INVITED REVIEW

Empowering Retina Care Through Artificial Intelligence

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ABSTRACT

Artificial intelligence is increasingly integrated into healthcare, with significant investments driving the growth of the global AI healthcare market. As retina specialists, we recognize the immense potential of AI integration across various domains. For instance, AI-based screening for retinal diseases such as diabetic retinopathy and retinopathy of prematurity can play a critical role in preventing blindness. AI algorithms can analyze fundus images to detect systemic and neurological conditions, broadening its utility beyond ophthalmology. AI-driven machine learning can enhance risk stratification and enable personalized management strategies. Furthermore, AI has the potential to reduce administrative burdens, such as documentation, charting, and billing, thereby improving workflow efficiency.However, caution must be exercised to address concerns related to the reliability and liability of these systems before their widespread implementation.

Key Words: Artificial Intelligence; Retina; Retina Specialist; Healthcare.

ARTIFICIAL INTELLIGENCE

We are currently living in the era of artificial intelligence (AI), where computers utilize multi-neural network models trained on extensive databases to mimic human intelligence.[1] An AI navigation app on your phone can integrate maps, predict traffic, suggest optimal routes, and estimate arrival time. Similarly, many cars now include Adaptive Cruise Control (ACC), enabling semi-autonomous driving with minimal human intervention.[2]

HEALTHCARE

In healthcare, AI integration has the potential to optimize administrative tasks, reduce workload, and improve patient care. Reliable AI systems depend on clean data, and efforts to improve data quality have significantly intensified over the past decade.[3] In 2016, the National Institutes of Health (NIH) funded the "All of Us" network, which began enrolling 1 million diverse participants in 2018 to advance biomedical research and health outcomes.[4] The NIH further launched the "Bridge2AI" program, investing $130 million USD to expand AI applications in biomedical and behavioral research and address critical health challenges.[5, 6] These efforts align with the rapid growth of the global AI healthcare market, which was valued at over $11 billion in 2021 and is projected to reach $188 billion by 2030, highlighting the transformative potential of such investments.[7]

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RETINA

When it comes to AI implementation in ophthalmology, investment in the retina is at the forefront. This is due to two key factors: imaging and systemic associations.[8] AI excels in image recognition, and most retinal disorders can be diagnosed through various imaging modalities. Additionally, the unique neurological and vascular anatomy of the retina may provide insights into associated central nervous system (CNS) and cardiovascular system (CVS) disorders.[9, 10, 11]

SCREENING

The use of AI in screening is an empowering advancement in retinal care. A single fundus image, processed in seconds, can detect and grade multiple retinal diseases with high sensitivity and specificity, often outperforming retina specialists.[12] These images can be captured in diverse settings, including primary care office, handheld cameras, mobile devices, or even at home.[13] The Food and Drug Administration (FDA) has approved several AI systems for retinal screening using fundus cameras. IDx-DR was the first AI tool cleared for autonomous detection of diabetic retinopathy (DR), providing immediate results without clinician involvement. The EyeArt AI System is also FDA-approved for screening DR, age-related macular degeneration (AMD), and glaucoma. The third system, RetinaScope by AEYE Health, offers both desktop and handheld camera versions, enabling cost-effective retinal screenings in primary care settings and improving accessibility to early detection.[12]

Several AI algorithms using different imaging modalities are being tested to empower the screening and diagnosis of various retinal disorders, such as Retinopathy of Prematurity (ROP), Retinal Detachment (RD), Sickle Cell Retinopathy (SCR), Uveitis, and Chloroquine Toxicity. [8, 12, 14, 15, 16] These AI systems have the potential to enhance early detection, improve diagnostic accuracy, and reduce the burden of screening and triage.

PERSONALIZED MANAGEMENT

The potential of AI in retinal care extends beyond screening and diagnosis to monitoring disease progression in both the affected and contralateral eye. By combining Optical Coherence Tomography (OCT) images with color fundus photography or assessing differences between images taken at different times, AI algorithms can track subtle changes, helping clinicians evaluate treatment effectiveness and predict future complications in diabetic retinopathy (DR) and age-related macular degeneration (AMD).[17, 18, 19] These technologies also offer potential for personalized treatments and risk scoring for retinal diseases.

MEDICAL DATA

Artificial intelligence (AI) has revolutionized big data extraction and management, enhancing precision and efficiency. In retinal imaging, decades of advancements have introduced biomarkers to assess ocular and systemic diseases, particularly through OCT.[12, 20] AI enables rapid quantification of retinal biomarkers such as subretinal fluid, intraretinal fluid, and hyperreflective foci, completing tasks in seconds that would otherwise require significant time from retina specialists.[21, 22] These data can seamlessly be imported and analyzed for clinical research and trials.[12] Furthermore, AI identifies at-risk patients and predicts treatment responses at both cohort and individual levels, optimizing research outcomes.[23]

CHATBOTS

Another breakthrough in AI is large language models (LLMs) like ChatGPT, Bing Chat and Gemini. These models, trained on large datasets, can interpret texts, commands, and questions across languages, enabling seamless communication that mimic human conversation. They are now being studied for use in retinal care.[24] Patients might use these models for education, counselling and efficient referrals.[25] Healthcare providers can use these models to summarize vast amounts of literature and guidelines, aiding both clinical practice and research.[26] Additionally these models have great potential to reduce administrative burdens, such as charting, billing, and coding, thereby enhancing clinical workflows and patient care.[24, 27]

CHALLENGES

AI has the potential to revolutionize retinal practice, but several challenges must be overcome before it can be fully implemented. Interpretability, generalizability, and liability are among the most pressing concerns.[8, 12, 16, 24] AI systems are often seen as black boxes, making it challenging for clinicians to understand their functioning and correct any

errors in behavior. Algorithmic bias could be a significant obstacle, as uncertainty in its performance may vary across different populations, ethnicities, and countries. Computers can make errors, and AI can "hallucinate," generating fabricated or incorrect outputs, as well as providing plausible-sounding but inaccurate responses.[28]the task of coding ICDs after each patient encounter is time-consuming on physicians, particularly in fast paced clinics such as retina clinics. Additionally, searching for the most specific, correct ICD code may add additional time, resulting in providers electing for more general ICD codes. LLMs may help to relieve this burden by analyzing notes written by a provider and automatically generate an ICD code that can be used for the encounter. Methods: In this study, we analyze the ability of ChatGPT to analyze retina encounters and to generate ICD codes for the encounter without any feedback. Text of mockup retina clinic encounters of various types of visits including new patient visits, return visits, post-operative visits, and injection-only visits were generated by three retina specialists. Results: A total of 181 retina encounters were evaluated, with 84 eyes as right eyes, 97 eyes as left eyes. A total of 597 ICD codes were generated, with 305 consisting of retina codes (1.68 retina codes per eye It remains unclear who should be held accountable -healthcare providers, developers, sellers, or regulators- when an AI system makes errors in real-world clinical practice. To address this, regulations and laws must be carefully examined and established before the widespread implementation of AI in healthcare.

CONCLUSION

AI will undoubtedly empower retina care, enhancing clinician workflows, increasing productivity, enabling the treatment of more patients, improving outcomes, and paving the way for novel advancements. However, with great power comes great responsibility**.**

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