

Factors associated with hypertension among diabetic patients at two tertiary Hospitals in Rwanda: a case-control study

Patrick Nsengiyumva

mpatrick0192@gmail.com

University of Rwanda

Eric Iracyahari

Africa Health Sciences University

Emile sebera

Africa Health Sciences University

Leopold Bitunguhali

University of Rwanda

Osee Sebatunzi

University of Rwanda

Damien Urengejeho

University of Rwanda

Florence Masaisa

University of Rwanda

Esubalew Woldeyes Asfaw

King Faisal Hospital Rwanda

Aloys Tuyizere

University of Rwanda

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Abstract

Background

Globally, 60–80% of diabetic patients develop hypertension, leading to increased cardiovascular mortality. In sub-Saharan Africa, including Rwanda, both conditions are on the rise due to urbanization and lifestyle changes. Despite high prevalence, specific risk factors for hypertension in Rwandan diabetic populations remain poorly understood, limiting targeted interventions. This case-control study aimed to identify risk factors for hypertension among diabetic patients at two tertiary hospitals in Rwanda (2020–2024).

Methods

This retrospective matched case-control study was conducted at two tertiary hospitals in Rwanda from January 2020 to December 2024. The cases consisted of diabetic patients with hypertension ($n = 200$), and the controls were diabetic patients without hypertension ($n = 200$), matched for gender. Medical records were reviewed using structured data extraction forms, and we conducted interviews with participants to collect data on lifestyle characteristics. Data analysis employed chi-square tests and multivariate logistic regression using SPSS version 28.0. A p -value of less than 0.05 was considered statistically significant at 95% confidence.

Results

Among eligible 400 participants in outpatient clinic (200 cases, 200 controls), hypertensive diabetic patients were older (60.3 vs 48.6 years), had longer duration of diabetes (12 vs 10 years), poorer glycemic control (HbA1C 9% vs 8%), and worse lifestyle factors including higher smoking rates (21.2% vs 5.2%) and lower physical activity (17.6% vs 43.8%). In multivariate logistic regression analysis, hypertension among diabetic patients was significantly associated with family history of hypertension (aOR = 3.12, 95% CI: 2.43–22.68), elevated creatinine levels $\geq 88 \mu\text{mol/L}$ (aOR = 4.23, 95% CI: 1.02–17.48), smoking (aOR = 2.46, 95% CI: 1.15–14.60), and poor glycemic control (HbA1c > 7%) (aOR = 3.46, 95% CI: 1.96–15.81). Engagement in physical exercise was inversely associated with hypertension (aOR = 0.17, 95% CI: 0.05–0.56). Hypertensive diabetic patients also exhibited higher frequencies of chronic kidney disease and cardiovascular complications compared with controls.

Conclusion

It was revealed that hypertension among diabetic patients is associated with a family history of hypertension, poor glycemic control, elevated kidney function, and smoking, while regular physical exercise has demonstrated a protective effect. These findings support routine risk assessment and

integrated diabetes care in service delivery by targeting these associated factors while promoting physical activity.

Background

Diabetes mellitus and hypertension are two of the most common non-communicable diseases (NCDs) known globally and the leading causes of cardiovascular diseases and all-cause mortality (1, 2). The World Health Organization (WHO) estimates that approximately 1.28 billion adults worldwide have hypertension, with the burden showing a rising trend, particularly in low- and middle-income countries. (1). Similarly, the global burden of diabetes mellitus has reached alarming levels, with 537 million people affected in 2021, a number projected to rise to 783 million by 2045 (3). Diabetes and hypertension, when combined, increase the risk of cardiovascular disease, kidney disease, and premature death (4).

Globally, the prevalence of hypertension in diabetic populations is notably higher, with studies estimating that 60% to 80% of people with diabetes also have hypertension (5). An extensive meta-analysis combining 102 studies concluded that diabetes increases the two-fold risk of cardiovascular disease (CVD), such as coronary artery disease (CAD), stroke, vascular mortality, and hypertension, further increasing the risk (6, 7). Furthermore, hypertension is considered the first CVD-attributable cause of morbidity and mortality among type 2 diabetes mellitus patients (8). Moreover, hypertension worsens diabetic cardiomyopathy and speeds up the development of diabetic kidney disease and cardiovascular disease among diabetic patients (9).

In sub-Saharan Africa, the burden of both hypertension and diabetes keeps rising and is worrisome. It is thought to be due to increasing lifestyle changes, urbanization, adopting the Western diet, and increased life expectancy (10). One systematic review and meta-analysis done for African countries estimated that the prevalence of hypertension was 58.1% in diabetic patients, with Central Africa ranked the highest, with a prevalence of 77%. In this study, they also found that being obese, employed, having a long duration of diabetes, and living in an urban area were associated with a high likelihood of developing hypertension (11).

Rwanda is no exception to this trend, where NCDs, including diabetes and hypertension, are becoming a significant public health concern. According to the WHO, hypertension affects approximately 15.9% of the Rwandan population. This figure is expected to be higher among diabetic patients. It rose to 17.82% by 2025, according to a study done in Rwanda to predict hypertension and its associated factors using the Gibbs sampling method (10, 12). Additionally, studies in Rwanda have highlighted that the majority of hypertensive patients remain undiagnosed or inadequately treated, further compounding the risks associated with comorbidities such as diabetes (13).

Initiating anti-diabetic treatment and maintaining adherence to medical care can lower the risk of developing hypertension by 20–40% and postpone the onset of complications by 4–6 years (14). Studies indicate that each 10 mmHg reduction in mean systolic blood pressure (SBP) decreases the risk of complications and mortality by 12% and 15%, respectively (15). In resource-limited settings such as

Rwanda, diabetes is often diagnosed at advanced stages with existing complications. In Rwanda, the concurrent occurrence of hypertension and diabetes mellitus has increased, driven by factors such as urbanization, shifting lifestyles, and longer life expectancy(16).

While previous studies conducted in various African countries, such as Ethiopia, Nigeria, and Morocco, have documented a high prevalence of hypertension among diabetic patients and explored its associated factors, there remains a significant gap in locally generated evidence from Rwanda (17, 18). The absence of Rwandan-specific data limits the ability to develop contextually appropriate prevention and management strategies that reflect the country's unique demographic, lifestyle, and healthcare dynamics.

In bridging g this gap, this study will compare hypertensive and normotensive diabetic patients attending tertiary hospitals in Rwanda to identify key demographic, clinical, and lifestyle factors contributing to the development of hypertension among diabetic patients. By generating evidence tailored to the Rwandan context, the study aims to inform targeted interventions and strengthen national efforts to reduce the growing burden of cardiovascular and renal complications among individuals living with both diabetes and hypertension.

Study Aim

To identify risk factors for hypertension among diabetic patients by comparing cases (with hypertension) and a control group (without hypertension) at KFHR and CHUK between 2020 and 2024.

Methodology

Study design

This was a retrospective matched case-control study conducted at KFHR and CHUK, which analyzed data from January 2020 to December 2024 in an outpatient clinic setting. Cases were defined as diabetic patients diagnosed with hypertension, while controls were diabetic patients without hypertension, matched for gender.

Study settings

This study was conducted at CHUK and KFHR, Rwanda's two largest tertiary hospitals. Both hospitals offer specialized care for complex cases related to cardiovascular and metabolic disorders, including hypertension, diabetes, and their complications. They serve as referral centers for patients with these conditions under study and are staffed with cardiologists and endocrinologists. Including data from two hospitals enhanced the representativeness of the study findings by capturing a diverse patient population that reflects variations in demographics, healthcare access, and treatment practices across

different settings. Additionally, this approach provided a larger sample size, increasing the statistical power of the analysis and improving the reliability of the results, particularly for subgroup analyses.

Study population

The study population consists of adult patients (≥ 18 years) with confirmed diabetes mellitus who received care at either Kigali University Teaching Hospital (CHUK) or KFHR between January 2020 and December 2024 in the Outpatient Department (OPD). Cases were defined as diabetic patients who had hypertension and were on antihypertensive medication during the study period. Controls were diabetic patients without hypertension, receiving care at the same facilities during the same time period. Patients with incomplete medical records, gestational diabetes, or those diagnosed with hypertension before diabetes were excluded from the study.

Selection criteria

Inclusion criteria

The study included adult patients aged 18 years and above who had been diagnosed with diabetes mellitus (type 1 or type 2) and subsequently developed hypertension, with accessible medical records available for data extraction.

Exclusion criteria

The study excluded patients below 18 years of age, those diagnosed with both diabetes and hypertension at baseline, patients with preexisting hypertension before diabetes diagnosis, pregnant women, and patients with incomplete or inadequate medical records.

Sampling

Sample size calculation

The sample size for this case-control study was determined using the Cochrane formula.

$$n = Z^2 P(1-P)/d^2$$

In this formula,

n is the required sample size

Z represents the degree of 95% confidence level with a Z -value of 1.96,

P denotes the expected proportion of risk factors in the population derived from previous studies (0.59).

d represents the absolute error or precision level (0.05)

Application of this formula yielded a minimum sample size of 372 participants. To account for potential data incompleteness or loss to follow-up, a 10% adjustment was applied, resulting in a final sample size of 400 participants, distributed equally into 200 cases and 200 controls, in a 1:1 matching ratio.

Sampling procedure

A systematic random sampling method was employed to select both cases and controls from the diabetes registries of the CHUK and KFHR. All eligible diabetic patients were sorted chronologically by their date of diagnosis. For each selected case (diabetic patient with hypertension), a matched control (diabetic patient without hypertension) was selected from the same facility, matching for gender to minimize selection bias. If a selected patient's medical records are incomplete, the next eligible patient in the registry is selected as a replacement.

Data collection procedure

Medical records were reviewed to collect data on potential risk factors for hypertension among the diabetic population. First, physical patient registers and clinic record books from the Endocrinology and Internal Medicine outpatient clinics were consulted to identify patients followed for diabetes during the study period (2020–2024). Medical record numbers (MRNs) of eligible patients were recorded from these paper registers. Using the MRNs, electronic medical records were then accessed: CHUK patient records were retrieved from the OpenClinic electronic medical record system, and King Faisal Hospital Rwanda records were retrieved from the SisoHIS / Sisoft hospital information system. A structured data extraction form was used to gather information on socio-demographic characteristics, clinical parameters (including blood pressure readings, blood glucose levels, BMI, etc), medication history, and comorbidities. However, for lifestyle characteristics like smoking status, alcohol drinking status, and doing physical activity, the patients were contacted and interviewed. Two trained research assistants extracted the data independently to ensure accuracy, and any discrepancies were resolved through consultation with a principal investigator.

Variable definition

Dependent variable

The dependent variable in this study is hypertension status among diabetic patients, defined as a binary categorical outcome. In this study, hypertension was defined as a chronic medical condition characterized by persistently elevated blood pressure, operationalized as patients who were on antihypertensive treatment at the time of data collection, as documented in medical records (19). The cases are diabetic patients who were subsequently diagnosed with hypertension, while the controls are diabetic patients without hypertension, matched for gender.

Independent variables

The independent variables comprise demographic, clinical, behavioral, and treatment-related factors hypothesized to influence hypertension risk. Demographic variables include age, sex, marital status, education level, occupation, and residence (urban/rural). Clinical variables encompass body mass index (BMI), duration of diabetes, glycemic control (recent HbA1c level), family history of hypertension, presence of diabetic complications (nephropathy, retinopathy, neuropathy, cardiovascular), and comorbidities. Lifestyle characteristics assessed were smoking status, alcohol drinking, and doing physical activity. Treatment-related variables consist of the type of diabetes treatment (oral hypoglycemic agents, insulin, or combination therapy).

Data analysis

Data analysis was performed using SPSS version 28.0. Descriptive statistics were presented using frequencies and percentages for categorical variables, while means were used for continuous variables depending on their distribution. The chi-square test was used to compare categorical variables between cases and controls. Multivariate logistic regression analyses were conducted to identify significant risk factors for hypertension among diabetic patients. Variables with p-values < 0.05 in the bivariate analysis were included in the multivariate model. Adjusted odds ratios (aOR) with 95% confidence intervals were calculated, and statistical significance was set at $p < 0.05$.

Results

Socio-demographic characteristics of the participants

This study included 400 eligible participants (with 200 in the case group and 200 in the control group). The sociodemographic analysis revealed distinct patterns between diabetic patients with and without hypertension (Table 1). The majority of hypertensive diabetic patients (49.5%) are over 60 years old, with a mean age of 60.3 years, compared to non-hypertensive patients who are more evenly distributed across age groups, with a mean age of 48.6 years. Both groups show an equal gender distribution (55.5% female, 44.5% male) and are predominantly married (84.9–87.8%) and Christian (90.2–92.2%). Educationally, the majority of non-hypertensive patients have secondary education (37.3%), while hypertensive patients predominantly have primary education (38.8%). Occupationally, most non-hypertensive patients are self-employed (34.6%), whereas the majority of hypertensive patients are unemployed (40.1%).

Table 1
Sociodemographic characteristics of the participants

Variables		Control)	Case	Total, n(%)
		n(%)	n(%)	
Mean age (years)		48.6	60.3	
Age group	18–30 years	10(5.9)	0(0)	10(3.6)
	31–40 years	39(23.1)	4(3.8)	43(15.7)
	41–50 years	44(26)	37(35.2)	81(29.6)
	51–60 years	44(26)	60(57.1)	104(38)
	> 60 years	32(18.9)	4(3.8)	36(13.1)
Gender	Male	89(44.5)	89(44.5)	178(44.5)
	Female	111(55.5)	111(55.5)	222(55.5)
Permanent residence	Kigali City	160(80.8)	164(62)	324(81.4)
	Eastern	16(8.1)	10(5)	26(6.5)
	Western	5(2.5)	5(2.5)	10(2.5)
	Northern	6(3)	3(1.5)	9(2.3)
	Southern	11(5.6)	18(9)	29(7.3)
Level of education	No formal education was attended	6(3.8)	36(20.2)	42(12.5)
	Primary education	45(28.5)	69(38.8)	114(33.9)
	Secondary education	59(37.3)	55(30.9)	114(33.9)
	University	46(29.1)	18(10.1)	64(19)
	Others	2(1.3)	0(0)	2(0.6)
Occupation	Self employed	49(34.6)	51(29.6)	100(31.8)
	Unemployed	37(26.2)	69(40.1)	106(37.8)
	Cultivator	17(12.1)	29(16.9)	48(15.3)
	Health care	5(3.5)	3(1.7)	8(2.5)
	Public servant	24(17)	16(9.3)	40(12.7)
	Retired	4(2.8)	4(2.3)	8(2.5)
	Student	2(1.4)	0(0)	2(0.6)
	Others	3(2.1)	0(0)	2(0.6)

Variables		Control) n(%)	Case n(%)	Total, n(%)
Marital status	Single	22(11)	4(2)	26(6.6)
	Married	169(84.9)	173(87.8)	342(86.4)
	Widow	8(4)	20(10.2)	28(7.1)
Religion	Christian	178(92.2)	174(90.2)	352(91.2)
	Muslim	8(4.1)	16(8.3)	24(6.2)
	Others	7(3.6)	3(1.6)	10(2.6)
Hospital	CHUK	97(48.5)	163(82.3)	260(65.3)
	KFHR	103(51.5)	35(17.7)	138(34.7)

Clinical characteristics of the participants

The clinical characteristics reveal distinct patterns between the control and case groups in this study (Table 2). Hypertensive diabetic patients (cases) demonstrated poorer disease control with longer diabetes duration (12 vs 10 years), higher HbA1C levels (9% vs 8%), and significantly elevated blood pressure (148/84 vs 127/78 mmHg). Cases showed worse kidney function with higher rates of elevated urea (55.7% vs 34%) and creatinine levels (73.8% vs 31.1%). Interestingly, hypertensive patients showed higher triglyceride levels (43.1% vs 33.5% above normal). The majority of both groups had Type 2 diabetes, though this was more pronounced in the hypertensive group (95% vs 87%).

Table 2
Clinical characteristics of the participants

Variables		Control	Case	Total, n(%)
		n(%)	n(%)	
Mean duration with diabetes (years)		10	12	
Mean duration from diagnosis of hypertension (years)			6	
Mean HbA1C		8	9	
Mean systolic blood pressure (mmHg)		127	148	
Mean diastolic blood pressure (mmHg)		78	84	
Family history of diabetes	No	97(51.3)	122(64.9)	219(54.8)
	Yes	50(26.5)	51(27.1)	101(25.3)
	Unknown	42(22.2)	15(8)	57(14.2)
Family history of hypertension	No	124(65.3)	141(76.6)	265(66.3)
	Yes	19(10)	28(15.2)	47(11.8)
	Unknown	47(24.7)	15(8.2)	62(15.5)
Type of diabetes	DM Type 1	26(13)	10(5)	36(9)
	DM Type 2	174(87)	190(95)	364(91)
Statins or lipid-lowering medications (eg, atorvastatin, Crestor, turbovas, ...)	No	107(53.8)	73(38.5)	180(45.1)
	Yes	92(46.2)	127(63.5)	219(54.9)
Recent HbA1C level	<=7%	59(31.1)	73(37.2)	132(34.2)
	> 7%	131(68.9)	123(62.8)	254(65.8)
Random blood sugar	<=10 mmol/l	97(63.4)	131(69.3)	228(66.7)
	> 10 mmol/l	56(36.6)	58(30.7)	114(33.3)
Total cholesterol level	<=6.1	144(87.8)	150(95.5)	294(91.6)
	> 6.1	20(12.2)	7(4.5)	27(8.4)
LDL Level	<=1.8 mmol/l	34(19)	38(20.3)	72(19.7)
	> 1.8 mmol/l	145(81)	149(78.7)	294(80.3)
HDL Level	< 1 mmol/l	83(46.4)	86(46)	169(46.2)
	>=1 mmol/l	96(53.6)	101(54)	197(53.8)

Variables		Control	Case	Total, n(%)
		n(%)	n(%)	
Triglyceride level	< 1.7	109(66.5)	95(56.9)	204(61.6)
	>=1.7	55(33.5)	72(43.1)	127(38.4)
Urea level	< 7.2	70(66)	27(44.3)	97(58.1)
	> 7.2	36(34)	34(55.7)	70(41.9)
Creatinine level	< 88	73(68.9)	16(26.2)	89(53.3)
	>=88	33(31.1)	45(73.8)	78(46.7)
Comorbidities	HIV	5(2.5)	7(3.5)	12(3.6)
	Hepatitis B	1(0.5)	1(0.5)	2(0.6)
	Hepatitis C	0(0)	1(0.5)	1(0.3)
	Thyroid disorder	6(3)	3(1.5)	9(2.7)
	Dyslipidemia	5(2.5)	2(1)	7(2.1)
	None	128(64)	172(86)	300(90.6)
	Others	19(9.5)	3(2.5)	12(3.6)
Body mass index	Underweight	0(0)	3(0.9)	3(0.9)
	Normal weight	57(28.5)	38(31.9)	95(29.8)
	Overweight	88(44)	131(41.1)	131(41.1)
	Obese	55(27.5)	35(29.4)	90(28.2)

Lifestyle characteristics of the participants

The lifestyle characteristics revealed significant differences between control and case groups across multiple risk factors (Table 3). Smoking prevalence was substantially higher among cases (21.2%) compared to controls (5.2%), representing a fourfold increase in tobacco use. Similarly, alcohol consumption was more prevalent in the case group (36.2%) versus controls (25.3%), indicating a notable difference in drinking patterns. Most strikingly, participation in physical exercise showed a dramatic disparity, with only 17.6% of cases engaging in physical activity compared with 43.8% of controls.

Table 3
Lifestyle characteristics of the participants

Variables		Control	Case	Total, n(%)
		n(%)	n(%)	
Smoking	No	165(94.8)	145(78.8)	310(86.6)
	Yes	9(5.2)	39(21.2)	48(13.4)
Alcohol use	No	130(74.7)	118(63.8)	248(61.9)
	Yes	44(25.3)	67(36.2)	111(30.9)
Physical exercises	No	95(56.2)	150(82.4)	245(69.8)
	Yes	74(43.8)	32(17.6)	106(30.2)

Medication for diabetes and hypertension management

Based on the medication data from this case-control study examining hypertension risk factors among diabetic patients, several key patterns emerge regarding treatment complexity and medication use (Table 4). Diabetic patients with hypertension (cases) demonstrated significantly more intensive diabetes management compared to diabetic patients without hypertension (controls), with cases more frequently receiving advanced combination therapies such as triple therapy (14.2% vs 1.3%), SGLT2 inhibitors (9.9% vs 1.9%), and Galvus monotherapy (11.7% vs 3.8%), while controls were more likely to be on simpler regimens like metformin alone (31% vs 4.9%) or no diabetes medication at all (16.5% vs 1.2%). Additionally, all hypertensive diabetic patients were appropriately receiving antihypertensive medications, with ACE inhibitors/ARBs being the most common first-line treatment (27.8%), followed by combination therapies including CCB + ARB combinations (25.9%) and triple combinations with diuretics (17.3%), suggesting that diabetic patients who develop hypertension require more complex, multi-drug therapeutic approaches for both conditions.

Table 4
Recent medication taken by the participants.

Medication Category	Control, n(%)	Case, n(%)
Diabetic Medications		
Insulin Only	26 (16.5)	25 (15.4)
Insulin + Metformin	10 (6.3)	22 (13.6)
Metformin + DPP4i (Galvusmet/Sitamet)	24 (15.2)	23 (14.2)
Metformin + Sulfonylurea (Diamicron/Daonil/Amaryl)	8 (5.1)	9 (5.6)
SGLT2i (Forxiga/Dapzin)	3 (1.9)	16 (9.9)
Galvus (Vildagliptin)	6 (3.8)	19 (11.7)
Triple Therapy (Galvus Met + Diamicron + Forxiga)	2 (1.3)	23 (14.2)
Metformin Only	49 (31)	8 (4.9)
Complex Combinations	4 (2.5)	15 (9.3)
No Diabetes Medication	26 (16.5)	2 (1.2)
Anti-Hypertensive Medications		
ACE Inhibitors/ARBs (Losartan, Captopril, Valsartan, Telmisartan)		45 (27.8)
CCB + ARB Combinations (Exforge)		42 (25.9)
CCBs (Nifedipine, Amlodipine)		15 (9.3)
Triple Combinations (CCB + ARB+Diuretic)		28 (17.3)
ARB + Diuretic (Losartan-H, Telmi-H)		22 (13.6)
Other Regimens		10 (6.2)

Factors associated with hypertension among diabetic patients with hypertension (cases) and diabetic patients without hypertension (controls)

1. **1. Bivariate analysis of the factors associated with hypertension among the participants.**
2. **1.1 Bivariate analysis for the sociodemographic factors associated with hypertension among the participants.**

Based on the bivariate analysis of sociodemographic factors (Table 5), only marital status showed a statistically significant association with hypertension among diabetic patients ($\chi^2 = 17.64$, $p < 0.001$).

Table 5
Bivariate analysis for the sociodemographic factors associated with hypertension among the participants.

Variables		Control	Case	Chi-square	P value
		n(%)	n(%)		
Age group (in years) of the participants	18–30 years	41(21)	0(0)	4.47	0.078
	31–40 years	39(20)	4(2)		
	41–50 years	44(22.6)	37(18.5)		
	51–60 years	44(22.6)	60(30)		
	> 60 years	27(13.8)	99(49.5)		
Gender	Male	89(44.5)	89(44.5)	0.001	0.999
	Female	111(55.5)	111(55.5)		
Permanent residence	Kigali City	160(80.8)	164(62)	4.114	0.391
	Eastern	16(8.1)	10(5)		
	Western	5(2.5)	5(2.5)		
	Northern	6(3)	3(1.5)		
	Southern	11(5.6)	18(9)		
Level of education	No formal education was attended	6(3.8)	36(20.2)	9.82	0.45
	Primary education	45(28.5)	69(38.8)		
	Secondary education	59(37.3)	55(30.9)		
	University	46(29.1)	18(10.1)		
	Others	2(1.3)	0(0)		
Occupation	Self employed	49(34.6)	51(29.6)	30.641	0.095
	Unemployed	37(26.2)	69(40.1)		
	Cultivator	17(12.1)	29(16.9)		
	Health care	5(3.5)	3(1.7)		
	Public servant	24(17)	16(9.3)		
	Retired	4(2.8)	4(2.3)		
	Student	2(1.4)	0(0)		

Variables		Control	Case	Chi-square	P value
		n(%)	n(%)		
Marital status	Others	3(2.1)	0(0)	17.64	< 0.001
	Single	22(11)	4(2)		
	Married	169(84.9)	173(87.8)		
	Widow	8(4)	20(10.2)		
Religion	Christian	178(92.2)	174(90.2)	4.312	0.116
	Muslim	8(4.1)	16(8.3)		
	Others	7(3.6)	3(1.6)		

1.2 Bivariate analysis for the clinical factors associated with hypertension among the participants.

The analysis of clinical factors identified several significant associations with hypertension (Table 6). Both a family history of diabetes ($\chi^2 = 15.65$, $p < 0.001$) and a family history of hypertension ($\chi^2 = 19.24$, $p < 0.001$) were significantly associated with the condition. The type of diabetes was also a significant factor ($\chi^2 = 7.814$, $p = 0.005$). Additionally, significant associations were observed for recent HbA1C levels ($\chi^2 = 12.644$, $p = 0.003$), total cholesterol levels ($\chi^2 = 6.23$, $p = 0.013$), statin use ($\chi^2 = 12$, $p = 0.001$). The strongest associations were related to kidney function, with both urea levels ($\chi^2 = 7.541$, $p = 0.006$) and, most notably, creatinine levels ($\chi^2 = 28.27$, $p < 0.001$) being significantly higher among hypertensive individuals.

Table 6

Bivariate analysis for the clinical factors associated with hypertension among the participants

Variables		Control	Case	Chi square	P value
		n(%)	n(%)		
Family history of diabetes	No	97(51.3)	122(64.9)	15.65	< 0.001
	Yes	50(26.5)	51(27.1)		
	Unknown	42(22.2)	15(8)		
Family history of hypertension	No	124(65.3)	141(76.6)	19.24	< 0.001
	Yes	19(10)	28(15.2)		
	Unknown	47(24.7)	15(8.2)		
Type of diabetes	DM Type 1	26(13)	10(5)	7.814	0.005
	DM Type 2	174(87)	190(95)		
Statins or lipid-lowering medications are used	No	107(53.8)	73(38.5)	12	0.001
	Yes	92(46.2)	127(63.5)		
Recent HbA1C level	≤7%	59(31.1)	73(37.2)	1.644	0.2
	> 7%	131(68.9)	123(62.8)		
Random blood sugar	≤10 mmol/l	97(63.4)	131(69.3)	1.33	0.249
	> 10 mmol/l	56(36.6)	58(30.7)		
Total cholesterol level	≤6.1	144(87.8)	150(95.5)	6.23	0.013
	> 6.1	20(12.2)	7(4.5)		
LDL Level	≤1.8 mmol/l	34(19)	38(20.3)	0.103	0.75
	> 1.8 mmol/l	145(81)	149(78.7)		
HDL Level	< 1 mmol/l	83(46.4)	86(46)	0.005	0.94
	≥1 mmol/l	96(53.6)	101(54)		
Triglyceride level	< 1.7	109(66.5)	95(56.9)	3.2	0.073
	≥1.7	55(33.5)	72(43.1)		
Urea level	< 7.2	70(66)	27(44.3)	7.541	0.006
	> 7.2	36(34)	34(55.7)		

Creatinine level	< 88	73(68.9)	16(26.2)	28.27	< 0.001
	>=88	33(31.1)	45(73.8)		
Comorbidities	HIV	5(2.5)	7(3.5)	4.6	0.067
	Hepatitis B	1(0.5)	1(0.5)		
	Hepatitis C	0(0)	1(0.5)		
	Thyroid disorder	6(3)	3(1.5)		
	Dyslipidemia	5(2.5)	2(1)		
	None	128(64)	172(86)		
	Others	19(9.5)	14(7)		
Body mass index	Underweight	0(0)	3(0.9)	6.3	0.095
	Normal weight	57(28.5)	38(31.9)		
	Overweight	88(44)	131(41.1)		
	Obese	55(27.5)	35(29.4)		

1.3 Bivariate analysis for the lifestyle factors associated with hypertension among the participants.

The bivariate analysis revealed significant associations between key lifestyle factors and hypertension (Table 4.7). Smoking was significantly more common among hypertensive cases compared to controls ($\chi^2 = 19.77$, $p < 0.001$). Similarly, alcohol use was significantly higher in the case group ($\chi^2 = 5.014$, $p = 0.025$). The strongest association was observed with physical activity, where a lack of exercise was significantly more common among individuals with hypertension compared to the control group ($\chi^2 = 28.55$, $p < 0.001$).

Table 7
Bivariate analysis for the lifestyle factors associated with hypertension among the participants.

Variables		Control	Case	Chi-square	P value
		n(%)	n(%)		
Smoking	No	165(94.8)	145(78.8)	19.77	< 0.001
	Yes	9(5.2)	39(21.2)		
Alcohol use	No	130(74.7)	118(63.8)	5.014	0.025
	Yes	44(25.3)	67(36.2)		
Physical exercises	No	95(56.2)	150(82.4)	28.55	< 0.001
	Yes	74(43.8)	32(17.6)		

2. Multivariate analysis of the factors associated with hypertension among the participants.

The multivariate analysis identified several significant predictors of the outcome (Table 8). Patients with a family history of hypertension had over three times higher odds of the outcome (aOR = 3.123, 95% CI: 2.430-22.678, $p = 0.013$). Elevated creatinine levels (≥ 88) were associated with more than four-fold increased odds (aOR = 4.227, 95% CI: 1.022–17.484, $p = 0.047$), while smoking significantly increased the risk (aOR = 2.457, 95% CI: 1.145–14.604, $p = 0.035$). Conversely, physical exercise demonstrated a strong protective effect, reducing the odds by 83% (aOR = 0.170, 95% CI: 0.052–0.557, $p = 0.003$). Poor glycemic control, indicated by HbA1c levels $> 7\%$, was associated with over three times higher odds (aOR = 3.46, 95% CI: 1.956–15.812, $p = 0.024$).

Table 8
Multivariate analysis of the factors associated with hypertension among the participants.

Variables		Having hypertension			
		aOR	95% CI		P value
Lower	Upper				
Family history of hypertension	No	Ref			
	Yes	3.123	2.430	22.678	0.013
	Unknown	0.717	0.133	3.867	0.699
Family history of diabetes	No	Ref			
	Yes	2.123	1.231	7.174	0.064
	Unknown	0.821	0.678	4.765	0.084
Type of diabetes	Type 1	Ref			
	Type 2	1.301	0.090	18.787	0.847
Total cholesterol level	<=6.1	Ref			
	> 6.1	0.321	0.045	2.293	0.257
Statins or lipid-lowering medications are used	No	Ref			
	Yes	1.253	0.089	1.784	0.086
Urea level	< 7.2	Ref			
	> 7.2	1.194	0.251	5.681	0.823
Creatinine level	< 88	Ref			
	>=88	4.227	1.022	17.484	0.047
Smoking status	No	Ref			
	Yes	2.457	1.145	14.604	0.035
Alcohol use	No	Ref			
	Yes	1.484	0.373	5.905	0.575
Physical exercises	No	Ref			
	Yes	0.170	0.052	0.557	0.003
Recent HbA1C level	<=7%	Ref			
	> 7%	3.46	1.956	15.812	0.024

Variables		Having hypertension			
		aOR	95% CI		P value
Lower	Upper				
Marital status	Single	Ref			
	Married	0.236	0.935	1.346	0.453
	Widow	0.096	0.254	0.937	0.236

4.6 Comparison of the long-term complications among diabetic patients with hypertension (cases) and diabetic patients without hypertension (controls).

Table 9 compares long-term diabetic complications between diabetic patients with hypertension (cases) and those without hypertension (controls). The data reveal that diabetic patients with concurrent hypertension experience higher rates of chronic kidney disease (18% vs 4.9%), peripheral neuropathy (10.5% vs 7.3%), ischemic heart disease (4% vs 1.8%), and stroke (4% vs 3%) compared to diabetic patients without hypertension. Notably, 61.5% of hypertensive diabetic patients had no complications versus 76.8% of non-hypertensive diabetic patients.

Table 9
Comparison of the long-term complications among diabetic patients with hypertension (cases) and diabetic patients without hypertension (controls).

Variables		Having hypertension	
		Control	Case
		n(%)	n(%)
Long-term complications	Stroke	5(3)	8(4)
	Ischemic Heart Disease	3(1.8)	8(4)
	Chronic Kidney Disease (CKD)	8(4.9)	36(18)
	Peripheral neuropathy	12(7.3)	21(10.5)
	Peripheral arterial disease	3(1.8)	2(1)
	Diabetic retinopathy	6(3.7)	2(1)
	None	126(76.8)	123(61.5)
	Others	1(0.6)	0(0)

Discussion

In this retrospective case-control study, we found that age, educational level, duration and type of diabetes, elevated HbA1C, smoking, and chronic kidney disease were associated with the presence of hypertension among diabetic patients (cases). The findings are consistent with existing literature from sub-Saharan Africa and provide locally relevant evidence on factors commonly observed among hypertensive diabetic patients.

The sociodemographic characteristics demonstrate a clear age-related pattern, with hypertensive diabetic patients being significantly older (mean age 60.3 years) compared to non-hypertensive diabetic patients (mean age 48.6 years). This age differential is consistent with findings from other research globally and particularly in Africa. Studies, including research from Malawi, Ethiopia, Libya, Morocco, and Saudi Arabia, revealed that hypertension is more commonly observed in advancing age in diabetic patients(9, 20, 21). Advancing age, a non-modifiable risk factor for hypertension, is associated with sedentary behavior, weight gain, and progressive atherosclerotic vascular changes that increase peripheral resistance and predispose individuals to elevated blood pressure(22). The educational disparities observed, with hypertensive patients having predominantly primary education (38.8%) compared to non-hypertensive patients with secondary education (37.3%), suggest that health literacy and socioeconomic factors play crucial roles in disease progression and management in Rwanda's healthcare context.

The clinical characteristics reveal patterns of disease control and metabolic dysfunction among hypertensive diabetic patients. The longer diabetes duration (12 vs 10 years), type 2 DM, elevated HbA1c levels (9% vs 8%), and significantly worse kidney function markers observed in the case group reflect the progressive nature of diabetic complications when combined with hypertension. Type 2 DM patients had 1.3 times the odds of developing hypertension compared to type 1 DM, and duration of diabetes above 10 years was associated with new onset of hypertension.

Furthermore, patients who had uncontrolled diabetes with HbA1c above 7% had 3.43 times the risk of having hypertension when compared to their counterparts with HbA1c below or equal to 7%. Our findings are comparable and consistent with other similar studies done around the globe; one done in South Ethiopia showed higher odds of 5 times of hypertension in type 2 DM(23). Studies in sub-Saharan Africa have shown that hypertension and diabetes comorbidity can increase healthcare expenditure and the risk of coronary heart disease, which aligns with our findings of poorly controlled diabetes among hypertensive patients (11).

The elevated creatinine levels in 73.8% of cases versus 31.1% of controls, combined with higher rates of chronic kidney disease (18% vs 4.9%), underscore the synergistic nephrotoxic effects of diabetes and hypertension. The burden of chronic kidney disease is particularly important among people with diabetes in Africa, and diabetic nephropathy presents with persistent albuminuria and a progressive decline in glomerular filtration rate, with substantial evidence indicating that early, aggressive treatment can delay or prevent progression (24, 25). This pattern is particularly concerning in Rwanda's healthcare

system, where resource constraints and access to specialized care may limit early detection and management of diabetic complications.

The lifestyle characteristics identified in this study provide crucial insights into modifiable risk factors that could be targeted for intervention in Rwanda's diabetic population. The fourfold higher smoking prevalence among hypertensive diabetic patients (21.2% vs 5.2%) is particularly striking and exceeds smoking rates reported in other African studies conducted in Ethiopia and Nigeria (26, 27). The burden of hypertension is rising rapidly in sub-Saharan Africa, posing significant health challenges and economic costs, with barriers across the care continuum, including individual-, provider-, and system-level obstacles (28). The low physical exercise participation among cases (17.6%) compared to controls (43.8%) represents a critical modifiable risk factor that could be addressed through community-based interventions, although the retrospective nature of the study does not allow conclusions regarding directionality. This finding is consistent with broader patterns observed across sub-Saharan Africa, where urbanization and changing lifestyles have contributed to increased sedentary behavior (27).

The multivariate analysis further confirms the protective effect of physical exercise, with an 83% reduction in odds of developing hypertension (aOR = 0.170), possibly reflecting the specific benefits of regular physical activity in Rwanda's highland environment or the study's comprehensive assessment of exercise patterns. These findings are consistent with the findings of the Jackson Heart Study among African-Americans (29).

The three-fold increased odds of hypertension among patients with a family history is consistent with findings from other African studies, including research from Ethiopia where family history of chronic kidney disease was significantly associated with complications among diabetic patients (30), and the recent AWI-Gen study across four sub-Saharan African countries which demonstrated that family history of type 2 diabetes had an odds ratio of 1.22 (95% CI: 1.01–1.46) for incident diabetes (31). The fourfold increased odds associated with elevated creatinine levels underscore the bidirectional relationship between hypertension and kidney dysfunction, a pattern that has been consistently observed across African populations where chronic kidney disease prevalence is rising alongside diabetes and hypertension comorbidity. The association between poor glycemic control (HbA1c > 7%) and increased hypertension risk mirrors findings from Morocco, where lack of regular physical exercise and high serum creatinine were significant risk factors for chronic complications (20), and Sudanese studies where poor glycemic control was associated with higher odds of hypertension among diabetic patients (32). These multivariate findings collectively reinforce the complex interplay between genetic predisposition, metabolic control, lifestyle factors, and organ dysfunction in the development of hypertension among diabetic patients, while highlighting the critical importance of comprehensive diabetes management strategies that address both modifiable and non-modifiable risk factors in the African context.

The complications profile revealed in this study has significant implications for healthcare planning and resource allocation in Rwanda. The higher rates of chronic kidney disease, peripheral neuropathy, ischemic heart disease, and stroke among hypertensive diabetic patients reflect the accelerated

cardiovascular and microvascular complications associated with dual pathology, which is aligned with the findings of a study that was conducted in six Sub-Saharan African countries (33). Studies across Northern Africa have reported chronic diabetes complications ranging from 8.1% to 41.5% for retinopathy, 21% to 22% for albuminuria, 6.7% to 46.3% for nephropathy, and 21.9% to 60% for neuropathy (34), with our findings showing comparable patterns in Rwanda. Recent reports consistently confirm the high and increasing prevalence of hypertension in sub-Saharan Africa, with poor detection, treatment, and control rates (35), suggesting that Rwanda's healthcare system needs to implement more aggressive screening protocols, early intervention strategies, and integrated care models that address both diabetes and hypertension simultaneously to prevent the cascade of complications observed in this study.

Study limitation

This study has some limitations that should be considered when interpreting the findings. First, this was a hospital-based case-control study conducted at two tertiary referral hospitals in Kigali, which predominantly manage more severe or complex cases of diabetes and its complications. As a result, selection bias is likely, and the study population may not be representative of diabetic patients managed in primary care or rural settings, thereby limiting the generalizability of the findings. Second, hypertension was operationally defined based on the use of antihypertensive medications, which may have led to misclassification bias. Diabetic patients with undiagnosed or untreated hypertension may have been incorrectly classified as controls, potentially underestimating the strength of observed associations. Third, lifestyle variables such as smoking and physical activity were assessed at the time of interview rather than at the time of hypertension diagnosis. This cross-sectional measurement makes it impossible to determine whether these exposures preceded the development of hypertension or whether the hypertension diagnosis itself influenced behavioral changes, introducing the possibility of reverse causation. Fourth, although multivariate logistic regression was performed to adjust for several covariates, residual confounding remains possible, as important factors such as dietary sodium intake, long-term alcohol consumption patterns, socioeconomic status, stress level, and medication adherence were not consistently documented or adjusted for. Fifth, matching was performed only on gender. At the same time, other key variables such as age and duration of diabetes were not matched, which may have contributed to the imbalance between cases and controls despite statistical adjustment. Sixth, missing data from medical records, particularly for laboratory variables such as lipid profiles, may have reduced statistical power and introduced information bias; analyses were therefore limited to available data, which was even contributed to wider confidence intervals on some variables. Finally, and most importantly, as a retrospective case-control study, this design does not allow confirmation of the temporal sequence between exposures and hypertension. Consequently, causal conclusions cannot be drawn, and all identified relationships should be interpreted strictly as associations that require confirmation through prospective longitudinal studies.

Conclusion

This study, conducted at two tertiary hospitals in Rwanda, provides compelling evidence that multiple factors are associated with hypertension among diabetic patients. It has been demonstrated that a family history of hypertension, poor glycemic control, elevated kidney function markers, and smoking are significantly prevalent in diabetic patients. Conversely, regular physical exercise is less frequent in hypertensive diabetic patients. Moreover, it was revealed that diabetic patients with concurrent hypertension also exhibit substantially higher rates of long-term complications, including chronic kidney disease, peripheral neuropathy, and cardiovascular events, compared to their non-hypertensive counterparts. These findings emphasize the urgency of strengthening the routine screening for hypertension and associated risk factors, while integrating glycemic and renal function monitoring into clinical diabetes management with habitual regular physical activity.

Abbreviations

CHUK

Centre Hospitalier Universitaire de Kigali

KFHR

King Faisal Hospital Rwanda

T2DM

Type 2 diabetes mellitus

WHO

World Health Organization

NCD

Non-communicable diseases

CAD

Coronary artery disease

CVD

Cardiovascular disease

eNOS

endothelial nitric oxide synthase

RAAS

Renin-Angiotensin-Aldosterone System

PI3K

Phosphatidylinositide 3-kinase

Akt

protein kinase B

NO

Nitric oxide

HbA1C

Glycated hemoglobin

OGTT

Oral glucose tolerance test
FBS
Fasting blood sugar
NADPH
Nicotinamide adenosine dinucleotide phosphate hydrogen
ROS
Reactive oxygen species
AOR
Adjusted odd ratio
ENaC
Epithelial sodium channel
SGK-1
Serum and glucocorticoid-regulated Kinase 1
SNS
Sympathetic nervous system
MRN
Medical record number
MAPK
Mitogen-activated protein kinases
CCB
Calcium channel blocker
BB
Beta Blockers
ACEI
Angiotensin-converting enzyme inhibitors
SGLT2
Sodium-glucose co-transporter 2 inhibitors
DPP4
Dipeptidyl peptidase-4 inhibitors
ARB
Angiotensin receptor blockers

Declarations

Ethics approval and consent to participate

This study has been implemented in strict adherence to the ethical standards and principles. It has been reviewed and approved by the University Institutional Review Board with REF: CMHS/IRB/057/2025, King Faisal Institutional Review Board with REF: KFH/2025/286/IRB, and CHUK Institutional Review Board with REF: EC/CHUK/020/2025. The consent form did not apply to the study as it used only secondary data. No personal identifiers have been collected to ensure anonymity, and the principal investigator

securely keeps the collected data. The study maintained adherence to the approved institutional review board ethical standards in accordance with the 1964 Helsinki Declaration and its later amendments.

Clinical Trial Number

Not Applicable

Informed Consent

Given that the study only involved the collection and analysis of secondary data, informed consent for participation has been waived by both the King Faisal Hospital Institutional Review Board and CHUK Institutional Review Board.

Consent for publication

Not applicable

Competing interests

All the authors declared no conflicts of interest.

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Authors' contributions

PN conceptualized the study and wrote the initial draft. E. I participated in data collection and cleaning the dataset. D.U and ES analysed and interpreted the data. LB, ES, and OS developed the initial draft of the report. PN and EI edited and wrote the final manuscript. A.T, FM, and EAW supervised the implementation of the whole project. All authors reviewed and approved the final version of the manuscript for publication.

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Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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