

Telehealth Artificial Intelligence Applications and Workflows Between Primary Care and Ophthalmologist: A Pilot Study

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Abstract

Diabetic Retinopathy (DR) remains a leading cause of preventable blindness worldwide. Despite clear screening guidelines, referral adherence from primary care to ophthalmology is suboptimal. Telehealth-enabled Artificial Intelligence (AI) workflows offer a potential solution for closing this gap. The purpose of this study is to assess the feasibility of a telehealth referral pathway between Primary Care Providers (PCPs) and an ophthalmologist using AI-enabled diabetic eye screening. A pilot program implemented an AI-based referral workflow at a single site. Retinal imaging was performed at point-of-care using a non-mydratic camera, processed using AI software (AEYE-DS) and securely transmitted to a subspecialty ophthalmologist. Referral outcomes, turnaround time and clinical decision impacts were recorded. Out of 47 patients (18 male, 29 female) screened, 16 (34.0%) were flagged for referral. Of the 13 patients referred to the lead ophthalmologist (BPB, a comprehensive ophthalmologist), 7 (53.8%) completed ophthalmology follow-up. The AI triage system reduced referral turnaround time and identified significant pathology including cataracts and retinal abnormalities. The integration of AI-supported imaging, secure transmission and structured referral workflows between PCPs and ophthalmologists is feasible and may improve adherence to DR screening guidelines.

Keywords: Diabetic Retinopathy; Telehealth; Teleophthalmology; Primary Care Referral; Artificial Intelligence; Screening Workflow; Health Informatics

Abbreviations

AI: Artificial Intelligence; AMD: Age-related Macular Degeneration; DR: Diabetic Retinopathy; ECP: Eye Care Practitioner; EHR: Electronic Health Record; ICD-10: International Classification of Diseases, 10th Revision; mtmDR: more than mild DR; NC: Not Conclusive; PCO: Posterior Capsular Opacification; PCP: Primary Care Physician; HbA1c: Hemoglobin A1c

Introduction

Diabetic Retinopathy (DR) is a progressive microvascular complication of diabetes and remains a leading cause of preventable vision loss worldwide [1-3]. Global estimates indicate that as of 2020, over 1.07 million people were blind and 3.28 million had moderate to severe visual impairment due to DR, with the burden projected to rise alongside increasing diabetes prevalence [3]. Approximately one in three people with diabetes will develop some degree of DR and about one in ten will progress to a vision-

threatening stage. Early detection and timely ophthalmologic referral are universally recognized as critical for preventing irreversible visual impairment. However, because DR remains asymptomatic until advanced stages, many patients delay or fail to seek specialist care in time [4,5]. Despite strong recommendations for routine DR screening, adherence to eye screening referrals in primary care settings is historically suboptimal, with only 40-70% of individuals with diabetes receiving regular eye exams in many healthcare systems [6]. Barriers include lack of patient awareness, socioeconomic challenges and fragmented referral pathways, resulting in delayed detection and preventable vision loss.

Artificial Intelligence (AI)-enabled telehealth screening offers a novel approach to bridge these gaps in care. By decentralizing retinal image acquisition to primary care clinics and utilizing autonomous AI for immediate diagnostic support, these platforms aim to expand access to early DR detection and streamline referral processes. Recent pragmatic studies in real-world primary care and endocrinology clinics have shown that AI-assisted models can achieve high diagnostic accuracy for referable DR and improve satisfaction among both patients and clinicians [7-10]. Notably, platforms such as the AEYE Diagnostic Screening (AEYE-DS) have received FDA clearance for fully autonomous DR diagnosis from handheld retinal images, with studies demonstrating high diagnostic rates in clinic settings and potential to dramatically increase early case finding [8]. Nevertheless, the integration of AI-enabled teleophthalmology into primary care workflows remains inconsistent. Reported barriers include challenges with Electronic Health Record (EHR) integration, the need for staff training, workflow complexity, up-front costs of technology adoption and ensuring image quality. This pilot study explores the feasibility of an integrated workflow between Primary Care Providers (PCPs) and ophthalmologists using an AI-powered diagnostic platform. Specifically, it evaluates an autonomous AI based on a non-mydratic fundus image, deployed as part of an integrated referral system, with the goal of identifying DR in real-time, triaging referable cases and expediting subspecialty care. The study also highlights the challenges posed by inconclusive imaging and discusses implications for workflow refinement.

Methodology

A single site pilot study was conducted in North Bergen, NJ over a 2-month period. A primary care practice was equipped with a fundus camera, a referral system (Harmony, Topcon Healthcare Inc, Oakland, NJ) and an AI algorithm for autonomously detecting more than mild diabetic retinopathy (AEYE Health, New York, NY). Site staff underwent a one-hour training session. Image acquisition typically required less than five minutes and AI results were returned within five minutes. Patients with type 1 or type 2 diabetes without an ophthalmologic evaluation in the past year were included.

A single center focused 45-degree fundus image was captured with a semi-automated non-mydratic camera (NW400, Topcon Corporation, Tokyo, Japan) for each eye. The pair of images were stored in an image archiving and referral system (Harmony, Topcon Healthcare, Inc., New Jersey). From Harmony, the images were uploaded to AEYE-DS, which returned an assessment of positive for more-than-mild diabetic retinopathy (mtmDR), negative for mtmDR or Not Conclusive (NC).

The primary care physician referred any patient with a finding of mtmDR or NC to an ophthalmologist using a structured form within the Harmony Referral System (Topcon Healthcare, Inc., Oakland, NJ). The form captured relevant medical information, as well as the images, the AI report and insurance information.

The ophthalmologist reviewed flagged cases and determined referral needs, which were communicated back to the referring site who informed the patient of the need for referral. If the patient completed the referral, the ophthalmologist then used a structured report in Harmony to send diagnostic information (ICD-10 code(s)) back to the PCP to close the care loop.

Fig. 1 shows the two structured forms used. Primary outcomes included number screened, referral rates, follow-up and safety. Workflow metrics and software performance were also evaluated.

Figure 1a: Patient Referral Form

TOPCON Healthcare Patient Referral Form

Name (First, Middle & Last):

First Name: Middle Name: Last Name:

DOB (mm/dd/yyyy):

Sex: Male Female

Type of Diabetes: Type 1 Type 2 Undocumented

Last A1C & Date Measured: (mm/dd/yyyy)

Reason for Referral:

Advert Contact Info:

Phone Number:

Phone Number:

Address:

Email Address:

Insurance:

Provider:

Phone Number:

Group Number:

Subscriber Number:

Referral Number:

Referral Number:

Figure 1b: Eye Care Diagnosis Form

TOPCON Healthcare Eye Care Diagnosis Form

Patient Name:

DOB:

Advert Gender: Male Female Other

EYE CARE PRACTITIONER DIAGNOSIS

DIAGNOSIS ICD-10:

ADDITIONAL DIAGNOSES

COMMENT IF ADDITIONAL INFO TO CAPTURE:

SIGNATURE

Eye Care Provider:

MR:

Date and time:

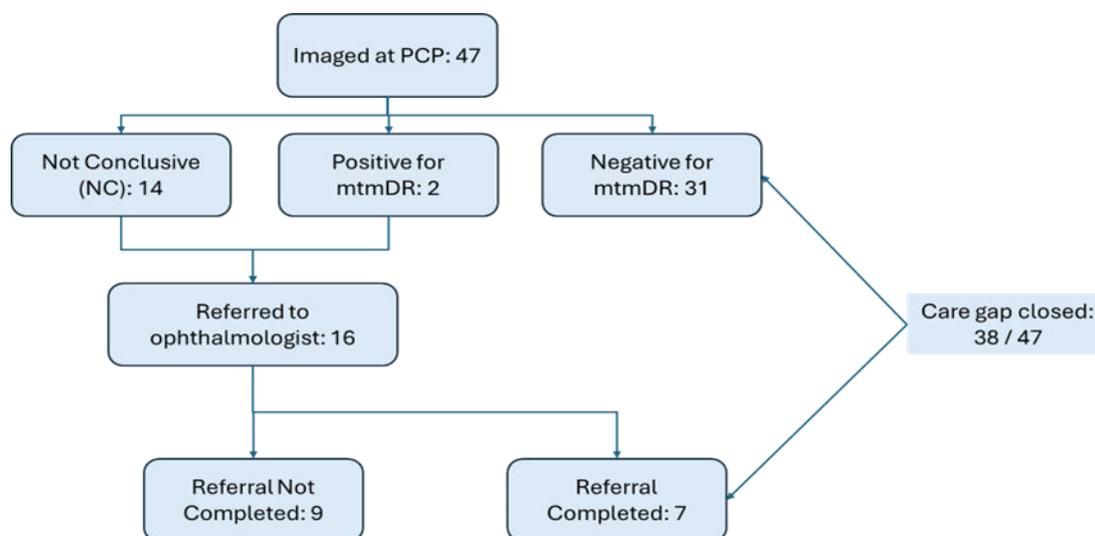
Disclaimer: This document is not an official source and is not a complete guide on all matters pertaining to reimbursement. Topcon Healthcare, Inc. does not guarantee that the use of this information will result in payment for services. The reader is reminded that this information can and does change over time and may be incorrect at any time following publication.

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Figure 1: Structured forms used in this study. 1a: referral from PCP to ECP. 1b: information from ECP to PCP after referral completion.

Results

A total of 47 diabetic patients (29 female, 18 male) were screened. Two patients were positive for mtmDR and 14 were referred due to non-conclusive imaging. The mean age of referred patients was 70 years (range: 21-93) and for non-referred patients, 59 years (range: 22-84). Most participants had type 2 diabetes; in two cases, diabetes type was undocumented. Among 16 patients requiring referral, 13 (81.3%) were referred to the lead ophthalmologist and 7 (53.8%) completed follow-up. The remaining three were referred externally, with no available outcome data. Of those completing follow-up, findings included cataract (6 cases), posterior capsular opacification (2), mild DR (3), dry AMD, serous pigment epithelial detachment and hypertensive retinopathy. The mean interval from screening to ophthalmology visit was 16 days. For the 31 patients with AI-negative results, DR absence was confirmed immediately at the time of imaging, yielding an overall closure rate of 81.0%.



A key observation was that every patient whose screening result was classified as Not Conclusive (NC) whether from insufficient image quality or incomplete image acquisition had senile cataracts confirmed on ophthalmic follow-up. This consistent association suggests that NC classifications may serve as indirect markers of media opacity and should not be dismissed as technical artifacts. Consequently, teleophthalmology workflows should be explicitly designed to generate automatic referrals for both AI-positive and NC cases, ensuring that potentially vision-limiting conditions such as cataract are not overlooked. The most common stated reasons for not completing the referral included lack of transportation and having a preferred ECP (Table 1).

Patients	Total	Not Referred	Referral Not Completed	Referral Completed
Total Screened	47	31	9	7
With mtmDR	2	N/A	1	1*
Could not be imaged	14	N/A	8	6***
Successful images and no mtmDR	31	31	N/A	N/A
※Findings: Posterior Capsular Opacification, dry AMD, serous Pigment Epithelial Detachment, Hypertensive retinopathy ※※6/6 senile cataract, 3/6 mild DR, Other findings: PCO, vascular attenuation, hypertensive retinopathy				

Table 1: Referral outcomes for this pilot study.

Discussion

This pilot demonstrates the feasibility and clinical utility of integrating autonomous AI screening with teleophthalmology referral workflows in primary care. The combined use of AEYE-DS and the Harmony platform allowed timely triage and coordination of ophthalmic referrals without on-site specialist presence. Our findings align with prior studies demonstrating the incidental detection of cataract during DR screening. For example, in a New Zealand DR program involving 22,000 participants, cataracts were identified in 37.1% of individuals over 75 years of age, underscoring the secondary benefits of DR imaging in detecting comorbid ocular disease [11]. This study also reinforces the workflow value of referring patients with poor image quality. All such cases in our pilot were subsequently found to have cataract, confirming that unreadable images can signal clinically relevant pathology. The study further highlights the operational value of AI integration in primary care. Structured referrals, rapid result turnaround and closed-loop feedback via the Harmony system enabled PCPs to manage diabetic eye screening effectively within routine visits. Although limited by its small sample and short duration, the mean referral completion time of 8 days compares favorably to prior manual workflows, where referral goals often extend to one year [5]. The referral workflow offered the opportunity to share clinically relevant information such as type of diabetes and HbA1c, but these elements were not required and were often missing from the forms. This demonstrates why Electronic Health Record (EHR) integration would be valuable, although it was not available in this implementation. Overall care-gap closure occurred in 81% of cases, including immediate AI-negative results (66%) and completed ophthalmology referrals (15%). The referral completion rate of 44% among referred patients reflects persistent barriers primarily transportation and provider preference-which align with previously reported challenges [12].

There are several limitations to this feasibility study. Only 47 patients were screened during the two-month period, limiting generalizability. Outcome measures such as referral completion and care-gap closure are therefore not definitive, although sufficient to demonstrate workflow feasibility. Another limitation is the absence of HbA1c values and diabetes duration for most participants. As glycemic control is a major determinant of DR risk and referral urgency, this limits contextual interpretation. Referring physicians determined urgency using clinical judgment, whereas ophthalmologists evaluated images based solely on available data. Outcome information was unavailable for patients referred outside the lead ophthalmologist, introducing potential attrition bias and likely leading to an underestimation of referral completion rates. Finally, the absence of EHR integration likely restricted data completeness and reduced scalability.

Conclusion

This pilot study demonstrates that AI-enhanced teleophthalmology workflows can feasibly integrate into primary care to improve diabetic eye screening coordination. Both AI-positive and non-conclusive image findings warrant referral, as each may reflect significant ocular pathology. Future studies should evaluate larger, multi-site implementations with EHR integration, automated scheduling and patient navigation to further optimize referral adherence and clinical outcomes.

Conflict of Interest

BB is a consultant for Topcon Healthcare, Inc. LC no conflicts to disclose; RR no conflicts to disclose.

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This study was supported by Topcon Healthcare, Inc. The corresponding author had full control over the study results and the formulation of conclusions.

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Data Availability Statement

Study-specific data are available from the corresponding author upon reasonable request.

Ethical Statement

The project did not meet the definition of human subject research under the purview of the IRB according to federal regulations and therefore, was exempt.

Informed Consent Statement

Verbal informed consent was obtained for this study; however, written Informed consent was not taken for this study.

Authors' Contributions

JL: Conceptualization. JB: Investigation, Data curation. BB: Conceptualization, Investigation, Writing-original draft, Writing-review and editing. MD: Writing-review and editing, Formal Analysis. All authors read and approved the submitted version.

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