OPEN ACCESS
Saudi Journal of Medical and Pharmaceutical Sciences
Abbreviated Key Title: Saudi J Med Pharm Sci
ISSN 2413-4929 (Print) | ISSN 2413-4910 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Review Article **N/A**

Integrative Care Models for Diabetic Retinopathy: A Multidisciplinary Review

Eyad Awad Alzahrani[1]*, Abdulhakim Ali Alshehri[2], Jamil Musaed Alshahrani[2], Ali Abdulrhman Alkhibari[1], Riyadh Abdullah Alzahrani[1], Abdullah Ali Alshehri[3], Saud Salman Alshehri[1], Abdulsalam Musleh Alshehri[1], Turki Talal Aldahiri[1], Ameera Hassan Al Dosari[4], Abdalhadi Abdalah Omar Almalki[5], Ahmed Issa Ahmed Al-Kathiri[1], Amani Wasel Alrehaili[6], Abrar Abdullah Alhaili[7], Anwar Mahmoud Moath[7]

[1]Nursing Technician, King Fahad Armed Forces Hospital, Jeddah, Saudi Arabia
[2]Optometric Technician, King Fahad Armed Forces Hospital, Jeddah, Saudi Arabia
[3]Laboratory Technician, Armed Forces Hospital Souther Region, Khamis Mushayt, Saudi Arabia
[4]Nursing Technician, Armed Forces Hospital of Wadi Ad-Dawasir, Ad-Dawasir, Saudi Arabia
[5]Senior Specialist of Health Administration, King Fahad Armed Forces Hospital, Jeddah, Saudi Arabia
[6]Nursing Specialist, King Fahad Armed Forces Hospital, Jeddah, Saudi Arabia
[7]Laboratory Specialist, King Fahad Armed Forces Hospital, Jeddah, Saudi Arabia

DOI: https://doi.org/10.36348/sjmps.2025.v11i10.010 | **Received:** 02.09.2025 | **Accepted:** 21.10.2025 | **Published:** 22.10.2025

***Corresponding author:** Eyad Awad Alzahrani
Nursing Technician, King Fahad Armed Forces Hospital, Jeddah, Saudi Arabia

Abstract

Diabetic retinopathy (DR) is fundamentally a neurovascular complication initiated and propelled by chronic hyperglycemia. DR represents a significant and escalating public health crisis, inextricably linked to the global diabetes pandemic. Traditional, fragmented healthcare delivery models poorly manage it. In response, integrated care has emerged as a person-centered, holistic framework designed to address these complex, interconnected needs. This narrative review synthesizes the evidence on integrated care for the diabetic patients. It explores the core components and theoretical underpinnings of integrated care, provides a typology of prominent models across primary care, hospital, community, and transitional care settings, and evaluates their evidence-based impact. The analysis covers rising global prevalence of diabetes and its complications creates a problem that standard care methods cannot be met by traditional models of care. Structured, tech-enabled teamwork is the cornerstone of a sustainable, egalitarian, and successful strategy to prevent vision loss from diabetic retinopathy. A comprehensive toolkit for system redesign is provided by the care paradigms examined here, ranging from the proactive coordination of the Patient-Centered Medical Home to the co-located expertise of Integrated Practice Units and the broad reach of teleretinal screening. With the help of data analytics and artificial intelligence, these models will be intelligently integrated to provide more proactive, individualized, and patient-centered care, which will define the future of DR management. The healthcare community may strive to guarantee that no one loses their valuable sight due to a complication that is nearly completely preventable with the correct system in place by adopting this multidisciplinary viewpoint.

Keywords: Diabetic retinopathy (DR), chronic hyperglycemia, diabetes, hospital, community.

INTRODUCTION

The Escalating Global Burden of Diabetic Retinopathy

Diabetic retinopathy (DR) represents a significant and escalating public health crisis, inextricably linked to the global diabetes pandemic. The International Diabetes Federation (IDF) reported that approximately 537 million adults were living with diabetes in 2021, a figure projected to surge to 783 million by 2045. This dramatic rise in diabetes prevalence is mirrored by a parallel increase in its microvascular complications, with DR being the most common and specific. Globally, DR is a leading cause of preventable vision impairment and blindness among working-age adults, imposing a substantial burden on individuals, healthcare systems, and economies [1].

Current estimates suggest that 22.27% of individuals with diabetes have some form of DR, affecting over 103 million people worldwide in 2020. Projections indicate this number will climb to 161 million by 2045. The burden of DR is not distributed equally. Prevalence rates vary widely by region, influenced by factors such as healthcare infrastructure, the implementation of screening programs, and socioeconomic conditions [2]. Rates are notably higher in regions like Africa (35.90%) and North America (33.30%), with low- and middle-income countries (LMICs) disproportionately affected by undiagnosed or poorly controlled diabetes. Analysis from the Global Burden of Disease Study highlights a stark reality: the number of people experiencing blindness and vision loss from DR more than tripled between 1990 and 2021. This alarming trend underscores the urgent need for more effective strategies for prevention, early detection, and management.

A Synopsis of Diabetic Retinopathy Pathophysiology

Diabetic retinopathy is fundamentally a neurovascular complication initiated and propelled by chronic hyperglycemia. The persistently elevated blood glucose levels characteristic of diabetes set off a complex cascade of damaging molecular events within the delicate retinal microvasculature. Key pathogenic mechanisms include increased oxidative stress, the induction of a chronic, low-grade inflammatory state, and the formation and accumulation of advanced glycation end-products (AGEs) [3].

Collectively, these processes inflict damage on the retinal capillaries. A hallmark of early DR is the loss of pericytes, contractile cells that wrap around capillaries and are essential for maintaining their structural integrity and regulating blood flow. This is accompanied by a thickening of the capillary basement membrane and progressive damage to the endothelial cells lining the vessels. These changes compromise the integrity of the blood-retinal barrier, leading to increased vascular permeability. Clinically, these early vascular changes manifest as microaneurysms (small outpouchings in the vessel walls), dot-and-blot hemorrhages, and leakage of fluid and lipids into the retinal tissue. When this leakage occurs in the macula—the central part of the retina responsible for sharp, detailed vision—it results in diabetic macular edema (DME), the most frequent cause of vision loss in people with diabetes [4].

As the disease advances, capillary occlusion becomes more widespread, leading to retinal ischemia, or a lack of adequate blood supply. In response to this chronic hypoxia, the retina upregulates the production of angiogenic signals, most notably Vascular Endothelial Growth Factor (VEGF). VEGF stimulates the growth of new, abnormal, and fragile blood vessels on the surface of the retina or optic nerve, a process known as neovascularization. This stage defines the transition to the most advanced and vision-threatening form of the disease: proliferative diabetic retinopathy (PDR). These new vessels are prone to bleeding into the vitreous cavity (vitreous hemorrhage), which can cause sudden and severe vision loss. They can also form fibrous scar tissue that contracts and pulls on the retina, leading to tractional retinal detachment and permanent blindness [5].

The Rationale for a Multidisciplinary Team Approach

The complex pathophysiology of DR, which originates from a systemic metabolic disorder but manifests with devastating local ocular consequences, renders a single-specialty, siloed approach to care fundamentally inadequate. The fact that DR remains a leading cause of preventable blindness, despite the existence of effective treatments, points not merely to failures of patient adherence but to a systemic failure in how care is organized and delivered. The fragmentation of healthcare, where primary diabetes management is often disconnected from specialized eye care, creates significant barriers, resulting in a persistent "care gap" where at-risk patients are not screened, diagnosed, or treated in a timely manner [6].

An integrated, multidisciplinary team (MDT) approach is therefore not just beneficial but essential for effective DR management. This model brings together a diverse group of healthcare professionals with complementary skills—including primary care physicians, endocrinologists, optometrists, ophthalmologists, nurses, dietitians, and laboratory scientists—to provide holistic, coordinated, and patient-centered care. The very composition of this team is dictated by the disease's pathophysiology; each professional role directly addresses a specific facet of the disease process, from the systemic metabolic control managed by the primary care team to the localized ocular pathology managed by eye care specialists. An MDT approach has been shown to improve a range of patient outcomes, including better glycemic control, a lower risk of complications, reduced hospitalizations, and enhanced patient satisfaction [7]. By fostering clear and consistent communication between providers, the MDT model breaks down professional silos, ensuring that the management of the eye is seamlessly integrated with the management of the whole patient, thereby preventing individuals from falling through the cracks of a disjointed system.

Aims and Scope of the Review

This article provides a multidisciplinary review of the evidence supporting integrative care models for the management of diabetic retinopathy. The primary objective is to synthesize the distinct and synergistic contributions of four key professional domains—optometry, nursing, laboratory sciences, and health administration—to this collaborative framework. By examining the foundational roles of each discipline and exploring how these roles converge within practical models of care, this review aims to construct a comprehensive blueprint for designing and implementing effective, patient-centered systems dedicated to preventing vision loss from diabetes [8].

Foundational Roles in the Diabetic Retinopathy Care Continuum

The Optometric Perspective: The Vanguard of Detection and Monitoring

Doctors of optometry serve as the frontline defense against vision loss from diabetes. Practicing in thousands of communities, they are often the most accessible primary eye care providers for patients with diabetes and are uniquely positioned within the diabetic care and management team. In many cases, an optometrist may be the first healthcare professional to detect the ocular signs of diabetes, sometimes even before the patient has received a formal systemic diagnosis. This strategic position makes optometry a critical vanguard for early detection, diagnosis, and long-term monitoring of DR [9].

Screening and Early Detection

The cornerstone of preventing DR-related blindness is timely screening, as early-stage disease is typically asymptomatic. The established gold standard for DR screening is a comprehensive eye examination with pupillary dilation, known as a dilated fundus examination (DFE), which allows for a thorough assessment of the retina. Evidence overwhelmingly shows that early detection and subsequent treatment can prevent up to 95% of severe vision loss associated with diabetes [10].

Clinical practice guidelines provide a clear framework for screening frequency. It is recommended that individuals with type 1 diabetes have their first DFE within five years of diagnosis, whereas those with type 2 diabetes should be screened at the time of their diagnosis due to the possibility that the disease has been present and undiagnosed for some time. Following the initial examination, annual screenings are the standard recommendation. However, for patients with no evidence of retinopathy on one or more annual exams, guidelines may permit extending the screening interval to every two years, in consultation with their eye care provider. In addition to DFE, validated digital imaging techniques, such as retinal fundus photography, have become an equally effective and widely adopted method for screening, forming the technological backbone of most teleretinal screening programs [11].

Diagnosis and Staging

Following detection, the optometrist's next critical responsibility is to accurately diagnose and stage the severity of DR. This classification is not merely academic; it is the primary determinant of a patient's risk of progression, the appropriate follow-up interval, and the urgency of referral for specialized treatment. The internationally recognized classification system, derived from the Early Treatment Diabetic Retinopathy Study (ETDRS), provides a standardized lexicon for communication among all members of the care team. The disease is broadly categorized into two main stages: non-proliferative diabetic retinopathy (NPDR) and the more advanced proliferative diabetic retinopathy (PDR) [12]. Diabetic macular edema (DME), a distinct but related pathology, can occur at any stage and is assessed separately. A summary of this clinical classification is provided in Table 1.

Table 1: Clinical Classification of Diabetic Retinopathy (DR) and Diabetic Macular Edema (DME)

Stage/Classification	Key Clinical Findings
Non-Proliferative DR (NPDR)	
No Apparent Retinopathy	No abnormalities detected.
Mild NPDR	Microaneurysms only.
Moderate NPDR	More than just microaneurysms but less severe than severe NPDR (e.g., dot/blot hemorrhages, cotton wool spots, hard exudates).
Severe NPDR	Presence of any one of the "4-2-1 Rule" criteria: severe intraretinal hemorrhages (>20 in each of 4 quadrants), definite venous beading in ≥2 quadrants, or prominent intraretinal microvascular abnormalities (IRMA) in ≥1 quadrant, with no signs of PDR.
Proliferative DR (PDR)	
PDR	Presence of neovascularization of the disc (NVD) or elsewhere on the retina (NVE), and/or vitreous or preretinal hemorrhage.
High-Risk PDR	Defined by specific criteria indicating a high risk of severe vision loss, such as NVD greater than approximately 1/3-disc area, any NVD with associated vitreous hemorrhage, or NVE greater than 1/2-disc area with associated vitreous hemorrhage.
Diabetic Macular Edema (DME)	
DME Absent	No apparent retinal thickening or hard exudates in the posterior pole.
DME Present	Apparent retinal thickening or hard exudates in the posterior pole.
Non-Center-Involving DME	Retinal thickening in the macula that does not involve the central 1 mm subfield zone.
Center-Involving DME (CIDME)	Retinal thickening in the macula that involves the central 1 mm subfield zone.

This table synthesizes classification criteria from multiple sources.

Monitoring and Co-management

Based on the clinical stage of DR, the optometrist establishes an appropriate schedule for monitoring to detect disease progression. These follow-up intervals are evidence-based, designed to catch progression to a more severe stage before vision is threatened. For instance, a patient with mild NPDR may be safely monitored annually, whereas a patient with moderate NPDR requires more frequent follow-up, typically every 6 to 9 months. Patients diagnosed with severe NPDR are at a very high risk of progressing to PDR within a year and must be monitored closely, every 3 to 6 months [13].

A crucial function of the optometrist is determining the appropriate timing for referral to an ophthalmologist, usually a retina specialist, for consideration of treatment. An immediate referral is mandated for any patient with PDR or center-involving DME. Patients with severe NPDR should also be referred promptly for evaluation, as early treatment may be considered in some cases. Furthermore, optometrists play an indispensable role in the co-management of patients following ophthalmological intervention. After a patient receives treatment such as panretinal photocoagulation (PRP) for PDR or intravitreal anti-VEGF injections for DME, the optometrist can provide ongoing monitoring, manage other aspects of the patient's ocular health, and serve as the local point of contact, ensuring seamless communication with the surgeon and the rest of the diabetes care team [14].

Technological Advancements in Optometry

The role of optometry in DR management is being fundamentally transformed by rapid technological innovation. These advancements do not merely refine existing capabilities but act as "role multipliers," expanding the scope and impact of the care that optometrists can provide.

- **Ultra-widefield (UWF) Imaging:**

UWF retinal imaging systems can capture up to a 200-degree view (or 82%) of the retina in a single, non-contact image, a dramatic improvement over the 30-45 degrees of traditional fundus photography. This expanded view allows for the visualization of the retinal periphery, where pathologies can be missed by standard examination techniques. The identification of "predominantly peripheral lesions" (PPLs) on UWF images has been shown to be a powerful independent predictor of DR progression, with their presence increasing the risk of progression to PDR by over four-fold [15]. Consequently, UWF imaging can result in a more accurate—and often more severe—staging of DR in a significant portion of patients, altering management decisions.

- **Optical Coherence Tomography (OCT):**

OCT has become the undisputed standard of care for the diagnosis and management of DME. This non-invasive imaging modality provides high-resolution, cross-sectional images of the retina, allowing for precise measurement of retinal thickness and the visualization of intraretinal fluid and cysts. This quantitative data is essential for classifying DME as center-involved or non-center-involved and for monitoring the response to treatment over time. A newer evolution, OCT Angiography (OCTA), provides depth-resolved visualization of the retinal and choroidal microvasculature without the need for dye injection. OCTA can detect early signs of diabetic vasculopathy, such as capillary nonperfusion and enlargement of the foveal avascular zone, often before any lesions are visible on clinical examination, offering a potential window for even earlier risk stratification [16].

- **Artificial Intelligence (AI):**

The emergence of AI algorithms for autonomous DR detection represents a paradigm shift in screening. Several AI systems have received regulatory approval and have demonstrated the ability to detect referable DR (i.e., moderate NPDR or worse, or the presence of DME) from retinal photographs with sensitivity and specificity often exceeding 90%. These AI tools can be deployed directly in primary care or optometry clinics, providing an immediate screening result ("referable DR detected" or "negative") without the need for human interpretation in most cases [17]. This innovation has the potential to dramatically increase the efficiency and accessibility of DR screening, reduce the burden on eye care specialists, and provide point-of-care results that can facilitate immediate patient counseling and referral scheduling.

The Nursing Perspective: The Linchpin of Patient-Centered Care

Within the multidisciplinary team, nurses are the essential linchpins of patient-centered care. They serve as educators, navigators, coordinators, and advocates, bridging the gap between clinical directives and the patient's lived experience. Their frequent and trusted interactions with patients position them to have a profound impact on self-management behaviors, care coordination, and psychosocial well-being [18].

Patient Education and Self-Management Support

One of the most critical functions of the nurse is patient education. Nurses are tasked with translating complex medical information into understandable and actionable guidance, empowering patients to become active participants in their own care. For DR, this education centers on the inextricable link between systemic metabolic control and ocular health. Key educational topics include the importance of consistent blood glucose monitoring, adherence to medication regimens, and the management of comorbidities like hypertension and dyslipidemia. Nurses explain the rationale behind lifestyle modifications, such as adopting a balanced diet and engaging in regular physical activity, and how these behaviors directly impact the risk of retinopathy development and progression. A crucial message conveyed by nurses is the necessity of annual dilated eye exams, even when vision seems normal, as the early, treatable stages of DR are often asymptomatic [19]. Evidence shows that patients who are well-informed and engaged are more likely to adhere to recommended screenings and treatments, leading to better clinical outcomes.

Care Coordination and Navigation

In the often-fragmented landscape of modern healthcare, nurses serve as vital care coordinators and patient navigators. They act as the central communication hub, liaising between the various specialists involved in a patient's care, including the primary care provider, endocrinologist, dietitian, and eye care specialists (both optometrists and ophthalmologists) [20]. This coordinating role is essential for creating and maintaining a cohesive, integrated care plan. Nurses are responsible for documenting changes in a patient's vision or systemic health status and communicating these findings to the relevant team members, facilitating timely adjustments to the treatment plan. By ensuring that appointments are scheduled, referrals are completed, and information flows freely between providers, nurses prevent patients from falling through the cracks and ensure the seamless execution of the clinical pathway, which is fundamental to the success of any integrated care model [21].

Primary-Level Screening

The role of nursing is expanding beyond traditional responsibilities to include direct participation in the DR screening process, particularly within teleretinal screening models. These models leverage technology to bring screening to the point of care in primary care clinics and diabetes centers. With minimal, focused training, a nurse, nursing assistant, or medical assistant can proficiently operate a non-mydriatic fundus camera to capture high-quality retinal images. The process is quick, typically taking less than three minutes per patient, and can be easily integrated into the existing workflow of a routine diabetes check-up [22]. In one successful integrated nursing-teleophthalmology model, nurses were responsible for image acquisition; the images were then securely transmitted to a remote ophthalmologist for interpretation. This system was found to significantly improve the triage process, reducing the number of unnecessary referrals to specialized ophthalmology care by more than half and allowing a majority of low-risk patients to be safely monitored within the primary care setting. This demonstrates how technology can act as a "role multiplier," empowering nurses to extend the reach and efficiency of DR screening programs [23].

Psychosocial Support

The dual burden of managing a chronic disease like diabetes and facing the threat of irreversible vision loss exacts a significant psychological and emotional toll on patients. Vision impairment from DR is associated with a wide range of psychosocial challenges, including depression, anxiety, fear, social isolation, loss of independence, and financial strain. The distress caused by vision loss can, in turn, make diabetes self-management—such as monitoring blood glucose or preparing healthy meals—more difficult, creating a vicious cycle of worsening health and declining well-being [24].

Nurses are uniquely positioned to provide essential psychosocial support. Their ongoing relationship with the patient allows them to assess for signs of diabetes distress, anxiety, or depression during routine interactions. Nursing interventions include providing a safe space for patients to verbalize their fears and concerns, offering reassurance, and delivering clear, hopeful communication about treatment plans and prognosis. They can teach patients coping strategies to deal with the emotional impact of their condition and the practical challenges of vision impairment. Furthermore, nurses play a key role in connecting patients with additional resources, such as social workers, mental health professionals, or patient support groups, when more intensive support is needed. Studies have shown that structured nursing guidelines focused on education and support can effectively improve patient knowledge while simultaneously relieving anxiety levels [25].

The Laboratory Perspective: The Bedrock of Systemic Management

Laboratory medicine provides the objective, quantitative data that forms the bedrock of modern diabetes and DR management. These biochemical measurements are indispensable for assessing a patient's level of systemic control, stratifying their risk for complications, monitoring disease progression, and guiding therapeutic decisions. The integration of this data into a comprehensive care model is essential for proactive and evidence-based clinical practice [26].

The Central Role of Glycemic Control (HbA1c)

The hemoglobin A1c (HbA1c) test, which reflects a patient's average blood glucose level over the preceding two to three months, is the universally accepted gold standard for monitoring long-term glycemic control. It stands as the single most powerful and consistent predictor of both the development and progression of diabetic retinopathy. A vast body of evidence, including landmark clinical trials such as the Diabetes Control and Complications Trial (DCCT) and the United Kingdom Prospective Diabetes Study (UKPDS), has unequivocally established this link. These studies demonstrated that intensive glycemic management, aimed at lowering HbA1c levels, significantly reduces the risk of DR onset and slows its progression [27].

There is a direct and robust positive correlation between HbA1c values and the severity of DR; as HbA1c levels rise, the stage of retinopathy tends to be more advanced. For this reason, a primary goal in diabetes management is to maintain an HbA1c level below 7.0% to substantially reduce the risk of developing vision-threatening DR. Each percentage point increase in HbA1c is associated with a quantifiable increase in the risk of DR progression, making this laboratory value a critical target for intervention and a key performance indicator for quality of care [28].

Essential Biomarkers for Comorbidities

While glycemic control is paramount, DR does not occur in a vacuum. It is a manifestation of systemic microvascular disease that is influenced by other comorbidities, which must also be monitored with laboratory testing.

- **Lipid Panel:**

Dyslipidemia, or abnormal blood lipid levels, is a well-recognized risk factor in the multifactorial etiology of DR. While the relationship can be complex, studies have consistently shown an association between lipid profiles and DR. In particular, elevated levels of low-density lipoprotein (LDL) cholesterol have been significantly associated with the presence and severity of non-proliferative DR. Monitoring the full lipid panel—including total cholesterol, LDL, high-density lipoprotein (HDL), and triglycerides—and managing abnormalities with lifestyle changes or pharmacotherapy is an integral component of reducing the overall microvascular and macrovascular risk in patients with diabetes [30].

- **Renal Function Tests:**

Diabetic nephropathy (kidney disease) and diabetic retinopathy share a common pathophysiology rooted in microvascular damage, and their presence and severity are often closely linked. Therefore, monitoring renal function is critical in the comprehensive assessment of a patient with DR. The most sensitive early indicator of diabetic kidney disease is the urine albumin-to-creatinine ratio (uACR), which detects small amounts of protein (albumin) in the urine. Studies have shown that the level of albuminuria is a better indicator of DR severity and progression than other renal function markers. As kidney damage progresses, the estimated glomerular filtration rate (eGFR), calculated from serum creatinine levels, will decline. A reduced eGFR is also independently associated with a higher prevalence and greater severity of DR [31].

Data Integration and Risk Prediction

The full potential of laboratory data is realized when it is systematically integrated into electronic health records (EHRs) and leveraged for proactive risk prediction. The advent of machine learning (ML) and deep learning (DL) has enabled the development of sophisticated predictive models that can analyze large, longitudinal datasets from EHRs—encompassing demographics, comorbidities, medications, and a wide array of laboratory results like HbA1c, serum creatinine, and lipid panels—to accurately forecast an individual patient's risk of developing DR.

These models can achieve a high degree of accuracy, with an area under the curve (AUC) often exceeding 0.80, demonstrating a strong ability to distinguish between patients who will and will not develop DR. By integrating these predictive analytics directly into the clinical workflow, healthcare systems can implement risk stratification at a population level. This allows for the identification of high-risk individuals who may benefit from more frequent screening, more aggressive management of their systemic risk factors, or earlier referral to eye care services. This data-driven approach is particularly valuable in resource-constrained settings, as it helps prioritize limited resources toward the patients who need them most [32].

Emerging Biomarkers and Future Diagnostics

While HbA1c remains the clinical cornerstone, the field is actively searching for novel biomarkers that may offer earlier or more specific detection of DR and its progression. This research spans multiple biological sample types, including blood, tears, and ocular fluids, as well as advanced imaging techniques.

- **Blood- and Tear-Based Biomarkers:**

A wide array of circulating molecules are being investigated as potential biomarkers. These include markers of inflammation (e.g., interleukins, C-reactive protein), angiogenesis (e.g., VEGF, placental growth factor [PlGF]), oxidative stress, and AGEs. Tear fluid is emerging as a particularly promising source for non-invasive biomarker discovery, with studies identifying altered concentrations of inflammatory and oxidative stress molecules in the tears of patients with DR [33].

- **Imaging Biomarkers:**

Advanced imaging modalities are providing new, quantitative ways to assess risk. As previously mentioned, UWF imaging has identified the presence of PPLs as a powerful prognostic biomarker for disease progression. Similarly, OCTA can quantify changes in retinal vascular density and perfusion, revealing microvascular damage that precedes the appearance of clinically visible lesions, thereby serving as an early structural biomarker of disease [34].

The Health Administration Perspective: The Architects of the System

While clinicians deliver care at the individual patient level, health administrators are the architects who design, fund, and oversee the larger systems and infrastructure that make effective, integrated care possible. Their role is crucial in translating clinical best practices into sustainable, scalable, and high-quality healthcare delivery models. They create the environment in which the multidisciplinary team can thrive [35].

Designing and Implementing Care Pathways

A primary responsibility of health administration is to lead the development and implementation of evidence-based clinical pathways. For DR, this involves a collaborative process with clinical leaders from ophthalmology, optometry, primary care, and nursing to map out the entire continuum of care. This pathway must clearly define each step, from initial screening and risk stratification to referral criteria, treatment protocols, and follow-up schedules. Administrators ensure that these pathways are not only aligned with the latest clinical guidelines but are also adapted to the specific resources, workforce, and patient population of their local health system. For example, in a rural system with limited access to ophthalmologists, an administrator would champion the design and implementation of a teleretinal screening pathway to maximize the use of primary care resources. Successful implementation requires strong administrative leadership to secure buy-in from all stakeholders, allocate resources for training, and oversee the integration of the pathway into the daily clinical workflow [36].

Resource Allocation and Financial Modeling

Health administrators are accountable for the financial viability and sustainability of clinical programs. For integrated DR care, this involves strategic resource allocation and rigorous financial modeling. A key task is securing capital funding for essential technology, such as the non-mydriatic retinal cameras, software platforms, and EHR integration required for a teleretinal screening program.

To justify these investments, administrators conduct detailed financial analyses, including cost-effectiveness and return-on-investment (ROI) calculations. Teleretinal screening programs have consistently been shown to be cost-effective, often reaching a financial break-even point within the first one to two years of operation by increasing screening compliance and enabling early, less costly interventions. A critical administrative function is navigating the complex landscape of reimbursement. This includes ensuring that services like teleretinal imaging are properly coded and billed, and advocating for payment models that support and incentivize preventive, coordinated care. Increasingly, reimbursement for DR screening is tied to performance in value-based care contracts and quality reporting programs, making successful program implementation a financial imperative [37].

Quality Improvement and Performance Metrics

A core tenet of modern health administration is a commitment to continuous quality improvement, which requires robust data and performance monitoring. Administrators are responsible for establishing a system to track Key Performance Indicators (KPIs) that measure the effectiveness of the DR care pathway. These KPIs typically span three key domains: patient and provider awareness, service delivery, and system capacity [38].

The most widely used and critical service delivery metric is the annual DR screening rate, which is a formal quality measure in programs like the Healthcare Effectiveness Data and Information Set (HEDIS) under the "Eye Exam for Patients with Diabetes" measure. Health systems often set ambitious goals to meet or exceed national benchmarks for this measure, such as reaching the 75th or 90th percentile of performance. Other vital KPIs include the time from screening to report availability, the time from referral to specialist appointment, the rate of patient adherence to follow-up appointments, and the image gradability rate in teleretinal programs. Administrators utilize data from EHRs and specialized screening platforms to create real-time dashboards that allow for ongoing monitoring of these metrics, identification of bottlenecks, and rapid implementation of quality improvement cycles [39].

Policy, Advocacy, and Public Health Initiatives

Beyond the walls of their own institutions, health administrators engage in broader policy and advocacy efforts to create a more supportive environment for integrated DR care. This involves collaborating with national and international organizations, such as the International Agency for the Prevention of Blindness (IAPB) and the IDF, to advocate for the formal integration of DR care into national diabetes policies and strategic health plans [40]. These advocacy efforts aim to raise the profile of DR as a public health priority, secure government funding for screening and treatment programs, and promote policies that facilitate task-sharing and the use of telemedicine, particularly in underserved and rural areas. Furthermore, administrators often oversee the development and launch of public health awareness campaigns. These initiatives are designed to educate the general population and at-risk individuals about the dangers of DR and the critical importance of regular eye examinations, directly addressing the significant barrier of low patient awareness [41].

Paradigms of Integrative Care in Clinical Practice

The principles of multidisciplinary collaboration are not merely theoretical; they are being actively implemented through various innovative models of care. These models represent a spectrum of integration strategies rather than mutually exclusive alternatives, each designed to reorganize care delivery around the patient's needs. The most effective healthcare systems often create hybrid approaches, combining the technological efficiency of teleretinal screening with the comprehensive philosophy of a patient-centered medical home and the specialized focus of an integrated practice unit [42].

The Teleretinal Screening Model: Extending Reach Through Technology

The teleretinal screening model is perhaps the most widespread and impactful example of integrated DR care in practice. It leverages technology to decouple the physical act of image acquisition from the expert act of image interpretation, thereby extending the reach of ophthalmologic expertise far beyond the walls of the specialty clinic. This model has been proven to be a highly effective and cost-effective strategy for increasing screening rates and closing the care gap, particularly for patients who face barriers to accessing traditional eye care.

The workflow is a clear example of multidisciplinary coordination facilitated by technology:

1. **Image Acquisition:** The process begins in a primary care clinic, diabetes center, or even a community pharmacy. A nurse, medical assistant, or trained technician uses a simple, often non-mydriatic, retinal camera to capture digital images of the patient's fundus. This step is designed to be quick (under five minutes) and can be conveniently integrated into a patient's routine diabetes follow-up visit [43].
2. **Secure Transfer:** The captured images are uploaded to a secure, cloud-based, HIPAA-compliant software platform. This crucial step, overseen by health administration and IT support, ensures the safe and encrypted transmission of patient data.
3. **Remote Interpretation:** The images are accessed by a board-certified ophthalmologist or a trained retinal specialist at a remote "reading center." The specialist interprets the images, grades the level of any DR present, and documents their findings in a standardized report.
4. **Reporting and Referral:** The diagnostic report, complete with findings and a recommendation for either routine follow-up or referral to an eye care specialist, is transmitted back to the primary care provider. This report is then integrated into the patient's EHR. If a referral is necessary, the platform can often facilitate an electronic referral, transmitting the report and images directly to a local ophthalmologist to ensure continuity of care and appropriate triage [44].

The Integrated Practice Unit (IPU) Model: Co-locating Expertise for Seamless Care

The Integrated Practice Unit (IPU) model represents a more profound structural reorganization of care. An IPU is organized around a patient's medical condition—in this case, diabetes and its complications—rather than around physician specialties. It brings together a dedicated, co-located, multidisciplinary team that assumes collective responsibility for the full cycle of care for that condition.

For diabetic retinopathy, an IPU would physically house all the necessary specialists and support staff in a single, dedicated clinical facility. A patient visiting the DR IPU could, in a single, coordinated visit, see their endocrinologist for diabetes management, undergo retinal imaging and examination with an optometrist, receive targeted education on diet and self-care from a certified diabetes nurse educator, and, if necessary, have an immediate consultation with a retina specialist to discuss treatment options [45].

This model offers several key advantages. It dramatically reduces the fragmentation and inconvenience that patients experience when navigating multiple appointments at different locations. It fosters real-time, face-to-face communication and collaboration among clinicians, leading to more cohesive and efficient care. The entire team in an IPU typically works with a shared administrative and scheduling system, measures patient outcomes and costs using a common platform, and accepts joint accountability for the results, creating a powerful engine for value-based care and continuous improvement [46].

The Patient-Centered Medical Home (PCMH) Model: Embedding Eye Care in Primary Health

The Patient-Centered Medical Home (PCMH) is a broad model of primary care that aims to provide comprehensive, coordinated, patient-centered, and accessible care. Rather than being a specific workflow, it is a philosophy of care delivery that places the primary care practice at the center of a patient's health journey. Given its focus on long-term management of chronic conditions, team-based care, and proactive population health, the PCMH model is exceptionally well-suited for managing diabetes [47].

Within a PCMH, DR screening is not treated as an external, disconnected task but is integrated as a core quality metric within the patient's overall diabetes management plan. The PCMH care team, led by the primary care physician, utilizes its EHR and patient registry to systematically track the entire diabetic population of the practice. This technology allows the team to proactively identify patients who are overdue for their annual eye exam and initiate outreach. A designated care coordinator, often a nurse, plays a pivotal role in this process. This individual is responsible for patient reminders, education about the importance of the exam, assistance with scheduling, and crucially, tracking referrals to ensure that patients who are sent to an eye care specialist complete their visit and that the report is received back into the patient's primary care record. Studies have demonstrated that practices achieving PCMH recognition have significantly higher rates of compliance with diabetic eye examinations, highlighting the model's effectiveness in closing this critical care gap [48].

Exemplars of Success: Case Studies in Integrated DR Management

The theoretical benefits of these integrated models are borne out by real-world success stories from health systems that have implemented programmatic approaches to DR screening.

- **St. Elizabeth Healthcare:**

This large health system in the Cincinnati area was struggling with DR screening compliance rates that had fallen below 60%. By partnering with a telehealth vendor (IRIS) to implement a teleretinal screening program across more than 20 of its primary care locations, the organization achieved a dramatic turnaround. Within the first year of implementation, the screening rate for eligible patients rose to over 80%. The program, which was fully integrated with the health system's Epic EHR, has since performed over 13,000 exams. Critically, it has identified sight-threatening pathology in more than 1,000 patients who were previously undiagnosed, allowing for timely intervention to save their vision [49].

- **CoxHealth:**

This Missouri-based health system faced an even greater challenge, with a screening compliance rate of only 32% among its 24,000 patients with diabetes. They implemented a similar teleretinal solution, emphasizing a deep, bidirectional integration with their Cerner EHR. This integration was deemed essential to the program's success, as it allowed diagnostic results to be returned as discrete data directly into the patient's chart. This provides the primary care provider with immediate, actionable information on end-organ damage, enabling them to pursue more aggressive systemic treatment plans. In just the first six weeks, the program conducted over 1,000 exams and newly diagnosed DR in 150 patients.

These cases illustrate a powerful conclusion: a programmatic approach, driven by administrative leadership and leveraging technology, can yield remarkable improvements in both clinical quality and financial performance. By bringing screening to the point of care, these models remove patient barriers, close critical gaps in care, and generate valuable data that enhances risk stratification and quality reporting. This creates a self-reinforcing cycle where better clinical outcomes lead to improved financial performance under value-based contracts, which in turn provides the resources to sustain and expand the program [50].

Overcoming Barriers and Charting Future Directions

While integrative care models hold immense promise, their widespread adoption is hindered by a range of systemic, financial, and practical barriers. Addressing these challenges while simultaneously harnessing the transformative power of emerging technologies like artificial intelligence and personalized medicine will define the future of diabetic retinopathy management.

Systemic and Practical Barriers to Implementation

The transition to integrated care is not without significant obstacles. A primary challenge remains the deeply entrenched professional and systemic silos within healthcare. The traditional separation between primary care and specialty eye care creates communication gaps and fragments the patient journey, making coordinated management difficult. This is often compounded by financial models; traditional fee-for-service reimbursement systems can fail to adequately incentivize the time-intensive work of care coordination, patient education, and preventive screening that are the hallmarks of integrated care [36].

Workforce shortages and geographic maldistribution of specialists present another major barrier. Rural and other underserved communities often lack sufficient access to ophthalmologists and optometrists, forcing patients to travel long distances for care—a significant burden that leads to poor screening adherence and delayed treatment. From a technological standpoint, the lack of interoperability between different EHR systems is a persistent frustration. Without the ability for seamless, automated data exchange between a primary care clinic's EHR and an ophthalmologist's records, care coordination becomes a manual, inefficient, and error-prone process [50].

Finally, a host of patient-level barriers contribute to low screening rates. These include financial burdens and out-of-pocket costs, lack of transportation, and insufficient awareness or understanding of the asymptomatic nature of early DR. Furthermore, psychosocial factors such as depression, anxiety, and fear can significantly impact a patient's ability and motivation to engage in self-care and attend appointments. Critically, studies have shown a marked divergence between the barriers perceived as most important by healthcare providers (e.g., lack of awareness, transportation) and those most frequently reported by patients themselves (e.g., financial concerns, depression), highlighting a communication gap that must be bridged to design effective interventions [51].

The Transformative Potential of Artificial Intelligence

Artificial intelligence is poised to be a key enabler of next-generation integrated care models, offering powerful solutions to challenges of efficiency, access, and scalability. The most immediate application of AI is in the autonomous detection of DR from retinal images. FDA-cleared AI algorithms can analyze a fundus photograph and provide an immediate, point-of-care result, identifying the presence or absence of referable DR with a level of accuracy comparable to human experts [52].

When integrated into a teleretinal screening workflow, AI can function as an efficient and reliable "first-read." Images identified as negative for referable DR can be automatically cleared, while only those flagged as positive or deemed ungradable by the algorithm are forwarded to a human specialist for review. This has the potential to reduce the interpretation workload for ophthalmologists by 80% or more, freeing up their valuable time to focus on complex cases and treatment. This dramatic increase in efficiency makes large-scale, population-level screening programs far more sustainable and scalable [53].

However, the role of AI extends beyond simple image analysis. Its true transformative potential may lie in its capacity to function as an "integration engine." AI models can be trained on vast, heterogeneous datasets from EHRs, fusing a patient's clinical images with their laboratory data, diagnostic codes, demographics, and medications. By processing all of this information simultaneously, AI can generate a holistic and highly accurate prediction of a patient's future risk of developing or progressing DR, providing an early warning long before clinical signs are visible. This fusion of image and non-image data has been shown to significantly outperform models that use either data source alone, enabling earlier and more precise referral decisions.

The Advent of Personalized Medicine in DR Care

The ultimate goal of an integrated, data-driven system is to move beyond generalized, one-size-fits-all guidelines and toward the practice of precision medicine. This paradigm aims to tailor screening, prevention, and treatment strategies to the unique biological and lifestyle characteristics of each individual patient [54].

This personalized approach will be fueled by the integration of novel data streams into the predictive models enabled by AI.

- **Genetic Data:**

A growing body of research has identified numerous genetic polymorphisms—common variations in genes such as *ACE*, *VEGF*, and *APOE*—that are associated with an individual's susceptibility to developing DR and their rate of progression. Incorporating this genetic risk information could allow clinicians to identify high-risk individuals at the time of their diabetes diagnosis, flagging them for more frequent screening intervals or more aggressive management of systemic risk factors from the outset.

- **Biomarker Data:**

The continued discovery of novel biomarkers in the blood, tears, and even from advanced imaging will provide a more dynamic and nuanced picture of a patient's real-time disease activity. For example, the detection of specific inflammatory markers in a patient's tear film or the identification of PPLs on a UWF image could trigger a recommendation to shorten that specific patient's screening interval, even if their current DR grade would otherwise suggest a longer follow-up period.

By using AI to synthesize these complex datasets—genetics, biomarkers, imaging findings, and traditional clinical data—it becomes possible to create a highly personalized risk score. This could lead to a fundamental "risk-based inversion" of the current care model. Instead of uniform annual screening for all patients, the low-risk majority could be safely monitored at extended intervals (e.g., every 24-36 months), while resources are concentrated on a smaller cohort of high-risk individuals who would receive more frequent, intensive, and proactive monitoring and management [55].

The Symbiotic Evolution of Healthcare Professional Roles

The adoption of these new technologies and care models will catalyze a significant and symbiotic evolution in the roles and responsibilities of all members of the healthcare team.

- Optometrists will increasingly function as chronic eye disease managers. Armed with advanced imaging and AI-driven decision support, their role will shift from primarily qualitative detection to more quantitative risk stratification, complex co-management of post-treatment patients, and interpretation of personalized risk data.
- Nurses will see their roles expand further into the diagnostic pathway as the primary operators of point-of-care screening technologies. They will also become crucial "data navigators" and health coaches, helping patients understand their personalized risk profiles and guiding them through tailored self-management plans [23].
- Primary Care Physicians and Endocrinologists will benefit from more rapid and detailed feedback on their patients' ocular health status, enabling them to make more timely and informed adjustments to systemic therapies in response to changes in the eye.
- Health Administrators will transition from managing volume and transactions to managing value and outcomes. Their focus will be on building and sustaining the technological infrastructure, data governance policies, and value-based payment models necessary to support a proactive, personalized, and fully integrated system of care.

CONCLUSION

Synthesizing a Collaborative Vision for the Future

The Synergy of a Multidisciplinary Approach

The evidence reviewed in this article converges on a clear and compelling conclusion: combating the epidemic of diabetic retinopathy requires a fundamental shift away from fragmented, specialty-centric care toward integrated, multidisciplinary systems. The complexity of the disease, with its systemic roots and localized ocular manifestations, demands a collaborative effort. This analysis has highlighted the critical and interdependent contributions of four key disciplines. Optometry serves as the accessible frontline for detection and monitoring. Nursing provides the essential patient-facing education, coordination, and support that translates clinical plans into patient action. Laboratory sciences deliver the objective, quantitative data that underpins risk stratification and guides systemic management. Finally, health administration constructs the operational, financial, and technological framework that enables the entire system to function effectively [56].

The synergy achieved through this integration creates a system that is far greater than the sum of its parts. It establishes a continuous feedback loop where laboratory data informs clinical screening, clinical findings trigger more intensive nursing education and systemic management, and administrative oversight uses performance data to constantly refine and improve the entire process. This collaborative model is the most potent strategy for breaking down the functional and communication silos that have historically allowed a preventable disease to become a leading cause of blindness [57].

CONCLUSION

The escalating global prevalence of diabetes and its complications presents a challenge that cannot be met by traditional models of care. A sustainable, effective, and equitable approach to preventing vision loss from diabetic retinopathy must be built on a foundation of structured, technology-enabled collaboration. The paradigms of care explored herein—from the expansive reach of teleretinal screening to the co-located expertise of Integrated Practice Units and the proactive coordination of the Patient-Centered Medical Home—offer a robust toolkit for system redesign. The future of DR management will be defined by the intelligent integration of these models, powered by data analytics and artificial intelligence, to deliver care that is increasingly proactive, personalized, and patient-centered. By embracing this multidisciplinary vision, the healthcare community can work to ensure that no individual loses their precious sight to a complication that is, with the right system in place, almost entirely preventable.

REFERENCES

1. Sun, H., Saeedi, P., Karuranga, S., Pinkepank, M., Ogurtsova, K., Duncan, B. B., & International Diabetes Federation Diabetes Atlas 10th edition scientific committee. (2022). IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. *Diabetes research and clinical practice*, *183*, 109119. Retrieved from https://www.medrxiv.org/content/10.1101/2025.07.24.25332019.full
2. Teo, Z. L., Tham, Y. C., Yu, M., Chee, M. L., Rim, T. H., Cheung, N.,... & Wong, T. Y. (2021). Global prevalence of diabetic retinopathy and projection of burden through 2045: systematic review and meta-analysis. *Ophthalmology*, *128*(11), 1580-1591. Retrieved from https://brancatoaward.eu/wp-content/uploads/2025/07/TINGscientificpublication-4.pdf
3. Tan, T. E., & Wong, T. Y. (2023). Diabetic retinopathy: looking forward to 2030. *Frontiers in Endocrinology*, *13*, 1077669. Retrieved from https://pmc.ncbi.nlm.nih.gov/articles/PMC10756246/
4. Global Burden of Disease Study 2021 Collaborators. (2025). The Global Burden of Diabetic Retinopathy. *The Ophthalmologist*. Retrieved from https://theophthalmologist.com/issues/2025/articles/september/the-global-burden-of-diabetic-retinopathy/
5. Wang, W., & Lo, A. C. Y. (2018). Diabetic retinopathy: pathophysiology and treatments. *International journal of molecular sciences*, *19*(6), 1816. Retrieved from https://www.mdpi.com/1422-0067/19/6/1816
6. Universa Medicina. (2025). Diabetic retinopathy: pathogenesis, pathophysiology, and treatment. *Universa Medicina*, *44*(2), 270-284. Retrieved from https://univmed.org/ejurnal/index.php/medicina/article/view/1719
7. American Academy of Ophthalmology. (n.d.). *What Is Diabetic Retinopathy?* Retrieved from https://www.aao.org/eye-health/diseases/what-is-diabetic-retinopathy
8. Cheung, N., Mitchell, P., & Wong, T. Y. (2010). Diabetic retinopathy. *The Lancet*, *376*(9735), 124-136. Retrieved from https://www.mdpi.com/1422-0067/26/20/9882
9. Fong, D. S., Aiello, L. P., Ferris III, F. L., & Klein, R. (2004). Diabetic retinopathy. *Diabetes care*, *27*(10), 2540-2553. Retrieved from https://pmc.ncbi.nlm.nih.gov/articles/PMC6032159/
10. Mayo Clinic. (n.d.). *Diabetic retinopathy*. Retrieved from https://www.mayoclinic.org/diseases-conditions/diabetic-retinopathy/symptoms-causes/syc-20371611
11. Eye Forum. (n.d.). *Diabetic Retinopathy for Medical Students: Classification*. Retrieved from https://webeye.ophth.uiowa.edu/eyeforum/tutorials/diabetic-retinopathy-med-students/Classification.htm
12. European Medical Journal. (2020). Multidisciplinary approach to management and care of patients with type 2 diabetes mellitus. *EMJ Diabetes*, *8*(1), 89-98. Retrieved from

https://www.emjreviews.com/diabetes/article/multidisciplinary-approach-to-management-and-care-of-patients-with-type-2-diabetes-mellitus/
13. Open Education resource on Diabetic Retinopathy. (n.d.). *Step 21: Multidisciplinary Approach*. Retrieved from https://oerdiabeticretinopathy.wordpress.com/step-21/
14. Centers for Disease Control and Prevention. (2024). *Multidisciplinary Team Approach*. Retrieved from https://www.cdc.gov/diabetes-toolkit/php/staffing-models/multidiscipline-team.html
15. Diabetes UK. (n.d.). *Specialist diabetes team: role and members*. Retrieved from https://www.diabetes.org.uk/for-professionals/improving-care/clinical-recommendations-for-professionals/healthcare-professional-staffing-competency/specialist-diabetes-team-role-and-members
16. Lee, P. G., & Cigolle, C. T. (2016). The evidence for the role of a multidisciplinary team in the management of diabetes. *Diabetes Spectrum*, *29*(2), 70-74. Retrieved from https://pmc.ncbi.nlm.nih.gov/articles/PMC10031602/
17. American Optometric Association. (2020). Integrating models of diabetic eye care. *AOA Focus*. Retrieved from https://www.aoa.org/news/clinical-eye-care/diseases-and-conditions/integrating-models-of-diabetic-eye-care
18. American Academy of Ophthalmology. (2019). *Diabetic Retinopathy PPP 2019*. Retrieved from https://www.aao.org/education/preferred-practice-pattern/diabetic-retinopathy-ppp
19. Alberta College of Optometrists. (2020). *Diabetes Clinical Practice Guideline*. Retrieved from https://collegeofoptometrists.ab.ca/wp-content/uploads/2020/04/Diabetes.pdf
20. American Diabetes Association. (2017). Diabetic retinopathy: A position statement by the American Diabetes Association. *Diabetes Care*, *40*(3), 412-418. Retrieved from https://diabetesjournals.org/care/article/40/3/412/36975/Diabetic-Retinopathy-A-Position-Statement-by-the
21. Diabetes Canada Clinical Practice Guidelines Expert Committee. (2018). Retinopathy. *Canadian Journal of Diabetes*, *42*(Suppl 1), S210-S216. Retrieved from https://guidelines.diabetes.ca/cpg/chapter30
22. DrOracle.ai. (n.d.). *How to classify diabetic retinopathy?* Retrieved from https://www.droracle.ai/articles/208897/classify-dm-retinopathy
23. National Center for Biotechnology Information. (2023). *Diabetic Retinopathy*. In StatPearls. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK560805/
24. EyeGuru. (n.d.). *Diabetic Retinopathy*. Retrieved from https://eyeguru.org/essentials/diabetic-retinopathy/
25. American Academy of Ophthalmology. (n.d.). *Diabetic Retinopathy Classification*. Retrieved from https://www.aao.org/Assets/2fc2cd4d-6c11-44da-aaf0-89de7da93cf5/637571034835670000/dbr-pdf?inline=1
26. Vujosevic, S., & Midena, E. (2013). Retinal layers changes in human preclinical and early clinical diabetic retinopathy. *Optometry and Vision Science*, *90*(11), 1381-1387. Retrieved from https://www.tandfonline.com/doi/full/10.2147/OPTO.S36603
27. Eyecare Center of Martin. (n.d.). *The Role of Optometrists in Eye Surgery Co-Management*. Retrieved from https://www.eyecarecenterofmartin.com/blog/the-role-of-optometrists-in-eye-surgery-co-management
28. Forbes Business Council. (2024). *The Critical Role Of Optometrists In Managing Diabetic Retinopathy*. Retrieved from https://www.forbes.com/councils/forbesbusinesscouncil/2024/06/26/the-critical-role-of-optometrists-in-managing-diabetic-retinopathy/
29. Optos Plc. (2022). *Product Announcement: Optos AI for DR*. Retrieved from https://www.optos.com/press-releases/product-announcement-optos-ai-for-dr/
30. Daskalaki, E., & Plainis, S. (2021). Ultra-widefield imaging in diabetic retinopathy: A narrative review. *Journal of Clinical Medicine*, *10*(15), 3300. Retrieved from https://www.mdpi.com/2077-0383/10/15/3300
31. Nittala, M. G., & Sadda, S. R. (2016). Ultra-wide-field imaging in diabetic retinopathy. *Current Opinion in Ophthalmology*, *27*(3), 229-235. Retrieved from https://pmc.ncbi.nlm.nih.gov/articles/PMC4909710/
32. Hayati, A., et al. (2025). Advancing Diabetic Retinopathy Screening: A Systematic Review of Artificial Intelligence and Optical Coherence Tomography Angiography Innovations. *Journal of Clinical Medicine*, *15*(6). Retrieved from https://www.researchgate.net/publication/389874893_Advancing_Diabetic_Retinopathy_Screening_A_Systematic_Review_of_Artificial_Intelligence_and_Optical_Coherence_Tomography_Innovations
33. Hayati, A., et al. (2025). Advancing Diabetic Retinopathy Screening: A Systematic Review of Artificial Intelligence and Optical Coherence Tomography Angiography Innovations. *Journal of Clinical Medicine*, *15*(6). Retrieved from https://pmc.ncbi.nlm.nih.gov/articles/PMC11941001/
34. Virgili, G., et al. (2015). Optical coherence tomography for the diagnosis of diabetic macular oedema. *Cochrane Database of Systematic Reviews*, (6). Retrieved from https://www.cochranelibrary.com/cdsr/doi/10.1002

/14651858.CD008081.pub3/full
35. Ting, D. S. W., et al. (2019). Optical coherence tomography angiography in diabetic retinopathy: a review of current applications. *Eye and Vision*, *6*(1), 1-10. Retrieved from https://www.researchgate.net/publication/337328464_Optical_coherence_tomography_angiography_in_diabetic_retinopathy_a_review_of_current_applications
36. Abramoff, M. D., et al. (2023). Artificial Intelligence and Diabetic Retinopathy: AI Framework, Prospective Studies, Head-to-head Validation, and Cost-effectiveness. *Diabetes Care*, *46*(10), 1728-1738. Retrieved from https://diabetesjournals.org/care/article/46/10/1728/153626/Artificial-Intelligence-and-Diabetic-Retinopathy
37. Letters in High Energy Physics. (2024). Nurses' Role in Primary Health Care for Managing Diabetic Eye Complications. Retrieved from https://lettersinhighenergyphysics.com/index.php/LHEP/article/download/1224/904/
38. Letters in High Energy Physics. (2024). The Nurse's Role in the Prevention and Management of Diabetic Retinopathy. Retrieved from https://lettersinhighenergyphysics.com/index.php/LHEP/article/download/810/705/
39. Nurseslabs. (2023). *Diabetes Mellitus Nursing Care Plans*. Retrieved from https://nurseslabs.com/diabetes-mellitus-nursing-care-plans/
40. Open Access Journals. (n.d.). *Diabetes Nursing: Improving Care for Patients with Diabetes*. Retrieved from https://www.openaccessjournals.com/articles/diabetes-nursing-improving-care-for--patients-with-diabetes.pdf
41. Retina Labs. (n.d.). *Teleretinal Screening*. Retrieved from https://www.retina-labs.com/teleretinal-screening
42. Fernandes, M., et al. (2024). Integrating Nursing–Teleophthalmology Improves Diabetic Retinopathy Screening in Primary Healthcare, Reducing Unnecessary Referrals to Specialist Healthcare. *Journal of Clinical Nursing*. Retrieved from https://pmc.ncbi.nlm.nih.gov/articles/PMC12000632/
43. Young-Hyman, D., et al. (2016). Psychosocial care for people with diabetes: a position statement of the American Diabetes Association. *Diabetes Care*, *39*(12), 2126-2140. Retrieved from https://www.diabetessociety.com.au/documents/Young-HymanetalDiabetesCare2016.pdf
44. Young-Hyman, D., et al. (2016). Psychosocial care for people with diabetes: a position statement of the American Diabetes Association. *Diabetes Care*, *39*(12), 2126-2140. Retrieved from https://pmc.ncbi.nlm.nih.gov/articles/PMC5127231/
45. Fenwick, E. K., et al. (2012). Social and emotional impact of diabetic retinopathy: a review. *Clinical & experimental ophthalmology*, *40*(1), 27-38. Retrieved from https://www.researchgate.net/publication/51129477_Social_and_emotional_impact_of_diabetic_retinopathy_A_review
46. Liu, Y., et al. (2023). The lived experience of visual impairment caused by diabetic retinopathy: A qualitative study. *Journal of Clinical Nursing*, *32*(11-12), 2748-2758. Retrieved from https://pmc.ncbi.nlm.nih.gov/articles/PMC10006591/
47. Simple Nursing. (n.d.). *Retinal Detachment Nursing Care Plan & Management*. Retrieved from https://simplenursing.com/retinal-detachment-nursing-care-plan/
48. Kar, S., et al. (2024). The lived experience and supportive requirements of individuals with diabetic retinopathy: A qualitative study. *Journal of Advanced Nursing*. Retrieved from https://pmc.ncbi.nlm.nih.gov/articles/PMC12119164/
49. El-Sayed, E. M., & El-Sobky, E. S. (2018). Effect of Nursing Guidelines on Improving Knowledge and Relieve Anxiety of Diabetic Patients with Retinopathy. *International Journal of Novel Research in Healthcare and Nursing*, *5*(2), 147-157. Retrieved from https://www.researchgate.net/publication/349350721_Effect_of_Nursing_Guidelines_on_Improving_Knowledge_and_Relieve_Anxiety_of_Diabetic_Patients_with_Retinopathy
50. Healthcare Bulletin. (2024). A one-year cross-sectional study on the relationship between HbA1c levels and the presence and severity of diabetic retinopathy in type II diabetes mellitus. Retrieved from https://healthcare-bulletin.co.uk/article/a-one-year-cross-sectional-study-on-the-relationship-between-hba1c-levels-and-the-presence-and-severity-of-diabetic-retinopathy-in-type-ii-diabetes-mellitus-2795/
51. International Journal of Contemporary Medical Research. (2020). A Study on the Association between Glycosylated Haemoglobin (HbA1c) Levels with Diabetic Retinopathy. *International Journal of Contemporary Medical Research*, *7*(2). Retrieved from https://ijceo.org/archive/volume/7/issue/2/article/21233
52. Sim, R., & Cheng, Y. (2016). The role of glycemic control in the prevention and treatment of diabetic retinopathy. *Current Diabetes Reviews*, *12*(2), 115-124. Retrieved from https://pmc.ncbi.nlm.nih.gov/articles/PMC5432556/
53. Journal of Clinical and Diagnostic Research. (2024). A Cross-sectional Study on the Association of Lipid Profile and Glycaemic Status with Non-proliferative Diabetic Retinopathy in Patients with Type 2 Diabetes Mellitus. Retrieved from

https://jcdr.net/articles/PDF/20620/75996_CE_QC(AnK)_F(SS)_PF1(VD_SHU)_Redo_PFA(IS)_PB(VD_IS)_PN(IS).pdf

54. ARVO Annual Meeting Abstracts. (2023). Association of abnormal lipid profiles with the risk of diabetic retinopathy. *Investigative Ophthalmology & Visual Science*, *64*(8), 2268-2268. Retrieved from https://iovs.arvojournals.org/article.aspx?articleid=2790579
55. Iranian Journal of Public Health. (2015). Association between renal function tests and retinal status in diabetic patients. Retrieved from https://www.journalrip.com/Article/JRIP_20150224101834
56. Frontiers in Public Health. (2022). The link between diabetic retinal and renal microvasculopathy is associated with dyslipidemia and upregulated circulating level of cytokines. Retrieved from https://www.frontiersin.org/journals/public-health/articles/10.3389/fpubh.2022.1040319/full
57. Investigative Ophthalmology & Visual Science. (2016). Association of estimated glomerular filtration rate with diabetic retinopathy and macular edema. *Investigative Ophthalmology & Visual Science*, *57*(4), 1899-1905. Retrieved from https://iovs.arvojournals.org/article.aspx?articleid=2417297