

Age and diabetes control in an HIV-endemic country: is there an association?

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Background: The prevalence of diabetes mellitus (DM) in South Africa (SA) is 12.80% and is rising, while that of HIV infection remains the highest globally (13%). Literature varies on the associations between glycaemic control and age in patients living with DM (PLWD). Through effective anti-retroviral treatment (ART), HIV-infected patients can now live longer and develop comorbidities as experienced by HIV-uninfected patients. Identification of challenges faced in diabetes control within the various age groups would help in developing strategies that can be implemented in order to provide effective diabetes care to patients as they age.

Objectives: This study aimed to determine an association between age and diabetes control in an HIV endemic area.

Methods: Data from standardised clinic sheets were used from the DM clinic at Edendale Hospital, Pietermaritzburg, South Africa, from January 1, 2019 to December 31, 2019. Statistical analysis was done.

Results: This study had 957 PLWD with 146 PLWD who were HIV-infected (PLWDH). Older age was associated with improved mean glycated haemoglobin (HbA1c) levels after adjusting for glomerular filtration rate (GFR) ($r = -0.141$, $p < 0.001$; before adjustment: $r = -0.108$; $p = 0.001$). HIV-infected patients had lower mean HbA1c levels than their HIV-uninfected counterparts while age was positively associated with patients' BMI ($r = 0.246$, $p < 0.001$). PLWDH with a mean HbA1c $> 7\%$ were significantly younger than those with HbA1c $\leq 7\%$ (47.38 years vs. 52.77 years, $p = 0.013$). GFR declined with age: PLWD with GFR < 60 ml/minute were significantly older than those with GFR ≥ 60 ml/minute (62.72 years vs. 48.30 years, $p < 0.001$), this remaining significant after factoring in for HIV infection and hypertension.

Conclusion: Younger PLWD have poorer glycaemic control and are likely to develop diabetes-related complications later in life. Notably, younger PLWDH also had poorer glycaemic control, which places them at increased cardio-metabolic risk from sequelae of both the HIV infection and DM. This study highlights that more emphasis needs to be placed on diabetes education and management in the younger age categories of both PLWD and PLWDH.

Keywords: age, diabetes mellitus, glycaemic control, HbA1c, HIV

Introduction

Globally, 79% of adult patients living with diabetes mellitus (PLWD) are from low- and middle-income countries (LMIC), with approximately 1 in 5 of these PLWD being older than 65 years.¹ In 2019, there were approximately 463 million PLWD and 4.2 million deaths that were related to diabetes mellitus (DM).¹ These numbers are expected to rise to 700 million by 2045.¹ In South Africa (SA), a country classified as a LMIC, the prevalence of DM is 12.80%.² SA also has the highest prevalence of HIV infection globally (13%).³ Results from both developed and developing countries suggest that younger age is associated with poorer glycaemic control.^{4,5} This finding was contrasted by Roerink *et al.*, who determined that older PLWD had poorer glycaemic control in a study conducted in the Netherlands,⁶ while Zuniga *et al.* found that there were no statistically significant differences in HbA1c values between older and younger adults.⁷ Additionally, a South African study showed that PLWD who were HIV-infected (PLWDH) were younger and had a lower mean HbA1c level.⁸ This 2018 study by Khoza *et al.*, conducted at the Chris Hani Baragwanath Academic Hospital DM Clinic, Soweto, SA, described 'The effect of HIV infection on glycaemia and renal function in type 2 diabetic patients'.⁸ In another South African study, Werfalli *et al.* determined that older PLWD have a poorer quality of life and greater disability.⁹ This is likely attributed to older PLWD being at increased risk of both acute and chronic microvascular and cardiovascular complications related to the disease.¹⁰

With the effective rollout of antiretroviral treatment (ART), HIV-infected patients can be expected to have a normal lifespan.¹¹ Kalra *et al.* highlighted the association between age and an HIV infection in PLWD and mentioned that DM can develop as a result of the normal course of ageing, metabolic factors related to the HIV-infection or due to ART.¹² As these patients can now live to an older age with co-morbidities, strategies need to be implemented to provide effective care to patients as they age.

Chetty *et al.* conducted a scoping review in 2021 describing the relationship between 'age' and 'glycaemic control' in PLWD in the context of HIV infection. Results of this scoping review demonstrated that data varied significantly on the associations between glycaemic control and age in PLWD.¹³ They recommended that additional studies be conducted in LMIC countries where there is a high prevalence of coexistent HIV and DM.¹³

Methods

A retrospective, analytical cohort study was performed using data collected from patients who attend a specialised diabetes clinic at Edendale Hospital (EDH), Pietermaritzburg, KwaZulu-Natal. Clinicians used a standardised, comprehensive clinic sheet for all patients consulted in this clinic, which has been approved by the University of KwaZulu-Natal Biomedical

Research and Ethics Committee (BREC)—BCA 194/15. The data for this study included patients of all ages who attended the diabetes clinic at EDH between January 1, 2019 and December 31, 2019.

Patient demographics, age, mean HbA1c, random blood glucose, HIV status and type of DM were recorded in addition to other variables from the datasheet. Missing or incomplete or incorrectly completed data were not considered.

Age was divided into the following groups: 13–17 years; 18–30 years; 31–45 years; 46–60 years; 61–75 years and ≥ 76 years old.

Good glycaemic control was defined as a glycated haemoglobin (HbA1c) value $\leq 7\%$ while poor glycaemic control was defined as HbA1c $> 7\%$.¹⁴ The Bio-Rad D-10 machine (Bio-Rad, Hercules, CA, USA) was used for analysing the HbA1c values at the laboratory. Both the laboratory and the machines are NGSP (National Glycohemoglobin Standardization Program) accredited to maintain standardisation of HbA1c results while the random glucose measurement (mmol/L) was determined using an Accu-Chek® glucometer (Roche, Basel, Switzerland).

Statistical analysis

Statistical analysis was conducted with numerical data using analysis of variance (ANOVA) whilst categorical data relationships were determined using either chi-square or Fisher's exact tests. A p -value < 0.05 was used as indicator of significance. Data were analysed by Statistical Package for Social Science (SPSS) version 25 for Windows (IBM Corp, Armonk, NY, USA).

Results

Epidemiology

Data of 957 PLWD were used for this study: T2DM (822, 86.20%) and T1DM (132, 13.80%) with 3 unknown. Approximately one-sixth of the cohort had an HIV infection (146, 15.30%). Of this HIV-infected cohort with DM, 84 (57.50%) were on a fixed-dose combination (FDC) of ART, while the other patients were either not yet initiated or were on alternative ART regimens. The majority of patients were between 46 and 60 years in both the PLWD and the PLWDH cohorts (see Table 1).

Age and HbA1c

The mean HbA1c had a weak negative correlation with age ($R = -0.108$; $p = 0.001$) (Figure 1). There was a statistically significant difference noted between the mean HbA1c value in the 13–17 years category compared with the ≥ 76 year category (10.36 vs

9.12, respectively, $p = 0.04$). All patients in the youngest and oldest age categories were HIV-uninfected. In addition to this, a statistically significant difference in HbA1c was observed between the 46–60-year and the 61–75-year age categories (9.73 vs. 9.16, respectively, $p = 0.002$). After adjusting for GFR, there was a stronger inverse correlation noted between age and HbA1c ($r = -0.141$, $p < 0.001$) while HIV-infected patients had lower mean HbA1c levels than their HIV-uninfected counterparts. This association was highlighted in the 46–60-year age category (9.08 vs. 9.90, respectively, $p = 0.004$). There were significant differences noted in the mean HbA1c values between the age groups when considering all the patients together ($p = 0.024$), within the HIV-uninfected group only ($p = 0.026$), and within the HIV-infected group only ($p = 0.039$) (see Table 1).

Type of diabetes

There were significantly more patients with T2DM vs. T1DM (822 vs. 132, respectively, $p < 0.001$). Patients living with type 2 diabetes mellitus (PLWT2DM) were significantly older than PLWT1DM ($p < 0.001$).

In PLWT1DM, younger patients had poorer glycaemic control (HbA1c $> 7.00\%$); however, this was not statistically significant (28.85 years vs. 34.54 years, respectively, $p = 0.07$). The mean age was also non-significant in PLWT2DM between those with good vs. poor glycaemic control (57.50 years vs. 57.41 years, respectively, $p = 0.942$). The poorer glycaemic control in PLWT1DM compared with PLWT2DM across the age categories is illustrated in Figure 2.

HIV infection

A comparison between mean HbA1c $> 7.00\%$ vs. HbA1c $\leq 7.00\%$ cohorts in PLWDH revealed that higher mean HbA1c values were associated with younger patients (47.38 years vs. 52.77 years, respectively, $p = 0.013$). In those without an HIV infection, there was no statistically significant difference between age and glycaemic control. PLWDH were younger than PLWD without an HIV infection in the cohort with HbA1c $> 7.00\%$ (47.38 years vs. 54.18 years, respectively, $p < 0.001$). Those with lower cluster of differentiation (CD4) counts were typically younger patients; however, this was not significant ($p = 0.075$). The poorer glycaemic control in older HIV-uninfected PLWD is highlighted in Figure 3.

Duration of DM

Overall, PLWD with good glycaemic control had a shorter duration of DM compared with those with sub-optimal control (7.24 years vs. 10.68 years, respectively, $p < 0.001$). This

Table 1: Age and HbA1c levels of patients in the context of an HIV infection.

Age categories (years)	All patients		HIV-uninfected		HIV-infected		p -values (HIV-uninfected vs. infected)
	Count	Mean HbA1c (%) (\pm SD)	Count	Mean HbA1c (%) (\pm SD)	Count	Mean HbA1c (%) (\pm SD)	
13–17	15	10.36 (1.96)	15	10.36 (1.96)	0	–	–
18–30	81	10.02 (2.24)	75	9.97 (2.27)	6	10.60 (1.93)	0.511
31–45	167	9.46 (2.19)	120	9.49 (2.17)	47	9.38 (2.28)	0.772
46–60	369	9.73 (2.22)	291	9.90 (2.18)	78	9.08 (2.25)	0.004
61–75	273	9.16 (2.30)	258	9.24 (2.30)	15	7.97 (1.87)	0.037
≥ 76	52	9.12 (2.04)	52	9.12 (2.04)	0	–	–
p -values		0.024		0.026		0.039	

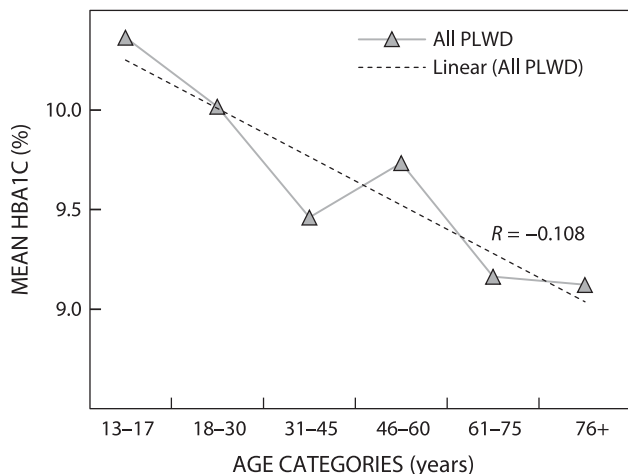


Figure 1: Association between age and mean HbA1c.

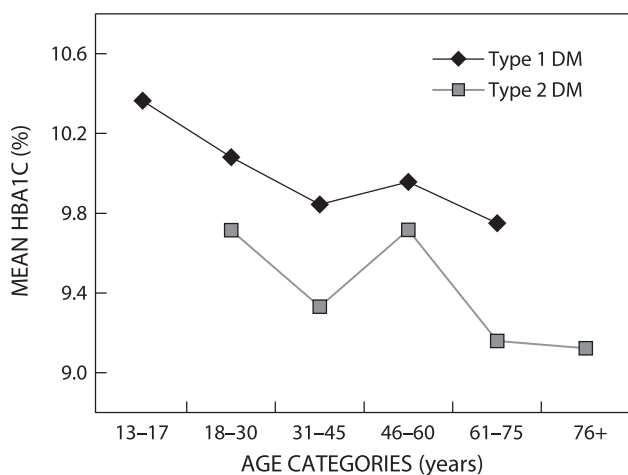


Figure 2: Association between age, type of DM and mean HbA1c.

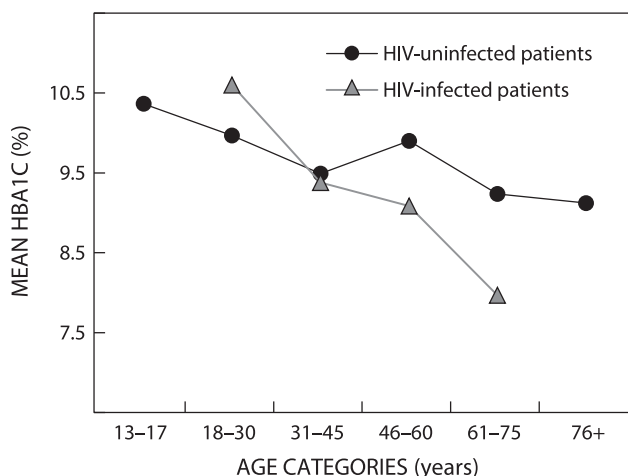


Figure 3: Association between age, mean HbA1c and HIV infection.

significant finding was also observed in the HIV-uninfected group (7.07 years vs. 11.30 years, respectively, $p < 0.001$). However, this did not occur in the HIV-infected group (7.92 years vs. 7.00 years, respectively, $p = 0.513$). In addition to this,

those with poor glycaemic control had a significantly longer duration of DM if they were HIV-uninfected (11.30 years vs. 7.00 years, respectively, $p < 0.001$) (see Table 2).

Blood pressure

PLWD with elevated blood pressure (systolic blood pressure [SBP] ≥ 140 mmHg) were significantly older than those with SBP < 140 mmHg (58.27 years vs. 50.25 years, respectively, $p < 0.001$). This finding was present in both the HIV-infected and HIV-uninfected patients ($p < 0.001$). HIV-uninfected patients with SBP ≥ 140 mmHg were significantly older than HIV-infected patients (59.08 years vs. 52.33 years, respectively, $p = 0.001$).

Patients with elevated diastolic blood pressure (DBP) ≥ 90 mmHg were significantly younger than those with DBP < 90 mmHg (50.36 years vs. 54.26 years, respectively, $p = 0.002$). There was no significance noted in patients with DBP ≥ 90 mmHg between the HIV-infected and HIV-uninfected cohorts ($p = 0.457$). Older patients had a significant positive correlation with mean SBP ($r = 0.298$, $p < 0.001$) while this association was not present with DBP ($p > 0.05$) (see Table 3 and Figure 4). Patients with hypertension were significantly older than those without ($p < 0.001$). Furthermore, those patients with GFR < 60 ml/minute were significantly older than those with GFR ≥ 60 ml/minute in both the hypertensive and non-hypertensive groups ($p < 0.001$ vs. $p = 0.015$, respectively) (see Table 4).

Dyslipidaemia

Elevated triglycerides levels ≥ 1.7 mmol/l were associated with older age (55.72 years vs. 51.91 years, respectively, $p < 0.001$). Decreased high-density lipoproteins (HDL cholesterol) levels in males were also significantly associated with older age (52.64 years vs. 47.78 years, respectively, $p = 0.032$) (see Table 5).

Gender

There were no statistically significant differences documented between mean HbA1c and gender in the different age categories.

Family history of DM (FHD)

Patients with a positive FHD and poor glycaemic control were significantly younger than those with good glycaemic control (51.57 years vs. 55.58 years, respectively, $p = 0.045$). Furthermore, PLWD with HbA1c $\leq 7\%$ were usually younger if a positive FHD was present (51.57 years vs. 55.14 years, respectively, $p = 0.002$) (Table 6).

Renal involvement

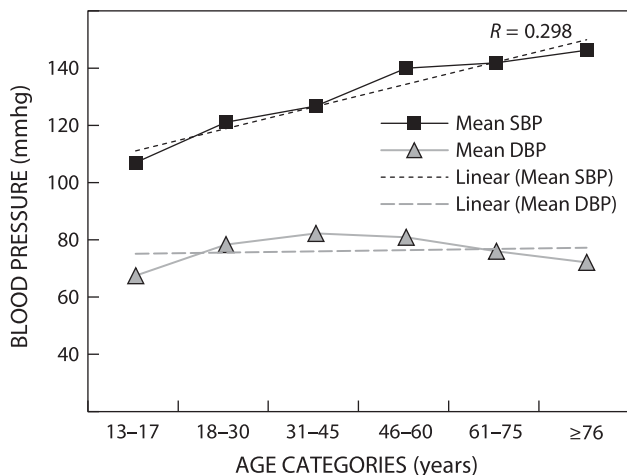
Patients with elevated creatinine ≥ 104 μ mol/l were significantly older than those with levels < 104 μ mol/l (62.01 years vs. 49.91 years, respectively, $p < 0.001$). This association occurred in both PLWDH as well as in the HIV-uninfected patients ($p < 0.001$) (see Table 7). Glomerular filtration rate (GFR) declined with age. Those with a GFR < 60 ml/minute were significantly older than those with GFR ≥ 60 ml/minute (62.59 years vs. 48.30 years, respectively $p < 0.001$) (Table 8). When factoring in for co-morbidities, PLWD with co-morbid hypertension and an HIV infection had a significantly lower age than PLWD without hypertension or an HIV infection (45.10 years vs. 54.02 years, respectively, $p = 0.013$).

Table 2: Duration of DM and mean HbA1c in the context of HIV infection

Mean HbA1c (%)	All patients		HIV-uninfected		HIV-infected		p-values (HIV-uninfected vs. infected)
	Count	Mean duration of DM (\pm SD) in years	Count	Mean duration of DM (\pm SD) in years	Count	Mean duration of DM (\pm SD) in years	
≤ 7	133	7.24 (7.68)	107	7.07 (7.89)	26	7.92 (6.84)	0.615
> 7	761	10.68 (8.93)	655	11.30 (9.16)	106	7.00 (6.30)	< 0.001
p-values		< 0.001		< 0.001		0.513	

Table 3: Blood pressure and age in the context of an HIV infection

SBP (mmHg)	All patients		HIV-uninfected		HIV-infected		p-values (HIV-uninfected vs. infected)
	Count	Mean age in years (\pm SD)	Count	Mean age in years (\pm SD)	Count	Mean age in years (\pm SD)	
< 140	567	50.25 (16.54)	467	51.08 (17.62)	100	46.35 (9.12)	0.009
≥ 140	382	58.27 (12.60)	336	59.08 (12.72)	46	52.33 (9.97)	0.001
p-values		< 0.001		< 0.001		< 0.001	
DBP (mmHg)	Count	Mean age in years (\pm SD)	Count	Mean age in years (\pm SD)	Count	Mean age in years (\pm SD)	p-value
< 90	758	54.26 (16.10)	648	55.32 (16.71)	110	48.01 (9.81)	< 0.001
≥ 90	191	50.36 (12.89)	155	50.70 (13.52)	36	48.92 (9.74)	0.457
p-values		0.002		< 0.001		0.629	

**Figure 4:** Line graph to show relationship between age and blood pressure.**Body mass index (BMI)**

Patients with a BMI ≥ 30 kg/m² were typically older than those who had a BMI < 30 kg/m² (55.92 years vs. 48.12 years, respectively, $p < 0.001$). This association of increased BMI and older age was also seen in the HIV-uninfected patients (57.17 years vs. 48.08 years, respectively, $p < 0.001$) but did not occur in HIV-infected patients ($p = 0.775$) (see Table 9). There was a

significant positive correlation noted between age and BMI in PLWD ($r = 0.246$, $p < 0.001$) (see Figure 5).

Discussion

Globally, results of studies have varied with regard to the relationship between age and glycaemic control. Results from both developed and developing countries suggest that younger age is associated with poorer glycaemic control.^{4,5} This finding was contrasted by Roerink *et al.* (Netherlands study) who determined that older PLWDH had poorer glycaemic control⁶ while Zuninga *et al.* found that there were no statistically significant differences in HbA1c between older and younger adults.⁷ In contrast to these, an Iraqi study found that younger patients were associated with poorer glycaemic control.¹⁵ Our study yielded results that were similar to this Iraqi study. A South African study conducted by Khoza *et al.* showed that PLWDH were younger and had a lower mean HbA1c level.⁸ Renal impairment decreases the clearance of insulin, thereby prolonging the half-life of the circulating insulin, resulting in decreased insulin requirements in PLWD.¹⁶ After adjusting for GFR, older patients still had improved glycaemic control, becoming more significant after the adjustment. We postulate that older patients, who often have other co-morbidities, might be more compliant with therapy and with clinic dates. Results of our study illustrate that we need to target improved glycaemic control in younger PLWD in order to prevent long-term complications.

Table 4: Associations between age and GFR in hypertensive vs. non-hypertensive patients

GFR (ml/min)	Non-hypertensive patients		Hypertensive patients		p-values
	Count	Mean age in years (\pm SD)	Count	Mean age in years (\pm SD)	
< 60	10	45.10 (15.96)	271	64.83 (9.98)	< 0.001
≥ 60	133	34.83 (12.41)	288	55.99 (11.32)	< 0.001
p-values		0.015		< 0.001	

Table 5: Associations between age and lipids

Factor	All PLWD	
	Count	Mean age (\pm SD)
Total cholesterol (mmol/l)		
< 4.5	444	53.16 (16.50)
\geq 4.5	436	53.97 (14.51)
<i>p</i> -value		0.44
LDL (mmol/l)		
< 1.8	154	54.69 (15.64)
\geq 1.8	420	53.64 (15.54)
<i>p</i> -value		0.474
HDL (in females) (mmol/l)		
< 1.2	239	55.37 (15.36)
\geq 1.2	269	55.67 (14.26)
<i>p</i> -value		0.82
HDL (in males) (mmol/l)		
< 1.0	76	52.64 (16.04)
\geq 1.0	155	47.78 (16.07)
<i>p</i> -values		0.032
Triglycerides (mmol/l)		
<1.7	497	51.91 (16.74)
\geq 1.7	378	55.72 (13.52)
<i>p</i> -values		< 0.001

The reason for younger patients with poorer glycaemic control is multi-factorial. Teenagers and younger adult patients often have T1DM where there is an absolute insulin deficiency.¹⁷ Lack of adherence to insulin in PLWT1DM is frequent with estimates of adherence issues occurring in 23–77% of patients—with higher values predicted in LMIC.¹⁸ Riaz *et al.* listed factors associated with non-adherence including: the educational level of the patients' parents, frequency of visiting DM clinics, knowledge regarding DM, lack of family support and the fear of hypoglycaemia.¹⁹ Fu *et al.* suggested that non-adherence often resulted from a fear of needles or injections in patients²⁰ while Patton described how PLWT1DM have issues relating to their diets, which is a cause of poor glycaemic control.²¹ It is thus essential to have good support with managing DM especially in the early stages of the disease, as failure to adequately manage this condition can lead to poorer glycaemic control and resultant complications.

In older patients, there is improved glycaemic control compared with younger patients; however, glycaemic control is still not always optimal. In our study the older working group (46–60-year-olds) had poorer glycaemia than the retirement group (61–75-year-olds). We postulate that this is due to having poor eating patterns and consumption of unhealthy foods in the work environment. Work has been identified as a factor that leads to non-adherence due to a busy schedule.² Other factors that relate to poorer adherence include patient-related factors (e.g. forgetfulness or intentionally not taking medication) or drug-related factors (cost of medication or side effects).²² A South African study determined the cost of eating healthier foods was between 30% and 110% more expensive (on average 69% or more) than eating a non-healthy diet.²³ This would favour the purchase of non-healthy food which has adverse effects on glycaemic control and health in general. This highlights the social challenges faced in managing DM (and other medical conditions) in all ages, especially in a LMIC.

Our study demonstrated that there was an increased prevalence of renal complications (defined by significantly increased creatinine and lower GFR levels) in older patients. In a developing country (such as SA), limited resources result in fewer patients having access to these scarce life-saving treatment modalities. In 2017, the incidence of initiation of renal replacement therapy (RRT) in SA was 25 per million population (pmp), which was significantly lower than countries with greater resources such as the United States of America (370 pmp) or the United Kingdom (121 pmp).²⁴ Furthermore, Maphumulo and Bhengu described how the long waiting times for medical intervention in SA may lead to patients developing complications or succumbing to the disease process as a result of not receiving timely intervention.²⁵ These findings emphasise the need for early implementation of effective management strategies in the younger PLWD to prevent or retard disease progression in order to decrease the burden on limited resources and treatment modalities.

It is well established that there is an association between hypertension and cardiovascular disease (CVD), commonly resulting in increased mortality.²⁶ PLWD have a 200–400% risk of dying from CVD,²⁷ while some estimate that it can be as high as 10 times the risk of the general population.²⁸ In patients with

Table 6: Associations between FHD, age and HbA1c

HbA1c (%)	Negative FHD		Positive FHD		<i>p</i> -value
	Count	Mean age in years (\pm SD)	Count	Mean age in years (\pm SD)	
\leq 7	69	54.96 (15.10)	64	55.58 (14.07)	0.807
> 7	354	55.14 (16.50)	407	51.57 (14.95)	0.002
<i>p</i> -values		0.933		0.045	

Table 7: Association between creatinine and age in the context of an HIV infection

Creatinine (umol/l)	All patients		HIV-uninfected		HIV-infected		<i>p</i> -values (HIV-uninfected vs. infected)
	Count	Mean age in years (\pm SD)	Count	Mean age in years (\pm SD)	Count	Mean age in years (\pm SD)	
< 104	625	49.91 (15.53)	531	50.64 (16.25)	94	45.76 (9.63)	0.005
\geq 104	273	62.01 (11.72)	227	63.86 (11.40)	46	52.85 (8.60)	< 0.001
<i>p</i> -values		< 0.001		< 0.001		< 0.001	

Table 8: Association between GFR and age

Factor	All patients	
	Count	Mean age in years (\pm SD)
GFR (ml/minute)		
< 60	329	62.59 (11.14)
\geq 60	500	48.30 (14.42)
<i>p</i> -values		< 0.001
Breakdown of GFR		
<15	20	65.75 (9.61)
15–29	78	64.22 (11.90)
30–59	231	61.77 (10.93)

hypertension and DM, the CVD risk increases by a further 75%.²⁹ In our study, systolic hypertension was positively associated with age. This is similar to what has been shown in other studies globally. An American study conducted by Ostchega *et al.* highlighted the increased prevalence of hypertension with age.³⁰ In contrast to this, our study found that the mean age of patients with increased DBP \geq 90 mmHg was younger than those with a DBP < 90 mmHg. According to Li *et al.*, DBP is an important risk factor for coronary disease in younger patients.³¹ It has also been shown to be a risk factor for formation of an abdominal aortic aneurysm.³² Clinicians should be aware of this risk factor and pay special attention to diastolic blood pressures just as much in the younger PLWD as they do for older patients. In SA, Steyn *et al.* highlighted that the care of patients with DM and hypertension is suboptimal.³³ Strained healthcare systems are a major challenge, especially in Africa, with only 2% of patients having good control of hypertension.³⁴ It is therefore important to implement effective early interventions to manage non-communicable diseases such as DM and HPT, especially when they coexist.

Our study also demonstrated that elevated triglycerides and lower HDL values (in males) were present in older patients in the overall patient population. This is commonly found in T2DM and is associated with insulin resistance, obesity and metabolic syndrome phenotype.³⁵ This is worrying as it increases the risk of developing cardiovascular disease and increases the risk of all-cause mortality.³⁶ Feingold found that approximately 60–70% of patients in the general population with obesity have dyslipidaemia.³⁷ Bekele *et al.* assessed this association of obesity and dyslipidaemia in PLWD and determined a similar finding.³⁸ In our study we found that older age is associated with increasing BMI. We postulate that the dyslipidaemia in older patients could be attributed to the increasing BMI values rather than due to glycaemic control.

As expected, we found that poorly controlled HbA1c was associated with a longer duration of DM. Mamo *et al.* also found that a duration of DM greater than seven years led to poorer glycaemic control.³⁹ This is likely due to progressive damage to insulin β -cell secretion with time and an increase in insulin

resistance.³⁹ Worsening glycaemic control with increased duration of DM plus advancing age increases the risk of cardiovascular morbidity and mortality. In our study, younger patients had significantly higher mean HbA1c levels than their older counterparts. Ramanathan highlighted that a long duration of DM with poor glycaemic control increases the microvascular complications of DM.⁴⁰ Petitti *et al.* recommended that poorly controlled glycaemia in younger patients warrants an urgent need for effective strategies to improve the metabolic status of patients.⁴¹ This was confirmed by Toh *et al.*, who found that younger patients had poorer glycaemic control than older patients and should receive targeted interventions to achieve 'optimal' glycaemic control.⁴² Our study findings suggest that more emphasis needs to be placed on intervention strategies targeting this group of PLWD in order to decrease long term diabetes-related complications resulting from poor glycaemic control.

The combination of HIV infection and DM remains a major concern for LMIC. We showed that those with an HIV infection were younger than their HIV-uninfected counterparts, implying longer future disease duration. Our study found that the younger PLWDH had poorer glycaemic control. This, coupled with increased disease duration secondary to young age and availability of ART, increases the risk of development of diabetes-related complications.

Overall, HbA1c was lower in HIV-infected patients when compared with PLWD without an HIV infection. Our results contrasted that of a study conducted in the Netherlands, which found that PLWDH had higher glucose levels and were older.⁶ This is a significant finding in our study and we postulate that this improved glycaemic control in HIV-infected patients could be attributed to either the quality of a specialised diabetes clinic that offers co-monitoring of the HIV infection and DM or could be a result of HIV-infected patients being more compliant with their medication, resulting in them taking both their ART and DM medication.

Within the PLWDH cohort, renal disease occurred at a younger age. Although no histological diagnosis of HIV-associated nephropathy (HIVAN) was obtained in these patients, we suspect that this could be a result of an HIV infection as all patients in the cohort were PLWD. This is important, as the development of renal disease at a younger age will result in more patients requiring renal replacement therapy, placing an increasing burden on the state and its limited resources.

In addition to this, those with elevated blood pressures were younger among HIV-infected patients compared with HIV-uninfected patients. A study conducted by Olaiya *et al.* found out that younger patients with undiagnosed and untreated hypertension had a longer duration of disease, during which they developed complications from hypertension.⁴³ This suggests that, regardless of the co-morbidity, undiagnosed and

Table 9: Association between obesity and age in the context of an HIV infection

Factor BMI (kg/ h ²)	All patients		HIV-uninfected		HIV-infected		<i>p</i> -values (HIV-uninfected vs. infected)
	Count	Mean age in years (\pm SD)	Count	Mean age in years (\pm SD)	Count	Mean age in years (\pm SD)	
< 30	343	48.12 (17.21)	280	48.08 (18.39)	63	48.29 (10.63)	0.930
\geq 30	532	55.92 (13.57)	461	57.17 (13.80)	71	47.82 (8.35)	< 0.001
<i>p</i> -values		<0.001		<0.001		0.775	

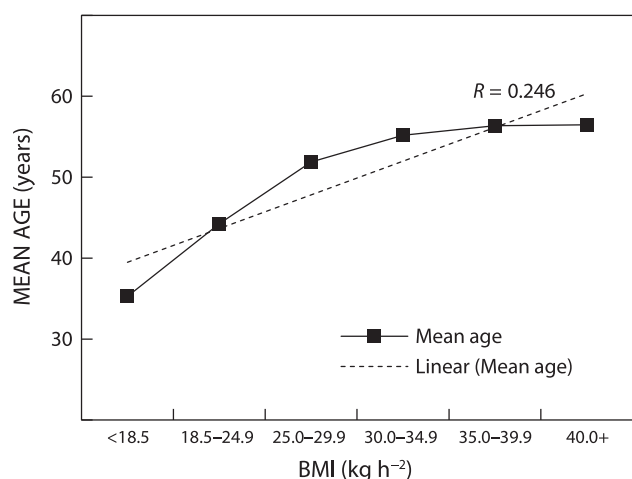


Figure 5: Association between BMI and age.

untreated disease in youth can have complications later in life. This emphasises the challenges that arise when HIV infection and non-communicable diseases interact.

Limitations

- Not all patients had all results filled in on their datasheets.
- As this was a retrospective study, no causal relationships could be determined; rather, associations were defined.

Conclusion

Younger PLWD have poorer glycaemic control and are likely to develop diabetes-related complications later in life. Notably, younger PLWDH also had poorer glycaemic control, which places them at increased risk from sequelae of both HIV and DM. This study has served to highlight that more emphasis in terms of diabetes education and management needs to be placed in the younger age category of PLWD and PLWDH.

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