

# BMJ Open Glycaemic, blood pressure and low-density lipoprotein-cholesterol control among patients with diabetes mellitus in a specialised clinic in Botswana: a cross-sectional study

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## ABSTRACT

**Objective** Control of glycaemic, hypertension and low-density lipoprotein-cholesterol (LDL-C) among patients with type 2 diabetes mellitus (T2DM) is vital for the prevention of cardiovascular diseases. The current study was an audit of glycaemic, hypertension and LDL-C control among ambulant patients with T2DM in Botswana. Also, the study aimed at assessing factors associated with attaining optimal glycaemic, hypertension and LDL-C therapeutic goals.

**Design** A cross-sectional study.

**Setting** A specialised public diabetes clinic in Gaborone, Botswana.

**Participants** Patients with T2DM who had attended the clinic for ≥3 months between August 2017 and February 2018.

**Primary outcome measure** The proportion of patients with optimal glycaemic (HbA1c<7%), hypertension (blood pressure <140/90 mm Hg) and LDL-C (<1.8 mmol/L) control.

**Results** The proportions of patients meeting optimal targets were 32.3% for glycaemic, 54.2% for hypertension and 20.4% for LDL-C. Age ≥ 50 years was positively associated with optimal glycaemic control (adjusted OR [AOR] 5.79; 95% CI 1.08 to 31.14). On the other hand, an increase in diabetes duration was inversely associated with optimal glycaemic control (AOR 0.91; 95% CI 0.85 to 0.98). Being on an ACE inhibitor was inversely associated with optimal hypertension control (AOR 0.35; 95% CI 0.14 to 0.85). Being female was inversely associated with optimal LDL-C control (AOR 0.24; 95% CI (0.09 - 0.59).

**Conclusion** Patients with T2DM in Gaborone, Botswana, presented with suboptimal control of recommended glycaemic, hypertension and LDL-C targets. These findings call for urgent individual and health systems interventions to address key determinants of the recommended therapeutic targets among patients with diabetes in this setting.

## INTRODUCTION

Diabetes mellitus and related cardiovascular complications are growing public health

## Strengths and limitations of this study

- The first study to objectively assess the three critical therapeutic targets in patients with diabetes in Botswana.
- The study was undertaken in one specialised public diabetes clinic, and the findings may not be generalised to other facilities in the country.
- The cross-sectional design limited the assessment of the temporal relationship between factors associated with poor control of glycaemia, low-density lipoprotein-cholesterol and hypertension.
- Systematic random sampling and incomplete data in some participants may not have yielded a representative sample of our clinic enrollees.

concerns worldwide.<sup>1 2</sup> There are approximately 16 million people with diabetes in Africa, and this number is projected to increase to 41 million by 2045 due to rapid urbanisation, lifestyles changes and nutrition transition in the continent.<sup>1</sup> This increase in prevalence and incidence of diabetes is attributable to type 2 diabetes, which is associated with multiple comorbidities such as obesity and hypertension requiring chronic care and catastrophic health expenditure.<sup>1</sup> Diabetes and associated comorbidities are known to increase patients' risk of developing cardiovascular diseases (CVDs), which are responsible for approximately 70% of diabetes-related deaths.<sup>3 4</sup> The risk to the development of CVD is higher in people with suboptimal glycaemic, hypertension and low-density lipoprotein-cholesterol (LDL-C) control.<sup>3 5</sup> A reduction of HbA1c to control targets along with optimal hypertension control and the use of statins to lower LDL-C levels have been shown to improve

long-term outcomes including reducing mortality among patients with diabetes.<sup>6–9</sup> Achieving these targets remains a challenge in most settings, especially those with limited access to standard diabetes care.<sup>10–16</sup> Only a minority of patients with diabetes in Africa achieves optimal therapeutic targets, leaving the majority of patients at high risk of diabetes-related complications.<sup>13 15</sup> Suboptimal treatment to recommended targets is a public health concern because the current total health expenditure in most sub-Saharan African countries remains far below the 15% recommended in the Abuja declaration.<sup>17</sup> The rising cost of managing diabetes complications will further make health system goals unattainable.<sup>1</sup> Thus, this study was an audit of glycaemic, hypertension and LDL-C control among ambulant patients with type 2 diabetes mellitus in Botswana. The study also assessed factors associated with the attainment of glycaemic, blood pressure and LDL-C therapeutic targets in these patients.

## METHODS

### Study design and participants

We conducted a cross-sectional study of outpatients with established type 2 diabetes attending a specialised public diabetes clinic in Gaborone, Botswana between August 2017 and February 2018. The clinic has been operational since 2011 as a referral centre for health facilities in Gaborone and nearby towns. Eligible patients were those aged  $\geq 18$  years and had received care from the clinic for at least 3 months. We needed a sample size of 500 to produce a two-sided 95% CI with a width equal to 3.86% based on the assumptions of approximately 26.2% glycaemic control among patients with type 2 diabetes in Botswana.<sup>16</sup> Systematic random sampling was used to select patients from a list of patients who attended the clinic every day. In a recruitment day, we randomly picked the first patient from the list of the first eight clinic attendees. Subsequently, we enrolled every eighth individual until either the daily target of 10 patients was reached or the clinic came to an end. As there was a daily variation of the number of clinic attendees, the number of our daily enrolments varied as well.

### Data collection and procedures

Patient information was collected using an interviewer-administered questionnaire and through reviews of medical charts and electronic records. The information included demographic data (age, gender, occupation, marital status and education), diabetes duration, history of hypertension, and medications for diabetes, hypertension and lipid disorders. We performed anthropometry (weight, height, waist and hip circumferences) and blood pressure measurements at enrolment. We conducted three blood pressure measurements after 10 min of rest, and the mean of the three measurements was recorded.<sup>18</sup> Moreover, we documented blood pressure readings from each patient's previous visit. Patients' serum creatinine, LDL-C and HbA1c, and urine dipstick for proteinuria

results over the past 6 months were abstracted from the electronic medical records.

### Definitions of the key outcomes and exposure variables

We calculated the diabetes duration as the date of enrolment into the study minus the date of a diabetes diagnosis. A patient was considered hypertensive by self-reported hypertension and the use of blood pressure-lowering medications or had sustained blood pressure  $\geq 140/90$  mm Hg during the previous visit and at enrolment.<sup>19–21</sup> Optimal glycaemic control was defined as HbA1c  $< 7\%$ .<sup>19 21</sup> For patients who were on lipid-lowering medications, optimal LDL-C control was LDL-C level  $< 1.8$  mmol/L.<sup>19</sup> We calculated patients' estimated glomerular filtration rate (eGFR) by the Modification of Diet in Renal Disease formula, and an eGFR  $< 60.0$  mL/min/1.73 m<sup>2</sup> defined chronic kidney disease.<sup>2 22 23</sup> Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in metres. We considered underweight as BMI  $< 18.5$  kg/m<sup>2</sup>, normal weight as BMI of 18.5–24.9 kg/m<sup>2</sup>, overweight as BMI of 25.0–29.9 kg/m<sup>2</sup> and obesity as BMI  $\geq 30$  kg/m<sup>2</sup>.<sup>24</sup> Waist:hip ratio (WHR) was calculated as waist circumference in centimetres divided by hip circumference in centimetres and classified as high when WHR was  $\geq 0.85$  and  $\geq 0.90$  for women and men, respectively.<sup>24</sup>

### Patient and public involvement

We did not directly involve patients in the design, recruitment to and conduct of the study. However, the development of the research question and outcome measures were informed by patients' priorities, experience and preferences. These were realised during the regular diabetes support group meetings where the authors of this study interact with patients and their families. Investigators working at the clinic will discuss the study findings with colleagues and provide them with critical results for sharing with patients (study participants). In close collaboration with the patient support group, the investigation team will summarise the results in plain language for a large poster and place it in a waiting room.

### Statistical analysis

We performed analyses using Stata V.14 (Stata Corp, College Station, Texas, USA). We used percentages to summarise categorical variables. Means and SD or medians and IQR were used to summarise continuous variables. Pearson's  $\chi^2$  or Fisher's exact test was used to assess statistical differences by gender for the categorical variables, while Student's t-test or the Mann-Whitney U test was used for the continuous ones. Bivariate logistic regression was used to explore factors associated with each primary outcome—glycaemic, hypertension and LDL-C control. We further performed three multivariate logistic regression models for each of the three outcomes. The independent variables selected for multivariate models were those displaying a p value  $< 0.2$  at the univariate analysis level in addition to those considered clinically meaningful (age

**Table 1** Clinical and sociodemographic characteristics of patients with type 2 diabetes at a specialised diabetes clinic in Gaborone (N=500)

Characteristics	All (N=500)	Men (n=170)	Women (n=330)	P value
Mean age (SD), years	58.9 (12.2)	55.4 (12.6)	60.8 (11.6)	<0.001
Age <50 years n (%)	109 (21.80)	57 (33.5)	52 (15.8)	<0.001
Age ≥50 years n (%)	391 (78.20)	113 (66.5)	278 (84.2)	
Diabetes duration, median (IQR), years	6 (2–13)	6.5 (2–14)	6 (2.5–13)	0.927
HbA1c mean (SD), %	8.4 (2.4)	8.6 (2.7)	8.4 (2.4)	0.199
Diabetes treatment				
Diet alone n (%)	11 (2.2)	3 (1.8)	8 (2.4)	<b>0.001</b>
Insulin alone n (%)	68 (13.6)	38 (22.3)	30 (9.1)	
OHA alone n (%)	271 (54.2)	82 (48.2)	189 (57.3)	
Insulin and OHA	150 (30.0)	47 (27.7)	103 (31.2)	
BMI, mean (SD), kg/m <sup>2</sup>	30.5 (6.0)	28.7 (5.2)	31.4 (6.2)	<0.001
Normal weight n (%)	93 (18.7)	46 (27.1)	49 (14.9)	<0.001
Overweight n (%)	155 (31.1)	61 (36.3)	94 (28.5)	
Obese n (%)	250 (50.2)	63 (37.1)	187 (56.7)	
Marital status				
Living alone n (%)	266 (53.20)	55 (32.4)	211 (63.9)	<0.001
Living with a partner n (%)	234 (46.8)	115 (67.6)	119 (36.01)	
Education status				
No formal education, n (%)	77 (15.4)	26 (15.3)	51 (15.5)	<0.001
Primary school, n (%)	229 (45.8)	56 (32.9)	173 (52.4)	
Secondary school, n (%)	131 (26.2)	55 (32.4)	76 (23.0)	
College/university, n (%)	63 (12.6)	33 (19.4)	30 (9.1)	
WC, mean (SD), cm	103.3 (12.5)	101.7 (11.9)	104.0 (12.7)	<b>0.049</b>
WHR	0.94 (0.10)	0.97 (0.09)	0.93 (0.10)	<0.001
Low WHR n (%)	75 (44.1)	16 (4.9)		<0.001
High WHR n (%)	95 (55.9)	314 (95.2)		
CKD n (%)	54 (10.8)	24 (14.1)	30 (9.1)	<b>0.086</b>
eGFR, median, IQR (mL/min/1.73 m <sup>2</sup> )	112.5 (84.3–138.1)	113.1 (80.8–139.5)	112.3 (84.4–137.9)	0.737
Cholesterol, mean (SD), mmol/L	4.4 (1.1)	4.3 (1.2)	4.5 (1.1)	<b>0.030</b>
LDL-C mean (SD), mmol/L	2.8 (1.0)	2.6 (1.0)	2.9 (1.0)	<b>0.006</b>
Proteinuria n (%)	51 (10.20)	27 (15.9)	24 (7.27)	<b>0.003</b>
Hypertension n (%)	404 (80.80)	120 (70.59)	284 (86.06)	<0.001
Dyslipidaemia n (%)	358 (71.60)	114 (67.06)	244 (73.94)	0.106

BMI, body mass index; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; LDL-C, low-density lipoprotein-cholesterol; OHA, oral hypoglycaemic agent; WC, waist circumference; WHR, waist:hip ratio.

and gender). We described results as crude OR, adjusted OR (AOR) and their corresponding 95% CIs. We used the Hosmer-Lemeshow goodness-of-fit test to assess how well the data fit the model.<sup>25</sup> A two-tailed p value <0.05 was considered statistically significant.

## RESULTS

The response rate was 97%, as only 17 (3.4%) of the approached participants declined participation because

of time constraints. We included 500 patients with type 2 diabetes in the study, of which 330 (66%) were women. The mean (SD) age was 58.9 (12.2) years, and 78.2% were aged >50 years. The median (IQR) diabetes duration was 6 (2–13) years. There was a high percentage of patients with hypertension (80.8%), overweight (31.1%) and obesity (50.2%). Table 1 summarises the patients' characteristics by gender. Female patients tended to be older (60.8 vs 55.4 years, p<0.001), obese

**Table 2** Factors associated with optimal glycaemic control among patients with type 2 diabetes at a specialised diabetes clinic in Gaborone (N=500)

Characteristic	Unadjusted OR (95% CI)	P value	Adjusted OR (95% CI)	P value
<b>Age group</b>				
>50 years	1			
≤50 years	2.16 (1.29 to 3.61)	<b>0.003</b>	5.79 (1.08 to 31.14)	<b>0.041</b>
Diabetes duration, years	0.97 (0.95 to 0.99)	<b>0.040</b>	0.91 (0.85 to 0.98)	<b>0.011</b>
<b>Use of insulin alone</b>				
No	1			
Yes	0.80 (0.45 to 1.43)	0.590		
<b>Use of OHA alone</b>				
No	1			
Yes	2.785 (1.862 to 4.167)	<b>&lt;0.001</b>	0.90 (0.46 to 1.74)	0.745
<b>Use of insulin plus OHA</b>				
No	1			
Yes	0.185 (0.124 to 0.356)	<b>&lt;0.001</b>	0.34 (0.07 to 1.70)	0.188
<b>BMI</b>				
Normal weight	1			
Overweight	1.10 (0.64 to 1.90)	0.721		
Obese	0.83 (0.50 to 1.39)	0.476		
<b>Gender</b>				
Male	1			
Female	0.92 (0.62 to 1.36)	0.663	0.42 (0.14 to 1.25)	0.120
<b>Education status</b>				
None	1			
Primary school	1.58 (0.88 to 2.81)	0.124		
Secondary school	1.14 (0.60 to 2.16)	0.687		
College/university	1.00 (0.47 to 2.13)	0.996		
<b>Marital status</b>				
Living alone	1			
Living with a partner	0.93 (0.64 to 1.36)	0.703		
<b>WHR</b>				
Low WHR	1			
High WHR	0.92 (0.57 to 1.50)	0.745		
Weight, kg	0.99 (0.98 to 1.01)	0.298		
eGFR (mL/min/1.73 m <sup>2</sup> )	1.00 (0.99 to 1.00)	0.074	1.00 (0.99 to 1.01)	0.766
<b>CKD</b>				
No	1			
Yes	1.053 (0.578 to 1.920)	0.866		
<b>Proteinuria</b>				
No	1			
Yes	1.16 (0.63 to 2.14)	0.624		
<b>Optimal hypertension control</b>				
No	1			
Yes	2.53 (1.63 to 3.93)	<b>&lt;0.001</b>	1.61 (0.63 to 4.13)	0.322
<b>Optimal LDL-C control</b>				
No	1			
Yes	2.10 (0.90 to 4.88)	0.086	2.20 (0.64 to 7.57)	0.209

BMI, body mass index; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; LDL-C, low-density lipoprotein-cholesterol; OHA, oral hypoglycaemic agent; WHR, waist:hip ratio.

**Table 3** Factors associated with optimal hypertension control among patients with type 2 diabetes at a specialised diabetes clinic in Gaborone (N=500)

Characteristic	Unadjusted OR (95% CI)	P value	Adjusted OR (95% CI)	P value
<b>Age group</b>				
<50 years	1	–	–	–
≥50 years	0.89 (0.48 to 1.62)	0.691	–	–
Diabetes duration, years	0.97 (0.94 to 0.99)	<b>0.023</b>	0.98 (0.92 to 1.03)	0.352
<b>Use of insulin alone</b>				
No	1	–	–	–
Yes	0.45 (0.24 to 0.82)	<b>0.009</b>	1.15 (0.30 to 4.44)	0.837
<b>Use of OHA alone</b>				
No	1	–	–	–
Yes	1.94 (1.30 to 2.91)	<b>0.001</b>	1.37 (0.51 to 3.66)	0.531
<b>Use of insulin plus OHA</b>				
No	1	–	–	–
Yes	0.59 (0.40 to 0.95)	<b>0.028*</b>	–	–
BMI, kg/m <sup>2</sup>	0.98 (0.94 to 1.01)	0.149	0.93 (0.86 to 1.01)	–
<b>Normal weight</b>				
1	1	–	–	–
<b>Overweight</b>				
0.79 (0.42 to 1.47)	0.449	–	–	
<b>Obese</b>				
0.77 (0.44 to 1.38)	0.384	–	–	
<b>Gender</b>				
Male	1	–	–	–
Female	1.43 (0.92 to 2.22)	0.117	0.97 (0.36 to 2.61)	0.949
<b>Marital status</b>				
Living alone	1	–	–	–
Living with a partner	0.68 (0.61 to 1.37)	0.67	–	–
<b>Education status</b>				
No formal education	1	–	–	–
Primary school	1.03 (0.58 to 1.83)	0.09	–	–
Secondary school	1.08 (0.56 to 2.09)	0.22	–	–
College/university	0.89 (0.41 to 1.92)	0.761	–	–
WHR	1.29 (0.14 to 12.00)	0.821	–	–
<b>Low WHR</b>				
1	1	–	–	–
<b>High WHR</b>				
1.18 (0.65 to 2.12)	0.589	–	–	
eGFR (mL/min/1.73 m <sup>2</sup> )	1.00 (1.00 to 1.01)	0.139	1.00 (0.99 to 1.02)	0.412
Total serum cholesterol	0.964 (0.80 to 1.16)	0.693	–	–
<b>Proteinuria</b>				
No	1	–	–	–
Yes	0.48 (0.26 to 0.92)	<b>0.027</b>	0.36 (0.07 to 1.80)	0.213
<b>Use of CCB</b>				
No	1	–	–	–
Yes	0.73 (0.72 to 1.61)	0.729	–	–
<b>Use of thiazides</b>				
No	1	–	–	–
Yes	1.58 (1.06 to 2.37)	<b>0.026</b>	1.44 (0.62 to 3.39)	0.399
<b>Use of ACE inhibitors</b>				
No	1	–	–	–

Continued



Table 3 Continued

Characteristic	Unadjusted OR (95% CI)	P value	Adjusted OR (95% CI)	P value
Yes	0.64 (0.43 to 0.95)	<b>0.028</b>	0.35 (0.14 to 0.85)	<b>0.020</b>
Use of ARB				
No	1	–	–	–
Yes	0.95 (0.57 to 1.58)	0.834	–	–
Alpha-blocker				
No	1	–	–	–
Yes	0.24 (0.09 to 0.68)	<b>0.007</b>	0.76 (0.14 to 4.20)	0.749
Beta-blocker				
No	1	–	–	–
Yes	0.70 (0.43 to 1.14)	0.149	0.51 (0.19 to 1.37)	0.184
Optimal glycaemic control				
No	1	–	–	–
Yes	2.53 (1.63 to 3.93)	<b>&lt;0.001</b>	1.92 (0.71 to 5.23)	0.201
Optimal LDL-C control				
No	1	–	–	–
Yes	0.55 (0.23 to 1.36)	0.199	0.75 (0.25 to 2.32)	0.623

\*Omitted because of collinearity.

ARB, angiotensin II receptor blocker; BMI, body mass index; CCB, calcium channel blocker; LDL-C, low-density lipoprotein-cholesterol; OHA, oral hypoglycaemic agent; WHR, waist:hip ratio; eGFR, estimated glomerular filtration rate.

(56.7% vs 37.1%,  $p<0.001$ ), have higher WHR (95.2% vs 55.9%), be hypertensive (86.1% vs 70.6%,  $p<0.001$ ), and have a higher mean total cholesterol (4.5 mmol/L vs 4.3 mmol/L,  $p=0.030$ ) and LDL-C (2.9 mmol/L vs 2.6 mmol/L,  $p=0.006$ ) than male patients. Urine dipstick was positive for protein in 10.2% of patients, mostly men (15.9% vs 7.3%,  $p=0.003$ ).

### Optimal glycaemic control

The mean (SD) HbA1c was 8.4% (2.4) overall, 8.6% (2.7) for female and 8.0% (1.6) for male patients ( $p=0.199$ ) (table 1). The proportion of the patients receiving oral hypoglycaemic agents alone was 54.2%; 30% were on oral hypoglycaemic agents combined with insulin; 13.6% on insulin alone and 2.2% were on a diet alone. Of the 218 patients on insulin, 184 (84.4%) were on premix insulin. Of the 421 patients on oral hypoglycaemic agents, 411 (97.6%) patients were on metformin, and 194 (46.1%) patients were on a sulfonylurea. Compared with patients on other antidiabetic medications, those on insulin injections were more likely to be men. We noted optimal glycaemic control in 159 (32.3%) patients, whose mean HbA1c was 6.1%. Age over 50 years was associated with optimal glycaemic control (AOR 5.79; 95% CI 1.08 to 31.14). On the other hand, an increase in diabetes duration was inversely associated with optimal glycaemic control (AOR 0.91; 95% CI 0.85 to 0.98). There was no association between gender, anthropometry, diabetes medications or education on the level of glycaemic control (table 2).

### Optimal hypertension control

There were 404 (80.8%) hypertensive patients (table 1). Age  $\geq 50$  years (AOR 4.95; 95% CI 2.81 to 8.73), increased WHR (AOR 3.87; 95% CI 1.72 to 8.71), eGFR (AOR 0.98; 95% CI 0.97 to 0.99) and a long diabetes duration (AOR 1.07; 95% CI 1.02 to 1.12) were associated with hypertension. Seventeen (4.2%) hypertensive patients did not receive any antihypertensive medication. Of the 389 patients who received antihypertensive medications, 219 (56.3%) received calcium channel blockers, 189 (48.6%) were treated with thiazide diuretics, 183 (47.0%) with ACE inhibitors and 74 (19.0%) with angiotensin II receptor blockers. The proportions of patients receiving  $\beta$ -blockers and  $\alpha$ -blockers were 22.4% and 5.4%, respectively.

Of the 389 patients who received antihypertensive medicines, optimal hypertension control was noted in 211 (54.2%) patients. Patients on ACE inhibitors were less likely to attain optimal hypertension control compared with those who were not on ACE inhibitors (AOR 0.24; 95% CI 0.09 to 0.59). There was no association between gender, anthropometry or education on the level of hypertension control (table 3).

### Optimal LDL-C control

A total of 225 (45%) patients were receiving lipid-lowering drugs, mostly (96.4%) atorvastatin. Of these, 147 (65.3%) patients had LDL-C measurements available. Only 30 (20.4%) achieved the optimal LDL-C control target. Women were less likely to achieve optimal LDL-C control as compared with men (0.24; 95% CI 0.09 to

0.59). There was no association of age, anthropometry or education on the level of LDL-C control (table 4).

## DISCUSSION

This outpatient cross-sectional study showed a low proportion of patients with optimal control of glycaemic, hypertension and LDL-C among patients with type 2 diabetes attending a diabetes clinic in Botswana. In the multivariate analysis, duration of diabetes and age above 50 years were significantly associated with optimal glycaemic control. Being on ACE inhibitors was inversely related to optimal hypertension control. Women were less likely to attain optimal LDL-C levels than men.

Only 32.3% of our participants achieved optimal glycaemic control. Similarly, low levels of glycaemic control have also been seen among patients with diabetes in Africa.<sup>11 13 26 27</sup> The proportion of patients with optimal glycaemic control (HbA1c<6.5%) in specialised diabetes care centres across six sub-Saharan African countries was reported to be 29%.<sup>13</sup> Similarly, only 7%–31% of patients attained optimal glycaemic control (HbA1c level <7%) in other settings in Africa.<sup>12 14 27</sup> Consequently, suboptimal glycaemic levels are an apparent concern in Botswana and also in other African countries. In most studies, the majority of the patients have HbA1c >8%, well above the recommended target (<7%) required to avoid the development of microvascular and macrovascular complications.<sup>12 13</sup> This suboptimal glycaemic control could explain the fourfold and tenfold prevalence of sight-threatening diabetic retinopathy and proliferative retinopathy, respectively, found among African populations compared with their European counterparts.<sup>28</sup> Despite poor glycaemic control level, only a few of our patients were on insulin, suggesting clinical inertia of our clinicians in response to low glycaemic control.<sup>29</sup> We will be investigating this further given concerns with the lack of glycaemic control in our patients. Similar to other studies in sub-Saharan Africa, the likelihood of attaining optimal glycaemic control decreased as the duration of diabetes increased.<sup>30</sup> There is evidence of a progressive loss of beta-cell function with increasing diabetes duration.<sup>7</sup> Insulin production progressively declines over time, leading to suboptimal glycaemic control unless higher dosages or additional agents are initiated.<sup>7</sup> Comparable with reports from other studies, older patients in our study were more likely to achieve optimal glycaemic control than young ones.<sup>31 32</sup> It is possible that young patients are less likely to be compliant with medication and lifestyle modification as compared with their older counterparts. However, again we need to research this further before making any concrete statements and instigating pertinent quality improvement programmes.

We also found a high prevalence (80.8%) of hypertension among patients attending our specialised diabetes clinic. A decade ago, the prevalence of hypertension among patients with diabetes in this setting was 61.2%.<sup>33</sup> Our findings may suggest an increasing burden of

hypertension as seen globally, but also a reflection of the improvement in the screening and diagnosis of hypertension over the past few years.<sup>34</sup> We are aware of the comparable high frequencies of hypertension in other African studies.<sup>13</sup> Consistent with previous studies, patients with hypertension were older, more obese, and had declining GFR and longer diabetes duration.<sup>11 35</sup> Thiazide diuretics, calcium channel blockers and ACE inhibitors were the three most prescribed antihypertensive agents. This finding is in line with the available evidence recommending thiazide diuretics and calcium channel blockers as the most effective antihypertensives in the black population.<sup>19 20 35</sup> Optimal hypertension control was observed in only 54.2% of the patients on antihypertensives, suggesting an urgent need for initiatives to improve the identification and control of hypertension. This low control level is a concern given the increased mortality if hypertension is not controlled.<sup>6</sup> Having said this, the proportion of patients with optimal hypertension control in our population was superior to several studies in Africa, notwithstanding the variation of the definitions of optimal hypertension control across these studies.<sup>11–14 35–37</sup> The proportion of type 2 diabetes with optimal hypertension in Africa is often below 35%.<sup>11 12 37</sup>

However, there is no room for complacency. In the present study, the use of ACE inhibitors was inversely associated with optimal hypertension control. Although ACE inhibitors are indicated for patients with diabetes and proteinuria, they have a clinically significant lesser reduction in both systolic and diastolic blood pressure in the black population. This could partly explain suboptimal hypertension control among predominantly black patients in our study. There appeared to be no influence of gender on hypertension control similar to other studies,<sup>38</sup> which is encouraging as a recent systematic review found that men in low-income and middle-income countries are more likely to be non-adherent to their medications.<sup>39 40</sup>

Less than half of the patients (45%) were on lipid-lowering drugs, mostly statins. This is not surprising as the prescription of lipid-lowering medications in Africa is as low as 3%–13% in patients with diabetes due to the limited access to these drugs as well as lack of facilities for monitoring lipid profiles while patients are on treatment, regular medication stock-outs and insufficient health professionals.<sup>13 40 41</sup> It is, however, a concern as the reduced use of statins will increase mortality rates in patients with diabetes.<sup>8</sup> In some countries, the issue of co-payments limits the prescription of expensive medications like statins.<sup>42</sup> However, this is not an issue in Botswana where medications are provided free of charge to patients. Although the lack of co-payments might have led to a higher prescription of statins in Botswana than in other African countries, we would expect the rate of statin prescriptions to mirror the high rates seen in Western countries.<sup>43</sup> Education and adherence to guidelines will possibly improve the prescription and use of statins among the majority of patients with diabetes according to treatment guidelines.<sup>19 21</sup> Even when statins were

**Table 4** Factors associated with optimal LDL-C control among patients with type 2 diabetes at a specialised diabetes clinic in Gaborone (N=500)

Characteristic	Unadjusted OR (95% CI)	P value	Adjusted OR (95% CI)	P value
<b>Age group</b>				
<50 years	1		–	–
≥50 years	0.56 (0.21 to 1.50)	0.249	–	–
Diabetes duration, years	1.02 (0.97 to 1.06)	0.525	–	–
<b>Use of insulin alone</b>				
No	1	–	–	–
Yes	1.58 (0.56 to 4.46)	0.389	–	–
<b>Use of OHA alone</b>				
No	1	–	–	–
Yes	0.95 (0.43 to 2.12)	0.900	–	–
<b>Use of insulin plus OHA</b>				
No	1	–	–	–
Yes	0.83 (0.35 to 1.97)	0.664	–	–
BMI	1.00 (0.93 to 1.07)	0.951	–	–
Normal weight	1	–	–	–
Overweight	1.43 (0.34 to 5.94)	0.624	–	–
Obese	1.27 (0.33 to 4.89)	0.730	–	–
<b>Gender</b>				
Male	1	–	–	–
Female	0.2 (0.09 to 0.47)	<b>&lt;0.001</b>	0.24 (0.09 to 0.59)	<b>0.002</b>
<b>Education status</b>				
No formal education	1	1	–	–
Primary school	0.79 (0.29 to 2.14)	0.647	–	–
Secondary school	0.28 (0.07 to 1.20)	0.087	–	–
College/university	0.79 (0.20 to 3.11)	0.731	–	–
<b>Marital status</b>				
Living alone	1	–	–	–
Living with a partner	0.99 (0.44 to 2.20)	0.973	–	–
HbA1c	1.00 (0.85 to 1.20)	0.917	–	–
WHR	7.59 (0.19 to 303.60)	0.281	–	–
Low WHR	1	–	–	–
High WHR	0.31 (0.11 to 0.89)	<b>0.030</b>	0.64 (0.20 to 2.10)	0.463
<b>Proteinuria</b>				
No	1	–	–	–
Yes	0.69 (0.14 to 3.27)	0.64	–	–
eGFR (mL/min/1.73 m <sup>2</sup> )	1.00 (0.99 to 1.01)	0.878	–	–
<b>CKD</b>				
No	1	–	–	–
Yes	1.88 (0.73 to 4.83)	0.193	1.67 (0.61 to 4.58)	0.321
<b>Hypertension</b>				
No	1	–	–	–
Yes	1.13 (0.30 to 4.23)	0.86	–	–

BMI, body mass index; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; LDL-C, low-density lipoprotein-cholesterol; OHA, oral hypoglycaemic agent; WHR, waist:hip ratio.



used, an undesirably small proportion of our patients achieved guideline-recommended LDL-C target level. Suboptimal LDL-C control rates are also frequent across different settings, even in developed countries.<sup>9 13 15 44</sup> This is disappointing as achieving LDL-C reduction is associated with the highest cardiovascular risk reduction than hypertension and HbA1c reduction.<sup>9</sup> Inadequate patients' adherence and possibly clinicians' under-dosage of statin for fear of potential side effects are some of the factors that possibly explain suboptimal LDL-C control in our patients.<sup>9</sup> Besides, clinicians may be unaware of the current LDL-C as well as those of HbA1c and hypertension therapeutic goals.<sup>19 21</sup> Irrespective of the reason, there is an urgent need to instigate measures to meet guideline-recommended therapeutic goals, and we have started to address this in our clinic. As reported in other studies, women were less likely than men to achieve optimal LDL-C control.<sup>44</sup> Although the reason for this gender difference is not apparent, this information is significant for clinicians to pay attention to the management of women with diabetes in Botswana and other African countries.

To the best of our knowledge, this is the first study to objectively assess the three critical therapeutic targets in patients with diabetes in one of the few specialised diabetes clinics in Botswana. However, our findings should be interpreted considering several limitations. First, the study was limited to one specialised public diabetes clinic, and the findings may not be generalised to other public and private facilities in the country. Nevertheless, being the leading specialised diabetes clinics in the country, our findings likely represent the 'best' quality of diabetes care in Botswana. Consequently, highlighted concerns are likely to be higher in non-specialist healthcare facilities treating patients with type 2 diabetes in Botswana. Second, the study was cross-sectional in design and therefore unable to establish a temporal relationship between the factors associated with poor control of glycaemia, LDL-C and hypertension. Third, the results may be subject to selection bias because of incomplete data in some participants. Another potential risk of selection bias is the fact that the study enrolled only those patients available at the clinic during the study period. As such, patients unable to attend the clinic or those whose appointments did not coincide with the study period did not participate. Despite these limitations, we believe our findings are robust to help improve the care of patients with type 2 diabetes in Botswana.

In conclusion, there was suboptimal glycaemic, hypertension and LDL-C control among patients with diabetes in our setting. These findings call for urgent individual and health systems interventions to address the factors associated with suboptimal control of the cardiovascular risk factors among patients with type 2 diabetes in Botswana. This will be the subject of future initiatives and research in our clinic given the growing prevalence of patients with type 2 diabetes in Botswana.

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