

# How to screen diabetic retinopathy within communities

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**Abstract:** Diabetic retinopathy (DR) remains a leading cause of irreversible vision loss in adult populations around the globe. Despite growing evidence of the effectiveness of routine assessments and early intervention, DR screening strategies are not widely implemented largely due to an inadequate availability of resources to cope with the growing burden of diabetes. Advances in technology in the field of DR screening are clearly warranted and the recent emergence of deep learning-based artificial intelligence (AI) grading of retinal pathology offers significant potential benefits including an increased efficiency, accessibility and affordability of screening programmes.

**Keywords:** Diabetic retinopathy (DR); screening; artificial intelligence (AI)

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Diabetic retinopathy (DR) is a leading cause of irreversible vision loss in adults of working age (1). Recent estimates suggest the global prevalence of DR is 34.6%, corresponding to nearly 100 million people worldwide (1). It is well established that DR is independently associated with decreased quality of life (QoL) (2) and poses a significant financial burden on society (3). With the prevalence of diabetes predicted to rise by at least 25% by 2030 (4,5), a significant increase in the health impact and economic burden of DR is expected (6).

It has been estimated that 98% of vision loss from DR is avoidable through early detection coupled with effective treatment strategies such as intravitreal anti-vascular endothelial growth factor injections and laser therapy (7,8). As such, screening for DR has long been endorsed by many international societies, including the American Academy of Ophthalmology, that recommend annual comprehensive ocular assessments for individuals with diabetes (9). However, despite the growing evidence of the effectiveness of routine assessments and early intervention, DR screening strategies are not widely implemented. This

is largely due to an inadequate availability of resources to cope with the rapidly growing burden of diabetes. As a result, there are known high rates of undiagnosed disease within communities (10), which can be largely attributed to DR being asymptomatic in its early stages.

Digital retinal photography is a validated, simple and effective screening tool for DR, with previous research demonstrating that single non-mydratic 45 degree retinal image can detect DR with 71–86% sensitivity and 92–96% specificity (11,12). While mydratic retinal photography improves the rate of gradable images (13), this results in the increased time of each screening encounter which significantly impacts on the cost-effectiveness of screening programmes. Recent advancements have seen the development of smartphone-based retinal photography that provide a relatively inexpensive means to capture high-quality images (14) and open up greater opportunities for telemedical approaches.

Internationally, several countries have implemented national DR screening programmes including the United Kingdom (UK) (15), Iceland (16), France (17)

and more recently Singapore (18). These programmes employ a telemedicine-based model that integrates retinal photography and the digital transfer of images to a centralized location (e.g., established grading centre) for retinal grading by ophthalmologists, optometrists, or specially trained non-physician technicians. From the point of screening patients without DR and those with mild disease are encouraged to return for routine screening, while those with sight-threatening DR (moderate or worse DR or diabetic macular edema) are referred to hospital ophthalmology services for treatment. Perhaps the strongest evidence of the long-term effectiveness of systematic DR screening comes from the NHS Diabetic Eye Screening program in the UK, that has achieved an average nationwide uptake of approximately 80% (19) and a significant reduction in blindness from DR over a 15-year period that has resulted in DR no longer being the leading cause of blindness in the working age group (20). The success of this initiative provides strong evidence that DR screening can be effectively performed by suitably trained non-clinical staff who undergo stringent quality assurance and continuous development. Despite this, there are a number of drawbacks associated with these telemedicine-based models that limit more widespread application. This includes a reliance on a costly reading centre supported by highly trained professionals and a delay in communicating screening results to patients.

An emerging area of DR screening involves the use of artificial intelligence (AI)-based automated grading of retinal pathology. The development of these systems is based on deep learning technology that involves learning the most predictive features of DR directly from large datasets of specialist graded retinal images (21,22). Recent research suggests that these automated platforms can achieve excellent sensitivities and specificities for detecting referable DR (23,24), and therefore offer great promise for the future of DR screening. Firstly, there is countless potential for these systems to improve the accessibility of screening programs in areas of low availability of optometry and ophthalmology services, such as under resourced developing nations and countries with large regional populations. Second, given the majority of images captured in the screening setting are normal (~70%), these systems could be incorporated into centralized reading centres to markedly improve efficiency. Finally, automated grading offers real-time reporting of results, thereby addressing many issues associated with the delayed communication including patient anxiety, documentation errors and

difficulties re-contacting patients (25).

Despite the obvious potential benefits of automated DR screening technologies, there is a paucity of data relating to the real-world clinical impact and cost-effectiveness of these systems. For example, whether or not this software can be effectively integrated with a retinal camera and used at the point of care to allow non-eye trained professionals (e.g., primary care providers and endocrinologists) to conduct opportunistic DR screening without the need for trained specialists warrants evaluation. Furthermore, many of the automated grading systems described in the literature do not identify other leading causes of vision impairment and blindness, including age-related macular degeneration (AMD) and glaucoma, which are typically included within manual DR screening programmes. In Guangzhou, together with a technology company (Healgoo Interactive Medical Technology Co. Ltd.) we have developed the first fully functioning AI system, the EyeGrader.com, for the screening of four common eye diseases including referable DR, glaucoma, late AMD and possible cataract. This system has been widely adopted in the Lifeline Express DR screening program in China and more recently adopted in Australian communities as a tool for opportunistic screening within general practitioner clinics and as a diagnostic assistance tool for endocrinologists in the management of diabetic patients within endocrinology clinics.

In summary, advances in technology in the field of DR screening are clearly warranted to cope with the increasing global burden of diabetes and DR. AI-based automated grading for DR offers significant potential benefits including an increased efficiency, accessibility and affordability of screening programmes. Considerable and sustained efforts are required to ensure the implementation and delivery of evidence-based and population-based DR screening solutions.

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