Perspective

A scalable, self-sustaining model for screening and treatment of diabetic retinopathy in rural Karnataka

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The Indian health infrastructure is struggling to handle the burgeoning number of people with diabetes. Managing the complications of diabetes in an organized manner through the government health programs is still a distant reality. Here, we describe a program aimed at addressing the problem of diabetic retinopathy in rural areas of Tumkur district in Karnataka. By amalgamating telescreening and our own novel distributive care model, we were able to screen 85% of the registered diabetics in the Government noncommunicable disease clinics and treat 95% of those needing laser therapy. We also describe the importance of using electronic medical records in public health programs which not only increase the efficiency in screening for disease but help in increasing uptake of treatment by tracking defaulters.

Key words: Diabetic retinopathy, mobile eye treatment unit, telescreening

The burden of diabetes mellitus (DM) has spread across the urban and rural population in India. Screening them all for diabetic retinopathy (DR) is a challenge. The challenge is further compounded with the poor linkages between the diabetologists/physicians and the ophthalmologists in our health care system.[1] Management of DR entails repeated ophthalmic examinations and treatment sessions requiring multiple visits to treatment centers.

Studies have reported high rates of diabetes among the rural poor who have limited access to health care facilities.[2,3] Apart from the direct cost of care, the overall cost of treatment to patients includes the cost of transportation, incidental expenses, and loss of income due to absence from work for patient and/or attendant. A program aimed at managing DR should address three main aspects, namely, (1) screening the people with diabetes for DR, (2) treating those identified with sight-threatening DR (STDR), and (3) repeated screening of those without retinopathy and follow-up of those treated.

However, there are at least three specific challenges to deliver this care in rural areas. These include: a mismatch between the number of care receivers and care providers as most specialists are concentrated in bigger towns and cities, lack of infrastructure and technology to diagnose and treat DR, and inability to attract the private sector since the recovery of investment on expensive equipment is challenging. The use of telescreening for DR by trained screeners and remote grading of images has been well established by different groups in India.[4-6] However, patients identified with STDR still need to be referred to base hospitals for treatment as investigation and treatment facilities are not always available locally.

To address the challenge of treating these patients locally, we had previously described a distributive care model, *Nayana*.[7] The Nayana is a mobile van with advanced eye treatment unit (AETU) which houses all equipment required for diagnosis and treatment of DR on a mobile platform. The equipment includes optical coherence tomogram (OCT), digital imaging with fundus fluorescein angiography (FFA), B scan, visual field analyzer, Yag laser, and applanation tonometer.[8] The mobile treatment van is leased to different rural centers for one day in a month where patients pooled through the month can be treated locally.

The primary objective of the project was to establish a screening and treatment program for DR in the five talukas

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(a group of villages in a district clubbed for administrative purpose) of Tumkur district, Karnataka. Through this program, we further aimed to train ophthalmologists in the diagnosis and treatment of DR. The additional goal was to increase the awareness on DR by sensitization of diabetologists, accredited social health activists (ASHA), and auxiliary nurse midwives (ANM) and by patient education.

Methods

A tripartite agreement was signed between the implementing partner (Vittala International Institute of Ophthalmology, VIIO, Bangalore, Public Health Foundation of India (PHFI), Hyderabad, and the Government of Karnataka. The program was implemented in the district hospital in Tumkur and the four taluka hospitals of Gubbi, Madhugiri, Koratagere, and Pavagada [Fig. 1].

Screening for diabetic retinopathy

Screening for DR was implemented in the noncommunicable disease (NCD) clinics of the taluka and district hospitals, where people registered with diabetes visit once a month to collect their monthly anti-diabetes medicines. The screening was scheduled for one day in a week in each of the hospitals. Screening was by telescreening through fundus photography by a technician led team of two people from the base hospital. Once trained, the technicians from the government hospital did the screening. The team was equipped with a portable fundus camera (Remedio, Bangalore, India), portable slit lamp, and applanation tonometer. Electronic medical records (EMR) (Graphene Services Pte Ltd, Singapore) were used for documentation, using laptops with Internet connectivity. Every person with diabetes attending the NCD clinic was registered on the EMR. Their demographic data, contact information, details of systemic condition, and diabetes-related details were recorded. The fundus photos in a five-field per eye pattern were captured and uploaded to the central grading center after obtaining an informed consent and pupil dilatation. At the grading center located in the base hospital, patients with DR needing treatment were identified and scheduled for treatment by trained optometrists/para medical ophthalmic assistants (graders). This was communicated back to the patient through a telephone call. Treatment was offered to

Figure 1: Map of India and Karnataka highlighting Tumkur district

eligible patients at the screening locations. Our Advanced Eye Treatment Unit on the Nayana visited each screening location once a month to treat the patients identified with sight-threatening DR in that location. The program strategy and flow of patients is shown in Fig. 2.

Use of robust EMR to screen, treat, and follow up patients

The EMR-based data was in digital format and was cloud-based. The software generated a monthly schedule of patients for investigation or treatment based on the recommendations entered into the central grading system by the graders. The software would also escalate "no-shows" for counseling and for scheduling further appointments. The counseling and appointment scheduling was done by the project manager through telephone calls. The graded images were also a good source of offline training for local ophthalmologists.

Training of technicians, graders, and ophthalmologists

Technicians in the NCD clinics were trained in the EMR system, capturing fundus photos, and uploading them onto a dedicated webspace. The optometrists/para medical ophthalmic assistants (graders) were trained to grade the images into normal, abnormal, or ungradable, and to quantify DR if present. Ophthalmologists in the district and taluka hospitals were trained in indirect ophthalmoscopy, slit-lamp biomicroscopy, performing and interpreting FFA and OCT. They were also trained in grading fundus images, performing laser therapy, and intravitreal injections. The training included both didactic lectures and hands-on training. Initially, a vitreoretinal surgeon from the base hospital traveled with the AETU to treat the patients and train the district ophthalmologists. Once trained, the government technicians screened the patients and the government ophthalmologists treated patients requiring laser treatment independently on the AETU, with referral to the base hospital of those requiring intravitreal injections or vitreoretinal surgery. The AETU was available to them in their hospital for one day in the month. Patients with ungradable images were scheduled appointments on the AETU for the ophthalmologist to identify the cause of ungradability by indirect ophthalmoscopy and slit-lamp examination.

Increasing awareness of diabetic retinopathy

ASHAs and ANMs were trained to increase general awareness about diabetes and its treatment and complications and the need for behavior change, including dietary modification in the local population.

Results

Five screening and treatment centers were established in the NCD clinics of Tumkur district hospital and the taluka hospitals of Gubbi, Koratagere, Madugiri, and Pavagada. The total population (2011 census) served was 1.53 million.[9] Details of the program and outcomes are shown in Tables 1 and 2.

Overall 7331 people with diabetes were registered in the NCD clinics, of whom 6259 (85%) were screened and 1944 eyes had ungradable images (15.52%). STDR was detected in 18.6% (*n* = 1164) people screened. Laser treatment was advised for 673 people, anti-vascular endothelial growth factor (anti-VEGF) injection for 546 people, and advanced vitreoretinal surgery for 355 people. In the final analysis, 639 (94.5% of advised) people received laser therapy, 139 (25% of advised) people received anti-VEGF injections, and
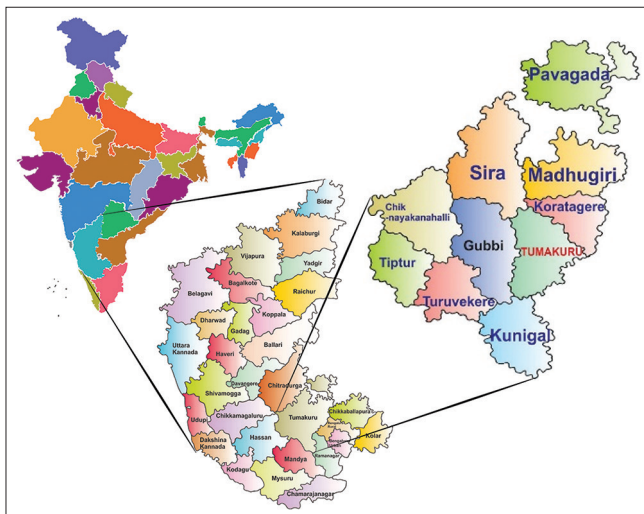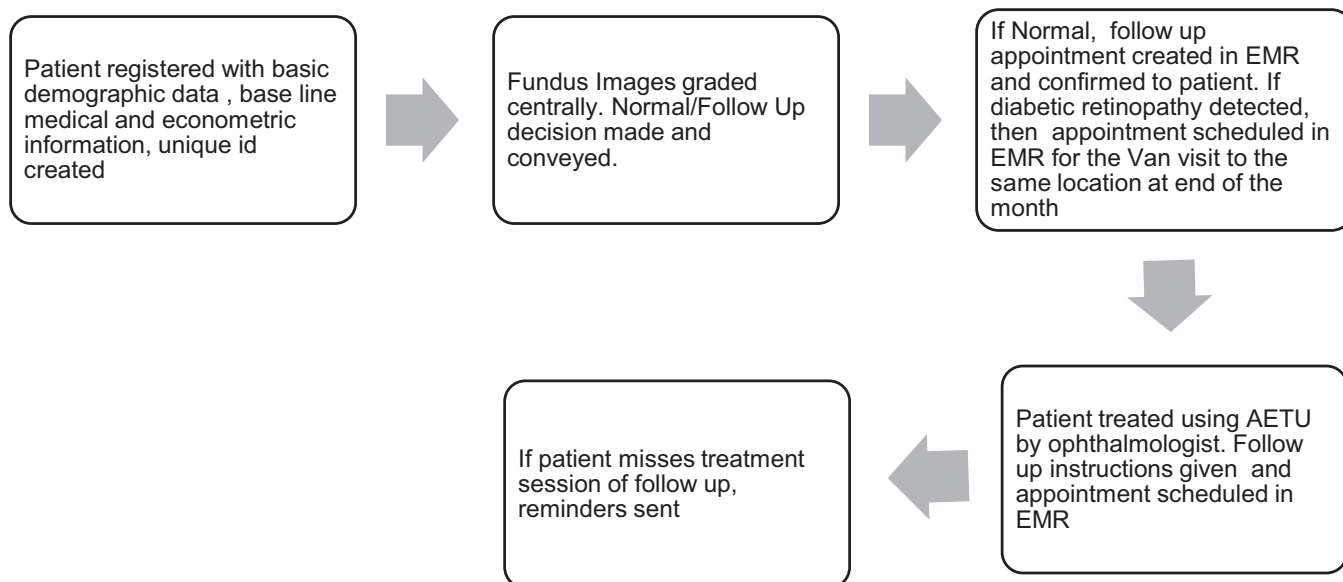
Figure 2: Illustrative flow of patients at screening and follow-up

Table 1: Summary of statistics of program

Indicator	Male	Female	n	%
Total number of diabetics registered in the NCDs	3865	3466	7331	
Total number of diabetics screened	3637	2622	6259	85%
Gradable images			10574/12518 eyes	84.5%
Findings in those with gradable images:				
Non proliferative diabetic retinopathy (NPDR)	157	86	243	21%
Sight threatening diabetic retinopathy (STDR)	824	340	1164	27%
Laser treatment	380	259	639	55%
Intravitreal injection	101	37	138	12%
Vitreoretinal surgery	65	29	94	8%
Total with STDR treated			871	75%
Number of patients who completed 1-year follow-up	708	243	951	15%

Table 2: Number of medical and paramedical personnel trained

Medical and Paramedical staff trained	Total
Number of doctors trained in diagnosis and treatment of DR	10
Number of screeners trained in retinal imaging	14
Number of diabetologists sensitized	13
Number of ASHAs sensitized	1186

94 (26.4%) received surgery. The overall uptake of treatment was 75%.

Discussion

Health programs addressing DR are more effective when screening occurs at the physician's clinics. Travelling to cities for treatment is a major barrier for rural patients. Offering treatment locally, nearer to the place of residence of patients, increases the compliance to treatment. Our results indicate 94.5% compliance with laser therapy when offered at the taluka hospitals. The compliance was much lower (25% and 26.4% for intravitreal injections and vitreoretinal surgery, respectively) when the patients needed to travel to Bangalore for treatment. In a country like India, the cost of treatment also plays a role in compliance. Anti-VEGF injections are not covered by health insurance schemes and are too expensive for many families. Hence, offering laser treatment for diabetic maculopathy in patients who cannot afford anti-VEGF injections is a viable option in the Indian scenario.

It is matter of concern that over a quarter of those screened and with gradable images had STDR, which may reflect the earlier onset of the diabetes epidemic in the State coupled

with poor control of risk factors. In addition, 8% required vitreoretinal surgery. Half of the patients with STDR were recommended laser therapy, but there is a lack of eye care facilities that able to provide laser treatment, as shown in a recent study in which nearly half the eye care facilities need training in retina care.[10] Through this program, we were able to enhance the skill of technicians and ophthalmologists in the government sector who are now screening and treating the patients independently. We are now training doctors in adjacent districts in an effort to scale up the model to other districts.

The AETU which was employed in this program has been on the road since 2006, covering over 1.2 million km, treated over 30,000 patients without transport-related damage to the equipment. Hence, it is a viable and sustainable option to share the equipment across hospitals on a mobile platform. It is also easily scalable as one set of equipment can serve close to 20 hospitals.

Conclusion

A major take away from this program is that it demonstrates a decentralized screening and treatment program at the taluka hospital benefits the care receivers. The use of EMR is invaluable in increasing the uptake of treatment by effectively tracking and contacting the defaulters. The program was also aligned with the national program for control of diabetes, hypertension, stroke, cardiovascular diseases, and cancer.

Conflicts of interest
There are no conflicts of interest.

References

1. Murthy GV, Gilbert CE, Shukla R, Vashist P, Shamanna BR. Situational analysis of services for diabetes and diabetic retinopathy and evaluation of programs for the detection and treatment of diabetic retinopathy in India: Methods for the India 11-city 9-state study. Indian J Endocrinol Metabol 2016;20(Suppl 1):S19.

2. Chow CK, Raju PK, Raju R, Reddy KS, Cardona M, Celermajer DS, *et al*. The prevalence and management of diabetes in rural India. Diabetes Care 2006;29:1717-8.

3. Vijayakumar G, Arun R, Kutty VR. High prevalence of type 2 diabetes mellitus and other metabolic disorders in rural central Kerala. JAPI 2009;57:563-7.

4. Raman R, Mahajan S, Padmaja RK, Agarwal S, Gnanamoorthy P, Paul PG. Tele-health program for diabetic retinopathy in Rural South India: A pilot study. E-Health Int 2005;2:13-8.

5. Bai VT, Murali V, Kim R, Srivatsa SK. Teleophthalmology based rural eye care in India. Telemed J e-Health 2007;13:313-21.

6. Prathiba V, Rema M. Teleophthalmology: A model for eyecare delivery in rural and underserved areas of India. Int J Family Med 2011;2011:683267.

7. Murthy KR, Murthy PR, Kapur A, Owens DR. Mobile diabetes eye care: Experience in developing countries. Diabetes Res Clin Pract 2012;97:343-9.

8. Murthy KR, Murthy PR, Rao SK, Murthy GJ, Kapur A, Lefebvre P. A novel model to deliver advanced eye care for people with diabetes living in resource-poor settings: Results of care provided to date. Diabetes Care 2012;35:e41.

9. Available from: http://www.census2011.co.in/census/district /267-tumkur.html. [Last accessed on 2019 Oct 02].

10. Gilbert CE, Babu RG, Gudlavalleti ASV, Anchala R, Shukla R, Ballabh PH, *et al*. 2016. Eye care infrastructure and human resources for managing diabetic retinopathy in India: The India 11-City 9-State Study. Indian J Endocrinol Metabol 2016;20(Suppl 1):S3.