WORLD VIEW

Analysis of a comprehensive diabetic retinopathy screening model for rural and urban diabetics in developing countries

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Aim: To present an analysis of a screening model for diabetic retinopathy and compare the results of screening between rural and urban populations.

Methods: Between June 2003 and September 2004, 51 diabetic retinopathy screening camps (rural, 25; urban, 26) were conducted in three southern districts of India. The target population, aged 30 years and above, underwent comprehensive eye evaluation and those with referable diabetic retinopathy (proliferative diabetic retinopathy, severe non-proliferative diabetic retinopathy, severe diabetic macular oedema, or a combination of these) were referred to the base hospital for further treatment.

Results: Among 7716 diabetic subjects, the age and sex adjusted prevalence of diabetic retinopathy was 18% in the rural areas and 17% in the urban areas. The prevalence of referable retinopathy was 6.8% in rural areas and 4.6% in urban areas (p<0.001). Around 63% of individuals in rural areas and 75% in urban areas had never previously had their eyes examined for diabetic retinopathy. Multivariate analysis revealed the following risk factors for diabetic retinopathy: age more than 50 years, known diabetes, prolonged duration of diabetes, and eyes with moderate or severe visual impairment (p<0.0001).

Conclusions: The study describes a comprehensive diabetic retinopathy screening model which can identify sight threatening retinopathy and provide necessary treatment for rural and urban populations.

D iabetes and diabetes related blindness are reaching alarming proportions in developing countries.[1] Despite improved understanding of the importance of early diagnosis and prompt treatment of diabetic retinopathy, it is estimated that half the diabetic population does not receive annual dilated eye examinations.[2] Treatment of end stage diabetic retinopathy does not provide satisfactory results and is frustrating for both the patient and the ophthalmologist.

Several studies have reported the cost-effectiveness of screening for diabetic retinopathy.[3–6] They have established that screening saves vision at a relatively low cost, many times less than the disability payments for people going blind in the absence of a screening programme.

It is vital to know the magnitude of diabetes related blindness in rural and urban areas. Studies focusing on differences between rural and urban diabetes related blindness will help in formulating appropriate preventive strategies. There have not been many studies reporting the differences between rural and urban populations regarding various levels of diabetic retinopathy at the time of initial screening.

This paper describes the analysis of a comprehensive diabetic retinopathy screening model used in screening camps conducted in rural and urban areas in southern districts of India. Differences in the age and sex adjusted prevalence rates of diabetic retinopathy between rural and urban populations and factors influencing them are also described.

METHODS

Fifty one diabetic retinopathy screening camps were held in two rural districts (Kanchipuram and Vellore) and in Chennai (Urban) in Tamil Nadu. The screening camp locations were selected on the basis of the accessibility of the population by social workers. The rural and urban locations were based on the Government of India Census 2001 definition.[7] The institutional review board approved the study design.

The methodology of the diabetic retinopathy screening model has been described in detail elsewhere.[8] To maximise the effectiveness of the diabetic retinopathy screening camp, attempts were made to conduct such camps in targeted areas. In each camp, the general population above the age of 30 years was screened for diabetes. Using a glucometer (Accutrend Alfa), a finger prick capillary blood sample was collected to estimate random blood glucose (by the glucose oxidase method). Patients were labelled as provisional diabetics if the random blood glucose levels were above or equal to 11.1 mmol/l (200 mg/dl).[9] All provisional diabetics and persons with borderline blood glucose levels (7.8–11.0 mmol/l (140–199 mg/dl)) were referred to diabetologists for further management. A patient was considered to be a known diabetic if they had a referral letter from the diabetologist or were on antidiabetic drug treatment.

In addition to the diabetes screening camps, other efforts were made to increase the effectiveness of the model by including referrals from diabetologists and local government hospitals, self reported diabetics (media propaganda or awareness efforts), and referrals from local voluntary groups. Table 1 shows the yield of various recruitment strategies.

Diabetic retinopathy screening model

In the diabetic retinopathy screening camp, to achieve a comprehensive evaluation all patients passed along several counters. At the registration counter, a unique 11 digit identification number was allocated to each patient. The number comprised a box denoting diabetic status, a box showing camp location, three boxes giving a pin code, and a box indicating the individual serial number. Blood pressure was measured by sphygmomanometry, with the patient in the sitting position. LogMAR charts were used to assess visual acuity.

The anterior segment was examined using a hand held slit lamp (Heines HSL 100 CE). Grading of peripheral anterior

Table 1 Recruitment strategy for diabetic retinopathy screening

Rural (n = 4517)	Urban (n = 3199)
Referred from	Referred from
● Diabetes screening camps: 3063 (68%)	● Diabetes screening camps: 143 (4%)
● General hospital: 432 (10%)	● General hospital: 2387 (74%)
● Physicians: 466 (10%)	● Physicians: 210 (8%)
● Self help groups: 556 (12%)	● Self help groups: 459 (14%)

chamber depth was done according to the Van Herick system. Patients with narrow angle configuration were referred to the glaucoma service for gonioscopy and prophylactic treatment at the base hospital. Intraocular pressure was measured in both eyes using a Schiotz indentation tonometer.

Height and weight were measured. A medical and ocular history was taken as the patients were waiting for full pupillary dilatation, in order to utilise the time optimally in the rural settings. Medical history included evaluating various risk factors for diabetic retinopathy, such as the duration of diabetes mellitus, physical activity status, alcohol intake, smoking habits, family income, family history of diabetes mellitus, neuropathy and nephropathy history (tingling, numbness, foot ulcers, amputated toe/foot), and diabetic treatment. The ocular history included details of first and last eye examinations, any visual complaints, and a history of laser or eye surgery.

A binocular indirect ophthalmoscope (Keeler Instruments, Pennsylvania, USA) and a +20 D lens (Nikon) were used to examine the fundus. All patients underwent fundal evaluation after pupillary dilatation. Diabetic retinopathy was clinically graded following the norms of the international clinical diabetic retinopathy and diabetic macular oedema severity scales.[10] Sight threatening diabetic retinopathy (referable diabetic retinopathy) was defined as severe non-proliferative diabetic retinopathy, proliferative diabetic retinopathy, or clinically significant macular oedema.[11] The availability of the HiMag attachment with the Keeler indirect ophthalmoscope allowed a view of the macular area at high magnification ($\times 5$). Fundus examination of all the patients was done by an experienced retinal specialist.

With the help of flip charts depicting awareness about diabetes and diabetic retinopathy, counselling was offered to all patients whether or not they had diabetic retinopathy. All patients visited a small exhibition on diabetic diet. Those with ocular problems other than diabetic retinopathy were counselled at a separate general inquiry counter.

Patients with sight threatening diabetic retinopathy (referable retinopathy) were re-examined at the base hospital for further tests such as fluorescein angiography and laser photocoagulation or vitreous surgery, if necessary. Those who did not report to the base hospital (non-respondents) were sent reminders and offered new appointments. All patients with sight threatening retinopathy were given counselling about the necessary follow up.

Statistical analysis

SPSS (version 9.0) was used for statistical analysis. Prevalence was expressed as percentages with 95% confidence intervals (CI). Tests of significance such as χ^2 tests, t tests, and z tests were applied appropriately. Univariate and multivariate logistic regression analyses were carried out to elucidate factors influencing the prevalence of diabetic retinopathy in rural, urban, and combined populations using various recruiting strategies for screening. Probability (p) values less than 0.05 were considered significant.

RESULTS

The mean (SD) age in the overall group was 55 (11.0) years (range 30 to 94): 55 (10.0) years (32 to 92) in the rural areas, and 54 (11.0) years (32 to 94) in the urban areas. Fifty one per cent were men in the overall group (48% in the rural areas and 60% in the urban areas). Most of the enrolled patients—nearly 75% from the urban population and 63% from the rural population—had not undergone fundus examination before.

The age and sex adjusted prevalence of diabetic retinopathy among all subjects was 17% (95% CI, 16.1 to 17.8): 18% in the rural areas (14.5 to 19.4) and 17% in the urban areas (15.7 to 18.3). No significant difference was observed with regard to the prevalence of diabetic retinopathy between patients in the rural and urban areas. Table 2 shows the diabetic retinopathy screening data.

Table 3 shows various types of diabetic retinopathy detected in the retinopathy screening camp. The non-referable diabetic retinopathy cases included those with mild and moderate non-proliferative diabetic retinopathy; the referable diabetic retinopathy cases included those with severe non-proliferative diabetic retinopathy, proliferative diabetic retinopathy, and clinically significant macular oedema.

Patients with referable diabetic retinopathy were re-examined at the base hospital for ancillary investigations and 432 patients underwent laser photocoagulation. Pan-retinal photocoagulation was undertaken in 115 patients and laser treatment for macular oedema in 317.

With regard to the correlation between referable diabetic retinopathy and visual acuity, only 8% in the overall group had

Table 2 Diabetic retinopathy screening data (self reported)

Characteristic	Rural data	Urban data	Pooled data
No of camps	25	26	51
Total No screened	n = 4517	n = 3199	n = 7716
Provisional diabetic	145/4517 (3.2%)	473/3199 (14.8%)	618/7716 (8%)
Known diabetic	4372/4517 (96.8%)	2726/3199 (85.2%)	7098/7716 (92%)
Type 1 diabetes*	68/4517 (1.5%)	14/3199 (0.4%)	82/7716 (1.06%)
Mean duration of diabetes (years)	7 (range 0 to 35)	4 (range 0 to 35)	6 (range 0 to 35)
Prevalence of diabetes	890/4517 (20%) (95% CI, 18.8 to 21.1)	475/3199 (15%) (95% CI, 13.7 to 16.2)	1365/7716 (18%) (95% CI, 17.1 to 18.8)
Provisional diabetes	10/145 (7%) (95% CI, 2.8 to 11.1)	25/473 (5%) (95% CI, 3.0 to 6.9)	35/618 (6%) (95% CI, 4.1 to 7.8)
Known diabetes	880/4372 (20%) (95% CI, 18.8 to 21.1)	450/2726 (16%) (95% CI, 14.5 to 17.5)	1330/7098 (19%) (95% CI, 18.0 to 19.9)

*Type 1 diabetics were defined as individuals with onset of diabetics before the age of 30 and who were on insulin treatment.[12]
CI, confidence interval.

Table 3 Severity of retinopathy in self reported diabetic subjects

Severity of retinopathy	Rural data	Urban data	Pooled data
Non-referable retinopathy	580/4517 (12.8%) (95% CI, 11.3 to 14.1)	327/3199 (10.2%) (95% CI, 8.6 to 11.6)	907/7716 (11.7%) (95% CI, 10.1 to 12.5)
Referable retinopathy	310/4517 (6.8%) (95% CI, 5.0 to 7.2)	148/3199 (4.6%) (95% CI, 3.4 to 5.7)	458/7716 (6%) (95% CI, 5.0 to 6.7)
Severe NPDR	20/310 (0.4%)	11/148 (0.3%)	31/458(0.4%)
PDR	76/310 (1.7%)	40/148 (1.3%)	116/458 (1.5%)
CSMO	214/310 (4.7%)	97/148 (3.0%)	311/458 (4.1%)

CI, confidence interval; CSME, clinically significant macular oedema; NPDR, non-proliferative diabetic retinopathy; PDR, proliferative diabetic retinopathy.

severe visual loss ($<20/200$) (6% in the rural areas and 11.5% in the urban areas). None of these patients had any concomitant ocular disease such as cataract or glaucoma accounting for decreased vision. In the overall group of referable retinopathy, 47% never had their fundus evaluated (45% in the rural group and 50% in the urban group).

Table 4 shows both univariate and multivariate logistic regression analysis of several risk factors associated with diabetic retinopathy in rural, urban, and combined populations. Both in univariate and multivariate logistic regression analysis, the odds of diabetic retinopathy increased with increasing age, with increasing duration of diabetes, in known diabetes compared with previously unknown diabetes, and in those with moderate to severe visual impairment compared with mild visual impairment. The odds of having diabetic retinopathy were lower in the urban population than in the rural population (adjusted odds ratio (OR) = 0.55 (95% CI, 0.46 to 0.67), $p<0.001$).

With regard to the association between recruitment strategy and diabetic retinopathy, the odds of diabetic retinopathy were greater in patients referred from diabetic screening camps than from Government hospitals in both the rural areas (adjusted OR = 5.65 (95% CI, 3.85 to 8.31), $p<0.001$) and the urban areas (adjusted OR = 4.01 (2.69 to 4.21), $p<0.001$).

The distribution of age and the duration of diabetes, and their correlation with the severity of diabetic retinopathy, are summarised in tables 5 and 6, respectively. The proportion of patients with both referable and non-referable diabetic retinopathy increased with increasing age and with longer duration of diabetes ($p<0.00001$).

DISCUSSION

Our diabetic retinopathy screening model has two objectives: screening the diabetic population for retinopathy, and educating them about diabetes and diabetic retinopathy. Awareness is an ongoing process and requires community involvement. The need for an awareness strategy is reflected by the fact that around two thirds of the rural population and three quarters of the urban population never had their eyes examined before these screening camps. Moss et al[13] reported similar trends in Wisconsin.

We need to create a diabetic network in the target areas involving physicians, diabetologists, government and private hospitals, and ophthalmologists. This network can provide an excellent yield of patients for targeted retinopathy screening, where diabetic individuals with certain high risk characteristics, as identified in this study, must be screened for diabetic retinopathy. These characteristics include age over 50 years,

Table 4 Risk factors for diabetic retinopathy in rural and urban populations

Variables	Odds ratio of risk of diabetic retinopathy (rural) (n = 4517)		Odds ratio of risk of diabetic retinopathy (urban) (n = 3199)		Odds ratio of risk of diabetic retinopathy (pooled) (n = 7716)	
	Univariate	Multivariate	Univariate	Multivariate	Univariate	Multivariate
Age group (years)						
30 to 39	1.00/1.00	1.00/1.00	1.00/1.00	1.00/1.00	1.00/1.00	1.00/1.00
40 to 49	**1.80** (1.06 to 3.05)	**1.74** (1.01 to 3.00)	**1.62** (1.06 to 2.49)	1.41 (0.91 to 2.18)	**1.72** (1.24 to 2.40)	**1.48** (1.06 to 2.08)
50 to 59	**3.10** (1.87 to 5.13)	**2.28** (1.34 to 3.86)	**2.45** (1.63 to 3.69)	**1.75** (1.15 to 2.66)	**2.77** (2.01 to 3.80)	**1.87** (1.35 to 2.59)
≥60	**3.45** (2.09 to 5.70)	**1.91** (1.12 to 3.26)	**2.96** (1.97 to 4.43)	**1.58** (1.03 to 2.41)	**3.26** (2.38 to 4.46)	**1.67** (1.20 to 2.32)
Male	1.00/1.00	1.00/1.00	1.00/1.00	1.00/1.00	1.00/1.00	1.00/1.00
Female	0.90 (0.74 to 1.10)	0.88 (0.71 to 1.10)	**0.83** (0.72 to 0.96)	**0.80** (0.69 to 0.94)	0.89 (0.79 to 1.00)	**0.85** (0.75 to 0.96)
Diabetic status						
Provisional diabetes	1.00/1.00	1.00/1.00	1.00/1.00	1.00/1.00	1.00/1.00	1.00/1.00
Known diabetes	**3.54** (2.34 to 5.37)	**1.73** (1.11 to 2.70)	**3.40** (1.78 to 6.49)	1.63 (0.84 to 3.16)	**3.84** (2.72 to 5.43)	**1.83** (1.27 to 2.63)
Visual impairment*						
Mild	1.00/1.00	1.00/1.00	1.00/1.00	1.00/1.00	1.00/1.00	1.00/1.00
Moderate	**2.03** (1.64 to 2.53)	**2.05** (1.59 to 2.63)	**1.92** (1.63 to 2.26)	**1.93** (1.61 to 2.31)	**1.96** (1.72 to 2.23)	**1.93** (1.67 to 2.24)
Severe	**2.01** (1.33 to 3.03)	**1.82** (1.16 to 2.87)	**1.53** (1.03 to 2.27)	**1.53** (1.01 to 2.33)	**1.68** (1.26 to 2.23)	**1.64** (1.21 to 2.22)
Duration of diabetes (years)	**1.13** (1.11 to 1.15)	**1.12** (1.10 to 1.15)	**1.11** (1.09 to 1.12)	**1.10** (1.09 to 1.12)	**1.12** (1.11 to 1.13)	**1.11** (1.10 to 1.12)
Group						
GH	1.00/1.00	1.00/1.00	1.00/1.00	1.00/1.00	1.00/1.00	1.00/1.00
DSC	**5.01** (3.51 to 7.16)	**5.65** (3.85 to 8.31)	**2.78** (1.95 to 3.97)	**2.92** (2.02 to 4.21)	**2.02** (1.75 to 2.33)	**2.64** (2.13 to 3.26)
Physicians	0.95 (0.61 to 1.48)	0.92 (0.58 to 1.47)	**4.30** (2.88 to 6.41)	**4.07** (2.69 to 6.16)	**2.26** (1.82 to 2.80)	**2.49** (1.94 to 3.18)
Self help	**2.23** (1.74 to 2.86)	**2.34** (1.79 to 3.05)	**3.26** (2.18 to 4.85)	**2.84** (1.88 to 4.29)	**2.29** (1.90 to 2.76)	**2.38** (1.93 to 2.94)
Rural	1					
Urban	**1.41** (1.25 to 1.59)	**0.55** (0.46 to 0.67)				

All bold numbers are statistically significant ($p<0.05$).
Visual impairment was defined as the level of visual acuity in the better eye: mild (6/6–6/12), moderate (6/18–6/60), and severe ($<6/60$).
DSC, diabetes screening camp; GH, general hospital.

Table 5 Correlation between age and severity of diabetic retinopathy

Age group	No retinopathy	Non-referable retinopathy	Referable retinopathy	p Value
30 to 39 years	540/586 (92.2%)	34/586 (5.8%)	12/586 (2.1%)	<0.00001
40 to 49 years	1588/1821 (87.2%)	166/1821 (9.1%)	67/1821 (3.7%)	
50 to 59 years	2046/2528 (80.9%)	314/2528 (12.4%)	168/2528 (6.6%)	
60 or more years	2177/2781 (78.3%)	390/2781 (14%)	214/2781 (7.7%)	

Table 6 Correlation between duration of diabetes and severity of retinopathy

Duration of diabetes	No retinopathy	Non-referable retinopathy	Referable retinopathy	p Value
Less than 5 Years	3937/4375 (90.0%)	309/4375 (7.1%)	129/4375 (3%)	<0.00001
5 to 10 years	1626/2120 (76.7%)	322/2120 (15.2%)	172/2120 (8.1%)	
More than 10 years	788/1221 (64.5%)	273/1221 (22.4%)	1160/1221 (12.8%)	

previously known diabetes, and moderate to severe visual impairment.

Another cost-effective approach is to use a tele-diabetic retinopathy screening strategy, wherein a mobile van with satellite connectivity goes to villages and digitised fundus images are viewed in real time by a retinal specialist at the base hospital.[14]

The effectiveness of our screening model was confirmed by the high response rate (94.3%) of those who were referred to attend the base hospital for laser photocoagulation. Other factors responsible for this high response rate included free transport and free food arrangements at the base hospital, and the excellent rapport built up by our diabetic retinopathy team with local non-governmental organisations (NGO) such as the Lions club, self help groups of villages, local physicians, and so on.

The results of our screening model suggest that the overall prevalence of diabetic retinopathy from a self reported screening camp population was 18%, and somewhat higher in the rural than in the urban population (20% vs 15%). The overall prevalence of diabetic retinopathy in newly detected provisional diabetics was 6%, and was again higher in the rural than in the urban population (7% vs 5%). The overall prevalence of diabetic retinopathy in known diabetics was 19%, and higher in the rural than in the urban population (20% vs 16%). However, when the values were adjusted for age and sex there was no difference in the prevalence (17%) in the rural and urban populations.

The prevalence statistics reported in our study could have been affected by selection bias, as the subjects were self selected attenders at the screening camps. No sample size could be estimated, though this is usually done in population based epidemiological studies. Thus the prevalence estimates may not be truly representative of the diabetic population in the two districts. Population based studies in India have estimated the prevalence to be 22.4% and 20.4%, respectively.[15 16] However, these studies did not compare the prevalence rates of diabetic retinopathy in rural and urban populations, as was done in the present study.

Both referable and non-referable types of diabetic retinopathy were more common in the rural than in the urban population (6.8% vs 4.6% and 12.8% vs 10.2%, respectively). A similar trend was observed by Leese et al.[17] Rural patients were more prone to have advanced diabetic retinopathy than those in the urban areas (13% vs 7%, p<0.001). These differences implied that screening efforts must reach the rural community more effectively than at present in order to prevent blindness. Of the referable diabetic retinopathy group, 92% presented with only mild to moderate visual impairment and a visual acuity of less than 20/200 was observed in 8% of the subjects. Had these patients not been examined and treated, they would have gone blind.

The use of indirect ophthalmoscopy as a screening tool, as in the present study, needs to be compared with the gold standard of seven-field stereoscopic photographs. Moss et al[18] reported that the sensitivity and specificity of indirect ophthalmoscopy for detecting any retinopathy were 82% (95% CI, 80% to 84%) and 95% (94% to 96%), and for sight threatening retinopathy, 72% (73% to 86%) and 100% (99% to 100%), respectively. The British Diabetic Association recommended that for any screening tool to detect diabetic retinopathy, the sensitivity should be around 80% and the specificity 95%.[19] Indirect ophthalmoscopy as a screening method has several advantages. It is portable, it provides wide angle viewing, and no slit lamp is needed. However, the possibility of missing macular oedema and subtle neovascularisation of the optic disc needs to be kept in mind. Hence we believe that indirect ophthalmoscopy with the availability of 5× magnification could be used as an initial screening device for mass community screening for diabetic retinopathy.

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