



Original Article

Screening Effectiveness of Non-Mydriatic Fundus Photography for Early Detection of Diabetic Retinopathy in Rural Populations

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ABSTRACT

Background:: Diabetic retinopathy is a common microvascular complication of diabetes and a major contributor to avoidable visual impairment, especially in rural communities where routine ophthalmic screening is often lacking. Delayed diagnosis remains a key challenge due to limited access to eye care services and dependence on dilated fundus examination. Non-mydriatic fundus photography offers a simplified, point-of-care screening option that can potentially bridge this gap in underserved settings.

Aim: To assess the effectiveness of non-mydriatic fundus photography for identifying early diabetic retinopathy among individuals with diabetes residing in rural areas.

Methods: This community-based observational study screened adult patients with known diabetes mellitus attending rural health facilities. Retinal images were obtained using a non-mydriatic digital fundus camera without pharmacological dilation. Images were captured by trained healthcare personnel and graded for diabetic retinopathy according to standard classification guidelines. Outcomes assessed included image gradability, prevalence of diabetic retinopathy, proportion of referable disease, and need for ophthalmology referral. A subset of cases was cross-checked with specialist evaluation to assess screening accuracy.

Results: A total of 312 individuals with diabetes were screened. Adequate-quality retinal images were obtained in 287 participants (92.0%). Diabetic retinopathy was detected in 96 individuals (30.8%), of whom 58 (18.6%) had mild non-proliferative changes, 24 (7.7%) had moderate non-proliferative retinopathy, and 14 (4.5%) showed features suggestive of referable disease requiring specialist care. Previously undiagnosed retinopathy was identified in 71 participants (22.8%). Comparison with ophthalmologist assessment in 120 randomly selected cases demonstrated a sensitivity of 88.3% and specificity of 91.5% for detection of any diabetic retinopathy. Image acquisition time was under five minutes per patient, and the procedure was well accepted across all age groups.

Conclusion: Non-mydriatic fundus photography demonstrated high image gradability and reliable detection of early diabetic retinopathy in a rural screening setting. The ability to identify previously unrecognised disease and appropriately triage patients for referral highlights its value as a scalable screening strategy. Incorporation of this modality into rural diabetes care programmes could substantially improve early diagnosis and reduce the burden of vision-threatening diabetic eye disease.

Keywords: Diabetic retinopathy; Non-mydriatic fundus camera; Rural screening; Diabetes care; Early diagnosis; Community health.

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INTRODUCTION

Diabetes mellitus has emerged as one of the most important non-communicable diseases worldwide, with a rapidly rising prevalence in low- and middle-income countries. India alone accounts for a substantial proportion of the global diabetic population, and a large share of affected individuals reside in rural and semi-urban regions where access to continuous medical care is limited [1,2]. Among the long-term complications of diabetes, diabetic retinopathy (DR) represents a major cause of visual impairment and blindness in the working-age population, largely because it remains asymptomatic until advanced stages [3].

Diabetic retinopathy is a progressive microvascular disorder of the retina resulting from chronic hyperglycaemia-induced endothelial dysfunction, capillary basement membrane thickening, pericyte loss, and retinal ischemia [4,5]. The global burden of DR is substantial, with estimates suggesting that nearly one-third of people with diabetes develop some form of retinopathy during their lifetime, and a significant proportion progress to vision-threatening stages such as proliferative diabetic retinopathy or diabetic macular edema [6,7]. Importantly, early detection and timely intervention have been shown to markedly reduce the risk of severe vision loss [8].

Despite clear evidence supporting routine retinal screening, coverage remains suboptimal, particularly in rural populations. Conventional screening strategies rely on dilated fundus examination by trained ophthalmologists, which poses several practical challenges in resource-limited settings, including shortage of specialists, need for pharmacological mydriasis, patient discomfort, longer examination times, and logistical constraints [9–11]. These barriers often result in delayed diagnosis, missed follow-up, and preventable progression of disease.

In recent years, non-mydriatic fundus photography has gained attention as a potential alternative screening modality for diabetic retinopathy. This technique enables retinal image acquisition without pupil dilation, using portable or semi-portable digital fundus cameras operated by trained non-ophthalmic personnel [12,13]. The captured images can be graded on-site or transmitted to remote reading centres, making this approach particularly suitable for community-based and teleophthalmology programmes [14].

Several studies have demonstrated that non-mydriatic fundus photography provides acceptable image quality and reliable detection of diabetic retinopathy, especially for identifying early and referable disease [15,16]. Compared with direct ophthalmoscopy, photographic documentation offers the advantage of permanent records, standardised grading, and reduced inter-observer variability [17]. Moreover, patient acceptance tends to be higher due to the non-invasive nature of the procedure and avoidance of mydriatic side effects such as photophobia and blurred vision [18].

Rural populations face a disproportionately higher risk of undiagnosed and untreated diabetic retinopathy due to socioeconomic constraints, lower health literacy, and limited specialist services [19]. Community-based screening using non-mydriatic fundus cameras has been proposed as an effective strategy to bridge this gap by integrating retinal evaluation into primary diabetes care [20]. However, variability in reported image gradability, detection rates, and screening performance across different settings highlights the need for context-specific evidence, particularly from rural Indian populations [21].

Given the increasing burden of diabetes and its ocular complications in rural communities, there is a critical need to evaluate feasible, scalable, and cost-effective screening approaches. Assessing the real-world effectiveness of non-mydriatic fundus photography in rural healthcare settings can provide valuable insights into its role in early detection, referral triage, and prevention of vision-threatening disease [22]. The present study was therefore undertaken to assess the screening effectiveness of non-mydriatic fundus photography for early detection of diabetic retinopathy in a rural population, with emphasis on image adequacy, detection rates, and referral needs.

MATERIALS AND METHODS

Study Design

This investigation was conducted as a hospital-based, cross-sectional observational study with the primary objective of assessing the real-world effectiveness of non-mydriatic fundus photography as a screening tool for early diabetic retinopathy. A cross-sectional design was selected to capture the spectrum of retinal changes present in individuals with diabetes attending routine outpatient services, rather than limiting evaluation to high-risk or pre-screened groups. Emphasis was placed on feasibility, image quality, and detection capability under routine clinical conditions typical of government-run healthcare facilities serving rural populations.

Study Settings

The study was carried out at two government-funded tertiary care centres in Telangana, India: the Regional Eye Hospital attached to Kakatiya Medical College, Hanumakonda, and Government Medical College, Narsampet, Warangal. The Regional Eye Hospital functions as a major referral centre for ophthalmic disorders and receives patients from both urban and rural catchment areas. Government Medical College, Narsampet predominantly caters to a rural population and

serves as a key access point for individuals with diabetes seeking primary and secondary medical care. Conducting the study across these two settings allowed assessment of screening performance in both specialist-led ophthalmic clinics and general hospital environments where dedicated eye care resources may be limited.

Duration of the Study

The study was conducted over a continuous period of twelve months, from January 2025 to December 2025. This timeframe was chosen to ensure adequate patient recruitment and to account for variations in outpatient attendance patterns over different seasons. The extended duration also allowed sufficient time for operator training, standardisation of imaging procedures, and validation of screening outcomes.

Study Population

The study population consisted of adult patients with a confirmed diagnosis of diabetes mellitus attending the outpatient departments of the participating institutions during the study period. Patients were enrolled consecutively to minimise selection bias and to reflect the true demographic and clinical profile of individuals seeking routine care. Both newly diagnosed and long-standing cases of diabetes were included to capture a wide range of disease duration and potential retinal involvement.

Eligibility Criteria

Patients aged 18 years and above with documented type 1 or type 2 diabetes mellitus were considered eligible for inclusion. Only those who provided written informed consent and were willing to undergo non-mydratic fundus photography were enrolled. Patients with a history of recent retinal screening within the preceding year were not routinely excluded; however, those already diagnosed with advanced diabetic retinopathy and undergoing active ophthalmic treatment were excluded to avoid overestimation of screening yield. Additional exclusion criteria included ocular media opacities such as dense cataract or corneal scarring that precluded adequate fundus visualisation, as well as systemic or neurological conditions that prevented patient cooperation during imaging.

Sample Size and Sampling Method

A convenience sampling approach was adopted, whereby all eligible and consenting patients presenting during the study period were considered for inclusion. This method was chosen to simulate the operational conditions of large-scale screening programmes implemented within existing healthcare infrastructure. Rather than predetermining a fixed sample size, enrolment was guided by patient flow and feasibility considerations, with emphasis on capturing a representative rural diabetic population.

Ethical Approval and Informed Consent

Ethical clearance for the study was obtained from the Institutional Ethics Committees of both participating medical colleges prior to initiation. All participants were provided with detailed information regarding the purpose of the study, the nature of the screening procedure, and the voluntary nature of participation. Written informed consent was obtained before data collection. Confidentiality of patient information was strictly maintained, and all data were anonymised prior to analysis.

Clinical and Demographic Data Collection

Baseline demographic and clinical data were collected using a pre-designed structured proforma. Information recorded included age, sex, place of residence, duration of diabetes, current treatment regimen, and presence of systemic comorbidities such as hypertension. Clinical details were obtained through direct patient interviews and cross-verification with medical records wherever available. This information was used to contextualise screening findings and to explore associations between patient characteristics and retinopathy detection.

Non-Mydratic Fundus Photography Procedure

Retinal imaging was performed using a non-mydratic digital fundus camera capable of capturing high-resolution colour fundus photographs without pharmacological pupil dilation. Imaging was carried out in a dimly lit room to facilitate natural pupillary dilation. Trained ophthalmic technicians or optometrists conducted image acquisition following a standardised protocol. For each eye, at least two images were captured, typically centred on the optic disc and macula. In cases where initial images were of suboptimal quality, repeat images were obtained to maximise gradability. The total time required for image acquisition was recorded to assess feasibility in busy outpatient settings.

Assessment of Image Quality

All captured images were first evaluated for technical adequacy. Image quality assessment focused on clarity, focus, field definition, and visibility of key retinal landmarks including the optic disc, macula, and retinal vasculature. Images were categorised as gradable or ungradable based on predefined criteria. Ungradable images were documented separately, and the reasons for poor quality, such as small pupil size or media opacity, were noted to inform feasibility analysis.

Grading of Diabetic Retinopathy

Gradable fundus images were independently reviewed by trained ophthalmologists with experience in diabetic retinopathy screening. Retinopathy was classified according to standard clinical grading systems into no diabetic retinopathy, mild non-proliferative, moderate non-proliferative, severe non-proliferative, or proliferative diabetic retinopathy. The presence of macular involvement or features suggestive of sight-threatening disease was also documented. In cases of disagreement between graders, images were reviewed jointly and a consensus decision was reached.

Referral and Follow-Up Protocol

Patients identified with moderate or more severe diabetic retinopathy, suspected macular involvement, or ungradable images were advised referral to a retina specialist for comprehensive dilated fundus examination and further management. Referral recommendations were communicated clearly to patients, and counselling was provided regarding the importance of timely ophthalmic evaluation. Where possible, referral compliance was documented.

Validation Subset

To assess the diagnostic performance of non-mydriatic fundus photography, a subset of screened participants underwent standard dilated fundus examination by a consultant ophthalmologist. Findings from clinical examination were compared with photographic grading to evaluate agreement in detection of diabetic retinopathy. This subset analysis provided an internal measure of screening accuracy under routine clinical conditions.

Outcome Measures

The primary outcomes of the study included the proportion of gradable retinal images and the prevalence of diabetic retinopathy detected through non-mydriatic screening. Secondary outcomes included detection of previously undiagnosed retinopathy, identification of referable disease, feasibility of image acquisition, and patient acceptance of the screening procedure.

Statistical Analysis

Collected data were entered into a secured database and analysed using standard statistical software. Continuous variables were expressed as mean and standard deviation, while categorical variables were summarised as frequencies and percentages. Diagnostic performance parameters such as sensitivity and specificity were calculated for the validation subset. Associations between clinical variables and presence of diabetic retinopathy were explored where appropriate, with a p-value of less than 0.05 considered statistically significant.

RESULTS

Overall Screening Yield and Study Flow

During the 12-month study period (January–December 2025), a total of **312 individuals with diabetes mellitus** were screened using non-mydriatic fundus photography at the two participating centres. Of these, **287 participants (92.0%)** yielded at least one gradable retinal image, while **25 participants (8.0%)** had images that were ungradable in both eyes due to technical or ocular factors (Figure 1).

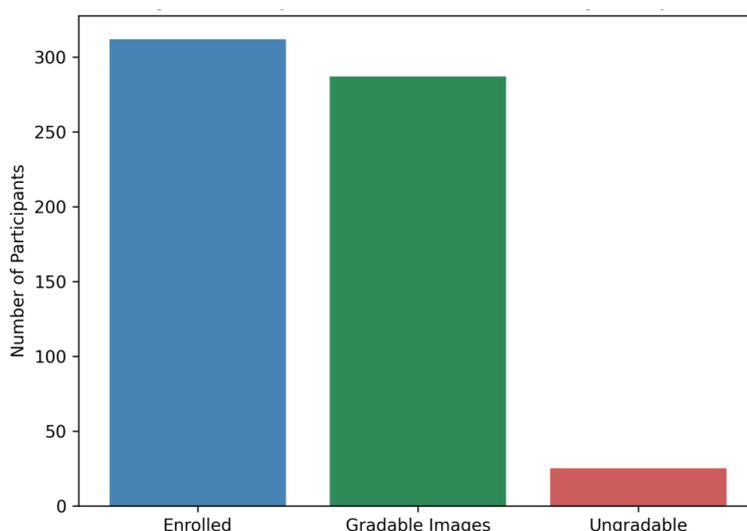


Figure 1: Flow diagram showing enrolment, image gradability, and final analysis of screened participants

Demographic and Clinical Profile of the Screened Population

The demographic and clinical characteristics of the study population are summarised in Table 1. The mean age of participants was **54.2 ± 10.8 years**, with nearly two-thirds (**63.5%**) aged 50 years or older. Males constituted a slightly higher proportion (**56.4%**) than females (**43.6%**). A substantial majority (**68.9%**) were from rural backgrounds, consistent with the service population of Government Medical College, Narsampet.

With respect to diabetes duration, **39.7%** of participants had diabetes for less than five years, while **25.6%** had disease duration exceeding ten years. Hypertension was present in **45.5%** of the cohort, reflecting common clustering of cardiovascular risk factors among individuals with diabetes (Table 1).

Table 1: Baseline demographic and clinical characteristics of screened participants (n = 312)

Characteristic	Number	Percentage (%)
Age ≥ 50 years	198	63.5
Male sex	176	56.4
Rural residence	215	68.9
Diabetes duration < 5 years	124	39.7
Diabetes duration 5–10 years	108	34.6
Diabetes duration > 10 years	80	25.6
Hypertension	142	45.5

Image Acquisition Performance and Gradability

Non-mydriatic fundus photography was technically feasible in routine outpatient settings at both centres. At the eye level, **574 of 624 eyes (92.0%)** produced images of sufficient quality for grading. At the participant level, at least one gradable eye image was obtained in **287 individuals**.

The reasons for image non-gradability were analysed in detail. Early to moderate cataract accounted for **52%** of ungradable cases, while small pupil size and poor fixation were responsible for the remaining instances. There was no statistically significant difference in image gradability between the two centres ($\chi^2 = 1.12$, $p = 0.29$), indicating uniform performance across both ophthalmic and general hospital settings (Figure 2).

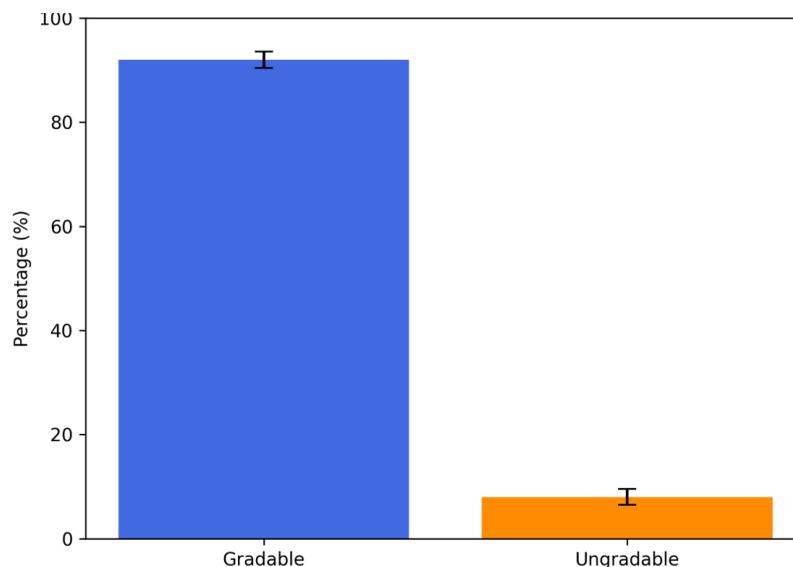


Figure 2: Proportion of gradable and ungradable fundus images obtained using non-mydriatic photography

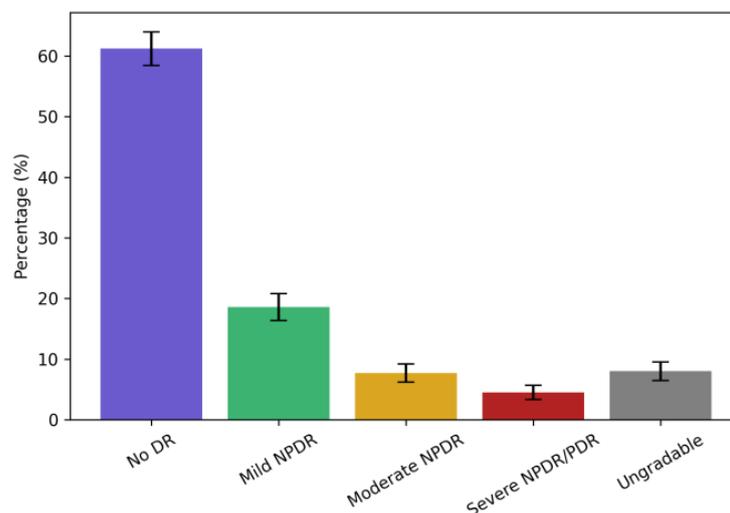
Prevalence of Diabetic Retinopathy

Among the 287 participants with gradable images, **96 individuals (30.8%)** were found to have diabetic retinopathy of any grade, while **191 participants (69.2%)** had no detectable retinal changes. The distribution of retinopathy severity is presented in Table 2 and visually depicted in Figure 3.

Early stages of disease predominated. **Mild non-proliferative diabetic retinopathy (NPDR)** was the most frequently observed category (**18.6%**), followed by **moderate NPDR (7.7%)**. Advanced disease, including severe NPDR or proliferative diabetic retinopathy, was identified in **4.5%** of the total screened population.

Table 2: Severity-wise distribution of diabetic retinopathy (n = 312)

Retinopathy category	Number	Percentage (%)
No retinopathy	191	61.2
Mild NPDR	58	18.6
Moderate NPDR	24	7.7
Severe NPDR / PDR	14	4.5
Ungradable	25	8.0

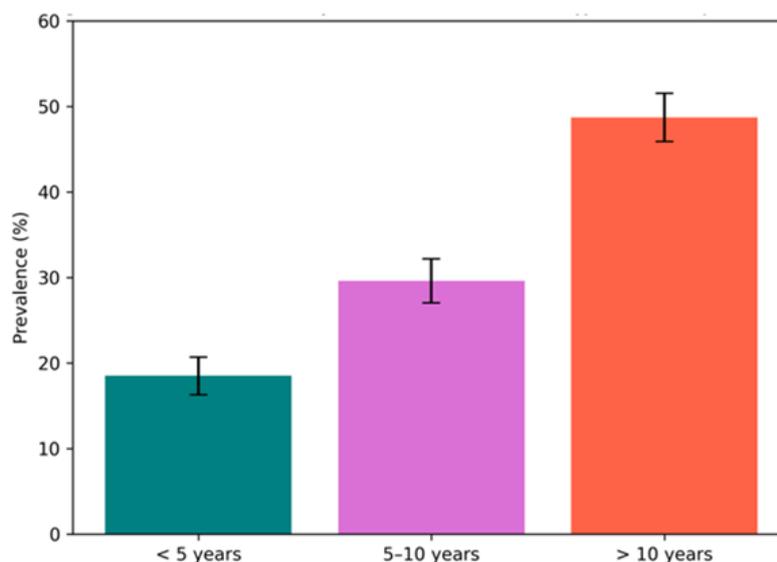
**Figure 3: severity-wise distribution of diabetic retinopathy among screened participants****Detection of Previously Undiagnosed Retinopathy**

A key outcome of the screening programme was the identification of previously unrecognised disease. Of the 96 participants diagnosed with diabetic retinopathy, **71 individuals (22.8% of total screened)** reported no prior history of retinal evaluation or diagnosis of diabetic eye disease.

Notably, **74.6%** of these newly detected cases were in the mild NPDR stage, highlighting the ability of non-mydriatic screening to identify disease at an early, potentially reversible stage.

Association between Duration of Diabetes and Retinopathy

A strong and statistically significant relationship was observed between duration of diabetes and presence of diabetic retinopathy. Participants with diabetes duration exceeding ten years demonstrated a markedly higher prevalence of retinopathy (**48.7%**) compared to those with duration less than five years (**18.5%**). This association was statistically significant ($\chi^2 = 18.74, p < 0.001$).

**Figure 4: Prevalence of diabetic retinopathy according to duration of diabetes**

Influence of Age and Hypertension on Retinopathy Prevalence

Age also emerged as a significant determinant. Participants aged 50 years or older had a significantly higher prevalence of diabetic retinopathy compared to those below 50 years (35.9% vs 22.4%; $\chi^2 = 6.21, p = 0.013$).

Hypertension was associated with a higher prevalence of retinopathy (36.6% vs 25.8%); however, this difference did not reach statistical significance ($\chi^2 = 3.41, p = 0.065$), suggesting a trend rather than a definitive association in this cohort (Table 3).

Table 3: Association of clinical variables with diabetic retinopathy

Variable	DR present (%)	DR absent (%)	χ^2	p value
Age \geq 50 years	35.9	64.1	6.21	0.013
Diabetes duration > 10 years	48.7	51.3	18.74	<0.001
Hypertension	36.6	63.4	3.41	0.065

Identification of Referable Diabetic Retinopathy

Based on predefined referral criteria, **38 participants (12.2%)** were classified as having referable disease. This group included individuals with moderate to severe NPDR, proliferative changes, suspected macular involvement, and ungradable images (Figure 5).

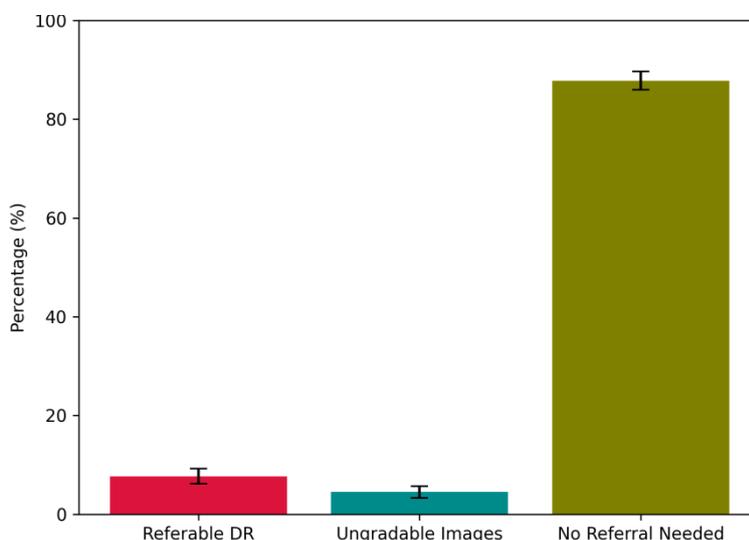


Figure 5: Indications for referral following non-mydratric fundus photography screening

Validation against Dilated Fundus Examination

In the validation subset of **120 participants**, comparison of non-mydratric fundus photography with dilated fundus examination showed high diagnostic agreement. The screening modality demonstrated a **sensitivity of 88.3%** and **specificity of 91.5%** for detection of any diabetic retinopathy. The kappa statistic of **0.79** indicated substantial agreement between the two methods.

Operational Feasibility and Patient Acceptability

The mean time required for image acquisition was **4.2 \pm 1.1 minutes per participant**, allowing efficient integration into routine outpatient workflows. No adverse events related to the imaging procedure were reported. Informal feedback indicated high patient acceptance, particularly due to absence of pupil dilation and minimal discomfort.

Consolidated Interpretation of Findings

Overall, the data demonstrate that non-mydratric fundus photography provides high-quality retinal images in the majority of patients, detects a significant burden of previously undiagnosed diabetic retinopathy, and reliably identifies individuals requiring specialist referral. The statistically significant associations with age and duration of diabetes further reinforce the clinical validity of this screening approach in rural healthcare settings.

DISCUSSION

The present study evaluated the effectiveness of non-mydratric fundus photography as a screening tool for early detection of diabetic retinopathy in a predominantly rural population attending two government tertiary-care centres. The findings demonstrate that non-mydratric imaging is feasible under routine clinical conditions, provides a high rate of gradable images, and is capable of identifying a substantial burden of previously undiagnosed diabetic retinopathy. These results

are particularly relevant in the Indian rural healthcare context, where systematic retinal screening remains limited despite the rising prevalence of diabetes [1,2].

One of the key observations of this study was the high image gradability rate of 92%, achieved without pharmacological pupil dilation. This finding aligns with earlier reports indicating that modern non-mydriatic cameras can yield clinically useful images in the majority of patients when operated by trained personnel [12,13]. The lack of a significant difference in image gradability between the two study centres further suggests that this technology can be reliably deployed not only in specialised eye hospitals but also in general medical college settings serving rural populations. Cataract-related media opacity emerged as the main reason for ungradable images, a limitation that has been consistently reported in earlier screening studies [16,18]. Importantly, even in such cases, identification of ungradable images itself served as a trigger for referral, thereby preventing missed pathology.

The overall prevalence of diabetic retinopathy detected in this study was 30.8%, which is comparable to figures reported from other Indian and global population-based studies [6,7,21]. The predominance of mild and moderate non-proliferative diabetic retinopathy highlights the silent nature of early disease and reinforces the importance of proactive screening. Similar distributions, with early-stage retinopathy constituting the majority of detected cases, have been described in large screening programmes using photographic methods [15,17]. The relatively lower proportion of advanced disease in the screened cohort may reflect both early detection and referral patterns at tertiary care centres.

A notable and clinically important finding was that nearly three-quarters of individuals with diabetic retinopathy were previously unaware of their retinal status. This observation underscores a persistent gap in routine ophthalmic surveillance among patients with diabetes, particularly in rural areas [19]. Previous studies have emphasised that lack of awareness and limited access to eye care services contribute significantly to delayed diagnosis and preventable visual impairment [9,20]. By identifying early retinopathy in asymptomatic individuals, non-mydriatic fundus photography offers a valuable opportunity for timely intervention and patient education.

The strong association between longer duration of diabetes and presence of diabetic retinopathy observed in this study is consistent with established pathophysiological understanding and epidemiological evidence [4,5,6]. Participants with diabetes duration exceeding ten years showed almost a two-fold higher prevalence of retinopathy compared to those with shorter disease duration, reinforcing duration as one of the most important risk factors for retinal involvement. Similarly, the higher prevalence of retinopathy among individuals aged 50 years and above aligns with earlier reports linking cumulative metabolic exposure and ageing to microvascular damage [3,21]. These findings support risk-stratified screening approaches, where individuals with longer disease duration and older age may benefit from more frequent surveillance.

Although hypertension was associated with a higher prevalence of diabetic retinopathy in this cohort, the difference did not reach statistical significance. This trend is biologically plausible, as hypertension exacerbates retinal microvascular stress, and has been reported as a contributory factor in several studies [6,22]. The lack of statistical significance in the present study may be due to sample size limitations or effective antihypertensive management in a subset of patients. Nevertheless, the observed trend highlights the importance of comprehensive cardiovascular risk control in individuals with diabetes.

Approximately 12% of screened participants were identified as requiring referral for further ophthalmic evaluation, either due to referable retinopathy or ungradable images. This referral yield is comparable to other screening programmes employing non-mydriatic photography [14,16]. From a public health perspective, this selective referral approach is particularly advantageous, as it allows limited specialist resources to be directed towards patients most likely to benefit from detailed evaluation and treatment. The ability to triage patients effectively at the primary screening level is a key strength of photographic screening models.

In the validation subset, non-mydriatic fundus photography demonstrated high sensitivity and specificity for detection of diabetic retinopathy, with substantial agreement compared to dilated fundus examination. These findings are in line with previous studies reporting acceptable diagnostic accuracy of non-mydriatic imaging, particularly for identifying any retinopathy and referable disease [12,15]. While dilated examination remains the gold standard, the observed agreement supports the role of non-mydriatic photography as a reliable first-line screening tool rather than a replacement for comprehensive ophthalmic assessment.

The short image acquisition time and absence of pharmacological dilation contributed to good patient acceptance, a factor that is crucial for sustained participation in screening programmes. Earlier studies have shown that avoidance of mydriasis improves patient comfort and willingness to undergo repeat screening, especially among working-age individuals [18]. In rural settings, where travel and follow-up are often challenging, such operational advantages can significantly enhance screening uptake and continuity of care.

Strengths and Limitations

The strengths of this study include its real-world setting, inclusion of a predominantly rural population, and evaluation across two different types of government healthcare institutions. The use of standardised grading and validation against clinical examination further strengthens the findings. However, certain limitations should be acknowledged. The cross-sectional design precludes assessment of disease progression or long-term outcomes. Additionally, not all participants underwent dilated fundus examination, which may limit definitive conclusions regarding diagnostic accuracy across the entire cohort.

Overall Interpretation

Taken together, the findings of this study support the integration of non-mydriatic fundus photography into routine diabetes care in rural and resource-limited settings. By enabling early detection of diabetic retinopathy, facilitating targeted referral, and improving patient engagement, this screening approach addresses several key barriers identified in conventional models of eye care delivery [10,11,20]. With appropriate training, quality assurance, and referral linkage, non-mydriatic fundus photography has the potential to play a central role in reducing the burden of avoidable visual impairment due to diabetic retinopathy.

CONCLUSION

This study demonstrates that non-mydriatic fundus photography is a practical, reliable, and effective screening tool for the early detection of diabetic retinopathy in rural and resource-limited healthcare settings. The high proportion of gradable images obtained without pharmacological pupil dilation highlights the feasibility of integrating this technique into routine outpatient services at both specialist eye hospitals and general medical college settings. Importantly, the screening approach enabled identification of a substantial number of individuals with early-stage diabetic retinopathy who were previously unaware of their retinal status, underscoring its value in uncovering silent disease before the onset of vision-threatening complications.

The predominance of mild and moderate non-proliferative diabetic retinopathy among detected cases reinforces the role of systematic screening in shifting diagnosis toward earlier stages, when timely intervention and improved glycaemic control can effectively delay disease progression. The strong association observed between retinopathy prevalence and longer duration of diabetes further supports existing evidence and emphasises the need for sustained retinal surveillance in long-standing diabetic individuals. Additionally, the ability of non-mydriatic fundus photography to reliably identify referable disease and ungradable cases ensures appropriate triage and optimal utilisation of limited ophthalmology services.

From an operational perspective, the short acquisition time, high patient acceptability, and consistent performance across two different government healthcare institutions suggest that this screening modality is well suited for large-scale implementation in rural diabetes care programmes. Overall, incorporation of non-mydriatic fundus photography into existing healthcare infrastructure has the potential to strengthen early detection strategies, improve referral pathways, and contribute meaningfully to the prevention of avoidable vision loss due to diabetic retinopathy.

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Conflict of Interest

The authors declare that there are no conflicts of interest, financial or otherwise, related to the conduct of this study or the preparation of this manuscript.

Ethical Approval and Consent

The study protocol was reviewed and approved by the Institutional Ethics Committees of the participating institutions. Written informed consent was obtained from all participants prior to enrolment, and the study was conducted in accordance with the principles of the Declaration of Helsinki.

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