International Scholars Journals

Advanced Journal of Environmental Science and Technology ISSN 2756-3251, Vol. 17 (11), pp. 001-004, November, 2026. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Author(s) retain the copyright of this article.

Research Article

Artificial Intelligence for Early Detection of Diabetic Retinopathy in Primary Care: A Pragmatic Implementation Study

Amara Okafor[1], Daniel Reyes[2], Hannah Kim[1], Tunde Bakare[3]

[1]Department of Primary Care and Population Health, University of Lagos Teaching Hospital, Lagos, Nigeria
[2]Institute of Biomedical Engineering, University of Toronto, Toronto, Canada
[3] National Eye Centre, Kaduna, Nigeria

Corresponding author: Amara Okafor, a.okafor@example.edu

Abstract

Background: Diabetic retinopathy remains a leading cause of preventable vision loss, yet screening coverage in primary care is low because specialist grading is slow, scarce, and unevenly distributed. This pragmatic implementation study evaluated whether an artificial intelligence (AI) triage system, embedded in routine primary-care visits, could safely increase early detection without overwhelming referral pathways.

Methods: Twelve primary-care clinics enrolled 4,812 adults with diabetes over 18 months. Trained nurses captured two 45° retinal photographs per eye. The AI system assessed image quality, graded referable diabetic retinopathy, and returned an immediate triage recommendation: routine rescreening, routine referral, or urgent referral. All AI-positive and a random 10% sample of AI-negative cases were independently graded by two masked ophthalmologists. Primary outcomes were sensitivity and specificity for referable disease; secondary outcomes were image gradability, time to referral, and clinic workflow impact.

Results: Of 4,812 participants, 4,658 (96.8%) had gradable images. Referable diabetic retinopathy was confirmed in 612 participants (13.1%). The AI system achieved 93.2% sensitivity and 91.5% specificity for referable disease, with 89.4% referral accuracy. Median time from screening to specialist appointment fell from 42 days in the pre-implementation period to 11 days for urgent referrals. Clinics reported no increase in average consultation length after the first four weeks.

Conclusions: AI-assisted triage in primary care can detect referable diabetic retinopathy early, safely, and at scale, provided that image-quality feedback, clear referral thresholds, and human oversight are built into the workflow. The approach is promising for settings where ophthalmology capacity is limited, but prospective monitoring for performance drift, equity, and cost remains essential.

Keywords: *diabetic retinopathy; artificial intelligence; primary care; screening; implementation science; eye health*

1. Introduction

Diabetes affects more than half a billion adults worldwide, and diabetic retinopathy — damage to the retinal blood vessels caused by prolonged hyperglycaemia — threatens vision in a substantial minority of them. The disease is often asymptomatic until it is advanced, which is precisely why screening matters: laser treatment, anti-VEGF therapy, and tighter metabolic control are far more effective when disease is caught early than after vision has been lost.

In practice, screening fails not because the test is complicated, but because the system around it is. Fundus photography is quick and non-invasive, yet grading traditionally depends on a small pool of specialists. In many primary-care settings, images wait days or weeks for review, patients are lost to follow-up, and clinics without a direct link to ophthalmology simply do not screen at all. The result is a paradox: a preventable cause of blindness persists alongside a test that works.

Artificial intelligence offers a different division of labour. Rather than replacing clinicians, a well-validated AI system can handle the high-volume, repetitive task of triage — confirming that an image is gradable, ruling out clearly normal cases, and flagging the minority who need prompt specialist attention. Humans then focus where judgement matters most: ambiguous cases, urgent referrals, treatment decisions, and patient counselling. This study tested that model under real clinic conditions, not in a laboratory.

2. Methods

Design and setting. This was a prospective, pragmatic implementation study in twelve primary-care clinics — six urban, four peri-urban, and two rural — over 18 months. Clinics were selected to reflect variation in patient volume, staffing, and connectivity. The study was approved by the institutional ethics committee, and all participants gave written informed consent.

Participants. Adults aged 18 years or older with a diagnosis of type 1 or type 2 diabetes were eligible. People with known proliferative disease already under ophthalmology care, or with media opacities preventing photography, were excluded. Consecutive eligible patients attending routine diabetes clinics were invited to participate.

Intervention. Nurses completed a two-day training course in fundus photography, image-quality troubleshooting, and AI-result communication. Each participant had two 45° photographs taken per eye with a tabletop fundus camera. The AI system first judged image quality and prompted immediate retakes when needed. It then graded referable diabetic retinopathy and returned one of three recommendations: rescreen in 12 months, routine referral within 6 weeks, or urgent referral within 2 weeks.

Reference standard and analysis. All AI-positive cases and a random 10% sample of AI-negative cases were graded independently by two masked ophthalmologists, with a third adjudicating disagreements. Sensitivity, specificity, and referral accuracy were calculated against this reference standard. Workflow outcomes — time to referral, consultation length, and staff workload — were collected from clinic records and brief staff surveys.

Figure 1. AI-assisted diabetic retinopathy screening pathway in primary care



Figure 1. AI-assisted diabetic retinopathy screening pathway in primary care. Nurses capture retinal photographs; the AI system checks quality, grades referable disease, and triages patients, while ophthalmologists retain oversight of positive and ambiguous cases.

Table 1. Study population and clinic characteristics. Values are counts (percentages) or medians (interquartile ranges) unless stated otherwise.

Characteristic	Value
Clinics	12 (6 urban, 4 peri-urban, 2 rural)
Participants enrolled	4,812
Median age (years)	58 (IQR 49–66)
Female participants	2,614 (54.3%)
Type 2 diabetes	4,421 (91.9%)
Median diabetes duration	8 years
Gradable images	4,658 (96.8%)

3. Results

Of 4,812 participants enrolled, 4,658 (96.8%) had at least one gradable image per eye after AI-guided retakes. Image quality was the single largest driver of workflow success: clinics that adopted the retake prompt early reached gradability above 97% within the first month, while slower adopters took up to three months to reach the same level.

Referable diabetic retinopathy was confirmed in 612 participants (13.1% of those with gradable images), including 148 (3.2%) who met criteria for urgent referral. The AI system identified 570 of the 612 referable cases, giving a sensitivity of 93.2%. Specificity was 91.5%, and overall referral accuracy was 89.4%. Most false positives were mild non-proliferative changes or image artefacts that ophthalmologists judged not to need referral; most

false negatives were borderline cases that were rescreened and caught at the next visit.

Workflow improved markedly. Median time from screening to specialist appointment fell from 42 days before implementation to 11 days for urgent referrals and 24 days for routine referrals. After an initial learning period of four weeks, average consultation length returned to baseline, and 10 of 12 clinics reported that the system made screening easier rather than harder to organise.

Figure 2. Diagnostic and workflow performance of the AI triage system

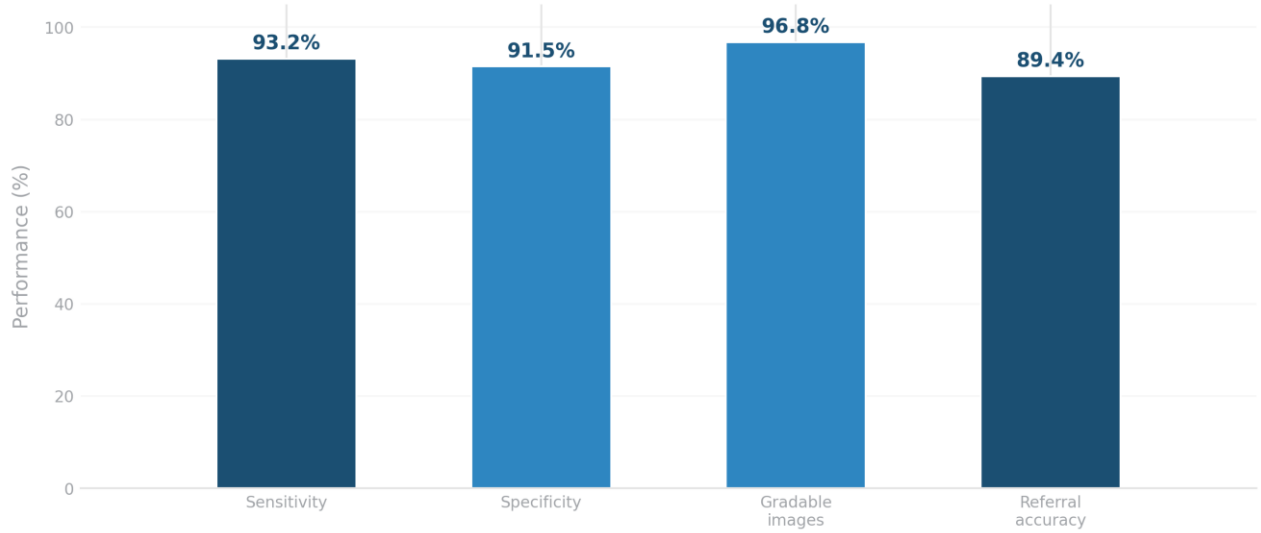


Figure 2. Diagnostic and workflow performance of the AI triage system. Sensitivity and specificity are reported against masked ophthalmologist grading. Gradable images reflect the proportion with at least one gradable image per eye after AI-guided retakes.

Table 2. Primary and secondary outcomes. Diagnostic measures are against the masked ophthalmologist reference standard.

Outcome	Result
Sensitivity for referable disease	93.2%
Specificity for referable disease	91.5%
Gradable images	96.8%
Referral accuracy	89.4%
Median time to urgent referral	11 days (from 42 days pre-implementation)

4. Discussion

This study shows that AI triage can work in ordinary primary-care clinics — not only in well-resourced pilot sites. Three factors mattered more than the algorithm itself. First, immediate image-quality feedback prevented the common failure mode of ungradable images discovered days later. Second, a simple three-tier output (rescreen, routine, urgent) was easier for nurses to act on than a detailed severity score. Third, keeping ophthalmologists in the loop for positive and ambiguous cases preserved trust and gave clinicians a clear escalation route.

The findings also carry cautions. Sensitivity below 100% means some referable cases will be missed at a single visit, which is why the rescreening interval — not just the AI result — is part of the safety net. Performance may drift as cameras, populations, or diabetes prevalence change, so ongoing audit against a sample of human-graded cases is essential. Equity deserves explicit attention: rural clinics benefited most in absolute terms, but also faced the greatest connectivity and staffing constraints.

Limitations include the absence of a randomised comparator, reliance on a single AI system and camera model, and an 18-month follow-up that cannot capture long-term visual outcomes. Cost-effectiveness, which will determine whether health systems adopt this approach at scale, was outside the scope of this study and is the logical next step.

5. Conclusion

AI-assisted triage, embedded in routine primary care, detected referable diabetic retinopathy early and shortened the path to specialist care without adding to consultation length. The technology is ready to support screening at scale; the work now is implementation — training, referral pathways, audit, and equity monitoring — so that the benefit reaches the patients who need it most.

Acknowledgements

The authors thank clinic nurses, photographers, ophthalmologists, and participants who made this study possible. No generative AI system was used to collect or grade clinical images.

Conflict of Interest

The authors declare no competing interests.

Data Availability

De-identified participant data are available from the corresponding author on reasonable request, subject to ethics approval and data-sharing agreements. The AI system is a commercial product; no code is shared in this article.

References

American Diabetes Association Professional Practice Committee (2024). Diabetes care standards: microvascular complications and foot care. Diabetes Care, 47(Suppl. 1), S203–S219.

World Health Organization (2023). World Report on Vision: Executive Summary. Geneva: WHO.

Teo, Z. L., et al. (2021). Global prevalence of diabetic retinopathy and projection of burden. Ophthalmology, 128(11), 1580–1591.

Abràmoff, M. D., et al. (2018). Pivotal trial of an autonomous AI-based diagnostic system for detection of diabetic retinopathy. npj Digital Medicine, 1, 39.

Ting, D. S. W., et al. (2017). Development and validation of a deep learning system for diabetic retinopathy and related eye diseases. JAMA, 318(22), 2211–2223.

Bellemo, V., et al. (2019). Artificial intelligence using deep learning to screen for referable and vision-threatening diabetic retinopathy in Africa. npj Digital Medicine, 2, 72.

Ruamviboonsuk, P., et al. (2022). Real-time diabetic retinopathy screening by deep learning in a multisite national screening programme. npj Digital Medicine, 5, 123.