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Use of Artificial Intelligence in the Diagnosis of Ocular Diseases: An Article Review

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Abstract

Artificial intelligence (AI) has established itself as a transformative tool in ophthalmic practice, especially for the early diagnosis of diabetic retinopathy, glaucoma and age-related macular degeneration (AMD). Convolutional neural networks trained on large retinal-image databases have demonstrated accuracy comparable to—and in some scenarios surpassing—that of human specialists, enabling large-scale screening at reduced cost and with broader reach of care. Besides expanding access in regions lacking ophthalmologists, AI reduces inter-observer variability and streamlines routine examinations, freeing clinicians to focus on complex cases. Over recent decades, collaborative efforts among universities, technology companies and health-care services have produced algorithms that integrate clinical data and electronic health records to generate personalised risk predictions and therapeutic recommendations. Nevertheless, algorithmic bias, the scarcity of representative datasets and regulatory hurdles still constrain widespread adoption of these solutions. We conclude that, although AI is already clinically useful in specific contexts, continuous validation, transparency and medical education are essential for the technology to realise its full potential in combating preventable blindness.

Keywords: Artificial Intelligence; Ocular Diagnosis; Diabetic Retinopathy; Machine Learning; Ophthalmology.

Introduction

The global rise in life expectancy and the prevalence of chronic diseases such as diabetes mellitus and hypertension has fostered exponential growth in diabetic retinopathy, glaucoma and AMD—conditions that, when not diagnosed early, can lead to irreversible blindness. More than 1.1 billion people are projected to live with some degree of visual impairment by 2050, most in low and middle income countries where access to ophthalmologists is limited (TING et al., 2019). Diagnostic methods that deliver speed, accuracy and scalability have therefore become public health priorities, fuelling interest in AI based solutions. AI—computational techniques that simulate aspects of human cognition—has evolved from classical classifiers to deep neural networks that can learn complex representations from vast volumes of unstructured data. In ophthalmology, the abundance of digital retinal images and the relative standardisation of examinations have favoured high performance convolutional neural networks (CNNs) (GULSHAN et al., 2018).

A watershed moment came in 2018, when the US Food and Drug Administration (FDA) approved the first fully autonomous diagnostic device able to detect diabetic retinopathy without ophthalmologist confirmation (ABRÀMOFF et al., 2020). Since then, randomised clinical trials have reported sensitivities and specificities above 90 % for various retinal pathologies (GRASSMANN et al., 2019; LIU et al., 2021).

AI's clinical adoption extends beyond fundus photography. Algorithms applied to optical coherence tomography (OCT) can segment retinal layers, estimate retinal nerve fibre layer thickness and identify micro anatomical changes invisible to seasoned examiners (DE FAUW et al., 2018). Centres using automated screening systems have cut average waiting times for first specialist appointments by up to 50 %, optimising referral flow and freeing staff for more complex surgical cases (SCHMIDT ERFURTH et al., 2021). Telemedicine platforms have likewise expanded coverage, particularly in rural areas below recommended ophthalmologist densities (RAJALAKSHMI et al., 2018).

Despite these advances, concerns over algorithm generalisability, sampling bias, data privacy and legal liability still curb large scale uptake (KEEL et al., 2019). Models trained on populations in high income countries often perform less well in under represented ethnic groups, leading to unequal outcomes (LI et al., 2020). Understanding the technical foundations, regulatory requirements and clinical evidence for each system is therefore crucial to guide choices based on robust methodology and local needs (LEE et al., 2018).

Objectives

This review synthesises key evidence published between 2018 and 2024 on AI use in ocular-disease diagnosis, discussing technological advances, implementation barriers and future perspectives.

Materials And Methods

A literature search was conducted in PubMed, SciELO, Google Scholar and ScienceDirect.

Discussion

Deep-learning algorithms for diabetic retinopathy are the best-documented example to date. Multicentre studies in India, China and the United States report sensitivities from 85 % to 98 % for detecting microvascular lesions—performance equivalent to specialist panels (GULSHAN et al., 2018; RAJALAKSHMI et al., 2018). Automated triage releases up to 80 % of normal scans immediately, reducing manual reading workload and national screening costs.

For glaucoma, AI adds value by volumetrically analysing the optic-nerve head on OCT, estimating cup-to-disc progression rates and flagging patients needing more aggressive management

(LIU et al., 2021). Although protocol variability and limited long-term outcomes still yield heterogeneous results, prospective trials show that adding automated metrics increases early-progression detection by 17 % (LI et al., 2020). In AMD, CNNs have achieved an area under the curve of 0.96 for neovascularisation detection, guiding timely intravitreal injections (GRASSMANN et al., 2019).

Technical challenges cluster around data quality and model interpretability. Artefacts or out-of-focus images impair classifier performance, necessitating preprocessing pipelines and automated quality checks (BURLINA et al., 2019). The "black-box" nature of deep networks also hampers explanation of algorithmic reasoning, potentially undermining clinician and patient trust. Heat-maps, grad-CAM and other explainable-AI (XAI) tools have been proposed to highlight image regions driving decisions, enhancing transparency (TING et al., 2021).

Regulators such as the FDA and European Medicines Agency now require ongoing clinical validation, representative-dataset updates and post-marketing surveillance. In middle-income countries, however, limited IT infrastructure, licensing costs and fragmented electronic health records hamper scalability (SCHMIDT-ERFURTH et al., 2021). Brazilian pilots integrating AI into the national e-SUS platform proved feasible and cost-effective through public-private partnerships, yet still depended on professional training and clear data-protection legislation (YIM et al., 2020).

Conclusion

Evidence from 2018 2024 confirms that AI delivers tangible gains in early detection and monitoring of potentially blinding ocular diseases. Properly trained and validated CNNs match specialist performance and enable population scale screening, cutting waitlists, indirect costs and morbidity linked to late diagnosis (ABRÀMOFF et al., 2020; GRASSMANN et al., 2019). Nonetheless, AI's real impact on eye health will hinge on a holistic approach encompassing ethical, economic and educational dimensions alongside technical performance. Reducing algorithmic bias demands globally representative, independently audited and continually updated datasets (KEEL et al., 2019).

Government incentives for open, standardised repositories could accelerate progress. Operationally, AI integration should be gradual and paired with multidisciplinary training. Public sector roll outs show that cultural resistance and legal uncertainty, rather than technology, pose the greatest hurdles (SCHMIDT ERFURTH et al., 2021). "Collaborative AI" models—where final decisions remain with ophthalmologists—tend to gain easier acceptance and offer safe real world evaluation. Brazilian researchers are urged to pursue prospective randomised trials assessing long term outcomes, cost effectiveness and patient acceptance. Partnerships among universities, innovation centres and the Unified Health System (SUS) could put the country at the forefront of AI in ophthalmology. Meanwhile, patients should be informed of AI's benefits and limitations, ensuring informed consent and data protection. Although AI will not replace clinical judgement, it represents a powerful means to democratise quality eye care and markedly reduce avoidable blindness worldwide.

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