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RESEARCH ARTICLE

Prevalence of microalbuminuria and associated factors among diabetic patients attending a general hospital in Central Uganda

L Kemigisha[1,2], CN Bagenda[1,2*], C Gumoshabe[1,2], P Walusimbi[1,2], A Deborah[1,2], C Nantongo[1,3], H Mudondo[1], E Ssemwanga[4], EA John[1,5], MJ Mugisa[1,6], V Mwesigye[1], JA Wafwoyo[1], LO Osuwat[6], B Musinguzi[7], W Akiteng[7], SP Rugera[1], D Tusubira[8] and R Wagubi[1,9]

[1]*Department of Medical Laboratory Science, Faculty of Medicine, Mbarara University of Science and Technology, Mbarara, Uganda*
[2]*Department of Medical Laboratory Science, Uganda Institute of Allied Health and Management Sciences, Kampala, Uganda*
[3]*Department of Medical Laboratory, Joint Clinical Research Centre, Kampala, Uganda*
[4]*School of Medical Laboratory Technology, Mayanja Memorial Medical Training Institute, Mbarara, Uganda*
[5]*Department of Microbiology and Parasitology, School of Medicine and Dentistry, University of Dodoma, Dodoma, Tanzania*
[6]*Department of Medical Laboratory Science, School of Health Sciences, Soroti University, Soroti, Uganda*
[7]*Department of Medical Laboratory Science, Faculty of Health Science, Muni University, Arua, Uganda*
[8]*Department of Biochemistry, Faculty of Medicine, Mbarara University of Science and Technology, Mbarara, Uganda*
[9]*Department of Medical Laboratory, Mbarara Regional Referral Hospital, Mbarara, Uganda*
**Correspondence: cbagenda@must.ac.ug*

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Introduction: Microalbuminuria is an early indicator of kidney damage and a strong predictor of diabetic nephropathy in diabetic patients. Its prevalence and associated factors vary across populations, necessitating region-specific studies. This study evaluated the prevalence of microalbuminuria and its associated factors among diabetic patients attending a general hospital in Central Uganda.
Methods: From September 2024 to December 2024, a structured questionnaire was used to carry out a descriptive and analytical cross-sectional study among patients with diabetes at Nakaseke General Hospital in Central Uganda. Blood and urine samples from each participant were also analysed for determination of HbA1c, serum gamma glutamyl transferase (GGT), and microalbumin respectively. Microalbuminuria was defined as urine microalbumin levels of 20–200 mg/L. Logistic regression analysis was used to assess associated factors.
Results: Of 298 participants, 220 (73.8%, 95% CI: 68.52–78.52) had microalbuminuria. The majority were females: 193 (64.8%). GGT levels were significantly higher in participants with microalbuminuria: 45.5IU/L (IQR: 33.5–57) than in those with normoalbuminuria: 39.5IU/L (IQR: 29–50), $p = 0.011$. HbA1c levels, indicative of glycaemic control, were noticeably greater in the microalbuminuria group: 8.2% (IQR: 7.2–9.65) as compared with those with normoalbuminuria: 7.6% (IQR: 6.9–9.1), $p = 0.012$. After adjustment for confounders, factors significantly associated with microalbuminuria were HIV-positive status (aOR = 3.20, $p = 0.030$), hypertension (aOR = 4.43, $p = 0.011$), and unemployment status (aOR = 2.32, $p = 0.023$).
Conclusion: Microalbuminuria is prevalent among patients with diabetes. Microalbuminuria is associated with elevated GGT, and HbA1c levels, HIV positivity, hypertension, and unemployment. Screening, more stringent glycaemic and blood pressure control, and targeted interventions are warranted in high-risk groups to prevent the onset of diabetic nephropathy.

Introduction

Microalbuminuria is defined as the urinary excretion of albumin ranging from 30 to 300 mg per day or an albumin-to-creatinine ratio (ACR) of 30–300 mg/g in at least two different spot urine samples.[1,2] It serves as an early marker of diabetic nephropathy (DN), a major contributor to diabetes patients' end-stage renal disease (ESRD).[3–5] In individuals with diabetes mellitus (DM), microalbuminuria is not only an indicator of kidney dysfunction but also a strong predictor of cardiovascular morbidity and mortality.[6] Early detection of microalbuminuria permits prompt interventions such as blood glucose control, blood pressure management, and lifestyle modifications, which can slow the progression to overt nephropathy and reduce associated complications.[7]

The prevalence of microalbuminuria among individuals with diabetes is heterogeneous in the world, with rates ranging between 20% and 40% in industrialised countries.[8] Systematic review has documented a pooled prevalence of 37.1% in sub-Saharan Africa, which testifies to the evolving burden of diabetes and its complications in the region.[9] In East Africa, the prevalence is estimated to be between 9.8% and 54.3% according to a few cross-sectional studies conducted in the region.[9] In Uganda, there are still limited studies that have assessed the factors contributing to burden of microalbuminuria among patients with diabetes.

Several factors contribute to the development of microalbuminuria in patients with diabetes, including poor glycaemic control, hypertension, dyslipidaemia, obesity, and genetic predisposition.[10] Recent evidence suggests that elevated serum gamma-glutamyl transferase (GGT) levels, a marker of oxidative stress and liver injury, correlate strongly with microalbuminuria in patients with diabetes.[11] Inadequate glycaemic control, reflected by elevated glycated haemoglobin (HbA1c) levels, remains a major impetus for diabetic nephropathy as chronic hyperglycaemia leads to glomerular damage through oxidative stress, inflammation, and endothelial dysfunction.[12] Despite these known risk factors, evidence on their role in microalbuminuria among Ugandan diabetic patients remains limited.

Past studies have generally incorporated renal complications in patients with diabetes without a specific focus on

microalbuminuria. Moreover, the relationship between serum concentrations of GGT, glycaemia, and microalbuminuria has not been clearly outlined in diabetic patients in the Ugandan context. The aim of this study was to determine the prevalence and determinants of microalbuminuria including serum GGT and the glycaemic control level in diabetic outpatients in a Central Ugandan general hospital. The findings provide critical data to inform early screening and specific interventions to relieve diabetic nephropathy burden among these individuals.

Methods

Study design, population, site, duration, and sampling technique

A descriptive and analytical cross-sectional study was conducted among diabetic patients at Nakaseke General Hospital between September 2024 and December 2024. Nakaseke Hospital is a public healthcare facility located in Nakaseke town, Nakaseke District, within the Luwero Triangle region. Geographically, the hospital is situated approximately 65 km north-west of Mulago National Referral Hospital and 35 km north-west of Bombo Military Hospital. The hospital provides a range of healthcare services, including diabetes clinics, an antiretroviral therapy (ART) clinic, orthopaedic services, and general medical care. The study involved male and female patients attending the diabetes clinic who provided written informed consent. The clinic primarily serves individuals already diagnosed with diabetes mellitus, including both type 1 and type 2 diabetes mellitus, who are under regular follow-up and receiving diabetic medication. Patients with missing medical history, those with a known diagnosis of kidney disease who were already receiving treatment for the condition, and those with communication impairments were excluded from the study. The participants were recruited consecutively in a manner such that all eligible individuals fulfilling the inclusion criteria were included until an adequate sample size was achieved.

Sample size determination

The Kish–Leslie formula[13] was used to determine the minimum required sample size using the following assumptions; prevalence of microalbuminuria of 22.9% among patients with diabetes,[3] 5% precision and a 95% confidence interval and a Z-statistic of 1.96.

$n = Z^2P(1\text{-}P)/d^2$ where n is required sample size, Z is Z-statistic for a level of confidence, P is hypothesised prevalence, and d is precision.

$n = 1.96^2 \times 0.229(1\text{-}0.229)/0.05^2 = 271.3$.

By considering a 10% non-response rate, the minimum sample size for this study was 298 participants. Therefore, the minimum sample size of 298 study participants was considered for this study.

Study variables

Dependent variable

Microalbuminuria was the primary dependent variable.

Independent variables

The independent variables are categorised as sociodemographic factors, behavioural factors, clinical factors, and HIV and/or ART-related factors. The sociodemographic factors include age, sex, residence, education level, religion, employed status, and marital status. The behavioural factors include smoking status, alcohol consumption, sleep duration, sleep quality, obstructive sleep apnoea, fruit and vegetable intake, and physical activity. Clinical factors will include comorbidities (hypertension, HIV, cardiovascular disease, dyslipidaemia), family history of comorbidities (hypertension, HIV, cardiovascular disease, dyslipidaemia), type of diabetes mellitus (DM), duration with DM, type of DM treatment, adherence to DM medication, family history of DM, anthropometric parameters (body mass index, waist circumference, waist-to-height ratio, waist-to-hip ratio, mid upper-arm circumference), blood pressure, and biochemical parameters (glycated haemoglobin).

Data collection tools, procedures, and operational definitions

A structured questionnaire was used to collect data on the sociodemographic, behavioural, and clinical factors. From medical records, we collected data on the duration of DM, type of DM treatment received, and the presence of chronic comorbid conditions including hypertension, HIV, and cardiovascular disease. Physical activity was assessed using the International Physical Activity Questionnaires (IPAQ) and categorised as < 600 (Low), 600–3 000 (Moderate), and > 3 000 (High) MET-minutes/week.[14] Obstructive sleep apnoea was assessed using the Stop Bang scoring model and classified as high risk and low risk.[15] Furthermore, data on anthropometric parameters (weight, height, waist circumference [WC], and hip circumference [HC]) and blood pressure (BP) were collected from the study participants by a well-trained nurse under the supervision of the principal investigators. In this study, blood pressure was measured using a digital sphygmomanometer, which was determined by taking the mean of two blood pressure readings that were collected five minutes apart. High blood pressure was defined as systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg.[16,17] The weight and height of the participant was measured using a portable weight and height scale. Body mass index (kg/m^2) was calculated from weight and height and was categorised as normal (< 25 kg/m^2), overweight (25–29.9 kg/m^2), and obese (≥ 30 kg/m^2).[18] A non-stretchable Seca Ergonomic Circumference Measuring Tape (Seca GmbH, Hamburg, Germany) was used to measure the waist and hip circumferences. Two circumference readings were taken, and a third measurement was only done if the difference between first two was greater than 3 cm. Waist and hip circumferences were taken as the mean of two or three measurements. High waist circumference was defined as > 80 cm for females and > 94 cm for males.[19] Waist-to-hip ratio was calculated from waist and hip circumferences and considered to be high if ≥ 0.85 for females and ≥ 0.9 for males.[19] Low fruit and vegetable intake was defined as consuming less than five servings of fruit and/or vegetables per day.[20.]

For HbA1c analysis, capillary blood was collected from each participant into a capillary tube, then placed into a test cartridge that was inserted into an Afinion™ HbA1c analyser (Abbott Diagnostics Technologies AS, Oslo, Norway) at Nakaseke Hospital laboratory for glycated haemoglobin level determination. HbA1c was categorised as ≤ 7% (good glycaemic control) and > 7% (poor glycaemic control).[21,22] About 4 mL of venous blood sample was also collected from each of the study participant using red top vacutainers by the principal investigators, left for 15 minutes to clot, then centrifuged to obtain serum and put into cryovials. The serum samples in cryovials were properly packaged in dry ice and shipped on the day of

collection to the Uganda Cancer Institute laboratory, a SANAS-accredited facility compliant with International Standard ISO 15189:2022 (Accreditation No. M0921). Serum GGT levels were determined using the Cobas 6000 Roche analyser (Roche Diagnostics Basel, Switzerland), with GGT being one of the twenty accredited chemistry tests. Serum GGT levels were categorised as ≤ 50 U/L and > 50 U/L.[23] The study participants were also requested to provide a urine sample, which was analysed for urine microalbumin using a semi-quantitative urine dipstick method COMBINA 13, a product of Human Diagnostics (Wiesbaden, Germany). Results of a visual reading of COMBINA 13 compared with the fully quantitative immunoturbidimetry laboratory assay show agreement of 97.2% for normal and 95.7% for positive urine specimens. The overall agreement for the presence of microalbumin with a variation of ± one test pad is 98.6%.[24] COMBINA 13 strips were designed for the determination of up to 13 different analytes including microalbumin in human urine to provide diagnostic information on kidney disorders, liver diseases, urinary tract infections, haemolytic disorders, diabetes, metabolic abnormalities, and problems with the acid-base equilibrium. Test strips were immersed into the urine sample for approximately 2 seconds; excess liquid was stripped off on tissue paper. The developing colour of the microalbumin pad was read within 60 seconds and the pad colour was visually compared with a colour reference chart on the tube. The microalbumin parameter on the strip is designed to capture participants with 10, 30, 80, and 150 mg/L. Microalbuminuria is defined as urine albumin levels between 20 and 200 mg/L.[25,26] A urine sample that resulted in a colour change on the COMBINA 13 strip corresponding to 30, 80, and 150 mg/L but negative for macroalbuminuria was considered to have microalbuminuria.

Statistical analysis

Microsoft Excel (Microsoft Corp, Redmond, WA, USA) was used to double-enter the gathered data, which were exported to STATA version 17 Software for analysis (StataCorp, College Station, TX, USA). Continuous variables were tested for normality using the Shapiro–Wilk normality test and were not normally distributed ($p < 0.05$) except for age. These were summarised using median (interquartile range: IQR) and a nonparametric test; a Mann–Whitney *U* test was used to compare their medians between participants with and without the outcome variable (microalbuminuria) to test whether there were any statistical differences between the two groups. A *p*-value < 0.05 was considered statistically significant. Age was summarised using mean ± standard deviation and the means in the two groups of the outcome were compared using Student's *t*-test. Categorical variables were summarised using frequencies and proportions (percentages).

The proportions of study participants with microalbuminuria and poor glycaemic control together with their 95% confidence intervals were determined by dividing the number of participants with each of the variables by the total number of study participants recruited and was expressed as a percentage and graphically presented using bar graphs. The distribution of microalbuminuria prevalence across the different levels of each of the categorical independent variables was compared using a chi-square test or Fisher's exact test. A *p*-value < 0.05 was considered to be statistically significant.

The studied factors were assessed using logistic regression. Microalbuminuria was the binary dependent variable (0 = absent, 1 = present). All independent variables, at bivariate level, were compared with the dependent variable. The statistically significant prevalence ratios were identified by a *p*-value ≤ 0.2 at the bivariate level, and the associations were evaluated using odds ratios and their 95% CI. The multivariable model evaluated the factors that were statistically and/or clinically significant at this level. Precision, accuracy, and collinearity were adjusted for in the multivariate analysis by dropping some of the variables from the multivariate model without significant loss in the validity of the model. *P*-values ≤ 0.05 were deemed significant for relationships in the final multivariable model. We also used Spearman's rank correlation test to assess the correlation of serum GGT and HbA1c levels with urine microalbumin.

Results

Characteristics of the study participants stratified by albuminuria status

A total of 298 participants with a mean age of 54.66 ± 13.05 years were recruited for this study. There was a significant age difference between participants with and without microalbuminuria: 56.29 vs. 50.08, $p < 0.001$. The majority of the study participants were females: 193 (64.8%), married: 198 (66.4%), Catholic: 97 (32.6%), and resided in rural areas: 176 (59.1%). Significantly higher levels: 45.5 IU/L (IQR: 33.5–57) of GGT were observed in participants with microalbuminuria compared with those with normoalbuminuria: 39.5 IU/L (IQR: 29–50), $p = 0.011$. HbA1c levels, indicative of glycaemic control, were significantly higher in the microalbuminuria group: 8.2% (IQR: 7.2-9.65) as compared with those with normoalbuminuria: 7.6% (IQR: 6.9–9.1), $p = 0.012$. Additionally, participants with lower education levels and unemployment were observed to be significantly more common in the microalbuminuria group: 34.1% vs. 15.4%, $p < 0.001$ and 55.5% vs. 37.2% $p = 0.006$ respectively. The proportion of those with hypertension was significantly higher among participants with microalbuminuria: 119 (54.1%) compared with those with normoalbuminuria: 23(29.5%), $p < 0.001$. High adherence to anti-diabetic medication was observed to be significantly higher in participants with microalbuminuria: 133 (60.5%) compared with those with normoalbuminuria: 44 (56.4%), $p = 0.010$. Further, significantly longer durations of diabetes and anti-diabetes medication were observed among participants with microalbuminuria (6 years vs. 5 years $p = 0.042$ and 6 years vs. 4.5 years, $p = 0.022$, respectively) compared with those with normoalbuminuria. Significantly higher systolic blood pressure and waist-to-height ratio were observed among participants with microalbuminuria ($p = 0.005$ and $p = 0.014$) respectively, as shown in Table 1. Other participant characteristics were evenly distributed in the two groups of albuminuria, $p > 0.05$ as indicated in Table 1.

Proportion of patients with diabetes who have microalbuminuria

Of the 298 participants who were recruited, 220 (73.8%) had microalbuminuria, giving an overall prevalence of 73.8% with a 95% CI of 68.52–78.52 as shown in Figure 1 and Table 2. The prevalence of microalbuminuria significantly increased with age, being highest among participants aged 60 years and above (81.0%), followed by those aged 50–59 years (76.7%), 40–49 years (71.8%), and lowest among those below 40 years (50.0%) ($p = 0.002$). The prevalence of microalbuminuria was also significantly higher among participants with elevated GGT levels (> 50 IU/L) compared with those with lower GGT levels (82.7% vs. 68.7%, $p = 0.007$). Educational attainment was

Table 1: Characteristics of the study participants stratified by albuminuria status

Variable	Total N = *298*	Albuminuria status		Statistical test	p-*value*
		Normalbuminuria $n_1 = 78$	**Microalbuminuria $n_2 = 220$**		
Age (years): mean (SD)	54.66 (13.05)	50.08 (13.39)	56.29 (12.57)	Student's *t*-test	< **0.001**
Gender:				Chi-square test	0.68
Male	105 (35.2%)	26 (33.3%)	79 (35.9%)		
Female	193 (64.8%)	52 (66.7%)	141 (64.1%)		
Gamma glutamyl transferase: median (IQR)	44 (30–56)	39.5 (29–50)	45.5 (33.5–57)	Mann–Whitney *U*	**0.011**
Haemoglobin A1c: median (IQR)	8.2 (7.1–9.6)	7.6 (6.9–9.1)	8.2 (7.2–9.65)	Mann–Whitney *U*	**0.012**
Marital status:				Chi-square test	0.083
Single	18 (6.0%)	6 (7.7%)	12 (5.5%)		
Married/cohabiting	198 (66.4%)	58 (74.4%)	140 (63.6%)		
Separated/divorced	82 (27.5%)	14 (17.9%)	68 (30.9%)		
Education level:				Chi-square test	< **0.001**
No education	87 (29.2%)	12 (15.4%)	75 (34.1%)		
Primary education	89 (29.9%)	24 (30.8%)	65 (29.5%)		
Secondary education	72 (24.2%)	19 (24.4%)	53 (24.1%)		
Tertiary education	50 (16.8%)	23 (29.5%)	27 (12.3%)		
Religion status:				Chi-square test	1.00
Catholic	97 (32.6%)	25 (32.1%)	72 (32.7%)		
Protestant	84 (28.2%)	22 (28.2%)	62 (28.2%)		
Moslem	46 (15.4%)	12 (15.4%)	34 (15.5%)		
Other	71 (23.8%)	19 (24.4%)	52 (23.6%)		
Employment status:				Chi-square test	**0.006**
Unemployed	151 (50.7%)	29 (37.2%)	122 (55.5%)		
Employed	147 (49.3%)	49 (62.8%)	98 (44.5%)		
Residence					0.10
Rural	176 (59.1%)	40 (51.3%)	136 (61.8%)	Chi-square test	
Urban	122 (40.9%)	38 (48.7%)	84 (38.2%)		
Smoking status:				Chi-square test	0.98
Never	231 (77.5%)	61 (78.2%)	170 (77.3%)		
Former	44 (14.8%)	11 (14.1%)	33 (15.0%)		
Current	23 (7.7%)	6 (7.7%)	17 (7.7%)		
Alcohol consumption:				Chi-square test	0.22
Never	167 (56.0%)	43 (55.1%)	124 (56.4%)		
Former	76 (25.5%)	16 (20.5%)	60 (27.3%)		
Current	55 (18.5%)	19 (24.4%)	36 (16.4%)		
IPAQ Total (MET min/week): Median (IQR)	4 823 (1 980–8 262)	5 617 (3 180–9 210)	4 617 (1 708.5–7 965)	Mann–Whitney *U*	0.081
Mean upper-arm circumference (cm): Median (IQR)	25.7 (24–27.8)	25 (24.1–26.7)	26 (24–28)	Mann–Whitney *U*	0.072
Vegetable fruit intake (days):				Chi-square test	0.87
< servings per day	231 (77.5%)	61 (78.2%)	170 (77.3%)		
≥ servings per day	67 (22.5%)	17 (21.8%)	50 (22.7%)		
Days vegetable consumption per week (days):				Chi-square test	0.37
≤ 4 days	238 (79.9%)	65 (83.3%)	173 (78.6%)		
> 4 days	60 (20.1%)	13 (16.7%)	47 (21.4%)		
Hypertension:				Chi-–square test	< **0.001**
No	156 (52.3%)	55 (70.5%)	101 (45.9%)		
Yes	142 (47.7%)	23 (29.5%)	119 (54.1%)		
HIV status				Chi–square test	0.059
Negative	256 (85.9%)	72 (92.3%)	184 (83.6%)		

(*Continued*)

Table 1: Continued.

Variable	Total N = *298*	Albuminuria status		Statistical test	p-*value*
		Normalbuminuria $n_1 = 78$	**Microalbuminuria $n_2 = 220$**		
Positive	42 (14.1%)	6 (7.7%)	36 (16.4%)		
Cardiovascular disease:				Chi-square test	0.22
No	205 (68.8%)	58 (74.4%)	147 (66.8%)		
Yes	93 (31.2%)	20 (25.6%)	73 (33.2%)		
Sleep duration (hours):				Chi–square test	0.10
< 5 h	35 (11.7%)	12 (15.4%)	23 (10.5%)		
5–7 h	190 (63.8%)	42 (53.8%)	148 (67.3%)		
> 7 h	73 (24.5%)	24 (30.8%)	49 (22.3%)		
Sleep quality:				Chi-square test	0.56
Poor	54 (18.1%)	16 (20.5%)	38 (17.3%)		
Moderate	126 (42.3%)	35 (44.9%)	91 (41.4%)		
Good	118 (39.6%)	27 (34.6%)	91 (41.4%)		
Obstructive sleep apnoea:				Chi-square test	0.26
Low risk of OSA	148 (49.7%)	43 (55.1%)	105 (47.7%)		
High risk of OSA	150 (50.3%)	35 (44.9%)	115 (52.3%)		
Family history of hypertension:				Chi-square test	0.17
No	148 (49.7%)	44 (56.4%)	104 (47.3%)		
Yes	150 (50.3%)	34 (43.6%)	116 (52.7%)		
Family history of cardiovascular disease:				Chi-square test	0.74
No	194 (65.1%)	52 (66.7%)	142 (64.5%)		
Yes	104 (34.9%)	26 (33.3%)	78 (35.5%)		
Family history of dyslipidaemia:				Chi–square test	0.094
Yes	103 (34.6%)	33 (42.3%)	70 (31.8%)		
No	195 (65.4%)	45 (57.7%)	150 (68.2%)		
Family history of kidney disease:				Chi-square test	0.85
No	239 (80.2%)	62 (79.5%)	177 (80.5%)		
Yes	59 (19.8%)	16 (20.5%)	43 (19.5%)		
Anti-diabetic medication adherence:				Chi-square test	**0.010**
Low adherence	53 (17.8%)	22 (28.2%)	31 (14.1%)		
Moderate adherence	68 (22.8%)	12 (15.4%)	56 (25.5%)		
High adherence	177 (59.4%)	44 (56.4%)	133 (60.5%)		
Duration with diabetes mellitus (years):	6 (4–10)	5 (2–8)	6 (4–10)	Mann–Whitney *U*	**0.042**
Duration on Diabetes mellitus medication (years): median (IQR)	5 (3–9)	4.5 (2–8)	6 (3–9.5)	Mann–Whitney *U*	**0.022**
Diabetes mellitus medication type:				Chi-square test	0.81
Insulin	15 (5.0%)	3 (3.8%)	12 (5.5%)		
Metformin	184 (61.7%)	48 (61.5%)	136 (61.8%)		
Oral hypoglycaemic agents	58 (19.5%)	14 (17.9%)	44 (20.0%)		
Mixed (insulin & metformin)	41 (13.8%)	13 (16.7%)	28 (12.7%)		
Systolic blood pressure (mmHg): Median (IQR)	124 (118–140)	120 (115–136)	126 (118.5–141)	Mann–Whitney *U*	**0.005**
Diastolic blood pressure (mmHg): Median (IQR)	80 (72–89)	80 (70–87)	80 (72–89)	Mann–Whitney *U*	0.62
Body mass index (kg/m^2): median (IQR)	26.00 (23.62–29.52)	25.67 (23.19–27.92)	26.28 (23.63–29.90)	Mann–Whitney *U*	0.24
Waist circumference (cm): median (IQR)	77.85 (69.20–82.20)	74.50 (68.50–80.20)	78.00 (70.25–82.60)	Mann–Whitney *U*	0.10
Waist-to-hip ratio: median (IQR)	0.93 (0.89–0.96)	0.93 (0.89–0.95)	0.93 (0.89–0.96)	Mann–Whitney U	0.44
Weight-to-hight ratio: median (IQR)	0.47 (0.44–0.51)	0.46 (0.42–0.5)	0.48 (0.45–0.51)	Mann–Whitney *U*	**0.014**

P-values in bold indicate statistically significant findings.

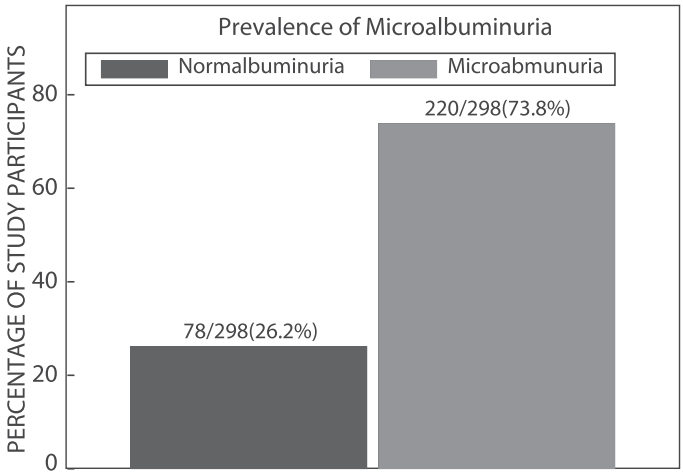


Figure 1: Bar graph showing proportion of diabetic patients with Microalbuminuria.

also associated with microalbuminuria prevalence, where individuals with no formal education showed the highest prevalence (86%, $p < 0.001$). Hypertensive individuals showed a higher prevalence of microalbuminuria (83.8%) compared with non-hypertensive participants (64.7%, $p < 0.001$). Anti-diabetic medication adherence also played a significant role, as those with moderate adherence displayed the highest prevalence of microalbuminuria (82.4%, $p = 0.010$), as shown in Table 2.

According to Spearman's rank correlation test, both GGT: rho = 0.2984 $p = < 0.001$, and HbA1C: rho = 0.3065 $p = < 0.001$ were significantly and positively correlated with urine microalbumin levels as indicated in Figures 2 and 3 respectively.

Following adjustment for confounders, HIV status, hypertension, and employment status were significantly associated with microalbuminuria (Table 3). HIV-positive individuals had significantly higher odds of developing microalbuminuria compared with their HIV-negative counterparts (aOR = 3.20, $p = 0.030$). Similarly, hypertension was strongly associated with microalbuminuria, with hypertensive participants demonstrating more than fourfold increased odds (aOR = 4.43, $p = 0.011$). Employment status also remained significant in the adjusted model, with unemployed individuals showing a more than twofold higher likelihood of microalbuminuria compared with those who were employed (aOR = 2.32, $p = 0.023$).

Discussion

The noted prevalence of microalbuminuria at 73.8% is significantly high, indicating a critical public health concern. This prevalence is notably higher than the overall pooled prevalence of 37.11% reported across various studies in Africa, indicating that diabetic nephropathy and its associated consequences may be more likely to occur in Ugandan patients with diabetes.[9,27] In contrast, studies in Uganda have reported varying rates; for instance, a study at Mulago National Referral Hospital found a prevalence of 13.7% among newly diagnosed patients.[28] In East Africa, microalbuminuria rates vary greatly, with some studies reporting figures as low as 29%.[29] The high prevalence observed in this study could be attributed to several factors, encompassing poor glycaemic control (76.8%), and associated comorbidities such as hypertension (47.7%) and HIV infection (14.1%), which, according to our analysis, are common in this demographic.

GGT levels were significantly higher in participants with microalbuminuria compared with those with normoalbuminuria. Clinically, elevated GGT, often with liver dysfunction, is also associated with oxidative stress, insulin resistance, and inflammation, all of which participate in renal dysfunction.[30–32] This suggests that diabetic patients with elevated GGT are more likely to be associated with microalbuminuria, an early marker of diabetic nephropathy. Though no Ugandan or East African and sub-Saharan African studies were registered, global research supports the association between GGT and diabetes-related kidney disease complications.[33] The study also found that the participants with microalbuminuria had significantly higher HbA1c levels compared with those with normoalbuminuria, indicating poorer glycaemic control in the microalbuminuria group. This agrees with previous evidence of a positive association between high levels of HbA1c and the risk of microalbuminuria.[34] The study found that HIV positivity was significantly associated with microalbuminuria. The biological link between HIV and microalbuminuria is well supported, as HIV infection induces chronic inflammation, while some antiretrovirals contribute to nephrotoxicity, exacerbating renal impairment.[35–38]

Additionally, insulin resistance and metabolic alterations seen in both diabetes and HIV further contribute to the increased risk of kidney dysfunction. Supporting evidence from existing literature consistently shows a higher prevalence of microalbuminuria among HIV-infected individuals compared with non-infected controls, with diabetes and HIV together significantly increasing the likelihood of albuminuria, reinforcing the study's findings.[35.]

Hypertension was strongly associated with microalbuminuria in our study. The biological link between hypertension and microalbuminuria is well established, as persistently high blood pressure can damage renal capillaries, leading to increased permeability and protein leakage into the urine.[39] This mechanism underscores the need for aggressive blood pressure control in individuals with diabetes to minimise renal complications. Supporting evidence from previous studies consistently identifies hypertension as a significant risk factor for microalbuminuria

Table 2: Distribution of the prevalence of microalbuminuria in the different levels of each independent variable

Variable	**Total** N = *298*	**Albuminuria status**		**Statistical test**	p-*value*
		Normalbuminuria $n_1 = 78$	**Microalbuminuria** $n_2 = 220$		
Age group (years):				Chi-square	**0.002**
< 40	38 (12.8%)	19 (50.0%)	19 (50.0%)		
40–49	71 (23.8%)	20 (28.2%)	51 (71.8%)		
50–59	73 (24.5%)	17 (23.3%)	56 (76.7%)		
≥ 60	116 (38.9%)	22 (19.0%)	94 (81.0%)		
Gender:				Chi-square	0.68
Male	105 (35.2%)	26 (24.8%)	79 (75.2%)		
Female	193 (64.8%)	52 (26.9%)	141 (73.1%)		
Gamma glutamyl transferase (U/L):				Chi-square	**0.007**
≤ 50	188 (63.1%)	59 (31.4%)	129 (68.6%)		
> 50	110 (36.9%)	19 (17.3%)	91 (82.7%)		
Haemoglobin A1c:				Chi-square	0.12
≤ 7%, Good	69 (23.2%)	23 (33.3%)	46 (66.7%)		
> 7, Poor	229 (76.8%)	55 (24.0%)	174 (76.0%)		
Marital status:				Chi-square	0.083
Single	18 (6.0%)	6 (33.3%)	12 (66.7%)		
Married/cohabiting	198 (66.4%)	58 (29.3%)	140 (70.7%)		
Separated/divorced	82 (27.5%)	14 (17.1%)	68 (82.9%)		
Education level:				Chi-square	< **0.001**
No education	87 (29.2%)	12 (14%)	75 (86%)		
Primary education	89 (29.9%)	24 (27%)	65 (73%)		
Secondary education	72 (24.2%)	19 (26%)	53 (74%)		
Tertiary education	50 (16.8%)	23 (46%)	27 (54%)		
Religion status:				Chi-square	1.00
Catholic	97 (32.6%)	25 (26%)	72 (74%)		
Protestant	84 (28.2%)	22 (26%)	62 (74%)		
Moslem	46 (15.4%)	12 (26%)	34 (74%)		
Other	71 (23.8%)	19 (27%)	52 (73%)		
Employment:				Chi-square	**0.006**
Unemployed	151 (50.7%)	29 (19.2%)	122 (80.8%)		
Employed	147 (49.3%)	49 (33.3%)	98 (66.7%)		
Residence:				Chi-square	0.10
Rural	176 (59.1%)	40 (22.7%)	136 (77.3%)		
Urban	122 (40.9%)	38 (31.1%)	84 (68.9%)		
Smoking status:				Chi-square	0.98
Never	231 (77.5%)	61 (26.4%)	170 (73.6%)		
Former	44 (14.8%)	11 (25.0%)	33 (75.0%)		
Current	23 (7.7%)	6 (26.1%)	17 (73.9%)		
Alcohol consumption:				Chi-square	0.22
Never	167 (56.0%)	43 (25.7%)	124 (74.3%)		
Former	76 (25.5%)	16 (21.1%)	60 (78.9%)		
Current	55 (18.5%)	19 (34.5%)	36 (65.5%)		
Physical activity (MET min/week):				Chi-square	0.28
< 600	44 (14.8%)	9 (20.5%)	35 (79.5%)		
600–1 500	20 (6.7%)	3 (15.0%)	17 (85.0%)		
> 1 500	234 (78.5%)	66 (28.2%)	168 (71.8%)		
Vegetable fruit intake (per day):				Chi-square	0.87
< servings	231 (77.5%)	61 (26.4%)	170 (73.6%)		
≥ servings	67 (22.5%)	17 (25.4%)	50 (74.6%)		
Vegetable consumption per week (days):				Chi-square	0.37
≤ 4	238 (79.9%)	65 (27.3%)	173 (72.7%)		
> 4	60 (20.1%)	13 (21.7%)	47 (78.3%)		

(*Continued*)

Table 2: Continued.

Variable	Total N = *298*	Albuminuria status		Statistical test	p-*value*
		Normalbuminuria $n_1 = 78$	Microalbuminuria $n_2 = 220$		
Hypertension				Chi-square	< **0.001**
No	156 (52.3%)	55 (35.3%)	101 (64.7%)		
Yes	142 (47.7%)	23 (16.2%)	119 (83.8%)		
HIV status:				Chi-square	0.059
Negative	256 (85.9%)	72 (28.1%)	184 (71.9%)		
Positive	42 (14.1%)	6 (14.3%)	36 (85.7%)		
Cardiovascular disease:				Chi-square	0.22
No	205 (68.8%)	58 (28.3%)	147 (71.7%)		
Yes	93 (31.2%)	20 (21.5%)	73 (78.5%)		
Sleep duration (hours):				Chi-square	0.10
< 5 h	35 (11.7%)	12 (34.3%)	23 (65.7%)		
5–7 h	190 (63.8%)	42 (22.1%)	148 (77.9%)		
> 7 h	73 (24.5%)	24 (32.9%)	49 (67.1%)		
Sleep quality:				Chi-square	0.56
Poor	54 (18.1%)	16 (29.6%)	38 (70.4%)		
Moderate	126 (42.3%)	35 (27.8%)	91 (72.2%)		
Good	118 (39.6%)	27 (22.9%)	91 (77.1%)		
Obstructive sleep apnoea:				Chi-square	0.26
Low risk of OSA	148 (49.7%)	43 (29.1%)	105 (70.9%)		
High risk of OSA	150 (50.3%)	35 (23.3%)	115 (76.7%)		
Family history of hypertension:				Chi-square	0.17
No	148 (49.7%)	44 (29.7%)	104 (70.3%)		
Yes	150 (50.3%)	34 (22.7%)	116 (77.3%)		
Family history of cardiovascular disease:				Chi-square	0.74
No	194 (65.1%)	52 (26.8%)	142 (73.2%)		
Yes	104 (34.9%)	26 (25.0%)	78 (75.0%)		
Family history of dyslipidaemia:				Chi-square	0.094
Yes	103 (34.6%)	33 (32.0%)	70 (68.0%)		
No	195 (65.4%)	45 (23.1%)	150 (76.9%)		
Family history of kidney disease:				Chi-square	0.85
No	239 (80.2%)	62 (25.9%)	177 (74.1%)		
Yes	59 (19.8%)	16 (27.1%)	43 (72.9%)		
Anti-diabetic medication adherence:				Chi-square	**0.010**
Low adherence	53 (17.8%)	22 (41.5%)	31 (58.5%)		
Moderate adherence	68 (22.8%)	12 (17.6%)	56 (82.4%)		
High adherence	177 (59.4%)	44 (24.9%)	133 (75.1%)		
Diabetes mellitus duration (years):				Chi-square	0.063
≤ 5	145 (48.7%)	45 (31.0%)	100 (69.0%)		
> 5	153 (51.3%)	33 (21.6%)	120 (78.4%)		
Diabetes mellitus medication duration (years):				Chi-square	0.068
≤ 5 years	157 (52.7%)	48 (30.6%)	109 (69.4%)		
> 5 years	141 (47.3%)	30 (21.3%)	111 (78.7%)		
Diabetes mellitus medication type:				Chi-square	0.81
Insulin	15 (5.0%)	3 (20.0%)	12 (80.0%)		
Metformin	184 (61.7%)	48 (26.1%)	136 (73.9%)		
Oral hypoglycaemic agents	58 (19.5%)	14 (24.1%)	44 (75.9%)		
Mixed (insulin & metformin)	41 (13.8%)	13 (31.7%)	28 (68.3%)		
Systolic blood pressure (mmHg):				Chi-square	0.16
< 140	219 (73.5%)	62 (28.3%)	157 (71.7%)		
≥ 140	79 (26.5%)	16 (20.3%)	63 (79.7%)		
Diastolic blood pressure (mmHg):				Chi-square	0.30

(*Continued*)

Table 2: Continued.

Variable	Total N = *298*	Albuminuria status		Statistical test	p-*value*
		Normalbuminuria $n_1 = 78$	**Microalbuminuria $n_2 = 220$**		
< 90	232 (77.9%)	64 (27.6%)	168 (72.4%)		
≥ 90	66 (22.1%)	14 (21.2%)	52 (78.8%)		
Body mass index (kg/m^2):				Chi-square	0.37
< 25	118 (39.6%)	31 (26.3%)	87 (73.7%)		
25–29	111 (37.2%)	33 (29.7%)	78 (70.3%)		
≥ 30	69 (23.2%)	14 (20.3%)	55 (79.7%)		
Waist circumference (cm):				Chi-square	0.47
Normal	232 (77.9%)	63 (27.2%)	169 (72.8%)		
High	66 (22.1%)	15 (22.7%)	51 (77.3%)		
Waist-to-hip ratio:				Chi-square	1.00
Normal	65 (21.8%)	17 (26.2%)	48 (73.8%)		
High	233 (78.2%)	61 (26.2%)	172 (73.8%)		
Waist-to-height ratio:				Chi-square	0.31
Normal	208 (69.8%)	58 (27.9%)	150 (72.1%)		
High	90 (30.2%)	20 (22.2%)	70 (77.8%)		

P-values in bold indicate statistically significant findings.

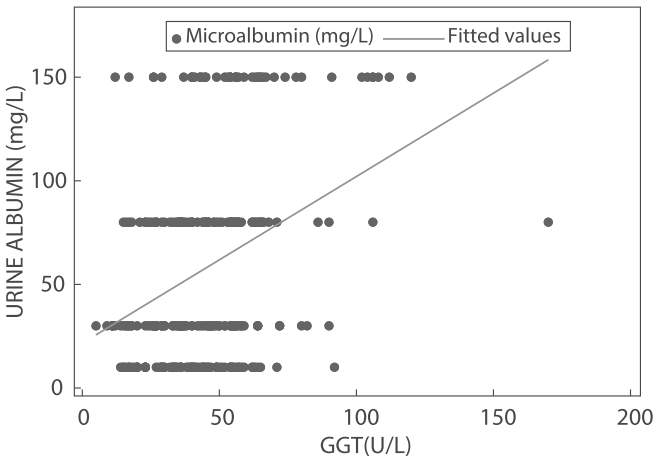


Figure 2: Correlation between GGT and urine albumin.

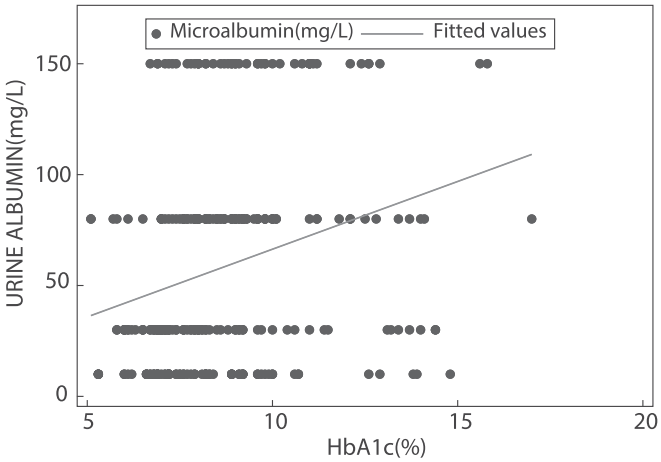


Figure 3: Correlation between HbA1c and urine albumin.

Table 3: Factors associated with microalbuminuria

	Bivariate analysis		Multivariate analysis	
Variable	**cOR (95%CI)**	p-*value*	**aOR (95%CI)**	p-*value*
Gamma glutamyl transferase (U/L):				
50	1.00		1.00	
> 50	**2.19 (1.22–3.92)**	**0.008**	1.60 (0.79–3.23)	0.191
Haemoglobin A1c:				
≤ 7%, Good	1.00		1.00	
> 7, Poor	1.58 (0.88–2.84)	0.125	1.42 (0.69–2.91)	0.341
Gender:				
Male	1.00		1.00	
Female	0.89 (0.52–1.54)	0.682	0.54 (0.22–1.37)	0.196
Age (years):				
< 40	1.00		1.00	
40–49	**2.55 (1.12–5.79)**	**0.025**	2.07 (0.77–5.61)	0.151
50–59	**3.29 (1.43–7.60)**	**0.005**	1.78 (0.62–5.07)	0.281
≥ 60	**4.27 (1.92–9.39)**	**< 0.001**	1.69 (0.54–5.34)	0.369
Marital status:				
Single	1.00			
Married/cohabiting	1.21 (0.43–3.37)	0.720		
Separated/divorced	2.43 (0.78–7.57)	0.126		
Education level:				
No education	1.00		1.00	
Primary education	**0.43 (0.20–0.93)**	**0.033**	0.60 (0.24–1.48)	0.270
Secondary education	**0.45 (0.19–0.99)**	**0.049**	0.81 (0.30–2.19)	0.678
Tertiary education	**0.19 (0.08–0.43)**	**< 0.001**	0.34 (0.11–1.02)	0.055
Religion:				
Catholic	1.00			
Protestant	0.98 (0.50–1.90)	0.949		
Moslem	0.98 (0.44–2.19)	0.968		
Other	0.95 (0.47–1.90)	0.886		
Employment status:				
Employed	1.00		1.00	
Unemployed	**2.10 (1.24–3.58)**	**0.006**	**2.32 (1.12–4.81)**	**0.023**
Residence:				
Rural	1.00			
Urban	0.65 (0.39–1.09)	0.105		
Smoking status:				
Never smoked	1.00		1.00	
Former smoker	1.08 (0.51–2.26)	0.846	0.78 (0.27–2.22)	0.638
Current smoker	1.02 (0.38–2.70)	0.974	0.72 (0.21–2.46)	0.605
Alcohol consumption:				
Never consumed	1.00		1.00	
Former drinker	1.30 (0.68–2.49)	0.429	1.17 (0.49–2.81)	0.726
Current drinker	0.66 (0.34–1.27)	0.209	0.64 (0.26–1.58)	0.335
Physical activity (MET min/week):				
> 1 500	1.00		1.00	
< 600	1.53 (0.70–3.35)	0.291	1.80 (0.31–10.43)	0.513
600–1 500	2.23 (0.63–7.85)	0.213	0.71 (0.27–1.88)	0.492
Vegetable fruit intake (per day):				
< servings	1.00			
≥ servings	1.06 (0.57–1.97)	0.865		
Vegetable consumption per week (days):				
≤ 4	1.00			
> 4	1.36 (0.69–2.67)	0.375		

(*Continued*)

Table 3: Continued.

Variable	Bivariate analysis		Multivariate analysis	
	cOR (95%CI)	p-*value*	**aOR (95%CI)**	p-*value*
Hypertension:				
No	1.00		1.00	
Yes	**2.82 (1.62–4.90)**	**< 0.001**	**4.43 (1.40–14.00)**	**0.011**
Cardiovascular disease:				
No	1.00		1.00	
Yes	1.44 (0.81–2.57)	0.218	0.48 (0.18–1.33)	0.159
HIV status:				
Negative	1.00		1.00	
Positive	2.35 (0.95–5.81)	0.065	**3.20 (1.12–9.18)**	**0.030**
Mid upper-arm circumference (cm)	1.12 (1.01–1.23)	0.028	1.06 (0.92–1.21)	0.421
Sleep duration (hours):				
< 5 h	1.00		1.00	
5–7 h	1.84 (0.84–4.00)	0.125	1.64 (0.62–4.34)	0.315
> 7 h	1.07 (0.45–2.50)	0.884	0.89 (0.31–2.57)	0.833
Obstructive sleep apnoea:				
Low risk of OSA	1.00			
High risk of OSA	1.35 (0.80–2.26)	0.262		
Sleep quality:				
Good	1.00			
Poor	0.70 (0.34–1.46)	0.344		
Moderate	0.77 (0.43–1.38)	0.381		
Family history of hypertension:				
No	1.00		1.00	
Yes	1.44 (0.86–2.43)	0.167	0.61 (0.25–1.47)	0.268
Family history of cardiovascular disease:				
No	1.00			
Yes	1.20 (0.64–1.89)	0.736		
Family history of dyslipidaemia:				
No	1.00			
Yes	1.57 (0.92–2.67)	0.095		
Family history of kidney disease:				
No	1.00			
Yes	0.94 (0.50–1.79)	0.854		
Anti-diabetic medication adherence:				
Low adherence	1.00		1.00	
Moderate adherence	**3.31 (1.45–7.59)**	**0.005**	2.60 (0.98–6.89)	0.055
High adherence	**2.15 (1.13–4.08)**	**0.020**	1.95 (0.87–4.36)	0.106
Diabetes mellitus duration (years):				
≤ 5	1.00		1.00	
> 5	1.64 (0.97–2.76)	0.064	0.94 (0.47–1.89)	0.860
Diabetes mellitus medication duration (years):				
< = 5 years	1.00			
> 5 years	1.63 (0.96–2.76)	0.070		
Diabetes mellitus medication type:				
Insulin	1.00		1.00	
Metformin	0.71 (0.19–2.62)	0.605	0.54 (0.11–2.64)	0.449
Oral hypoglycaemic agents	0.79 (0.10–3.19)	0.736	0.44 (0.08–2.36)	0.336
Mixed (insulin & metformin)	0.54 (0.13–2.24)	0.395	0.47 (0.09–2.55)	0.380
Systolic blood pressure (mmHg):				
< 140	1.00			
≥ 140	1.55 (0.83–2.90)	0.165		

(*Continued*)

Table 3: Continued.

Variable	Bivariate analysis		Multivariate analysis	
	cOR (95%CI)	p-*value*	aOR (95%CI)	p-*value*
Diastolic blood pressure (mmHg):				
< 90	1.00			
≥ 90	1.41 (0.73–2.73)	0.300		
Body mass index (kg/m^2):				
< 25	1.00		1.00	
25–29	0.84 (0.47–1.50)	0.560	0.68 (0.33–1.38)	0.286
≥ 30	1.40 (0.68–2.86)	0.357	1.00 (0.33–3.03)	0.990
Waist circumference (cm):				
Normal	1.00		1.00	
High	1.27 (0.67–2.41)	0.471	0.74 (0.27–2.05)	0.567
Waist-to-hip ratio:				
Normal	1.00		1.00	
High	1.00 (0.53–1.87)	0.997	1.67 (0.59–4.67)	0.331
Waist-to-height ratio:				
Normal	1.00		1.00	
High	1.35 (0.76–2.42)	0.308	1.14 (0.42–3.10)	0.804

P-values in bold indicate statistically significant findings.

and other kidney disease markers.[39,40] Our findings align with these observations across diverse populations, reinforcing the critical need for integrating hypertension management into diabetes care to protect kidney function and prevent further complications.

The study identified a significant association between unemployment and microalbuminuria, suggesting that socioeconomic factors influence diabetes management and kidney health. Clinically, this underscores the need to address socioeconomic disparities to improve access to healthcare services essential for managing chronic conditions like diabetes. Biologically, while unemployment is not directly linked to microalbuminuria, it can introduce stressors that negatively impact health behaviours, such as diet quality and medication adherence, due to financial constraints and limited healthcare access. Although not directly linking unemployment to microalbuminuria, the literature indicates that lower socioeconomic status is associated with a higher prevalence of microalbuminuria.[41] This highlights the broader impact of socioeconomic status on chronic disease management and kidney health.

Conclusion

Microalbuminuria is prevalent among diabetic patients. Microalbuminuria is associated with elevated GGT, and HbA1c levels, HIV positivity, hypertension, and unemployment. Screening, more stringent glycaemic and blood pressure control, and targeted interventions are warranted in high-risk groups to prevent the onset of diabetic nephropathy.

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Ethics considerations – This study was approved by the Faculty Research Committee (FRC) of Mbarara University of Science and Technology with approval number (MUST/MLS/24-16U). Administrative clearance was also obtained from the Officer in Charge, Nakaseke Hospital before conducting the study.

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