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MEDICINE

# Microvascular Complications and Their Associated Risk Factors Among Rural Type 2 Diabetic Population: A Cross-Sectional Study

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## Abstract

To determine the factors associated with progression of microvascular complications in T2DM patients and also to investigate the relationship between glycated hemoglobin (HbA1c, %) levels and risk factors associated with microvascular complications. A cross-sectional study was conducted in the rural area of Guntur, Andhra Pradesh, India. A total of 64 subjects with the history of T2DM more than 5-year duration were included in the study. Micro-albuminuria, fundoscopy examination, and other biochemical parameters were assessed to rule out nephropathy and retinopathy. Out of the total 64 subjects, 48 (75%) were males and 16 (25%) were females. The mean age among the subjects was 57.9 ± 8.3 years. A strong association between poor glycemic control and progression of non-proliferative diabetic retinopathy (NPDR) and severely increased urinary albumin-creatinine ratio (UACR, mg/g) and diabetic nephropathy (DN) ($p$ = 0.018, *OR* 3.95, and *95% CI* 1.22, 12.78 and $p$ = 0.0005, *OR* 6.5, and *95% CI* 2.7.19.48) was observed. The level of education, annual income, and body mass index (BMI, kg/m$^2$) are strongly associated with the development of NPDR ($p < 0.05$), and annual income, hypertension, and duration of T2DM are the influencing progression of micro-albuminuria ($p < 0.05$). The risk of developing NPDR, DN, and poor glycemic control among hypertensives (OR 1.5, 0.6, and 0.7) are more compared to normotensives. Some risk factors were not significant. The level of education, annual income, duration of diabetes, and BMI are the major risk factors for the progression of NPDR and also poor glycemic control that provokes to microvascular complications. Interventions are needed to regulate glycemic control to prevent or reverse the further progression of these complications.

**Keywords** Diabetic retinopathy · Diabetic nephropathy · Glycated hemoglobin · Duration of T2DM · Socioeconomic status

## Introduction

Type 2 diabetes mellitus is an ever-growing major epidemic lifestyle disease. According to the International Diabetes Federation (IDF) published in diabetes atlas (2015), it was predicted that the number of adults with diabetes will increase to more than 640 million by 2040. The numbers will be high in low- and middle-income countries [1]. In the global ranking of diabetes, India ranks second after China. The burden of diabetes in India has been increasing in leaps and bounds in both urban and rural areas. Type 2 diabetes is the most prevalent type of diabetes in India [2].

The microvascular complications such as diabetic retinopathy (DR), diabetic nephropathy (DN), and diabetic neuropathy are major long-term complications increasing parallelly [3] and affecting approximately 30% of patients with type 1 diabetes mellitus and 40% in T2DM patients [4]. DN is the leading cause of end-stage renal disease (ESRD) worldwide and nearly 20% of T2DM patients experience ESRD during their lifetime [5]. DR is also another major cause of blindness among uncontrolled diabetics [6]. Multiple studies in India and other countries have confirmed a higher level of HbA1c is an independent risk for developing microvascular complications. Hence, there is a need to conduct screening programs in rural areas to bring awareness regarding microvascular complications as well as lifestyle modifications and its

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benefits to prevent blindness, ESRD, and other complications [7–12].

The unconstrained glycemic levels are the cornerstone to develop microvascular complications in long-standing diabetics which has to be addressed by adopting adequate precautions and lifestyle. Our hypothesis is to test the association among glycated hemoglobin levels ("POOR" control (HbA1C ≥ 8%) and "FAIR" control (HbA1C < 8%) of glucose levels) and microvascular complications in patients with more than 5-year history of T2DM in the rural area. According to the American Diabetic Association, the reference values of HbA1C include 4.5–5.6%, normal; 5.7–6.4%, pre-diabetic; >6.5%, diabetic; 6.6–7%, adequate control; 7–8%, inadequate control; and >9%, very poor control. Most guidelines consider HbA1c ≤ 7% as the general target of glucose control for optimum diabetes management [13–15]. The objectives of the study are (1) to assess the glycemic control in the study population, (2) to study various complications of type 2 diabetes mellitus, and (3) to study the relationship of glycemic control and other factors with microvascular complications.

## Materials and Methods

### Study Design and Participants

A cross-sectional study of a total of 64 subjects of either sex with more than 5 years of history of type 2 diabetes mellitus which were screened during a medical camp, conducted at a rural area of Guntur, Andhra Pradesh, India, from the month of January to March 2020. Subjects with T1DM, known case of glaucoma, and end-stage renal disease (ESRD) were excluded from the study. Retrieved all medical histories of enrolled subjects and physical examination, biochemical analysis, and fundoscopy were carried out by suitable expertise. The study protocol was approved by the Institutional ethics committee of Endo-life Specialty Hospital, Guntur, and written informed consent was obtained from each subject.

### Methods Adopted

$HbA_1C$ was measured by using the Variant™ II Hemoglobin Testing System (HPLC of Bio-RaD A1C a fully automated), USA. Fasting blood glucose levels and lipid profile, serum creatinine, and serum electrolytes are measured by using Roche Cobas c311. eGFR was calculated using the MDRD equation. Nephropathy was diagnosed based on the urine albumin-creatinine ratio (UACR, mg/g) of a single urine spot sample. Eye examination was carried out by a qualified ophthalmologist for assessing proliferative/non-proliferative retinopathy/normal eye by using Easilens slit lamp (EC-5000). BMI ($kg/m^2$) was categorized, using the current World Health Organization (WHO) definitions. BMI of < 18.5 $kg/m^2$, 18.5–24.9 $kg/m^2$, 25–29.9 $kg/m^2$, 30–34.9 $kg/m^2$, 35–39.9 $kg/m^2$, and ≥ 40 $kg/m^2$ were used to define underweight, normal weight, overweight, and obesity classes I, II, and III, respectively. The study subject's blood pressure was classified according to the Joint National Committee (JNC) 8th report [16]. Glycemic control was categorized into two groups, "POOR" HbA1c ≥ 8% and "FAIR" HbA1c < 8%. Hereafter, HbA1c ≥ 8% and < 8% were considered as POOR and FAIR glycemic controls. The diagnosis of diabetic nephropathy is based on the presence of UACR (mg/g). UACR values are described and range from normal to mildly increased (< 30 mg/dL), moderately increased (30–300 mg/g), and severely increased (> 300 mg/g).

*Modification of diet in renal disease (MDRD) study equation:*

$$\mathrm{eGFR} = 186 \times (\mathrm{creatinine} \times 88.4)^{-1.154} \times (\mathrm{age})^{-0.203} \times (0.742 \text{ in female}) \times (1.210 \text{ if black})$$

### Statistical Analysis

The data entry and analysis were performed using IBM Statistical Package for Social Science (SPSS) version 20. The data distribution of continuous variables was assessed using unpaired *t*-test, and the chi-square test was applied for categorical variables for assessing between HbA1c levels, retinopathy, and nephropathy (eGFR and UACR) values. Odds ratio and 95% confidence interval were applied to assess the risk of DR and DN among both groups using SPSS software. All results were confirmed at a 5% level of significance and the value of less than 0.05 was considered statistically significant.

## Results

The demographic details of 64 subjects are shown in Table 1.The mean age is 57.9 ± 8.3 years with75% (*n*=48) and 25% (*n*=16) of males and females respectively. The mean BMI was 26.4 ± 4.2 $kg/m^2$, of which 24 (37%) are of normal weight, 19 (29.6 %) are of overweight, 8 (12%) are of obesity class I, and 02 (3.1%) and 01 (1.5%) subjects are of obesity class II and class III respectively. The average duration of the history of hypertension was 8.4 years with a mean of 147/85.6 mmHg, of which 54 subjects (84.3%) were on medication of angiotensin-converting enzyme (ACE) inhibitors, 18 (28.1%) on beta-blockers (BB), and 12 (18.7%) subjects are having a past medical history of ischemic heart disease (IHD).

The mean duration of history of DM was 10.6 ± 5.3 years and the number of subjects on treatment with oral hypoglycemic agents (OHGA) was 42 (65.6%) and those with OHGA

**Table 1** Demographic detail of study participants

| Parameters | $N = 64$ (%) |
|---|---|
| Mean age (yr), SD | 57.9 ± 8.3 |
| Gender | |
| Male | 48 (75) |
| Female | 16 (25) |
| Mean BMI (kg/m$^2$) | 26.4 ± 4.2 |
| BMI categories | |
| Normal weight (18.5–24.9) | 24 (37.5) |
| Over weight (25–29.9) | 29 (45.3) |
| Obesity class I (30–34.9) | 08 (12.5) |
| Obesity class II (35–39.9) | 02 (3.1) |
| Obesity class III (≥ 40) | 01 (1.5) |
| Mean SBP (mm of Hg) | 147 |
| Mean DBP (mm of Hg) | 85.6 |
| Mean duration of BP (yr) | 8.4 ± 4.5 |
| Medications for BP | |
| BBs | 18 (28.1) |
| CCBs | 02 (3.1) |
| ACEi | 54 (84.3) |
| ARBs | 06 (9.3) |
| Comorbidities | |
| IHD | 12 (18.7) |
| Stroke | 02 (3.1) |
| Mean duration of DM (yr), SD | 10.6 ± 5.3 |
| DM treatment | |
| OHGA | 42 (65.6) |
| OHGA + insulin | 22 (34.3) |
| Others | 00 (00.0) |
| Smoking history | |
| Current smoker | 08 (12.5) |
| Non-smokers | 56 (87.5) |
| Educational level | |
| Illiterates | 12 (18.7) |
| 10+2 or below | 36 (56.2) |
| University degree or above | 16 (25) |
| Household annual income (Rs.) | |
| ≤1.5 lakhs (low) | 23 (35.9) |
| > 1.5 to < 3 lakhs (lower middle) | 13 (20.3) |
| > 3 to < 5 lakhs (middle) | 20 (31.2) |
| ≥ 5 lakhs (upper-middle and high) | 08 (12.5) |
| Medication adherence | |
| Non-adherent (< 70%) | 30 (46.8) |
| Partially adherent (70–80%) | 20 (31.2) |
| Adherent (>80%) | 14 (21.8) |
| Retinopathy (NPDR) | |
| Normal eye/no NPDR | 20 (31.2) |
| Mild NPDR | 23 (35.9) |
| Moderate NPDR | 10 (15.6) |
| Severe NPDR | 11 (17.1) |

*IHD* ischemic heart diseases, *OHGA* oral hypoglycemic agents, *NPDR* non-proliferative diabetic retinopathy

along with insulin were 22 (33.3%). There are 8 (12.5%) subjects who are current smokers and the remaining are non-smokers. The education levels among subjects were found to be 12 (18.7%) illiterates, 36 (56.2%) higher secondary education or below, and 16 (25%) graduation or above. The annual household income was observed to be 35.9% as a low-income group, 31.2% as lower middle class, and the remaining as upper-middle and above. The subjects who were non-adherent to medications are 30 (46.8%), 20 (31.2%) of them are partially adherent, and 14 (21.8%) are completely adherent to prescribed medications. The eye examination results show that 20 (31.2%) subjects were free from retinopathy and the remaining 44 (68.8%) with non-proliferative diabetic retinopathy (NPDR), among them 23 (35.9%) are with mild NPDR, 10 (15.6%) are with moderate NPDR, and 11 (17.1%) are having severe NPDR.

Table 2 represents continuous variables of metabolic, renal, and other parameters among individuals with poor and fair glycemic control. The observed difference in the mean values of the variables such as age, BMI, B.P, lipid levels, Hb, renal, and electrolytes between the two groups is not statistically significant ($p > 0.05$). The difference in the mean values of duration of history of diabetes and duration of history of hypertension and fasting plasma glucose (FPG) between poor

**Table 2** Metabolic, renal function, and other parameters among both groups

| Parameters | Hba1C ≥ 8%, $N$=30, mean ± SD | Hba1C < 8%, $N$=34, mean ± SD | $p$ value of unpaired $t$ test |
|---|---|---|---|
| Age (yrs) | 58.7 ± 9.2 | 57 ± 7.5 | 0.425 |
| BMI (kg/m$^2$) | 26.8 ± 4.6 | 26 ± 3.9 | 0.459 |
| SBP (mm of Hg) | 143 ± 18.7 | 151 ± 15.8 | 0.072 |
| DBP (mm of Hg) | 83.6 ± 9.1 | 87.6 ± 10.4 | 0.106 |
| Duration of BP (yr) | 9.7± 6.1 | 7.2 ± 3 | 0.048* |
| Duration of DM (yr) | 12.9 ± 7.1 | 8.3 ±3.5 | 0.003* |
| FPG (mg/dL) | 196.3 ± 51.8 | 160.3 ± 32.9 | 0.002* |
| TC (< 200 mg/dL) | 185.8 ± 62 | 181.2 ± 37.2 | 0.727 |
| HDL (> 40 mg/dL) | 41.4 ± 8.6 | 37.6 ± 7.8 | 0.075 |
| LDL (< 100 mg/dL) | 118.9 ± 57.6 | 115.3 ± 34.9 | 0.772 |
| TG (< 150 mg/dL) | 199.9 ± 83.8 | 187.5 ± 76.4 | 0.540 |
| Hemoglobin (11.5–15.5 g/dL) | 12.1 ± 1.8 | 12.4 ± 1.4 | 0.543 |
| eGFR (mL/min/BSA) | 56.5 ± 11.4 | 60.7 ± 9.9 | 0.129 |
| Scr (0.55–1.02 mg/dL) | 1.38 ± 0.2 | 1.33± 0.2 | 0.501 |
| BUN (7–20 mg/dL) | 19 ± 4.8 | 16.7 ± 3.3 | 0.039* |
| Serum potassium (3.5–5.1 mmol/L) | 4.65 ± 0.6 | 4.2 ± 0.5 | 0.005* |
| Serum albumin (3.5–5.0 g/dL) | 3.8 ± 0.6 | 4.0 ± 0.4 | 0.266 |
| Serum sodium (136–145 mmol/L) | 135.7 ± 5.2 | 137.3 ± 10.7 | 0.436 |

All values of mean ± SD are $p$ <0.05 which were considered statistically significant

*Indicate the level of significance as the $p < 0.05$.

**Table 3** Association between retinopathy (NPDR) and HbA1C

| HbA1C | NPDR | | OR | 95% CI | *p* value |
|---|---|---|---|---|---|
| | Yes | No | | | |
| HbA1C ≥ 8% *n* =30 (%) | 25 (83.3) | 5 (16.6) | 3.95 | 1.22, 12.78 | 0.018* |
| HbA1C < 8% *n*=34 (%) | 19 (55.8) | 15 (44.1) | | | |

The *p* value <0.05 was considered statistically significant

*Indicate the level of significance as the $p < 0.05$.

and fair glycemic control groups is statistically significant ($p< 0.05$).

Table 3 indicates the categorical variables of subjects with NPDR and without NPDR in both poor and fair glycemic control groups. The observations suggest that subjects with poor glycemic control were more likely to have NPDR (83.3%) as compared to fair glucose control. Therefore, a statistically significant ($p <0.05$) association was observed between the group with poor glycemic control and occurrence of NPDR. The poor glycemic control group was 3.95 times more at risk of developing NPDR than that of the group with fair glycemic control (odds ratio.3.95). However, the 95% confidence levels showed that the risk of such occurrence is not less than 1.22 and not more than 12.78 respectively.

Table 4 shows eGFR and poor glycemic control. There is no statistical difference in the reduction of eGFR mL/min/BSA between poor and fair glucose control groups ($p> 0.05$). This could have occurred by chance or other factors.

Table 5 represents the association between diabetic nephropathy (DN) (UACR, mg/g) in both groups. There is a statistically significant association between the development of severe diabetic nephropathy (UACR >300 mg/dL) among the poor glycemic control group ($p< 0.05$) compared with the fair glycemic control group. In addition, the chances for the development of moderate DN were observed in 76.4% of the fair glycemic control group and 33.3% of the poor glycemic control group. Subjects with poor glycemic control were 6.5 times at more risk of developing severe DN than the fair glycemic control group (odds ratio.6.5). However, we are 95% confident that the risk is not less than 2.7 and not more than 19.48.

Table 6 depicts the relation between the level of education and annual household income, hypertension, duration of T2DM, and BMI on DR, DN, and glycemic control. All risk factors were significantly associated with NPDR, except B.P and duration of B.P. Severe UACR has strongly associated with all risk factors ($p< 0.001$) except BMI. Poor glycemic control was associated with annual income ($p=0.030$), and other risk factors had no effect on glycemic control. Nearly all risk factors were contributing to develop microvascular complications among screened subjects.

## Discussion

T2DM is a deceptive illness with a preclinical asymptomatic phase of many years. During this, the body is exposed to ill effects of asymptomatic hyperglycemia. The findings in this study were observed in a small population; in our findings, mean duration of T2DM 12.9 ± 7.1 years and duration of B.P 9.7 ± 6.1 years and FPG 196 ± 51.8 and 160.3 ± 32.9 mg/dL are considered as major risk factors for poor glycemic control among screened subjects. A significant association was observed between the duration of diabetes ($p< 0.05$) and the development of microvascular complications, and the duration of B.P showed no significance.

Hung et al. [17] reported that increased duration of DM > 8 years had DR and DN, which also progresses to end-stage renal disease (ESRD). Raman et al. [7] in a study about predictors for diabetic retinopathy stated that the prevalence of diabetic retinopathy was 18% in an urban population with diabetes mellitus in India and the duration of diabetes is one of the strongest predictors for the same. In our study, we observed the relationships between NPDR 83.3% in the poor glycemic control group as compared with the fair glycemic control group 55.8%, and

**Table 4** Association between eGFR and HbA1C

| HbA1C | eGFR, 59–30 mL/min/BSA | eGFR, 89–60 mL/min/BSA | *p* value |
|---|---|---|---|
| HbA1C ≥ 8% *n* =30 (%) | 16 (53.3) | 14 (46.6) | 0.3148 |
| HbA1C < 8% *n*=34 (%) | 13 (38.2) | 21 (61.7) | |

The *p* value <0.05 was considered statistically significant

**Table 5** Association between UACR and HbA1C

| HbA1C | UACR, > 300 mg/g | UACR, 30–300 mg/g | OR | 95% CI | *p* value |
|---|---|---|---|---|---|
| HbA1C ≥ 8% *n* =30 (%) | 20 (66.6) | 10 (33.3) | 6.5 | 2.7, 19.-48 | 0.0005** |
| HbA1C < 8% *n*=34 (%) | 08 (23.5) | 26 (76.4) | | | |

The *p* value <0.05 was considered statistically significant

**Indicate the level of significance as the $p < 0.05$.

**Table 6** Association between literacy levels, socioeconomic status, B.P, duration of B.P, duration of T2DM and BMI and DR, DN, and HbA1c

| Parameters | | *N* = 64 (%) | NPDR | | *p* value | UACR, mg/g | | *p* value | HbA1c, % | | *p* value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Yes, *N*=44, (%) | No, *N*=20, (%) | | >300, *N*=28, (%) | 30–300, *N*=36, (%) | | ≥ 8%, *N*=30, (%) | <8, *N*=34 (%) | |
| Level of education | Illiterate | 12 (18.75) | 12 (27.2) | 0 (00) | 0.001 | 12 (42.8) | 0 (00) | <0.001*** | 8 (26.6) | 4 (11) | 0.074 |
| | 10+2 or below | 36 (56.25) | 26 (59) | 10 (50) | | 16 (57.1) | 15 (41.6) | | 18 (60) | 18 (52.9) | |
| | UG/PG/Ph.D | 16 (25) | 06 (13.6) | 10 (50) | | 0 (00) | 21 (58.3) | | 4 (13.3) | 12 (35.2) | |
| Income Rs. Lakhs | < 1.5 | 23 (35.9) | 18 (40.9) | 5 (25) | <0.001*** | 18 (64.2) | 7 (19.4) | <0.001*** | 12 (40) | 11 (32.3) | 0.030 |
| | 1.5–3 | 13 (20.3) | 12 (27.2) | 1 (5) | | 5 (17.8) | 8 (22.2) | | 6 (20) | 7 (20.5) | |
| | 3–5 | 20 (31.2) | 7 (15.9) | 13 (65) | | 0 (00) | 19 (52.7) | | 6 (20) | 14 (41.1) | |
| | >5 | 08 (12.5) | 7 (15.9) | 1 (5) | | 5 (17.8) | 2 (5.5) | | 6 (20) | 2 (5.8) | |
| Blood pressure | Hypertension | 51 (79.6) | 36 (81.8) | 15 (75) | 0.523 | 21 (75) | 30 (83.3) | <0.001*** | 23 (76.6) | 28 (82.3) | 0.572 |
| | Normotension | 13 (20.4) | 8 (18.8) | 5 (25) | | 7 (25) | 6 (20) | | 7 (23.3) | 6 (16.6) | |
| Duration of B.P (years) | <5 | 9 (14) | 6 (13.6) | 3 (15) | 0.101 | 1 (3.5) | 8 (22.2) | <0.001*** | 3 (10) | 6 (16.6) | 0.176 |
| | 5–10 | 43 (67) | 26 (59) | 17 (85) | | 19 (67.8) | 24 (66.6) | | 18 (60) | 25 (73.5) | |
| | 11–15 | 7 (10.9) | 7 (15.9) | 0 ( 0) | | 5 (17.8) | 2 (5.5) | | 5 (16.6) | 2 (5.8) | |
| | 16–20 | 4 (6.2) | 4 (9) | 0 (0) | | 2 (7.1) | 2 (5.5) | | 3 (10) | 1 (2.9) | |
| | ≥ 21 | 1 (1.5) | 1 (2.2) | 0 (0) | | 1 (3.5) | 0 (0) | | 1 (3.3) | 0 (0) | |
| Duration of T2DM (years) | 5–10 | 43 (67) | 24 (54.5) | 19 (95) | 0.026 | 14 (50) | 29 (80.5) | 0.022 | 16 (53.3) | 27 (9.4) | 0.105 |
| | 11–15 | 9 (14) | 9 (20.4) | 0 (0) | | 4 (14.2) | 5 (13.8) | | 5 (16.6) | 4 (11.7) | |
| | 16–20 | 9 (14) | 8 (18.8) | 1 (5) | | 7 (25) | 2 (5.5) | | 6 (20) | 3 (8.8) | |
| | 21–25 | 1 (1.5) | 1 (2.2) | 0 (0) | | 1 (3.5) | 0 (0) | | 1 (3.3) | 0 (0) | |
| | ≥ 26 | 2 (3.1) | 2 (4.5) | 0 (0) | | 2 (7.1) | 0 (0) | | 2 (6.6) | 0 (0) | |
| BMI, kg/m$^2$ | 18.5–24.9 | 24 (37.5) | 20 (45.4) | 4 (20) | 0.026 | 10 (35.7) | 14 (38.8) | 0.591 | 10 (33.3) | 14 (38.8) | 0.734 |
| | 25–29.9 | 29 (45.3) | 19 (43.1) | 10 (50) | | 14 (50) | 15 (41.6) | | 15 (50) | 14 (38.8) | |
| | 30–34.9 | 08 (12.5) | 2 (4.5) | 6 (30) | | 2 (7.1) | 6 (16.6) | | 3 (10) | 5 (13.8) | |
| | 35–39.9 | 02 (3.1) | 2 (4.5) | 0 (00) | | 1 (3.5) | 1 (2.7) | | 1 (3.3) | 1 (2.7) | |
| | ≥ 40 | 01 (1.5) | 1 (2.2) | 0 (00) | | 1 (3.5) | 0 (00) | | 1 (1.3) | 0 (00) | |

The $p$ value < 0.05 was considered statistically significant

***Indicate the level of significance as the $p < 0.05$.

the same has been associated with the level of education. The risk of NPDR is nearly 4 times more in poor glycemic control individuals compared with the fair glycemic control group. All 64 subjects exhibited the presence of micro-albuminuria (UACR, mg/g), among them 66.6% of the subjects were with severely increased urine albumin excretion (> 300 mg/g) in the poor glycemic control group and 23.5% in the fair glucose control group. A 33.3% of poor and 76.4% in fair glucose control group individuals exhibited moderately increased urine albumin excretion (30–300 mg/g); our comparison of severe and moderately increased albumin excretion among poor and fair glycemic control groups shows a significant difference; the risk of developing severe micro-albuminuria excretion is 6.5 times more in the poor glycemic control group as compared with the fair glycemic control groups. Similarly, Jitraknatee et al. observed uncontrolled glycemic levels (HbA1c <7% and ≥7%) as the risk factor for patients and may lead to progression leading to chronic kidney disease (CKD) [18]. The glomerular filtration rate was decreased to 59–30 mL/min/BSA in 53.3% of poor and 38.2% of fair glycemic control groups. There is no association between reduction of eGFR and poor glycemic control. The eGFR 89–60 mL/min/BSA was observed in 46.6% of poor and 61.7% of fair glycemic control groups. The risk of reduction of eGFR to 59–30 mL/min/BSA in the poor glycemic control group is 1.8 times as compared with the fair glycemic control group. Kundu et al. [19] reported a significant correlation of HbA1c with both UACR and eGFR and serum creatinine, whereas Kommineni et al. observed a negative correlation between HbA1c and eGFR and a positive correlation with serum creatinine. Good maintenance of glycemic levels prevents its progression to ESRD [20].

The relation between the level of education and annual household income, hypertension, duration of T2DM, and BMI on DR, DN, and glycemic control revealed that the level of education, annual income, duration of T2DM, and BMI contribute to developing NPDR ($p< 0.05$) and severe UACR > 300mg/g, which in turn may be due to hypertension and duration of T2DM ($p< 0.05$). The annual income could have an impact on glycemic control ($p< 0.05$). Sarrafan-chaharsoughi et al. reported an inverse relation between DR and BMI [21]. The results of Kaštelan et al. showed a significant independent association of BMI and the prevalence of DR in type 2 diabetic patients ($p< 0.01$) [22]. Some of the risk factors had a significant association ($p<0.05$) and some were not significant ($p> 0.05$) in progressing microvascular complications and glycemic control. The risk of developing retinopathy and severe UACR in poor glycemic control are OR 1.5, 0.6, and 0.7 times among hypertensives compared to normotensives subjects. Tao et al. [23] and Lee et al. [24] reported that low social-economic status was associated with poor metabolic control and more diabetes complications in adult patients in China. Hypertension alone had not shown any significant association in our study.

Poor glycemic control, low literacy levels, annual household income, duration of diabetes, and obesity or overweight is the major risk factors for the progression of microvascular complications. All subjects were diagnosed with micro-albuminuria, of whom 66.6% (20) of subjects exhibited severe micro-albuminuria in the poor glycemic control group and 23.5% (8) in the fair glycemic control group. The burden of retinopathy was 83.3% (25) in poor glycemic and 55.8% (19) in fair glycemic control group. The obtained results can be considered as recommendations for the patients in rural areas of developing countries. They also need periodic health checkups in addition to promoting awareness about diabetes and its associated comorbid conditions. Self-blood glucose monitoring and lifestyle interventions are vital to prevent the progression of such microvascular complications.

## Conclusion

The level of education, annual income, duration of diabetes, and BMI are the major risk factors for the progression of NPDR and also poor glycemic control, which provokes to microvascular complications. Interventions are needed to regulate glycemic control to prevent or reverse the further progression of these microvascular complications.

### Limitations of the Study

As it is a screening program during the medical camp of rural area, the enrolled subjects were very low; it may not be possible to generalize the observations in large populations.

### Future Perspectives

Large-scale community-based studies are needed to be planned that will give a clear estimate of the odds ratio.

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## Declarations

**Ethics Approval** The study procedure was approved by the Institutional Ethics Committee, Endo-life Specialty Hospital, Guntur, India, and the study was conducted in accordance with the Declaration of Helsinki.

**Consent to Participate** Informed consent was obtained from all subjects prior to screening.

**Conflict of Interest** The authors declare no competing interests.

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