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Research Article

Integrating Diabetic Retinopathy Screening into Cataract Camps: A Cross-Sectional Study from Semi-urban and Rural India

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Abstract

Diabetic retinopathy (DR) is a major cause of preventable vision loss among adults with diabetes. In regions where access to routine eye care is limited, integrating DR screening into existing cataract camps offers an effective and cost-efficient approach for early detection. In this prospective, cross-sectional study, 2,265 individuals attending 53 cataract camps in semi-urban and rural areas around Bangalore, India, were screened; 390 (17.2%) were identified as diabetic. All diabetic patients underwent dilated fundus evaluation using indirect ophthalmoscopy with a 20-diopter lens, and diabetic retinopathy was graded according to the Early Treatment Diabetic Retinopathy Study (ETDRS) criteria. Sixty-six diabetic patients (16.9%) were diagnosed with DR, and nearly 92% exhibited significant cataract. Multivariate analysis showed that male gender and diabetes duration of 5-10 years were significant risk factors. This study demonstrates the feasibility and effectiveness of incorporating diabetic retinopathy screening into cataract camps in resource-limited settings. The approach enabled early identification of individuals with DR among high-risk individuals, with male gender and intermediate diabetes duration emerging as key risk factors. These findings support integrated screening as a practical strategy to enhance early detection and reduce preventable vision loss in vulnerable populations.

Keywords: Cataract Camp; Diabetic Retinopathy; Eye Care; Ophthalmoscopy

Abbreviations

DM: Diabetes Mellitus; DR: Diabetic Retinopathy; HTN: Hypertension; RBS: Random Blood Sugar; OR: Odds Ratio; CI: Confidence Interval; SD: Standard Deviation; f: Frequency

Introduction

Diabetes mellitus (DM) has emerged as one of the most significant global health challenges, particularly in low and middle-income countries such as India [1]. In recent decades, the prevalence of type 2 diabetes has increased dramatically, resulting in a surge of its associated complications. Approximately 30% of diabetic pa-

tients develop some form of diabetic eye disease, predominantly Diabetic retinopathy (DR) [2]. The global prevalence of DR is estimated at 93 million [3] and is the leading cause of vision loss in the working-age population globally [4]. In India, DR is a leading cause of vision impairment and blindness, affecting 5-7% of the diabetic population [5]. Prolonged diabetes (hyperglycaemia), poor glycaemic control damages the retinal microvasculature and consequently leads to a spectrum of retinal abnormalities that range from mild non-proliferative changes to advanced, sight-threatening conditions if not detected and treated early [4,6]. Oxidative stress, particularly through the activation of NADPH oxidase 2, plays a critical role in the pathogenesis of DR [7]. Despite effective treatments that can reduce visual loss risk by up to 60%, DR remains prevalent due to challenges in early detection and management [8].

In India, the challenge of managing DR is further compounded by the prevalence of cataract, which is significantly increased in diabetic individuals [9]. Both cataract and DR share common risk factors such as advancing age, chronic hyperglycaemia and diabetes duration, indicating that individuals undergoing cataract evaluation may also be at increased risk for underlying retinal pathology [10,11]. In resource-constrained settings, where access to tertiary eye care is limited, cataract/surgical camps, due to their cost-effectiveness and lower equipment requirements, make them suitable for mass outreach [12] and for providing vital eye care services [13]. Traditionally, these camps focus on diagnosing and managing cataracts, yet they also provide an opportunity to identify additional diabetic complications in high-risk individuals.

Integrating DR screening within existing health services, such as cataract camps, leverages established community infrastructure and mobilisation strategies, enabling early detection of retinopathy, which is crucial for reducing vision loss [14-16]. Early screening, timely intervention can significantly mitigate the burden of diabetic retinopathy and reduce the risk of blindness [15,16]. Recent studies have demonstrated that community-based screening programs can be both effective and sustainable in resource-limited environments [17,18].

Against this backdrop, the present study employs an integrated DR screening approach within cataract camps conducted in semi-urban and rural areas around Bangalore. The study objectives were to determine the detection rate of DR among diabetic subjects presenting at cataract camps and to identify key demographic and clinical risk factors associated with DR. By addressing these objectives, the integrated model aims to not only enhance early detection of DR but also to reduce the overall burden of preventable blindness in high-risk populations. This approach is expected to inform future public health initiatives and eye care strategies tailored to the unique challenges of resource-constrained settings.

Materials and Methods

Study design and setting

A prospective, cross-sectional study was conducted over 18 months (June 2019-December 2020) at 53 cataract camps organised by B. W Lion's Superspeciality Eye Hospital in semi-urban areas around Bangalore, India. The study received approval from the Institutional Scientific Committee of Bangalore West Lions Superspeciality Eye Hospital.

Sample Size, inclusion and exclusion criteria

The prevalence of diabetic retinopathy (DR) among cataract cases is estimated at approximately 1.2% (based on an assumed 6% prevalence of diabetes among cataract cases and a 20% prevalence of DR among diabetics) [19,20]. Assuming a relative precision of 40% of this estimated prevalence corresponding to a margin of error (e) of 0.0048 for a 95% confidence interval (Z = 1.96)—and anticipating a non-response rate of 10% (k = 0.1), the sample size (n) was calculated using the formula:

$n = Z^2 \cdot p(1-p)/[e^2 (1-k)]$

Substituting these values yields a sample size of approximately 2,196.5, which was rounded to 2,200. Therefore, a sample size of approximately 2,200 adults aged 40 years and above is required to reliably estimate the DR prevalence among diabetic subjects in the study.

Inclusion criteria included individuals aged 40 years and above who presented to the cataract camps.

Exclusion criteria included patients with very dense media opacity, obscuring detection/grading of diabetic retinopathy in cataract camps and those with retinal problems other than diabetic retinopathy.

Participant recruitment

Individuals aged 40 years and above were offered screening during these camps. Diabetes was identified based on self-report, confirmation from medical records, or on-site finger-prick random blood sugar (RBS) measurement (defined as RBS ≥ 200 mg/dL). Out of a total of 2,265 individuals screened, 390 (17.2%) were diagnosed as diabetic and subsequently enrolled for DR screening. Informed written consent was received from all the study participants prior to inclusion.

Screening procedure

- **Cataract and Visual Acuity Evaluation:** Each participant underwent an anterior segment examination and visual acuity measurement using standardised protocols (e.g., Snellen acuity chart). Cataract severity was classified as "significant" if the lens opacity adversely affected vision.
- **Collection of Medical History:** Detailed histories were obtained, including the duration of diabetes, current medication usage, hypertension status, and smoking history. Diabetic subjects were then grouped into three categories based on the duration of diabetes: less than 5 years, 5-10 years, and more than 10 years.
- **Pupil Dilation and Fundus Examination:** Diabetic patients received 3% tropicamide for adequate pupil dilation, after which indirect ophthalmoscopy with a 20-diopter lens was performed. DR was graded according to the Early Treatment Diabetic Retinopathy Study (ETDRS) criteria [6]. In cases where a dense cataract precluded retinal visualisation, the fundus examination was deferred until after cataract extraction. These deferred cases were later examined following cataract surgery and included in the DR prevalence analysis, where fundus visualisation became possible.

Statistical analysis

Data were recorded using standardised proformas and entered into Microsoft Excel. Statistical analyses were performed using SPSS version 22. Descriptive statistics (means, standard deviations, frequencies, and percentages) were calculated, and inferential tests (Chi-square tests and independent t-tests) were applied. Logistic regression analysis was used to identify independent risk factors for DR, with statistical significance set at $p < 0.05$ or $p < 0.01$.

Results

Variables		DM (n = 390)		No DM (n = 1875)		Total (n = 2265)		P value
		f	%	f	%	f	%	
Age	<40 years	2	0.5%	35	1.9%	37	1.6%	<0.001*
	40 to 49 years	19	4.9%	26	1.4%	45	2.0%	
	50 to 59 years	85	21.8%	385	20.5%	470	20.8%	
	60 to 69 years	185	47.4%	963	51.4%	1148	50.7%	
	>70 years	99	25.4%	466	24.9%	565	24.9%	
	Mean ± SD	63.19 ± 8.529		63.80 ± 8.036		63.69 ± 8.12		0.178
Gender	Female	198	50.8%	990	52.8%	1188	52.5%	0.465
	Male	192	49.2%	885	47.2%	1077	47.5%	
Location	Rural	219	56.2%	1238	66.0%	1457	64.3%	<0.001*
	Semi-Urban	171	43.8%	637	34.0%	808	35.7%	
Smoking	No	289	74.1%	1682	89.7%	1971	87.0%	<0.001*
	Yes	101	25.9%	193	10.3%	294	13.0%	
Duration of Diabetes Mellitus	<5 years	254	65.1%	0	0.0%	254	65.1%	-
	5 to 10 years	99	25.4%	0	0.0%	99	25.4%	
	>10 years	37	9.5%	0	0.0%	37	9.5%	
Hypertension	No	198	50.8%	1512	80.6%	1710	75.5%	<0.001*
	Yes	192	49.2%	363	19.4%	555	24.5%	
Kidney disease	No	390	100.0%	1862	99.3%	2252	99.4%	0.099
	Yes	0	0.0%	13	0.7%	13	0.6%	

Table 1: Prevalence rate of Diabetics in the study population. *Statistically significant at $p < 0.05$, **Statistically significant at $p < 0.01$.

A total of 2,265 individuals were screened at the cataract camps. As shown in Table 1, 390 participants (17.2%) were identified as diabetic. The mean age of the diabetic group was 63.19 ± 8.53 years, which was comparable to the overall study sample (63.80 ± 8.04 years, p = 0.178). Notably, only 0.5% of diabetic participants were under 40 years of age, compared with 1.9% among non-diabetics (p < 0.001). Additionally, 56.2% of diabetics resided in rural areas, a significantly lower proportion than the 66.0% observed among non-diabetics (p < 0.001). Systemic risk factors were more common in the diabetic subgroup, with 25.9% reporting smoking and 49.2% having hypertension, significantly higher than the 10.3% and 19.4% observed in non-diabetics (p < 0.001 for both).

Variables		Diabetic Retinopathy(DR)						P-value
	Yes (n = 66)		No (n = 324)		Total (n = 390)			
	f	%	f	%	f	%		
Age	<40 years	0	0.0%	2	0.6%	2	0.5%	0.131
	40 to 49 years	6	9.1%	13	4.0%	19	4.9%	
	50 to 59 years	16	24.2%	69	21.3%	85	21.8%	
	60 to 69 years	34	51.5%	151	46.6%	185	47.4%	
	>70 years	10	15.2%	89	27.5%	99	25.4%	
	Mean ± SD	61.06 ± 7.49		63.62 ± 8.67		63.19 ± 8.53		0.026*
Gender	Female	25	37.9%	173	53.4%	198	50.8%	0.022*
	Male	41	62.1%	151	46.6%	192	49.2%	
Location	Rural	36	54.5%	183	56.5%	219	56.2%	0.773
	Urban	30	45.5%	141	43.5%	171	43.8%	
Smocking	No	44	66.7%	245	75.6%	289	74.1%	0.130
	Yes	22	33.3%	79	24.4%	101	25.9%	
Duration of Diabetes Mellitus	<5 years	29	43.9%	225	69.4%	254	65.1%	<0.001**
	5 to 10 years	26	39.4%	73	22.5%	99	25.4%	
	>10 years	11	16.7%	26	8.0%	37	9.5%	
Hypertension	No	34	51.5%	164	50.6%	198	50.8%	0.894
	Yes	32	48.5%	160	49.4%	192	49.2%	
Kidney disease	No	66	100.0%	324	100.0%	390	100.0%	-

Table 2: Prevalence of Diabetic Retinopathy among Diabetic Subjects.

*Statistically significant at p < 0.05, **Statistically significant at p < 0.01.

Table 2 presents the results on diabetic retinopathy (DR) among the diabetic subjects. A total of 66 diabetic patients (16.9%) were diagnosed with DR. The mean age of patients with DR was 61.06 ± 7.49 years, which was significantly lower than that of diabetic subjects without DR (63.62 ± 8.67 years, p = 0.026). Furthermore, gender distribution differed significantly; 62.1% of patients with DR were male compared to 46.6% in the non-DR group (p = 0.022). Analysis by duration of diabetes revealed that only 43.9% of those with DR had been diabetic for less than 5 years, while 56.1% had a duration exceeding 5 years (p < 0.001).

Table 3 presents a comparative analysis of diabetic patients with and without DR across various demographic and clinical parameters. Significant associations were observed with gender and duration of diabetes. Males were more likely to have DR than females (p = 0.022), and patients with a disease duration exceeding five years showed a markedly higher prevalence of DR (p < 0.001), underscoring the impact of prolonged hyperglycaemia on retinal health. Although illiteracy was more common among those with DR, the association with educational status approached but did not

Variables		DR (n = 66)		No DR (n = 324)		Total (n = 390)		P-value
		f	%	f	%	f	%	
Age	<50 Years	8	12.1%	25	7.7%	33	8.5%	0.241
	>50 Years	58	87.9%	299	92.3%	357	91.5%	
Gender	Female	25	37.9%	173	53.4%	198	50.8%	0.022*
	Male	41	62.1%	151	46.6%	192	49.2%	
Location	Rural	36	54.5%	183	56.5%	219	56.2%	0.773
	Urban	30	45.5%	141	43.5%	171	43.8%	
Education	Illiterate	48	72.7%	269	83.0%	317	81.3%	0.051
	Literate	18	27.3%	55	17.0%	73	18.7%	
Cataract significance	Non-Significant	5	7.6%	25	7.7%	30	7.7%	0.969
	Significant	61	92.4%	299	92.3%	360	92.3%	
DM Duration	<5 Years	29	43.9%	225	69.4%	254	65.1%	<0.001**
	>5 Years	37	56.1%	99	30.6%	136	34.9%	
RBS	<180	34	51.5%	191	59.0%	225	57.7%	0.265
	>180	32	48.5%	133	41.0%	165	42.3%	
Vision	<6/60	49	74.2%	218	67.3%	267	68.5%	0.267
	6/60 and better	17	25.8%	106	32.7%	123	31.5%	

Table 3: Comparison of Diabetic Patients with and without Diabetic Retinopathy.

* Statistically significant at $p < 0.05$, ** Statistically significant at $p < 0.01$.

reach statistical significance ($p = 0.051$). No statistically significant associations were found for age, residential location, cataract status, glycaemic control, or vision status, did not differ significantly between groups indicating these may not be independent predictors of DR. In addition, nearly 92% of diabetic subjects, irrespective of their DR status, had significant cataract, emphasising the coexistence of lens opacity and retinal pathology in this cohort.

Multivariate logistic regression (Table 4) identified male gender and a diabetes duration of 6-10 years as significant independent risk factors for DR. Specifically, male gender was associated with an adjusted odds ratio (OR) of 1.928 (95% CI: 1.099-3.381, $p = 0.022$), while a diabetes duration of 6-10 years carried an adjusted OR of 3.088 (95% CI: 1.356-7.035, $p = 0.007$), indicating that male patients and those with a diabetes duration of 6 to 10 years were more likely to have DR than those patients with less than 5 years of diabetes. Other factors such as age, hypertension, and random blood sugar levels did not reach statistical significance.

Discussion

Our study demonstrates that an integrated screening model implemented in cataract camps can effectively identify diabetic retinopathy (DR) in a high-risk population. Several programs across India have demonstrated that screening for DR during organised eye camps, whether dedicated solely to cataract surgery or in combination with other ocular examinations, can yield a significant detection rate of diabetes [21,22]. Among the 2,265 individuals screened, 17.2% were identified as diabetic, and the prevalence of DR among these subjects was 16.9%. These findings are consistent with previous studies that have reported DR prevalence in community-based settings to range between 14% and 18% [23,24]. Such a relatively high detection rate reinforces the relevance of opportunistic screening, particularly in regions where routine eye care is limited.

		Total Number (n = 390)		P-value	Adjusted OR	95% Confidence Interval for Adjusted OR	
		f	%			Lower Bound	Upper Bound
Age	<50yr (reference)	33	8.5%	0.334	0.639	0.257	1.586
	>50yr	357	91.5%				
Gender	Female (reference)	198	50.8%	0.022*	1.928	1.099	3.381
	Male	192	49.2%				
Duration of DM	<5yr (reference)	254	65.1%				
	6-10yr	99	25.4%	0.007**	3.088	1.356	7.035
	>10yr	37	9.5%	0.878	1.069	0.454	2.519
HTN	No (reference)	198	50.8%	0.814	0.935	0.536	1.632
	Yes	192	49.2%				
Kidney disease	No	390	100.0%	-	-	-	-
Vision	6/60 and better (reference)	267	68.5%	0.194	0.656	0.348	1.239
	Worse than 6/60	123	31.5%				
RBS	Normal range (reference)	225	57.7%				
	Higher	165	42.3%	0.387	1.284	0.729	2.263

Table 4: Multiple Logistic Regression Analysis of Factors Associated with Diabetic Retinopathy.

*Statistically significant at $p < 0.05$, **Statistically significant at $p < 0.01$.

The demographic characteristics of our diabetic cohort reveal several important trends. Notably, the mean age of the DR group (61.06 years) was significantly lower than that of diabetic subjects without DR (63.62 years), suggesting that retinal changes may occur earlier in some individuals. In addition, the proportion of males in the DR group (62.1%) was significantly higher than that in the non-DR group (46.6%), which concurs with previous studies that have identified male gender as an independent risk factor for DR [23,24]. Furthermore, our analysis of diabetes duration showed that subjects with a duration of 5-10 years were at the highest risk for DR, with an adjusted odds ratio (OR) of 3.088. This finding aligns with earlier research indicating that an intermediate duration of diabetes represents a critical window during which microvascular damage becomes clinically apparent [25-27].

Multiple logistic regression analysis confirmed that both gender and duration of diabetes were independent predictors of DR. Specifically, male patients had nearly a two-fold increased risk of developing DR compared to females, while subjects with a diabetes duration of 6 to 10 years had approximately a three-fold higher risk compared to those with less than 5 years of diabetes [25-27]. These findings highlight an intermediate duration of diabetes as a critical window during which substantial microvascular damage becomes evident.

The high prevalence of significant cataract (approximately 92%) among diabetic individuals in our sample further underscores the dual burden of ocular pathology in this population. Cataract not only diminishes vision but can also compromise fundus visualisation, thereby complicating the diagnosis of DR. However, our integrated approach, where cataract management and DR evaluation are performed concurrently, highlights a practical advantage and confirms that leveraging existing community-based eye care infrastructure can yield substantial benefits.

In summary, our findings support the feasibility and effectiveness of integrating DR screening into cataract camps. By capitalising on the existing community-based eye care infrastructure, this model provides a cost-efficient strategy for early DR detection and has the potential to play a crucial role in reducing the burden of preventable blindness in high-risk populations.

Conclusion

This study demonstrates the feasibility and effectiveness of integrating diabetic retinopathy screening within cataract camps for the early detection of retinal pathology in low resource settings and high-risk individuals. The screening model effectively identified a substantial proportion of individuals with diabetes and detected cases of DR. Notably, risk analysis indicated that male gender and an intermediate duration of diabetes were significant predictors of retinopathy. These findings highlight the potential of opportunistic DR screening in cataract camps to reduce preventable blindness, particularly in resource-constrained settings. The results support broader implementation of such integrated screening strategies as a pragmatic approach to enhance early diagnosis and timely intervention in vulnerable populations.

Limitations

The study is limited by selection bias, as participants were exclusively drawn from cataract camps and may not represent the general diabetic population. The use of indirect ophthalmoscopy in participants with dense cataracts may have limited the accurate detection of early-stage diabetic retinopathy.

Recommendations

Future research should expand recruitment to include a more diverse population from various healthcare settings, utilise advanced imaging modalities such as digital fundus photography or OCT to mitigate media opacity issues, and incorporate long-term follow-up and economic analyses to better identify and address barriers to treatment uptake.

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