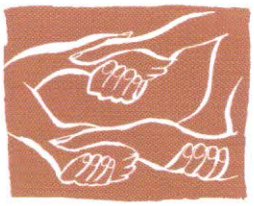


EXCHANGE

# How technology has brought care and reduced cost in management of Diabetic Retinopathy?


**Rajiv Raman**
MS, DNB, Medical Director,
ChoithramNetralaya,
SriramTalawali, Indore
E mail: **rajivpgraman@gmail.com**

**AlokSen**
(MS)
**Institutional Affiliation:**
ChoithramNetralaya, Indore,
Shri Sadguru Trust Hospital, Chitrakoot

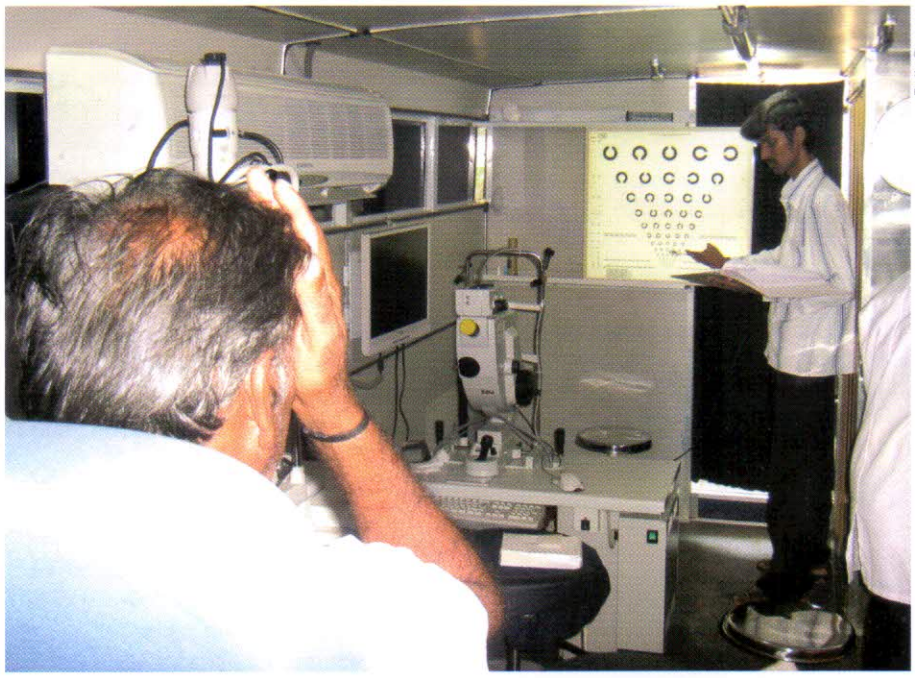

The cardinal principles of screening of human diseases was defined by World health organization in 1968 and diabetic retinopathy fulfills all of them. Visual impairment due to diabetic retinopathy is a significant health problem; however, it has a recognizable pre-symptomatic stage.The Diabetes Control and Complication Trial and the United Kingdom Prospective Diabetes Study established that intensive diabetes management to obtain near-euglycemic control can prevent and delay the progression of diabetic retinopathy in patients with diabetes. Timely laser photocoagulation therapy can also prevent loss of vision in a large proportion of patients with sight-threatening diabetic retinopathy.[5]Screening for diabetic retinopathy saves vision at a relatively low cost, which has been showed in various studies. American Academy of Ophthalmology recommends annual dilated eye examinations beginning at the time of diagnosis for patients with Type II diabetes. For those with Type I diabetes, the recommendation is retinal examination 3–5 years after diagnosis, with annual exams thereafter. The barriers for successful screening are numerous and include the high cost of care, poor awareness levels, socio-economic factors and poor geographical access to care.[1] Current screening programs for diabetic retinopathy are either Ophthalmologist –based (with actual presence of ophthalmologist at the site of screening) or Ophthalmologist-led (absence of actual presence of Ophthalmologist at site of screening). Table 1 summarizes the differences between the two models. Telemedicine for retinopathy screening is an ophthalmologist-led screening model, which may be a logical potential alternative for patients who have been noncompliant with the traditional face-to-face examination by an ophthalmologist. Ophthalmology is uniquely suited for telemedicine as it is a highly visual and image intensive specialty and digital imagery is easily transmitted by electronic means. Remote assessment for diabetic retinopathy provides an ideal model for telehealth screening initiatives and, in fact, has become one of the most common uses for telemedicine in ophthalmology.

***Table 1: Differences between the Ophthalmologist led and Ophthalmologist based model for screening of diabetic retinopathy***

| | Ophthalmologist based model (Telescreening) | Ophthalmologist led model |
|---|---|---|
| Brief description | Para-medical staff acquire data/images, which are transferred for interpretation by ophthalmologist | Screening is done by ophthalmologist |
| Feasibility | Yes with less human resource | Needs trained expert |
| Maintenance | Required | Not required |
| Capital expenditure | More | Less |
| Revenue expenditure | Less | More |
| Interobserver bias | Less | More |
| Digital photo archieval | Yes | No |
| Acceptance by community | Yes | Yes |

## STEPS OF TELESCREENING

In brief, patient enrollment is performed after defining the data to be collected. Since ocular telescreening services for DR satisfy the criteria of low risk telehealth-procedures and are within commonly accepted standards of practice, signatureconsent may not be required. However, practitioners should provide patients information about the telescreening program they would reasonably want to know, including differences between care delivered using ocular telehealth and face-to-face, and description of what is to be done at the patient's site and the remote site. The data collected includes fundus images, along with patient examination (identification, demographic and medical information) and some morphological information that is used to make a clinical decision. Fundus images of the both eyes of the patient are acquired under a fixed, predetermined imaging protocol. These images are taken by a trained technician using a fundus camera. Due to various factors, the acquired images can be below the grading standard, thus not providing any meaningful information for examination by the reader. This can be addressed by employing an automatic image quality assessment module. An automatic image quality assessment module will ensure that the images transmitted for diagnosis conform to prescribed gradable standards. During the quality assurance, the gradable images are selected for compression, whereas the poor quality images can be reimaged by the technician.The patient



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data comprising the clinical data and the fundus images are compressed to make them suitable for low-bandwidth network connectivity.Patient data are transmitted to the servers via the Internet or satellite. At the reading centre, the images are graded forretinal lesions and determining levels of DR; referred to 'next level' graders if necessary; and retinopathy structured report is generated. Only qualified readers should performretinal image grading and interpretation. If a reader is not a licensed eye care provider, specific training isrequired. A licensed, qualified eye care provider with expertise in DR and familiarity with telescreening-program technology should supervise the readers. An adjudicating reader (an ophthalmologist with special qualifications in DR by training or experience) may resolve controversial interpretation.Image processing algorithms should undergo rigorous clinical validation.A report comprising the findings, the results and the medical advice given by the expert is made available to the patient and the care team at the remote site through their interface.

## EVALUATING TELESCREENING PROGRAMS

### Efficacy

Telescreening has been shown to detect-diabetic retinopathy and macular edema with a reasonably high sensitivity and specificity.[2,3] Whited et al.[4] reviewed the available literature and noted that the sensitivity and specificity values ranged from 50% to 93% for detection of DR. Similar high efficacy was reported on comparing teleophthalmologyto both gold standards for macular edema detection, slit-lamp biomicroscopy and stereoscopic photography.[4]

### Patient satisfaction

Since telescreening involves remote care without in-person evaluation by the doctor, there are concerns regarding lack of satisfaction among the patients. Studies have shown that it has equal, if not better, satisfaction than in-person evaluation by doctor.[5,6]

Paul et al assessed patient satisfaction levels and factors influencing it during teleophthalmology consultation in India using a patient satisfaction questionnaire.6 34% of the patients felt that telescreening is more satisfying than in-person evaluation, and 60% felt that both models are equally satisfying. It was also noted that patients who asked questions during the screening were 2.18 times more likely to be satisfied with teleophthalmology than those who did not.

### Cost effectiveness

Bjorviget al.[7], in an economic analysis, concluded that telemedicine was a less costlyoption for screening in places with higher patient workloads.Telemedicine was also proved to be cost-effective in the prison populations by Aoki et al.[8], where it may have special utility due to costs and safety issues associated with transporting the prisoners.

Gomez-Ulla et al. did a comparative cost analysis of diabetic retinopathy telescreening versus standard ophthalmoscopy, from both Public Healthcare System (PHS) and patient perspectives. The authors concluded that from the PHS perspective, direct fundus examination is less costly than telescreening due to higher capital costs required by the equipment needed to obtain the digital image. However, from a global perspective, the digital image alternative is more convenient because the travel cost and loss of income of the patient are lower.

Recently, Jones et al. reviewed the evidence available on cost-effectiveness. They concluded that telemedicine is cost-effective for retinopathy screening in remote and rural communities and other groups with difficulties and the cost-effectiveness increases with an increase in patient workload.

## ADVANCES IN TELESCREENING

Recent advances resulting in better and faster telecommunication, miniaturization of diagnostic equipments including digital cameras, and automation of retinal image analysis, offer good opportunity to drive telescreening services in further remote areas.

The shortage of manpower imposes a limitation on the screening capability of tele- programs serving the continuously increasing diabetic population. Therefore, an automated image analysis system able to detect diabetic retinopathy is a vital necessity, especially in the coming years.

Over the last decade, several attempts have been made to either semi-automate or fully-automate retinal image analysis. Tools have been developed for analyzing and enhancing the image quality (correction of illumination, increasing image contrast, histogram equalization, vessel segmentation, edge sharpening, image deconvolution);and for providing automated identification of retinal pathology lesions (neural networks, region growing, morphological analysis and classification algorithms).[9] Automated identification of retinal lesions can grade the absence or presence of diabetic retinopathy based on the detection of microaneurysms and dot hemorrhages (dark lesions),[10]or can detect referable retinopathy based on the detection of exudates (bright lesions) and blot hemorrhages (dark lesions).[10]