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RESEARCH ARTICLE

The Study of Distributive Patterns of Microalbuminuria and Retinopathy in Pre-Diabetes at Tertiary Care Hospital

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Abstract: ***Background***: Diabetes mellitus (DM) comprises a group of metabolic disorders defined by chronic hyperglycemia and resulting in secondary pathophysiological alterations across multiple organ systems. Pre-diabetes, which refers to impaired glucose regulation that does not meet the diagnostic criteria for diabetes, increases the risk of microvascular complications including nephropathy and retinopathy. The presence of microalbuminuria and retinopathy in individuals with pre-diabetes may indicate early vascular dysfunction and predict the development of diabetes-related complications. ***Objectives***: To assess the distribution pattern of microalbuminuria and retinopathy in pre-diabetes and to determine their association with clinical variables. ***Methods***: This cross-sectional, hospital-based study was conducted in the Department of General Medicine at Sree Balaji Medical College and Hospital, Chennai, from December 2023 to December 2024. The study enrolled fifty-nine pre-diabetic patients aged over 30 years. Researchers collected detailed clinical histories and performed physical examinations. Investigations included oral glucose tolerance tests, lipid profiles, renal function tests, micral tests for microalbuminuria, and fundus examinations. Statistical analyses utilized Pearson's correlation, analysis of variance (ANOVA), and chi-square tests. ***Results***: Among the 59 participants, 83.1% exhibited microalbuminuria and 16.9% exhibited macroalbuminuria. Retinopathy was present in all patients. Mild non-proliferative diabetic retinopathy (NPDR) was identified in 56.6% of cases, moderate NPDR in 23.7%, and proliferative diabetic retinopathy (PDR) in 18.6%. Albuminuria demonstrated a significant association with frothy urine and pedal edema ($p<0.05$). Retinopathy was significantly associated with blurring of vision, reduced visual acuity, and floaters ($p<0.01$). No significant association was observed with age, gender, fasting glucose, blood pressure, or lipid profile. ***Conclusion***: Microalbuminuria and retinopathy frequently occur in individuals with pre-diabetes. These conditions underscore the importance of early screening and targeted intervention to reduce the risk of developing diabetes and associated complications.

Keywords: Pre-diabetes, microalbuminuria, retinopathy, fundus changes, endothelial dysfunction, early screening.

INTRODUCTION

Diabetes mellitus (DM) is a group of metabolic disorders characterized by hyperglycemia, resulting in long-term damage to multiple organ systems. The global incidence of diabetes increased from 30 million in 1985 to 382 million in 2013 [1]. Projections by the International Diabetes Federation estimate that 592 million people will be living with diabetes by 2035. India is expected to contribute significantly, with 66.85 million cases already documented among individuals aged 20 to 79 years [2]. In the United States, approximately 23.6 million individuals are living with diabetes, with 90% diagnosed with type 2 diabetes mellitus (T2DM). The Centres for Disease Control and Prevention (CDC) has identified diabetes as a significant public health concern, noting that its incidence quadrupled between 1990 and 2005 [3]. Pre-diabetes is defined as impaired fasting glucose (100–125 mg/dL), impaired glucose tolerance (140–199 mg/dL after 2 hours of oral glucose tolerance test), or hemoglobin A1c (HbA1c) between 5.7 and 6.4 percent. Individuals with pre-diabetes have a 5 to 6 times higher risk of developing type 2 diabetes mellitus (T2DM) [4]. They also face an increased risk of microvascular and cardiovascular complications. Epidemiological studies indicate that complications such as nephropathy and retinopathy can develop during the pre-diabetic stage, before the clinical diagnosis of diabetes [4].

The National Kidney Foundation defines microalbuminuria as a urine albumin excretion rate of 30–300 mg per day in two of three consecutive sterile urine samples [5]. Microalbuminuria serves as a marker of endothelial dysfunction, inflammation, and vascular disease burden. Early detection of microalbuminuria facilitates the identification of individuals at increased risk for cardiovascular and renal complications.

Similarly, diabetic retinopathy, defined as microvascular changes in the retina, has been observed in individuals with pre-diabetes. Data from the American Diabetes Association (ADA) indicate that nearly 8% of individuals with pre-diabetes exhibit early retinopathy [6]. Other studies report that approximately 13% of individuals newly diagnosed with diabetes already present with retinopathy, indicating that vascular damage precedes the clinical onset of diabetes by several years. India has over 30 million individuals at risk of developing diabetes, with urban prevalence of impaired glucose tolerance estimated at 8.7% and rural prevalence at 7.9%. Nearly 35% of those with impaired glucose tolerance progress to diabetes [7]. Early identification of

pre-diabetes and related complications enables timely intervention, which can delay or prevent the onset of diabetes mellitus and its microvascular complications [8].

This study aims to evaluate the prevalence of microalbuminuria and retinopathy among pre-diabetic individuals at a tertiary care hospital and to identify their clinical associations.

MATERIALS AND METHODS

Study Design and Setting:

This hospital-based cross-sectional study was conducted in the Department of General Medicine, Sree Balaji Medical College and Hospital, Chennai, from December 2023 to December 2024.

Study Population:

The study included adults above 30 years of age who were diagnosed with pre-diabetes according to the American Diabetes Association (ADA) criteria [4]. A total of 59 participants were recruited.

Inclusion Criteria:

- Age ≥30 years
- Diagnosis of pre-diabetes (as per ADA criteria) [4]

Exclusion Criteria:

- Patients younger than 30 years
- Hypertension (blood pressure >140/90 mmHg)
- History of renal disease
- Urinary tract infection
- Elevated serum creatinine (>1.5 mg/dL)
- Abnormal urine microscopy (presence of red blood cells, white blood cells, or bacteria)

Sampling Method:

Purposive sampling was employed to recruit eligible participants from outpatient and inpatient services of the hospital.

Data Collection:

All participants underwent detailed clinical evaluation, including:

- **History:** demographic details, family history of comorbidities, and relevant clinical symptoms.
- **Examination:** general and systemic examination.
- **Investigations:**
  - Fasting blood glucose and 2-hour oral glucose tolerance test (OGTT)
  - Lipid profile (total cholesterol, LDL, HDL, triglycerides)
  - Renal function tests (serum creatinine, blood urea)
  - Urine analysis
  - Micral test for detection of microalbuminuria
  - Ophthalmological evaluation (fundus examination by both direct and indirect ophthalmoscopy)

Operational Definitions:

Microalbuminuria was defined as urinary albumin excretion between 30–300 mg/day, while values >300 mg/day were considered macroalbuminuria [5]. Retinopathy was classified as mild, moderate, or proliferative based on fundus findings, following established diabetic retinopathy grading systems [6].

Sample Size:

The sample size of 59 was determined using statistical calculation for comparison of two proportions, with 95% confidence level, 80% power, and expected proportions of 60% and 35%.

Statistical Analysis:

Data were entered and analyzed using SPSS software.

- Categorical variables were expressed as frequencies and percentages.
- Continuous variables were summarized as mean, median, standard deviation, and range.
- Chi-square test was applied for associations between categorical variables.
- Independent sample t-test and ANOVA were used for group comparisons.
- Pearson's correlation was employed to determine the degree of linear relationship between variables.
  A p-value <0.05 was considered statistically significant.

Ethical Considerations:

All participants provided informed consent before enrollment. The study was self-funded.

RESULTS

Baseline Characteristics

A total of 59 participants with pre-diabetes were included. The mean age was 49.4 ± 11.5 years (range: 30–70). The majority were in the 40–49 age group (37.3%). Males constituted 74.6% of the cohort.

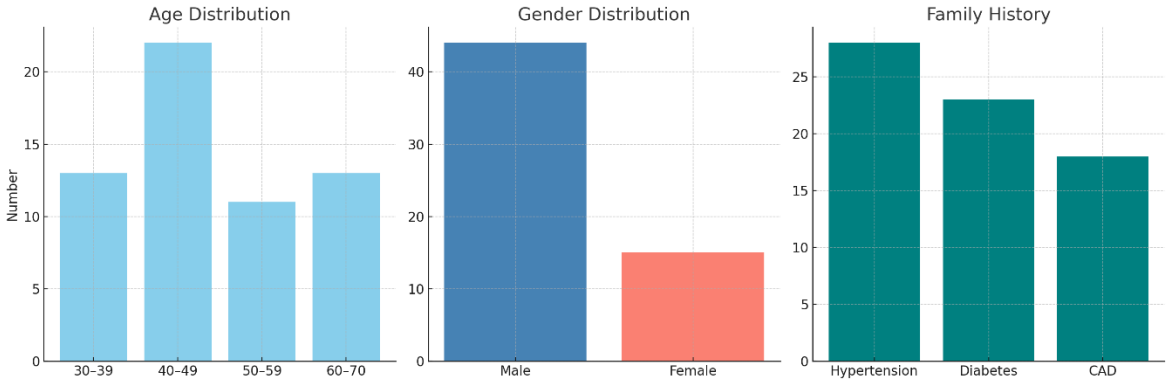
Table 1. Baseline demographic characteristics (n=59)

Variable	Category	Frequency (%)
Age (years)	30–39	13 (22.0)
	40–49	22 (37.3)
	50–59	11 (18.6)
	60–70	13 (22.0)

Gender	Male	44 (74.6)
	Female	15 (25.4)

Family and Lifestyle History

Hypertension was reported in 47.5% of family histories, diabetes in 39.0%, and coronary artery disease in 30.5%. Smoking history was present in 40.7%.

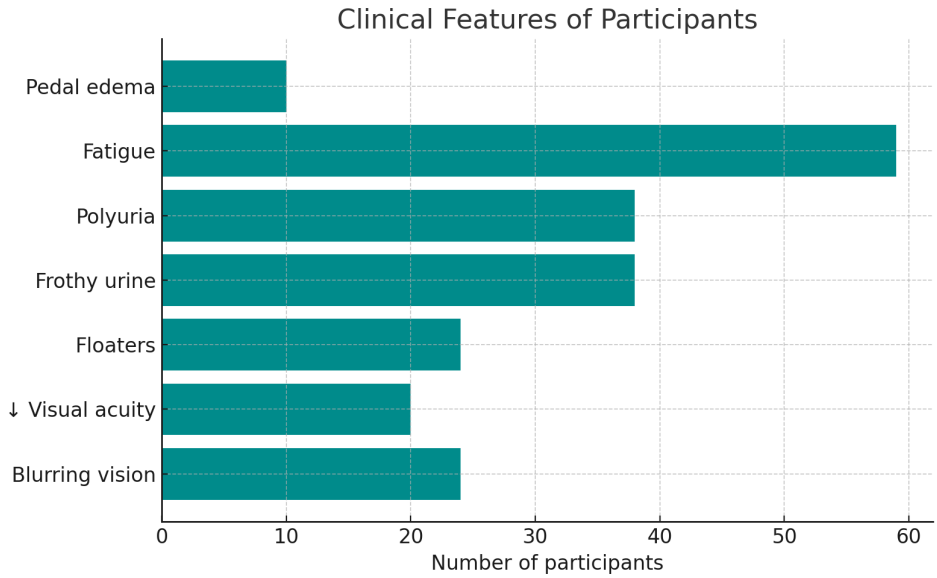


Clinical Symptoms and Signs

Blurring of vision was present in 40.7%, decreased visual acuity in 33.9%, and floaters in 40.7%. Frothy urine and polyuria were both reported by 64.4% of participants. Pedal edema was seen in 16.9%. Fatigue was universal (100%).

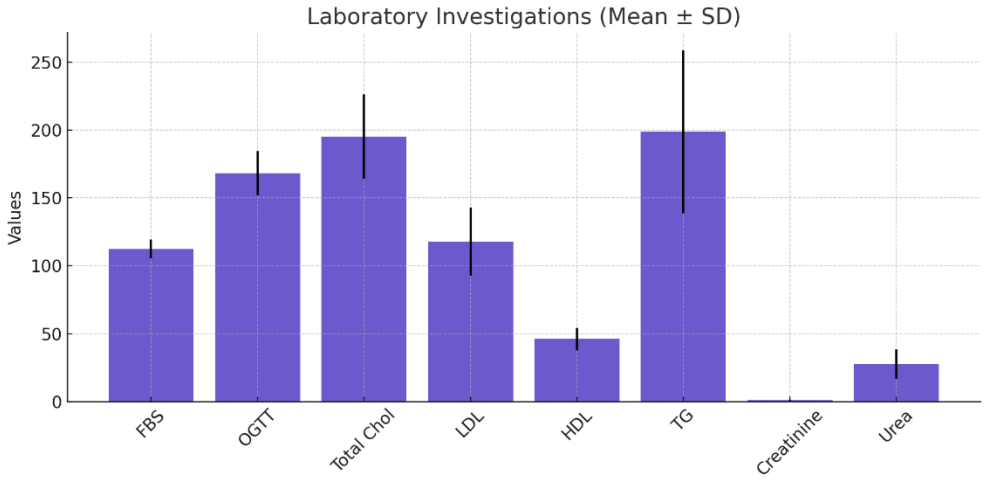
Table 2. Clinical features of participants (n=59)

Feature	Frequency (%)
Blurring of vision	24 (40.7)
Decreased visual acuity	20 (33.9)
Floaters	24 (40.7)
Frothy urine	38 (64.4)
Polyuria	38 (64.4)
Fatigue	59 (100)
Pedal edema	10 (16.9)



Laboratory Investigations

The mean fasting blood glucose was 112.5 ± 7.0 mg/dL, and mean 2-hour OGTT was 168.1 ± 16.2 mg/dL. Lipid profile showed mean total cholesterol of 195.3 ± 31.1 mg/dL, LDL 118.0 ± 25.1 mg/dL, HDL 46.1 ± 8.3 mg/dL, and triglycerides 198.8 ± 60.1 mg/dL. Renal function tests revealed mean serum creatinine of 0.96 ± 0.28 mg/dL and blood urea of 27.5 ± 11.0 mg/dL.

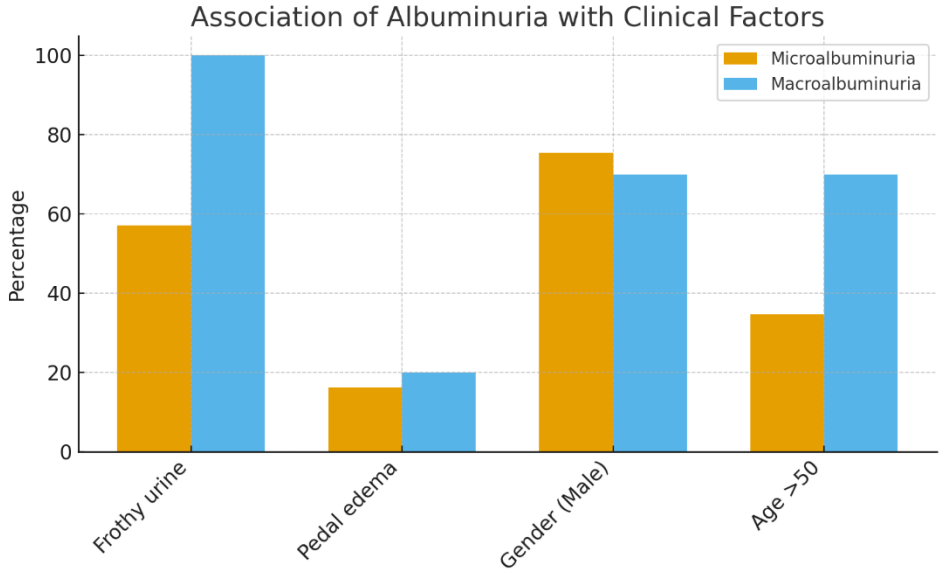


Microalbuminuria

Microalbuminuria was detected in 83.1% of participants, while 16.9% had macroalbuminuria. Albuminuria showed significant associations with frothy urine ($p<0.05$) and pedal edema ($p<0.05$), but not with age, gender, blood pressure, fasting glucose, or lipid profile.

Table 3. Microalbuminuria and clinical associations

Parameter	Microalbuminuria (%)	Macroalbuminuria (%)	p-value
Frothy urine present	28 (57.1)	10 (100)	<0.05
Pedal edema present	8 (16.3)	2 (20.0)	<0.05
Gender (Male)	37 (75.5)	7 (70.0)	>0.05
Age >50 years	17 (34.7)	7 (70.0)	>0.05



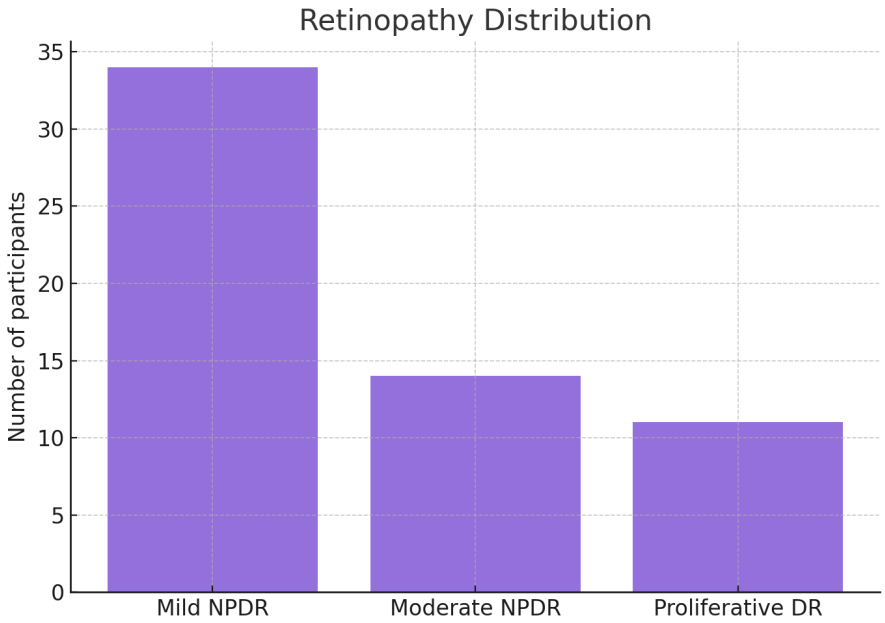
Retinopathy

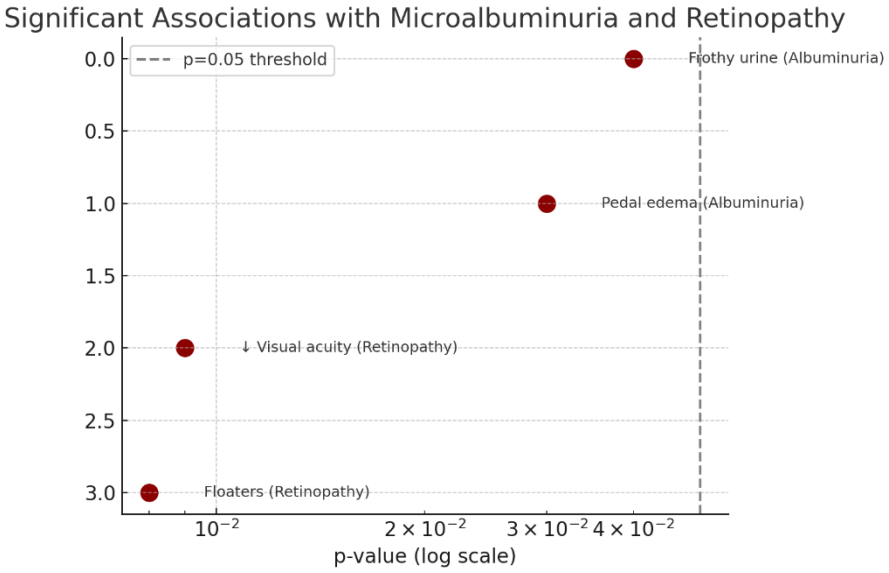
All participants had some form of retinopathy: mild NPDR (57.6%), moderate NPDR (23.7%), and proliferative DR (18.6%). Retinopathy showed significant association with blurring of vision, decreased visual acuity, and floaters (all $p<0.01$), but not with age or gender.

Table 4. Retinopathy distribution and associations

Category	Frequency (%)	Significant associations
Mild NPDR	34 (57.6)	
Moderate NPDR	14 (23.7)	Blurring of vision (p<0.01)

Proliferative DR	11 (18.6)	Decreased visual acuity (p<0.01), Floaters (p<0.01)





Blood Pressure and Biochemical Parameters

Mean systolic blood pressure was 136.9 ± 14.3 mmHg, and diastolic was 82.2 ± 9.1 mmHg. No significant difference was observed between microalbuminuria and macroalbuminuria groups for blood pressure, fasting glucose, OGTT, lipid profile, or renal parameters.

DISCUSSION

In this cross-sectional study of 59 individuals with pre-diabetes, we found a high prevalence of microvascular complications. Microalbuminuria was present in 83.1% and macroalbuminuria in 16.9%, while all participants exhibited some form of diabetic retinopathy, ranging from mild NPDR (57.6%) to proliferative DR (18.6%). These findings strongly suggest that microvascular changes begin much earlier in the natural history of diabetes than traditionally believed.

The prevalence of microalbuminuria in pre-diabetes observed in our study is considerably higher than reported in earlier population-based studies, where estimates ranged between 5–25% as described by Valmadrid et al. [9] and Haffner et al. [10]. This discrepancy may reflect differences in study population, diagnostic criteria, and methods of albuminuria detection. Nevertheless, our results corroborate prior evidence from Mogensen [11] that microalbuminuria can manifest during pre-diabetic states and is associated with

generalized endothelial dysfunction. The significant association between albuminuria and clinical features such as frothy urine and pedal edema further underscores its clinical relevance, although traditional risk factors such as age, gender, blood pressure, and lipid abnormalities were not significantly associated in our cohort.

Retinopathy was universal among participants in our study. Wong et al. [12] and Zhang et al. [13] reported retinopathy prevalence of 6–12% in pre-diabetes, with some showing even higher rates in selected high-risk groups. The much higher prevalence in our study may be explained by hospital-based recruitment, smaller sample size, and possible selection bias, yet it highlights the importance of early retinal screening even before the onset of diabetes. Our observation that retinopathy correlated significantly with blurring of vision, floaters, and decreased visual acuity, but not with demographic or metabolic parameters, aligns with findings of Klein et al. [14], who noted that retinal vascular changes may progress independently of glycemic status.

The underlying mechanisms for these early complications likely involve chronic low-grade hyperglycemia, insulin resistance, and associated metabolic stress. As Brownlee [15] demonstrated, hyperglycemia-induced oxidative stress, activation of protein kinase C, and advanced glycation end-products contribute to endothelial dysfunction and microvascular damage. These processes can begin in pre-diabetes and explain the occurrence of complications even in the absence of overt diabetes.

Our findings are consistent with Indian data reported by Ramachandran et al. [7], highlighting the high burden of pre-diabetes and its progression to diabetes. With nearly one-third of individuals with impaired glucose tolerance progressing to diabetes, early recognition of microalbuminuria and retinopathy may provide opportunities for targeted interventions.

Clinical Implications:
The high prevalence of microvascular complications in pre-diabetes underscores the need to integrate routine screening for microalbuminuria and fundus changes into pre-diabetes management protocols. This could help in identifying high-risk individuals who may benefit from early lifestyle modification, pharmacological interventions, and closer follow-up. Current guidelines primarily emphasize glycemic control, but our study suggests that vascular complication screening should begin much earlier.

Strengths and Limitations:
Strengths of this study include systematic clinical evaluation, standardized investigations, and focus on a relatively understudied population. However, certain limitations should be acknowledged: the cross-sectional design precludes causal inference; the sample size was modest; and being a single-center hospital-based study, the findings may not be generalizable to the broader population. Additionally, the high prevalence rates observed may partly reflect referral bias**.**

CONCLUSION

Microalbuminuria and retinopathy were highly prevalent among individuals with pre-diabetes in this hospital-based study. These results reinforce the evidence that microvascular complications begin in the pre-diabetic stage, highlighting the importance of early detection. Integrating routine screening for albuminuria and retinal changes into pre-diabetes care pathways could allow timely intervention and potentially reduce the burden of future diabetic complications.

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