screening rates have also been documented in youth with diabetes. Thomas et al. (106) reported that 34.2% of the youth with type 1 or type 2 diabetes in their cohort had not had a prior diabetes-related eye exam. Being of non-White race and having Medicaid or other public insurance, lower household
income, and parents with a high school education or less were all associated with being less likely to have had a prior eye exam. Another study involving youth with type 1 diabetes reported that White children were significantly more likely than Black children to be screened for DRD (OR 1.64) and that Black children in the study cohort were seven times more likely than White children to have public health insurance (107). The authors noted that youth who were not screened were more likely to have poorer diabetes control, suggesting that those who were not receiving eye exams were also the most at risk for DRD.

Interventions to Improve DRD Screening Rates
Numerous barriers to obtaining guideline-recommended screening exams have been documented, including patient-, physician-, and system-level factors (Table 1) (103,105,108,109). It is important to note that, in addition to patient-level factors, several provider- and system-level factors can be addressed to improve DRD screening rates.

Various strategies have been implemented successfully to improve retinal screening rates. These have included patient and provider education programs, strategies to improve access to health care, computer-based registration or reminder systems, collaboration among organizations that provide retinal screenings, and the development of a community-based health care system (110). Interventions aimed specifically at non-White, low-income, and low–health literacy communities may also be effective (105).

Health education and reminder interventions focusing on both people with diabetes and their health care providers have been shown to improve screening rates (110–112). Educating patients about diabetes-related eye disease can help them understand the importance of regular screening and motivate them to participate more in their own care. Educating primary care providers about eye screening guidelines and improving provider-patient relationships by increasing providers’ cultural competency may help to reduce the disparities in screening rates noted in minority populations. Walker et al. (113) increased DRD screening by 74% using a telephone intervention in a minority, low-income population. The telephone intervention, which was conducted by a bilingual interventionist, served to educate and motivate individuals about the importance of having an annual dilated eye examination and afforded the opportunity to discuss risk and the frequent lack of symptoms early in DRD and elicit and troubleshoot barriers. Another study (114) tested a health education intervention using a face-to-face session delivered in the local language, with pictorial educational materials in the local language, and telephone reminders. It found that personalized health education was the most important predictor of follow-through with screening referrals. Basch et al. (111) doubled the rate of ophthalmic examination among African Americans with diabetes from 27.3 to 54.7% using educational materials that included a low-literacy booklet, a motivational videotape, and telephone education and counseling.

At the system level, patient registries, collaboratives, and prompts within electronic medical record (EMR) systems have all been shown to help providers identify patients who are not getting recommended DRD screening (115,116). Kollipara et al. (116) increased screening rates in a large endocrinology clinic from 49 to 69% using a multifaceted approach that included a diabetes patient registry and decision-support tools within the EMR system. Use of the registry facilitated the identification of care gaps, and use of the EMR system facilitated patient outreach using bulk messaging through the patient portal as well as placement of referrals to ophthalmology and provided an efficient system for tracking the successful delivery of care.

### TABLE 1 Barriers to Recommended DRD Screening

<table>
<thead>
<tr>
<th>Component</th>
<th>Considerations</th>
</tr>
</thead>
</table>
| Patient-level factors| - Lack of education about/understanding of DRD and the availability of treatment
|                      | - Cost/insurance issues                                                        |
|                      | - Lack of follow-through on referral/recommendation                            |
|                      | - Lack of access to care                                                      |
|                      | - Patient-provider communication issues (e.g., language barriers, limited health literacy, and lack of trust) |
| Provider-level factors| - Lack of awareness of screening guidelines, skill, or equipment to perform eye exams |
|                      | - Patient-provider communication issues (e.g., language barriers, limited health literacy, and lack of trust) |
|                      | - Time limitations                                                            |
|                      | - Inconsistent primary care provider referral patterns                          |
| System-level factors | - Insurance issues                                                            |
|                      | - Understaffing of eye care professionals/difficulty obtaining diagnostic imaging |
|                      | - Long wait times for appointments                                             |

Adapted from ref. 105.
Telemedicine to Improve DRD Screening Rates

The use of telemedicine using retinal imaging with remote interpretation by eye care specialists can increase DRD screening rates (117–119). Studies have shown a high degree of accuracy in detecting DRD by image-based telemedicine, with sensitivity of >80% and specificity of >90% in most studies (120). This approach has been implemented widely in many countries, including Singapore, China, and India (121), and is the standard for DRD screening in the United Kingdom (45). In 2014, Liew et al. (10) noted a decline in the absolute number and relative proportion of blindness certifications resulting from DRD/maculopathy among working-age adults after the 2003 introduction of the National Health Service Diabetic Eye Screening Programme in England. These authors also reported that, by 2009–2010, DRD/maculopathy was no longer the leading cause of certifiable blindness among working-age adults in England and Wales for the first time in at least five decades. In the United States, digital retinal imaging with remote interpretation has been implemented successfully by the Veterans Health Administration (VHA) and found to be cost-effective and to increase population reach (122).

The placement of digital imaging equipment in primary care offices for point-of-care testing can further reduce patient-level obstacles such as lack of transportation, inconvenience, and language barriers (123). This strategy decreases the travel distance and time required for DRD screening because it does not require a separate visit to a different location. In the Tribal Vision Project (124), people randomized to telemedicine were more likely to receive a DRD screening exam than those receiving traditional surveillance throughout a 6-month period.

Although studies of the VHA’s teleretinal screening program have demonstrated cost-effectiveness (122), these results are not directly applicable to teleretinal programs implemented in community primary care clinics in the United States (125). The initial investment for retinal imaging devices and training may be prohibitively high for many primary care clinics without additional sources of funding. Although there is active research and development in the field of retinal imaging, a low-cost, validated, nonmydriatic retinal camera is not yet commercially available (103,125).

In addition, reimbursement for telemedicine Current Procedural Terminology (CPT) codes for retinal screening does not adequately reflect the work performed and is insufficient to cover the cost of most DRD telemedicine programs (103). In 2011, CPT codes 92227 and 92228 were introduced for remote imaging for detection of retinal disease. For individuals with no known retinal disease, CPT code 92227 (remote imaging for detection of retinal disease with analysis and report under physician supervision) has no compensation for physician work and is associated with very low reimbursement (average allowable amount <$16). CPT code 92228 (remote imaging for monitoring and management of active retinal disease with physician review, interpretation, and report) is used for people with active retinal disease and has slightly higher reimbursement (average allowable amount <$40). Despite the benefits of telemedicine for DRD screening, financial sustainability continues to be a major barrier to its widespread implementation (103,125).

Conclusion

Significant disparities exist in rates of both DRD and DRD screening. Black, Hispanic, and Native American populations are disproportionately affected, with higher rates of DRD and lower rates of DRD screening. Additionally, screening rates are affected by socioeconomic factors such as income, education level, insurance payor, and geographical location. Numerous patient-, physician-, and system-level factors contribute to these disparities, and various interventions have been shown to be effective in addressing barriers at each of these levels.

It is important for practitioners to recognize that socio-demographic factors play key roles in diabetes management and risk for complications such as DRD. Strong clinician-patient relationships and a better understanding of barriers faced by different racial/ethnic and socioeconomic groups will allow for targeted interventions such as providing people with literature in their native language and at an appropriate health literacy level, offering financial counseling, or engaging social work services to assist with transportation. System-level changes such as instituting EMR reminders and prompts and teleretinal imaging are also important strategies to improve rates of DRD screening. In particular, teleretinal imaging is an emerging and important strategy to address disparities in DRD disease burden, although financial sustainability remains a barrier to its widespread implementation. Recognition of the value of telemedicine services by payers and government agencies could lead to significant improvements in access to care and reductions in DRD disparities.
Summary and Conclusion

Thomas W. Gardner, MD, MS, University of Michigan Medical School, Kellogg Eye Center, Ann Arbor, MI

Diabetes is a multifactorial disease process, and its long-term management requires the active involvement of people with diabetes and their families, as well as a large multidisciplinary care team to ensure optimal health, quality of life, and productivity. Keeping up with new medications, emerging technology, and evolving treatment recommendations can be challenging, and the language and care processes commonly used by practitioners in one discipline may be less familiar to other diabetes care professionals.

In the realm of diabetes-related eye care, our ability to prevent the progression of diabetes-related retinal disease and thereby preserve vision has never been greater. However, far too many people with diabetes still are not receiving appropriate screening to identify eye disease early and ensure its timely treatment.

It is our hope that this compendium has provided information and guidance to improve communication and encourage collaboration between eye care professionals and other diabetes health care professionals and allow them to more effectively cooperate to reduce barriers to care and improve both the ocular and systemic health of their shared patients.
REFERENCES


35. Wright AD, Dodson PM. Medical management of diabetic retinopathy: fenofibrate and ACCORD Eye studies. Eye (Lond) 2011;25:843–849
38. Agardh E, Tabatab-Khani P. Adopting 3-year screening intervals for sight-threatening retinal vascular lesions in type 2 diabetic subjects without retinopathy. Diabetes Care 2011;34:1316–1319
47. Zhang L, Krzentowski G, Albert A, Lefebvre PJ. Risk of developing retinopathy in Diabetes Control and Complications Trial type 1 diabetic patients with good or poor metabolic control. Diabetes Care 2001;24:1275–1279


Free Eye Health Resources for You and Your Patients

Participate in free continuing education, download patient materials, and access practice resources from Focus on Diabetes™, an American Diabetes Association® initiative.

These tools were developed by primary care and eye health professionals and are available for the entire diabetes care team. Vision loss from diabetes-related eye disease is preventable.

Learn more and see how you can get involved at diabetes.org/EyeHealth.

Join the Eye Health Interest Group of the American Diabetes Association®

Become a member of the Eye Health Professional Interest Group and network with other health care professionals who are dedicated to preserving vision by preventing and optimally treating diabetes-related eye disease.

- Stay up to date on the latest in diabetes-related eye care
- Network with renowned eye health and diabetes experts
- Learn about career development opportunities and share information with your peers via online forums
- Advocate for comprehensive eye care

Learn more at professional.diabetes.org/interestgroups