

# Prevalence of Microvascular Complications and Associated Risk Factors among Diabetes Mellitus Patients Attending Nyeri County Referral Hospital, Kenya: A Cross-Sectional Study

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## Abstract

Microvascular complications are one of the major causes of morbidity and mortality worldwide among patients with diabetes mellitus (DM). More than 50% of Nyeri County Referral Hospital (NCRH) admissions result from non-communicable diseases (NCDs) and over 55% of hospital deaths are attributable to NCDs. In Kenya, Nyeri County has the highest prevalence of diabetes mellitus compared to other counties. This study therefore sought to assess the prevalence of microvascular complications and the associated risk factors among patients attending Nyeri County Referral Hospital in Kenya. A hospital-based cross-sectional study was conducted on 314 DM patients on follow-up at NCRH from August 2022 to October 2022. Data were analyzed using STATA version 17. Univariate and multivariate logistic regression analyses are used to determine the risk factors associated with Microvascular complications of DM. Among the 314 participants with DM, 58% were females. The overall prevalence of Microvascular complications (MVCs) is 36.62%. Diabetic peripheral neuropathy was the most frequent complication (27.4%). Inadequate physical exercise was a risk factor for all MVCs. Age, marital status, and level of education were risk factors for neuropathy while smoking and alcohol intake were risk factors for nephropathy. Non-smokers were 98% less likely to have nephropathy (OR = 0.024; 95% CI 0.003 - 0.145). The odds of those who exercise once weekly getting retinopathic complications reduced by 83% (OR = 0.18, 95% CI 0.049 - 0.398) compared to those who exercise daily. The findings highlight the implication of lifestyle factors in the development of MVCs among DM patients. Therefore, benefits of micro-

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vascular complications prevention should thus be factored into the management of patients with diabetes mellitus.

### Keywords

Diabetes Mellitus, Microvascular Complications, Risk Factors, Retinopathy, Neuropathy, Nephropathy

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## 1. Introduction

Diabetes mellitus is a major global health challenge, exerting a disproportionate impact on economic and health outcomes, particularly in low- and middle-income countries (LMICS) [1]. Diabetic complications are usually divided into two main categories, Macrovascular, and Microvascular complications. Diabetes macrovascular complications include coronary artery disease (CAD), heart failure, peripheral arterial disease, stroke, myocardial infarction among others. Microvascular complications such as Diabetes retinopathy, nephropathy, and peripheral neuropathy are the most common complications of diabetes [2].

The global prevalence of these Microvascular complications varies considerably. This is attributable to the population characteristics, screening and treatment methods used in different regions [3]. Diabetes peripheral neuropathy (DPN) is the most common Microvascular complication across all the regions. Globally the prevalence it is estimated to be 18.8%, while Africa has a prevalence of 14.5% [4]. The prevalence of diabetes retinopathy (DR) is estimated to be 35%; out of this 12% are at risk of losing eye sight. Likewise, between 10% and 67% of patients with different levels of renal failure and renal disease are attributed to diabetes. More than 80% of end-stage renal disease (ESRD) is caused by diabetes [5].

The African Region is projected to experience a significant surge in diabetes cases, with an expected increase of 48% by 2030 and 143% by 2045. In 2019, diabetes was responsible for 6.8% of mortality, primarily affecting individuals under 60 years old. A considerable proportion of these deaths occur in LMICs, accounting for 41.8% and 58.2% respectively. Approximately 19.4 million adults aged 20 - 79 years are estimated to have diabetes, yet a staggering 59.7% of them remain undiagnosed, likely contributing to the region's low reported prevalence. Among the reported cases, 8.8% are aged between 65 - 69 years, with 5.9% residing in urban areas and 2.4% in rural areas. [5].

About 2.4% of Kenyan population are diabetic, 3.1% are pre-diabetic and a substantial proportion of 52.8% people with undiagnosed diabetes are at risk of developing complications. Only 21.3 % of the patients with diabetes reported to be on treatment. Glycemic control was achieved in 7% of the patients on treatment [6]. These low glycemic control levels could result in the development of complications and premature deaths. The burden of non-communicable diseases continues to increase in Nyeri County having a diabetes prevalence of 6.4%

which is almost triple of national prevalence. Two out three deaths reported in Nyeri are attributed to NCDs. Besides, the prevalence of chronic kidney disease (CKD) stages 3 to 5 in this adult population who are above 30 years, with type 2 diabetes, is 39.0% [7]. As the prevalence of diabetes continues to rise and the burden of diabetic Microvascular complications will increase in the future. People with diabetes have an increased risk of developing Microvascular complications, which, if undetected or left untreated, can have a devastating impact on quality of life and place a significant burden on health care costs [8].

Therefore, this study assessed the prevalence of diabetes Microvascular complications and associated risk factors among diabetes mellitus patients attending Nyeri County Referral Hospital, Kenya.

## **2. Methodology**

### **2.1. Study Area**

The study was carried out in Nyeri County Referral Hospital (NCRH) in Nyeri County, Kenya. Nyeri County is one of the 47 counties in Kenya and is located in the central highlands of Kenya. It had a population of 759,164 (Male – 49%, Female – 51%) in 2019 and has an annual growth rate of 0.8%. The main economic activity is agriculture with cash crop being tea and coffee. Other sources of livelihood include; maize, potato, cabbage and dairy farming. Nyeri County has a diabetes prevalence of 6.4% which is almost triple of national prevalence.

NCRH is the only level 5 referral hospital in the county and serves a population of over 800,000 from within the county and neighboring counties. It is a 407-bed facility, providing in-patient and outpatient care. The predominant diseases seen among the adults are Cancer, Diabetes, Hypertension and HIV.

### **2.2. Study Design**

A hospital based cross-sectional study was carried out at NCRH's Diabetic Clinic and Diabetes Outpatient Clinic (DOPC) from August 8th, 2022, to October 31st, 2022. The diabetes clinic operates on weekdays, while the DOPC is only operational on Friday. Both clinics offer comprehensive general healthcare services to patients with diabetes mellitus.

### **2.3. Study Participants**

First, we estimated the population seeking diabetes care in Nyeri county referral hospital. According to the hospital health records and information department, there were about 2000 adults on follow-up for diabetes. We used systematic random sampling to recruit diabetes patients aged at least 18 years on follow-up and treatment for at least six months in NCRH in the DOPC. Participants with a complete follow-up and management documentation in the file were included. Eleven participants were excluded from the study due to incomplete documentation about their previous treatment and follow-up, two participants with gestational diabetes were excluded.

## 2.4. Data Collection

Data was collected from all eligible and consenting participants using a validated researcher administered semi structured questionnaire for a period of three months from August 8th, 2022, to October 31st, 2022. four research assistants were assigned to the clinics to identify eligible participants and administer questionnaires to the respondents.

## 2.5. Study Tool

Data was collected using a manually filled paper-based questionnaire. Each questionnaire comprised both closed and open-ended questions regarding demographic factors (such as age, gender, marital status, education type, and ethnicity), socio-economic factors (monthly income and social security), bio-clinical information (such as disease duration, treatment, physical activity, systolic and diastolic blood pressure, waist circumference, body mass index (BMI) and risk factors for diabetes microvascular complications. The participants were also examined for presence of any MVC (neuropathy, retinopathy and nephropathy) using standard clinical guidelines for fundoscopy, Tuning fork and monofilament for assessment of reflexes among others. Additionally, biochemical parameters such as random blood sugar, Hb1AC, lipid profile, renal function test, liver function test among others were obtained from the patient's records. Standard and validated protocols were used to classify various biochemical parameters. Finally, details of co-morbidities were obtained from their records as well as from history.

## 2.6. Quality Control

Diabetes research experts were involved to ensure research tools validity. Prior to data collection, we pre-tested the questionnaire for consistency and suitability at a non-participating hospital *i.e.* Murang'a County referral hospital. The test-retest pre-reliability method was used to ascertain consistency of the research tools by administering them on a 10% of the expected sample size twice. The comments and suggestions from the pilot study were used to revise the tool and ensure questions were understandable.

All the research assistants received training emphasizing the significance of informed and voluntary consent, confidentiality, anonymity, and privacy prior to commencement of the study. Additionally, they were involved in a pretesting study three weeks prior to the actual study. During data collection, debriefing meetings were held at the end of each day to review data and identify any omissions and errors.

## 2.7. Sample Size

Sample size was calculated using the Cochran's formula for single population proportion. The prevalence of reported neuropathy, retinopathy and nephropathy in other areas in Kenya is 41, 33 and 0.9% respectively. Based on this finding

from previous studies 41% prevalence rate ( $p$ ) of diabetic neuropathy complication was used in margin of error ( $d$  0.05); and 95% confidence interval. Since the target population was below 10,000 a finite correction formula was applied to get a working sample size of 314 participants. Systemic random sampling was used to collect data from the patients; where the first subject was selected randomly and then every sixth subject was selected for the study till sample size was achieved.

## 2.8. Data analysis

The completed questionnaires were examined by the first author to ensure completeness and consistency of data collected. The data were then entered and cleaned in Microsoft Excel and backed up in external hard drive. The quantitative data were later analyzed using STATA Version 17. Descriptive statistics such as mean, frequency, percentages, means and standard deviation were computed for continuous and categorical variables. Chi-square test was used in analysis of categorical variables to test for associations between independent and dependent variables of the subjects. Logistic regression was used to test the association between significant variables from Univariate and multivariate analysis. Results were expressed as odds ratios (OR) and 95% confidence intervals (CI). A  $p$ -value of  $< 5\%$  was considered statistically significant.

## 2.9. Ethics Statement

This study was conducted according to the research guidelines in the Declaration of Helsinki, and all procedures involving human subjects study participants. Ethical Review Committee of Jomo Kenyatta University of Agriculture and Technology (JKU/2/4/896B), the National Commission for Science Technology and Innovation (NACOSTI/P/22/18990), and the County Director of Health Services in Nyeri County (CGN/HEALTH/HRM/5/VOL.II) prior to data collection. Informed consent both written and oral was obtained from all participants. All study participants were presented with information regarding the purpose of the study, the right to withdraw and measures put in place to ensure confidentiality, and gave their written informed consent.

## 3. Results

### 3.1. Distribution of Microvascular Complications by Socio-Demographic Characteristics of the Study Participants

Out of the 314 diabetes mellitus participants involved in this research, 182 (58%) were female and 132 (42%) were male. The average age of the participants was  $58.49 \pm 17.43$  years, with 66.6% being married. A significant majority of the subjects (90.5%) had completed primary education. Additionally, 79% of all subjects in the study resided in rural areas.

Most of the participants on follow-up at DOPC 68 (43.9%) had microvascular complications compared to those from DM clinic 47 (29.6%). Almost half 73

(46.8%) of the participants aged  $\geq 61$  years old had microvascular complications. Those aged  $\leq 30$  years old were the least affected 4 (15.4%) with 71 (39%) of females affected. More than half of the widowed group and those with no education with 28 (56%) and 18 (60%) respectively had microvascular complications (Table 1).

**Table 1.** Distribution of microvascular complications by Socio demographic characteristics of participants

| Variable           | Description         | Participants with MVCs Freq (n%) | Participants without MVCs freq (n%) | Total |
|--------------------|---------------------|----------------------------------|-------------------------------------|-------|
| Follow Up Clinic   | DOPC                | 68 (43.9)                        | 87 (56.1)                           | 155   |
|                    | DM Clinic           | 47 (29.6)                        | 112 (70.4)                          | 159   |
| Age Group          | $\leq 30$ Years     | 4 (15.4)                         | 22 (84.6)                           | 26    |
|                    | 31 - 45 Years       | 13 (31)                          | 29 (69)                             | 42    |
|                    | 46 - 60 Years       | 25 (27.8)                        | 65 (72.2)                           | 90    |
|                    | $\geq 61$ Years     | 73 (46.8)                        | 83 (53.2)                           | 156   |
| Gender             | Male                | 44 (33.3)                        | 88 (66.7)                           | 132   |
|                    | Female              | 71 (39)                          | 111 (61)                            | 182   |
| Marital Status     | Married             | 78 (37.3)                        | 131 (62.7)                          | 209   |
|                    | Single              | 7 (16.3)                         | 36 (83.7)                           | 43    |
|                    | Divorced/Separated  | 2 (16.7)                         | 10 (83.3)                           | 12    |
|                    | Widowed             | 28 (56)                          | 22 (44)                             | 50    |
| Religion           | Christian           | 114 (36.7)                       | 197 (63.3)                          | 311   |
|                    | Muslim              | 1 (50)                           | 1 (50)                              | 2     |
|                    | Hinduism            | 0 (0)                            | 1 (100)                             | 1     |
| Level Of Education | Primary             | 58 (36.7)                        | 100 (63.3)                          | 158   |
|                    | Secondary           | 26 (28.9)                        | 64 (71.1)                           | 90    |
|                    | Tertiary            | 13 (36.1)                        | 23 (68.9)                           | 36    |
|                    | None                | 18 (60)                          | 12 (40)                             | 30    |
| Occupation         | Government Employee | 0 (0)                            | 7 (100)                             | 7     |
|                    | Private Employment  | 9 (47.4)                         | 10 (52.6)                           | 19    |
|                    | Business            | 21 (40.4)                        | 31 (59.6)                           | 52    |
|                    | Farmer              | 63 (34.4)                        | 120 (65.6)                          | 183   |
|                    | Unemployed          | 22 (41.5)                        | 31 (58.5)                           | 53    |
| Residence          | Rural               | 94 (37.9)                        | 154 (62.1)                          | 248   |
|                    | Urban               | 21 (31.8)                        | 45 (68.2)                           | 66    |
| Ethnicity          | Kikuyu              | 108 (36.7)                       | 186 (63.3)                          | 294   |
|                    | Embu                | 3 (33.3)                         | 6 (66.7)                            | 9     |
|                    | Meru                | 0 (0)                            | 4 (100)                             | 4     |
|                    | Others              | 4 (57.1)                         | 3 (42.9)                            | 7     |

### 3.2. Prevalence of Diabetes Microvascular Complications by Demographic Characteristics

The overall prevalence of microvascular complications (MVCs) is 36.6%. Peripheral neuropathy was the most common complication affecting 86 (27.4%) of the participants; while retinopathy was at 34 (10.8%) and nephropathy was the least 25 (8%). The majority of the respondents with diabetic neuropathy complications were from the DOPC 49 (31.6%) and more common among those aged  $\geq 61$  years 56 (35.9%). More than half 16 (53.3%) of the respondents with diabetic neuropathy had no formal education.

Diabetic nephropathy complication majorly affected 14 (9%) of individuals from the DOPC clinic. It was most common among those aged  $\geq 61$  years 18 (11.5%) and males were more affected 14 (10.6%). Additionally, respondents with no formal education and those with rural residence were more affected at 5 (16.7%) and 22 (8.9%) respectively. DOPC clinic recorded more patients 23 (14.8%) with diabetic retinopathy. Retinopathy complication was most common among those aged  $\geq 61$  years 21(13.5%) and least common 1 (4%) amongst those aged  $\leq 30$  years. Diabetic retinopathy was most prevalent 4 (21.1%) among those in private employment compared to government employees who reported zero prevalence (Table 2).

**Table 2.** Prevalence of Diabetes Microvascular complications by demographic characteristics.

| Characteristic Variable | Type of MVCs       |                 |                 | n          | Total N |     |
|-------------------------|--------------------|-----------------|-----------------|------------|---------|-----|
|                         | Neuropathy (%)     | Nephropathy (%) | Retinopathy (%) |            |         |     |
| Follow Up Clinic        | DOPC               | 49 (31.6%)      | 14 (9%)         | 23 (14.8%) | 155     | 314 |
|                         | DM Clinic          | 37 (23.3%)      | 11 (6.9%)       | 11 (6.9%)  | 159     |     |
| Age Group               | $\leq 30$ Years    | 1 (4%)          | 2 (8%)          | 1 (4%)     | 26      | 314 |
|                         | 31 - 45 Years      | 8 (19%)         | 3 (7.1%)        | 4 (9.5%)   | 42      |     |
|                         | 46 - 60 Years      | 21 (23.3%)      | 2 (2.2%)        | 8 (8.9%)   | 90      |     |
|                         | $\geq 61$ Years    | 56 (35.9%)      | 18 (11.5%)      | 21 (13.5%) | 156     |     |
| Gender                  | Male               | 33 (25%)        | 14 (10.6%)      | 10 (7.6%)  | 132     | 314 |
|                         | Female             | 53 (29.1%)      | 11 (6%)         | 24 (13.2%) | 182     |     |
| Marital Status          | Married            | 57 (27.3%)      | 14 (6.7%)       | 23 (11%)   | 209     | 314 |
|                         | Single             | 5 (11.6%)       | 2 (4.7%)        | 1 (2.3%)   | 43      |     |
|                         | Divorced/Separated | 1 (10%)         | 1 (10%)         | 0 (0%)     | 12      |     |
|                         | Widowed            | 23 (46%)        | 8 (16%)         | 10 (20%)   | 50      |     |
| Religion                | Christian          | 85 (27.3%)      | 25 (8%)         | 34 (10.9%) | 311     | 314 |
|                         | Muslim             | 1 (50%)         | 0 (0%)          | 0 (0%)     | 2       |     |
|                         | Hinduism           | 0 (0%)          | 0 (0%)          | 0 (0%)     | 1       |     |

## Continued

|            |                     |            |            |            |     |     |
|------------|---------------------|------------|------------|------------|-----|-----|
| Education  | Primary             | 42 (26.6%) | 15 (9.5%)  | 16 (10.1%) | 158 | 314 |
|            | Secondary           | 21 (23.3%) | 3 (3.3%)   | 6 (6.7%)   | 90  |     |
|            | Tertiary            | 7 (19.4%)  | 2 (5.6%)   | 6 (16.7%)  | 36  |     |
| Education  | None                | 16 (53.3%) | 5 (16.7%)  | 6 (20%)    | 30  |     |
|            | Government Employee | 0 (0%)     | 0 (0%)     | 0 (0%)     | 7   |     |
| Occupation | Private Employment  | 7 (36.8%)  | 0 (0%)     | 4 (21.1%)  | 19  |     |
|            | Business            | 15 (28.8%) | 5 (9.6%)   | 4 (7.7%)   | 52  | 314 |
|            | Farmer              | 50 (27.3%) | 12 (6.6%)  | 19 (10.4%) | 183 |     |
|            | Unemployed          | 14 (26.4%) | 8 (15.1%)  | 7 (13.2%)  | 53  |     |
| Rural      | 71 (28.6%)          | 22 (8.9%)  | 27 (10.9%) | 248        |     |     |
| Residence  | Urban               | 15 (22.7%) | 3 (4.5%)   | 7 (10.6%)  | 66  | 314 |

### 3.3. Risk Factors Associated with Diabetes Retinopathy, Nephropathy and Neuropathy

Univariate and multivariate analysis revealed that physical exercise, age cohort, marital status and level of education had a significant relationship with neuropathy complications were with P-values of 0.002, 0.001, 0.002 and 0.007 respectively. Further, it showed a significant relationship exists between nephropathy complications and smoking, history of alcohol intake, physical exercise and HBIAC test with p values of 0.001, 0.001, 0.0002 and 0.011 respectively. 0.002, 0.001, 0.002 and 0.007 respectively. Additionally, a significant relationship between retinopathy complications was physical exercise and marital status with p values of 0.013 and 0.033 respectively (Table 3).

### 3.4. Regression Analysis for Risk Factors for Diabetes Microvascular Complications

Controlling for frequency of exercise, marital status and level of education; age cohorts were not significantly associated with neuropathic complications. Similarly holding age cohorts, frequency of exercise and level of education constant, marital status were not significantly associated with neuropathic complications (Table 4).

Holding for age cohorts, frequency of exercise and level of education, the odds of those who are not smoking getting nephropathy reduced by 98% compared to smokers (OR = 0.024, CI 0.003 - 0.192, P= 0001) (Table 5).

Adjusting for marital status, the odds of those who do exercise once weekly getting retinopathy complication reduces by 83% compared to those who do exercise daily (OR = 0.18, 95% CI 0.047 - 0.691, P = 0.012). Controlling for marital status, the odds of those who do exercise 2-3 times a week reduces by 87% compared to those who do exercise daily (OR = 0.14, 95%CI 0.049 - 0.398, P = 0.0001) (Table 6).

**Table 3.** Risk factors associated with diabetes retinopathy, nephropathy and neuropathy among diabetes mellitus patients.

| Variable           | Variable choices   | Type of Complication and P Value |         |                   |         |                   |         |
|--------------------|--------------------|----------------------------------|---------|-------------------|---------|-------------------|---------|
|                    |                    | Neuropathy (%)                   | P value | Nephropathy n (%) | P value | Retinopathy n (%) | P value |
| BMI                | Normal             | 37 (29.6)                        | 0.236   | 10 (%yes)         | 0.633   | 15 (12)           | 0.864   |
|                    | Over weight        | 40 (29.9)                        |         | 13 (9.7)          |         | 15 (11.2)         |         |
|                    | Obese              | 9 (17.6)                         |         | 2 (3.9)           |         | 4 (7.8)           |         |
| Smoke              | Yes                | 3 (17.6)                         | 0.267   | 5 (29.4)          | 0.001   | 0 (0)             | 0.233   |
|                    | No                 | 83 (27.9)                        |         | 20 (6.7)          |         | 34 (11.4)         |         |
| alcohol intake     | Yes                | 4 (23.5)                         | 0.481   | 5 (29.4)          | 0.001   | 1 (5.9)           | 0.705   |
|                    | No                 | 82 (27.6)                        |         | 20 (6.7)          |         | 33 (11.1)         |         |
| physical exercise  | Yes                | 62 (23.8)                        | 0.002   | 15 (5.8)          | 0.002   | 23 (8.8)          | 0.013   |
|                    | No                 | 24 (44.4)                        |         | 10 (18.5)         |         | 11 (20.4)         |         |
| age group          | ≤30 years          | 1 (3.8)                          | 0.001   | 2 (7.7)           | 0.078   | 1 (3.8)           | 0.494   |
|                    | 31 - 45 years      | 8 (19)                           |         | 3 (7.1)           |         | 4 (9.5)           |         |
|                    | 46 - 60 years      | 21 (23.3)                        |         | 2 (2.2)           |         | 8 (8.9)           |         |
|                    | ≥61 years          | 56 (35.9)                        |         | 18 (11.5)         |         | 21 (13.5)         |         |
| Gender             | Male               | 33 (25)                          | 0.249   | 14 (10.6)         | 0.14    | 10 (7.6)          | 0.114   |
|                    | Female             | 53 (29.1)                        |         | 11 (6)            |         | 24 (13.2)         |         |
| marital status     | Married            | 57 (27.3)                        | 0.002   | 14 (6.7)          | 0.142   | 23 (11)           | 0.033   |
|                    | Single             | 5 (11.6)                         |         | 2 (4.7)           |         | 1 (2.3)           |         |
|                    | Divorced/separated | 1 (8.3)                          |         | 1 (10)            |         | 0 (0)             |         |
|                    | Widowed            | 23 (46)                          |         | 8 (16)            |         | 10 (20)           |         |
| level of education | Primary            | 42 (26.6)                        | 0.007   | 15 (9.5)          | 0.078   | 16 (10.1)         | 0.134   |
|                    | secondary          | 21 (23.3)                        |         | 3 (3.3)           |         | 6 (6.7)           |         |
|                    | Tertiary           | 7 (19.4)                         |         | 2 (5.6)           |         | 6 (16.7)          |         |
|                    | None               | 16 (53.3)                        |         | 5 (16.7)          |         | 6 (20)            |         |
| employment         | Private            | 7 (36.8)                         | 0.497   | 0 (0)             | 0.206   | 4 (21.1)          | 0.482   |
|                    | Business           | 15 (28.8)                        |         | 5 (9.6)           |         | 4 (7.7)           |         |
|                    | Farmer             | 50 (27.3)                        |         | 12 (6.6)          |         | 19 (10.4)         |         |
|                    | Unemployed         | 14 (26.4)                        |         | 8 (15.1)          |         | 7 (13.2)          |         |
| HBIAC              | Normal             | 37 (29.6)                        | 0.475   | 4 (3.2)           | 0.011   | 17 (13.6)         | 0.199   |
|                    | Abnormal           | 49 (25.9)                        |         | 21 (11.1)         |         | 17 (9)            |         |

**Table 4.** Regression analysis for risk factors for diabetic neuropathy.

| Multivariate Analysis         |             |         |
|-------------------------------|-------------|---------|
| Independent Variable          | OR (95% CI) | P value |
| Age cohorts (Base-≤ 30 years) |             |         |
| ≤30 years                     | 1           | 1       |

## Continued

|                                    |                       |       |
|------------------------------------|-----------------------|-------|
| 31 - 45 years                      | 0.452 (0.158 - 1.30)  | 0.14  |
| 46 - 60 years                      | 0.731 (0.356 - 1.40)  | 0.392 |
| ≥61 years                          | 1                     | 1     |
| marital status (Base-Married)      |                       |       |
| Single                             | 0.833 (0.251 - 2.764) | 0.765 |
| Divorced/Separated                 | 0.376 (0.044 - 3.189) | 0.37  |
| Widowed                            | 1.49 (0.635 - 3.492)  | 0.359 |
| level of education (Base-Primary)  |                       |       |
| Secondary                          | 1.384 (0.665 - 2.88)  | 0.359 |
| Tertiary                           | 1.183 (0.402 - 3.475) | 0.76  |
| None                               | 1.89 (0.635 - 5.645)  | 0.252 |
| Frequency of exercise (Base-Daily) |                       |       |
| Once weekly                        | 0.812 (0.34 - 1.94)   | 0.252 |
| 2 - 3 times a week                 | 0.537 (0.254 - 1.133) | 0.639 |
| 2 weeks to one month               | 1                     | 1     |
| Only when recommended by HC person | 0.768 (0.072 - 8.22)  | 0.827 |

Table 5. Regression analysis for risk factors for diabetic nephropathy.

| Multivariate Analysis              |                         |         |
|------------------------------------|-------------------------|---------|
| Independent Variable               | OR (95% CI)             | P value |
| Age cohorts (Base-≤ 30 years)      |                         |         |
| ≤30 years                          | 1                       | 1       |
| 31 - 45 years                      | 1                       |         |
| 46 - 60 years                      | 0.226 (0.005 - 9.509)   | 0.435   |
| ≥61 years                          | 4.505 (0.163 - 124.742) | 0.374   |
| level of education (Base-Primary)  |                         |         |
| Secondary                          | 0.278 (0.027 - 2.827)   | 0.279   |
| Tertiary                           | 1.613 (0.203 - 12.84)   | 0.652   |
| None                               | 0.568 (0.078 - 4.13)    | 0.576   |
| Frequency of exercise (Base-Daily) |                         |         |
| Once weekly                        | 4.176 (0.635 - 27.461)  | 0.137   |
| 2 - 3 times a week                 | 0.687 (0.108 - 4.378)   | 0.692   |
| 2 weeks to one month               | 1                       |         |
| Only when recommended by HC person | 1                       |         |
| Smoking (Base-Yes)                 |                         |         |
| No                                 | 0.024 (0.003 - 0.192)   | 0.0001  |
| hb1ac                              | 2.217 (0.509 - 9.653)   | 0.289   |

**Table 6.** Regression analysis for risk factors for diabetic Retinopathy.

| Multivariate Analysis              |                        |         |
|------------------------------------|------------------------|---------|
| Independent Variable               | OR (95% CI)            | P value |
| marital status (Base-Married)      |                        |         |
| Single                             | 0.15 (0.018 - 1.217)   | 0.076   |
| Divorced/Separated                 | 1                      |         |
| Widowed                            | 1.6 (0.51 - 5.02)      | 0.421   |
| Frequency of exercise (Base-Daily) |                        |         |
| Once weekly                        | 0.18 (0.047 - 0.691)   | 0.012   |
| 2 - 3 times a week                 | 0.14 (0.049 - 0.398)   | 0.0001  |
| 2 weeks to one month               | 2.872 (0.165 - 50.111) | 0.469   |
| Only when recommended by HC person | 1                      |         |

#### 4. Discussion

The aim of this study was to determine the prevalence of microvascular complications and their associated risk factors among patients receiving care at Nyeri County Referral Hospital in Kenya. The study revealed an overall prevalence of microvascular complications at 36.6%. Among these complications, peripheral neuropathy had the highest prevalence at 27.4%, followed by retinopathy at 10.8%, and nephropathy at 8%. These results align closely with findings from studies conducted in other low-income countries like Ethiopia, Tanzania, and India [9] [10] [11]. Nevertheless, these findings may vary in terms of specific percentage proportions, with differences potentially attributed to factors such as healthcare accessibility and advancement in different regions, as well as variations in patient adherence to medication and healthcare practices [12].

Univariate analysis revealed significant associations between certain factors and peripheral neuropathy, nephropathy, and retinopathy ( $P < 0.05$ ). Specifically, lower education levels, occupation (e.g., farmers), and rural residency were significantly linked with peripheral neuropathy. Lower education, unemployment, smoking, and rural residency were significantly associated with nephropathy. Additionally, lower education levels, infrequent exercise, and private employment were significantly correlated with retinopathy.

Moreover, all three microvascular complications (MVCs) were found to have higher prevalence rates among patients attending the Diabetes Outpatient Clinic (DOPC) compared to those attending the general diabetes clinic. This disparity in prevalence rates in the DOPC could be attributed to delayed diagnosis, inadequate self-care practices, and suboptimal health-seeking behaviors [13], as the DOPC operates only once per week with longer appointment intervals, whereas the general diabetes clinic operates daily with shorter return dates.

Lower educational attainment emerged as a consistent and independent risk factor for all MVCs. Educational level plays a crucial role in shaping diabetes

awareness, medication compliance, and healthcare-seeking behavior. Studies have consistently demonstrated a higher risk of diabetes complications among individuals with lower educational levels. Moreover, in rural areas of Kenya, agriculture serves as the primary occupation, exposing farmers to foot injuries during work, which could help explain the elevated prevalence of neuropathy among this demographic [10] [14].

The occurrence of Diabetic Peripheral Neuropathy (DPN) and Nephropathy showed associations with residing in rural areas and having lower household incomes. This association could possibly stem from the tendency of individuals with lower socioeconomic status to underutilize healthcare services, leading to delayed diagnosis and inadequate management of DM. Past research has indicated that individuals with lower socioeconomic status tend to exhibit poorer metabolic control of DM. Furthermore, the heightened risk observed among rural residents might be attributed to limited access to superior healthcare facilities that are more readily available in urban areas [15].

Multiple regression analysis indicated that individuals who engage in exercise 2-3 times per week experienced an 87% reduction in the risk of diabetic Retinopathy compared to those who exercise daily (OR = 0.18, 95% CI 0.049 - 0.398, P = 0.0001). Despite compelling evidence linking physical activity to disease status, global adherence to the minimum physical activity recommendations set forth by the American College of Sports Medicine (ACSM) and other Public Health and Exercise Authorities remains low. Physical activity (PA) plays a pivotal role in lifestyle interventions for managing diabetes. Consistent with prior research, this study concurs with findings that demonstrate reduced overall physical activity levels in patients with severe to very severe non-proliferative and proliferative diabetic retinopathy [16] [17].

When adjusting for age cohorts, frequency of exercise, and level of education, non-smokers exhibit a 98% reduction in the odds of developing nephropathy compared to smokers (OR = 0.024; 95% CI 0.003 - 0.145, P = 0.0001). Smoking, a widely recognized and preventable risk factor for numerous diseases, has been consistently identified as an independent risk factor for the onset and progression of diabetic nephropathy. This study emphasizes the robust association between chronic cigarette smoking and diabetic nephropathy. Findings align with various studies suggesting that smoking contributes significantly to the development of high oxidative stress and subsequent hyperlipidemia, accumulation of advanced glycation end products, and activation of the renin-angiotensin system and Rho-kinase, all of which are implicated in the pathogenesis of diabetic nephropathy. Additionally, cigarette smoking among diabetic patients with vascular complications induces a range of pathological changes in the kidney, including thickening of the glomerular basement membrane, mesangial expansion, glomerular sclerosis, and interstitial fibrosis, ultimately leading to end-stage renal failure [18] [19].

## 5. Study Limitations

As a cross-sectional study, this research is limited in its ability to establish causal

relationships and can only infer associations. Additionally, Participants HIV status was not considered during the study and this could also result in bias. However, the study offers valuable insights into the prevalence of microvascular complications (MVCs) and their associated risk factors among patients with diabetes mellitus (DM), which can inform the development of targeted interventions

## 6. Conclusion

In this study, 36.6% of patients with DM exhibited a microvascular complication, with 27.4% percent experiencing neuropathy and 10.8% exhibiting retinopathy. Factors such as physical activity, dietary practices, level of education, clinic of follow-up, and area of residence were found to be associated with these complications. Identifying individuals at risk of microvascular complications can facilitate targeted interventions aligned with the Kenyan government's Non-Communicable Disease (NCD) policy and the Sustainable Development Goal (SDG) 3.4 target, which aims to reduce premature mortality from NCDs through prevention and treatment. Furthermore, public health initiatives should incorporate measures to ensure that health promotion and education regarding chronic conditions like DM are integrated into routine management and care practices.

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## Authors' contribution

Rachael Ireri conceptualized the study, designed the study, collected and analyzed data, interpreted data, prepared and the reviewed manuscript for the final submission. Gideon Kikuvi, Susan Mambo and Besty Cheriro formulated research question and assisted and validated the manuscript for the final submission

## Competing Interests

The authors declare no competing interests.

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