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Screening for Diabetic Retinopathy by Non-Ophthalmologists: A Task-Shifting Approach for Low and Middle-Income Countries

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Abstract

Diabetic Retinopathy (DR) is a devastating ocular complication of diabetes mellitus that is expected to affect approximately 200 million people globally by 2030 over time, high blood sugar levels can cause damage to retinal blood vessels, which can result in leakage, swelling, constriction, and outgrowths of these vessels. Damage to retinal blood vessels causes one's vision to become cloudy or blurred, and if not treated in a timely manner these changes can become permanent.

Approximately 35% of diabetic patients develop DR over the course of the disease. If le t untreated, DR can progress to partial or even total blindness; however, early intervention is effective in preventing the development of blindness. In fact, regular eye examinations in diabetic patients have been shown to prevent approximately 98% of diabetes-related vision loss. Early diagnosis and treatment is the gold standard in preventing blindness. DR screening aims to detect sight threatening lesions while they can be effectively treated with photocoagulation or anti-Vascular Endothelial Growth Factor (VEGF) injections into the eye, preventing their progression and blindness. Accordingly, many countries have developed comprehensive screening programs to detect DR in its early stages.

More than 80% of the diabetes and sight-threatening DR burden is concentrated in low and middle income countries, especially India and China. Low and Middle Income Countries (LMIs), as de ined by The World Bank, are disproportionally affected by DR due to the rising prevalence of obesity, sedentary lifestyles, and lack of DR screening and treatment as a result of poor healthcare infrastructures.

Keywords: Diabetic retinopathy; Retinal blood vessels; photocoagulation; Anti-vascular endothelial growth factor

Introduction

DR screening is recommended to be performed every one to two years, however, due to limited accessibility and availability of screening programs these general recommendations are rarely adhered to in LMI countries [1-5]. Accordingly, the World Health Organization (WHO) has published a guide to improving DR screening programs suggesting the incorporation of trained non-ophthalmologists in DR screening, such as technicians, nurses, and optometrists [6]. This tactic aims to increase the availability of screening and decrease the burden on an already stressed healthcare system. In accordance with the WHO, the Malaysian Ministry of Health published the statement: "The use of non-ophthalmologists to take retinal photographs for assessment by well-trained graders, may be a cost-effective method of screening for diabetic retinopathy[7-8]. Training a non-ophthalmologist to use a retinal camera effectively may be easier than training them to use an ophthalmoscope effectively to recognize signs of diabetic retinopathy" [9].

Therefore, the objective of this review is to evaluate the accuracy and effectiveness of DR screening using digital retinal imaging by non-ophthalmologists to determine whether this is a potential solution to the screening issues in LMI countries.

Literature Review

This review aims to summarize the published literature on the effectiveness of task-shifting interventions in the detection of diabetic retinopathy by non-ophthalmologists in low- and middle-income countries [10].

Methods

Eligibility criteria and study context

We included studies evaluating the accuracy and effectiveness of DR screening and grading by non-ophthalmologist. Digital imaging and tele-screening based programs were considered for this review. Studies using non-digital imaging methods were excluded.

Search and study selection

A PubMed search was performed to identify studies evaluating task-shifting interventions for the detection of diabetic retinopathy using the following keywords: diabetic retinopathy screening (detection, severity, diagnostic accuracy) and individual low- and middle-income countries. Only abstracts and articles in the English language were included. Eight studies met the inclusion criteria for this review (see Table 1).

Table 1: Characteristics and results of the 8 studies that meet the criteria for inclusion.

Reference	Country	Screening method	Training duration	Findings*
Verma et al., 2003	India	Direct ophthalmoscopy by GP and optometrist	25 hours	Specificity: 84-91% Sensitivity: 77-96%
Ramasamy et al., 2021	India	Single-field fundus photography by hospital staff, graded by optometrists	7 months	Specificity: 78-91% Sensitivity: 72-94%
Rosses et al., 2017	Brazil	Two-field fundus photography by FPs	15 hours	Sensitivity: 83% Specificity: 92%
Cunha et al., 2018	Brazil	Two-field fundus photography by medical students, graded by FPs	3 months	Agreement between FPs and RS (kappa): 0.56–0.73
Bhargava et al., 2012	Singapore	Single-field fundus photography by nurses, graded by FPs and NPGs	2 hours (FPs)	Sensitivity: 69.8 % (NPGs), 44.7% (FPs)
			1 year (NPGs)	Specificity: 94.4% (NPGs), 92.4% (FPs)
Suansilpong & Rawdaree, 2008	Thailand	Single-field fundus photography by nurse practitioner, graded by endocrinologist	Unknown	Sensitivity: 65.6% Specificity: 84.9%
Safi et al., 2019	Iran	Three-field fundus photography by hospital staff, graded by GPs	15 days	Sensitivity: 82.8% Specificity: 86.2%
Romero et al., 2010	Spain	Two-field fundus photography by technician, graded by GPs	Unknown	Sensitivity: 95.2% Specificity: 98.6%

Results

Large-scale pilot studies performed in various countries evaluating the use of non-ophthalmologists for DR screening using digital retinal imaging have yielded promising results. In India, a seven-month program utilizing optometrists to performed DR screening with fundus photography achieved an overall sensitivity and specificity of 88% and 90%, respectively [11]. In a smaller study from India, general physicians and optometrists underwent 25 hours of training on evaluating and scoring sample fundus images from patients with varying degrees of retinopathies. They subsequently performed direct evaluations of diabetic patients and these were compared to the evaluations performed by an ophthalmologist, their diagnoses matched in 92% of cases. Individually, the general physician misdiagnosed 2.9% of DR cases as compared to 14.5% by the optometrist [12].

In Brazil, one study enrolled Family Physicians (FP), Retinal Specialists (RS), and General Ophthalmologists (GO) to a 6 hour a week training program on retinal image analysis for a total duration of 3 months. The resulting level of agreement of FP and GO compared to the RS was moderate, although it was lower for FP than GO [13]. In a similar study from Brazil, FP underwent 15 hours of training and then had their examinations compared to RS. The reported sensitivity was 83% and the specificity was 92%. Importantly, almost 60% of patients avoided an unnecessary referral to an ophthalmologist [14].

In Singapore, a study looked at DR screenings performed in primary care clinics where the images were scored by non-

physician graders and FP. Unexpectedly, the non-physicians had a far higher rate of agreement with RS (k=0.66) than did the FP (k=0.4). However, the overall sensitivity was rather low (70% for non-physicians and 45% for FP) while specificity reached acceptable levels (94% for non-physicians and 92% for family physicians) [15].

In Thailand, different professionals, such as endocrinologists and nurse practitioners, were trained to perform and evaluate digital retinal images. Endocrinologists in this study allowed patients to obtain DR screening during regular visits for their diabetes management. However, the sensitivity and specificity was only 65% and 85%, respectively. Moreover, the agreement between digital screening and direct ophthalmoscopy by an ophthalmologist was low to moderate (kappa=0.48) [16].

In Iran, a telemedicine approach with general partitioner graders inspired by similar programs in France and the UK was tested in a community setting over four months. The sensitivity and specificity rates were 83% and 86%, respectively. In addition, at least 50% of diabetic patients attended these examinations, which was considered a positive performance indicator [17].

In Spain, a large proportion of DR screening is performed using digital retinal imaging which is subsequently evaluated by general practitioners [18]. The reported sensitivity and specificity of this method was reported to be 95% and 98%, respectively [18]. Moreover, when compared in a subsequent prospective study, the diagnoses by general practitioners were almost equivalent when compared to ophthalmologists [19].

Discussion

When evaluating a screening program one must consider both the disease and the actual screening test. A disease with irreversible consequences that can be prevented if detected early is an important criteria when deciding if screening programs are appropriate. In regards to DR, when diagnosed early it can be effectively treated and the irreversible loss of vision can be prevented. In addition, the prevalence of DR is expected to increase to approximately 200 million by 2030, making it a significant threat to many diabetics and a significant burden on the medical community [1]. The success of screening programs in wealthy nations further confirms the importance of developing screening programs for DR. However, in LMI countries where there are shortages of experienced professionals this can be challenging. Therefore, by implementing screening programs in community or primary care settings one can greatly reduce the pressure on ophthalmologists and improve access.

For patients, such programs can have beneficial effects by avoiding long waiting lists or having to commute over long distances to the nearest ophthalmologist, which are both factors that can negatively influence their willingness to get screened. For instance, one study found the availability of telemedicine for screening increased the number of patients who attended examinations [20]. Accordingly, more accessible screening may increase attendance and improve patient outcomes, since there would be shorter delays to treatment and diagnosis.

There is no question that DR screening programs are needed but is the task-shifting approach utilizing digital retinal imaging a reliable, appropriate screening test? When answering this question one must weigh multiple factors such as adequate sensitivity and specificity, cost, ease of administration, safety, and acceptance by patients and practitioners.

When considering a DR screening test, the minimally acceptable level of sensitivity and specificity has been determined to be 80% and 95%, respectively [21]. Our review of the available literature confirms that these levels of sensitivity and specificity can be achieved but multiple factors affecting these screening characteristics become apparent.

Firstly, a wide range in sensitivity and specificity exists even when ophthalmologists are used in the evaluation and grading of the images. For example, one study reported a sensitivity and specificity as low as 53% and 89%, respectively, for ophthalmologists using a one-field 45° image [22].

Secondly, only around half of the images taken by the trained technicians were found to be of good quality. Accordingly, the lower sensitivity and specificity rates may be related to the quality of the images or skills of the technician rather than as a true weakness of digital retinal imaging. The variability in the number of fields imaged and the number of images taken can account for the lower sensitivity and specificity, as well. Although the gold standard for DR screening is seven-field stereoscopic fundus retinography, two-field imaging seems to be the most common method used in DR screening due to its practicality [23]. Accordingly, the acquisition of high-quality images, especially when two-field imaging is used, is critical for the success of a DR screening program and should be regarded as a performance indicator.

Thirdly, the variability in training modalities and backgrounds of those taking and grading the images hinders an accurate comparative analysis between the different studies. The type of training, length of training, and whether re-training is included are all factors that can influence the success of a DR screening program. For instance, when family medicine physicians received only one hour of training the sensitivity and specificity were 33% and 77%, respectively [24]. The studies with far higher sensitivity and specificity rates involved longer initial training, in addition to re-trainings in some instances [11,14,17]. One promising option to address training shortfalls is the use of eye exam simulators as it appears to be effective in improving one's ability to recognize normal features of the retina [25].

In regards to cost, a single retinal imaging device is sufficient for 200,000 people and would require an initial investment of around $30,000 [26]. One study estimated that screening with digital retinal imaging could be up to 44% cheaper than regular examinations by an ophthalmologist [27]. In addition, the higher number of patients benefiting from the early screening and prevention of blindness would dramatically shift the cost savings towards task-shifting DR screening.

An important obstacle that is commonly overlooked, yet must be addressed, is the willingness of professionals to undergo training and administer DR screening. A study that was carried out in Australia showed that 41% of general practitioners felt a

moderate to strong desire to be involved in a community DR screening program [28]. A pilot study from Australia that used two general practitioners to screen patients for DR was overall a positive experience, and the doctors mentioned they would be "happy if they could save their patients without retinopathy from having to attend ophthalmology outpatients or a private ophthalmologist for screening" [29]. Importantly, only a few general practitioners in each region may be sufficient for a screening program significantly enhancing the access of DR screening to patients in rural communities in LMI countries. For example, in a three-year study conducted in Australia, DR screening was implemented at five general practice sites in rural and urban locations where screening rates reached 100%, which was significantly higher than at control sites (22-53%) [30]. With only a select group of professionals, the number of patients obtaining adequate care will significantly increase and thus treat one of the most common and often preventable causes of blindness throughout the world.

The use of a task-shifting DR screening program utilizing digital retinal imaging in LMI countries can lower the healthcare burden of DR and improve access to millions of people. This review points out many factors that can impact a screening program, and factors to focus on to make programs more successful. By emphasizing training programs, developing criteria for image acquisition, and embracing advances in technology these programs can improve and become an asset in LMI countries. In addition, reviewing attempted screening programs can help those making the decisions in regards to screening and enhance their efforts in preventing blindness. It is our belief that the strengths of this method, particularly in LMI countries, outweigh the limitations and it is essential for more countries to strive to improve their DR screening methods.

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