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Patient-related Factors Associated with type-2 Diabetes Mellitus Control in Peri-Urban Primary Care Setting South Africa

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Abstract

Introduction: *Diabetes mellitus is rising globally. Yet, paucity of data exists on factors associated with its control at primary care level.* ***Aim*** *was to explore patient factors associated with type 2 diabetes control. Objectives were to describe the socio-demographics, proportion of diabetic control and associations between control and factors.* ***Methods****: The site was in Daveyton township and eight satellite clinics, Ekurhuleni, South Africa. A cross-sectional descriptive study systematically selected 200 participants by picking every third patient attending review from March to June 2015. A questionnaire covering socio-demographics, diabetes information, physical activities, depressive symptoms, blood pressure, weight, height and glycated hemoglobin was administered by researchers. Microsoft excel, and strata 13 software were used for data capture and analysis. Chi-square or Fisher's exact test was used to compare categorical variables with control. Logistic regression was used for binary variables and to compare relationships. P-values of <0.05 was statistically significant.* ***Results and analysis:*** *Good control was 36% (n=72), significantly associated with mean age of 65 (p=0.001), formal housing (p=0.020) or income (p=0.001). Hypertension (p=0.056), normal weight (p=0.056) and physical activities (p=0.059) were not significant. Poor control was 64% (n=128) and significantly associated with younger mean age of 55.66 (p=0.001) and informal housing (p=0.020). Neither good nor poor control was observed with depression, compliance, co-morbidities and complications.* ***Conclusion:*** *Older patients were more likely to be controlled compared to younger ones. To improve care, effort should focus on younger patients. Further studies should be conducted on depression and glycaemic control.*

Keywords: *diabetes, control, glycaemic, primary.*

Background

Diabetes mellitus affects people worldwide and poses major public health and socio-economic challenges. The disorder was previously thought to be rare or undocumented in rural Africa, but over the past few decades it has emerged as an important non-communicable disease (NCD) in sub-Saharan Africa. It is a global disorder that affects populations in developing countries, minority groups and disadvantaged communities in richer nations face the greatest risk. The increases are expected to be largest in developing regions because of ageing and urbanization, according to the International Diabetes Federation (IDF, 2019) and the Society of Endocrinology Metabolism and Diabetes of South Africa (SEMDSA, 2017).

Africa is also experiencing one of the most rapid demographic transitions, a phenomenon that can be linked to the global trends of an increased prevalence of diabetes. The South Africa's black population is rapidly increasing with an estimated 56% of the country's population now living in urban areas. This has resulted in changes in the epidemiology of disease in South Africa, including diabetes. Urbanization, known to be a major risk factor for chronic disease was associated with dietary and lifestyle changes which include the higher intake of animal fats, sugars, cigarette smoking, alcohol consumption and lower physical activity (SEMDSA, 2017 and World Health Organization (WHO, 2014).

Diabetes being a complex chronic disease attributed to 321 100 deaths for the African region in the year 2015, with more than 79% occurring in the economically productive age group < 60 years old. It

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was 1.7 times higher in women than in men. Globally, nearly four million people aged between 20 and 79 years died from diabetes in 2017, as reported by the International Diabetes Federation (IDF, 2019) and American Diabetes Association (ADA, 2019).

Good glycaemic control, as measured by glycated hemoglobin (HbA1C), reduced the risk of developing diabetic complications. The United Kingdom Prospective Diabetes Study (UKPDS) showed that in type 2 diabetes, each 1% reduction in mean HbA1C was associated with 21% reductions in deaths related to diabetes, 14% for myocardial infarction and 37% for microvascular complications (Green B and Zoepke A, 2013; SEMDSA, 2017).

There was paucity of studies which investigated factors associated with glycaemic control in T2DM patients in the primary care setting in South Africa. Hence, the aim of the study was to explore patient-related factors associated with glycaemic control in T2DM patients in a community with significant peri-urban population and high proportion of migrant workers (Statistics South Africa, 2014). It was anticipated that the findings of this study would contribute to clinical effectiveness through quality improvements of chronic diabetic care. By identifying patient-related factors in the population, health promotion and diabetes prevention strategies at the primary care platform would target individuals most at risk in order to detect diabetes early and prevent complications.

Materials and methods

Study design and population

The study was conducted at Daveyton township main clinic including patients drawn from 8 satellite clinics in Ekurhuleni, South Africa. The researcher conducted a cross-sectional descriptive study involving 200 patients in which the third patient was systematically picked as they visited the clinic for a period of four months from March 2015 to June 2015.

The initial information about the study was provided by primary care nurses who managed patients with diabetes mellitus during routine consultations. Willing participants were referred to the researcher and two trained assistants. The study team explained details of the study to all willing participants, assessed the suitability of the patients and obtained their consent.

Finally, a patient questionnaire including socio-demographics, diabetes information, co-morbidities, a global physical activity questionnaire (GPAQ) and a depression screening questionnaire called Patient Health Questionnaire-2 (PHQ 2) were administered, blood for HbA1C was collected and anthropometric measurements performed.

The sample was divided into two arms according to the level of glycaemic control. Poor glycaemic control was HbA1C > 7 % or > 7.5 % for age groups below 60 and above 65 years old, respectively. The group with HbA1C above 7 or 7.5 (poor glycaemic control) formed the study arm. The group with an HbA1C $\leq$7 or good glycaemic control was the control case. The number of participants for each group was determined by HbA1C results of the blood test collected during recruitment.

Collection of data from patients' clinical records was done using a designed template. Identification of the patients was by a code allocated by the researcher. The patient factors considered were gender, age, housing, education, employment, duration of diabetes, compliance, body mass index, physical activities, co-morbidities, complications and depression screening.

The research was approved by the University of the Witwatersrand Human Research Ethics Committee (HREC) and ethics clearance number was 150269. Also, permission to conduct research was obtained from Ekurhuleni Health District.

Results

All the participants in the study were from the same racial group which was designated as black in South Africa. The minimum age was 26 with a maximum of 89 years old. Seventy-seven percent (77%) were female and 33% male. Participants with good glycaemic control were older with the majority (84%, n=167) lived in formal housing and earned a form of income. A great majority of participants (86%, n=171) had completed some primary or secondary education level. Overweight or obese participants were eighty two percent (82%, n=176) and normal body mass index of 18%. Fifty percent of participants were pensioners who obtained old age pension grant. *(Table 1)*. Nearly a third

of participants had poor glycaemic control (64%, n=128) with a mean glycaemic level measured by HbA1C at 8.65 and a standard deviation of 2.30. *(Table 2)*

The older age group had good glycemic control (at mean age of 64.17 years, standard deviation of 11.61 years) compared to those with poor glycaemic control who were younger (mean age of 55.66 years, standard deviation 10.62 years) Moreover, a quarter did not participate in physical activities although 25% of them took part in activities that raised the heart rate. Also, 84% (n=167) had a sedentary life of more than 4 hours daily. Most of the participants (68% n=136) had no complications, although 26% (n=51) had peripheral neuropathy (*Table 3*).

Table 1. Baseline Socio-demographic characteristics of participants

Characteristics	**Frequencies % (n=200)**
Sex	
Male	46 (23.00)
Female	154 (77.00)
Age (mean, std)	58.72 (11.7)
Education level	
None	18 (9.0)
Primary	80 (40.0)
Secondary	91 (45.50)
Tertiary	11 (5.50)
Type of housing	
Formal	167 (83.50)
Informal	33 (16.50)
Employment status	
Employed	45 (22.50)
Unemployed	56 (28.00)
Pensioner	99 (49.50)
Height (mean, std) m	17.67 (7.01)
Weight (mean, std) kg	85.98 (17.49)
BMI categories	
Normal	18 (9.28)
Overweight	49 (25.26)
Obesity	56 (28.87)
Moderate	37 (19.07)
Severe	34 (17.53)

- Note the above table shows a mean age of participants of 58.72 years and weight mean of 85.98 kg. the majority had secondary level education, lived in formal accommodation and earned an income or a pension grant. Also, the majority were obese.

Table 2. Patient-related factors associated with glycaemic control

Characteristics	**Frequency %**
Systolic BP (mean, std)	145.07 (16.54)
Diastolic BP (mean, std)	84.35 (10.06)
Blood pressure (BP) categories	
Normal	37(18.50)
Hypertensive	163(81.50)
HbA1C (mean, std) in %	8.65 (2.30)
Good control	72 (36)
Poor control	128 (64)
Comorbidities	
Hypertension	182 (91.92)
Others	16 (8.08)

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HIV Status	
Positive	4 (2.01)
Negative	91 (45.73)
Unknown	104 (52.26)
Duration of T2DM (mean, std)	7.32 (5.95)
Compliance	
Yes	157 (78.50)
No	43 (21.50)
Under treatment of hypertension	
Yes	181 (90.50)
No	19 (9.50)
PHQ-2	
Without depressive symptoms	190 (95.00)
With depressive symptoms	10 (5.00)

- Note the above table shows a mean HbA1c of 8.65%. Good control was 36% (n=72) and poor glycaemic control of 64% (n=128). The duration of diabetes was mean of 7.32 years. Almost all participants did not report depressive symptoms

Comparisons were performed using Chi-square and Fisher's exact tests between good and poor glycaemic control for main variables such as age, type of housing, employment status, weight, HIV status and other comorbidities. Significant associations were observed between good glycaemic control and age (p=0.001) and formal housing (p=0.020) as well as employment (p=0.001). Findings on weight (p=0.056) and hypertension (p=0.056) were not statistically significant. *(Tables 3, 4 & 5).*

Table 3. Association of socio-demographic, patients-related factors and good control

Characteristics	**Good** (n=72)	**Poor** (n=128)	**p-value**
Sex			
Male	19 (41.30)	27 (58.70)	0.393
Female	53 (34.42)	101 (65.58)	
Age (mean, std)	64.17 (11.61)	55.66 (10.62)	0.001
Education level			
None	9 (50.00)	9 (50.00)	0.502
Primary	28 (35.00)	52 (65.00)	
Secondary	30 (32.97)	61 (67.03)	
Tertiary	5 (45.45)	6 (64.55)	
Type of housing			
Formal	66 (39.52)	101 (60.48)	0.020
Informal	6 (18.18)	27 (81.82)	
Type of employment/ income			
Employed	11 (24.44)	34 (75.56)	0.001
Unemployed	11 19.64)	45 (80.36)	
Pensioner	50 (50.51)	49 (49.49)	
Height (mean, std) in m	18.54 (6.69)	17.18 (7.16)	0.194
Weight (mean, std) in Kg	82.80 (14.63)	87.77 (18.74)	0.056
Normal	7 (38.89)	11 (61.11)	
Overweight	20 (40.82)	29 (59.18)	
Obese	21 (37.84)	35 (62.50)	0.360
Moderate obesity	14 (37.84)	23 (62.16)	
Severe obesity	7 (20.59)	27 (79.41)	
Systolic blood pressure	143.45 (16.94)	145.98 (16.30)	0.304

(mean, std)			
Diastolic blood pressure (mean std)	82.35 (9.31)	85.21 (10.39)	0.108
Blood pressure categories			
Normal	15 (40.54)	22 (59.46)	0.524
Hypertensive	57 (34.97)	106 (65.03)	
Comorbidities			
Hypertension (HT)	69 (37.91)	2 (12.50)	0.056[F]
Others	113 (62.09)	14 (87.50)	
HIV status			
Negative	23 (25.27)	68 (74.73)	0.011[F]
Positive	2 (50.00)	2 (50.00)	
Unknown	46 (44.23)	58 (55.77)	
Duration of diabetes (mean, std) years	7.93 (7.01)	6.97 (5.27)	0.274

- Note the above table shows age, type of housing and type of employment or earning an income to be statistically significant as p-values were < 0.05. The weight was marginally insignificant.

Table 4. Association of socio-demographic, patients-related factors and good control

Characteristics	**Good** (n=72)	**Poor** (n=128)	**p-value**
Compliance			
Yes	54 (34.59)	103 (65.61)	0.366
No	18 (41.86)	25 (58.14)	
Hospital admission			
Yes	19 (38.78)	30 (61.22)	0.641
No	53 (35.10)	98 (64.90)	
Hypertension (HT)			
Yes	69 (38.12)	112 (61.88)	0.054
No	3 (15.79)	16 (84.21)	
HT treatment			
Yes	68 (37.57)	113 (62.43)	0.154
No	4 (21.05)	15 (78.95)	
PHQ-2			
Without depression	69 (36.32)	121 (63.38)	1.000
With depression	3 (30.00)	7 (70.00)	

- Note: the table above shows that compliance, hypertension, its treatment, previous hospital admissions and depression were all not statistically significant as judged from p-values which were > 0.05.

Further, doing exercises which increased the participant's heart rate was one of the patient factors which enhanced good glycaemic control. Participants undergoing such exercises were two (2) times (Odds ratio=2.14) more likely to have good glycaemic control compared to those who did not exercise (Table 5).

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Table 5. Association of socio-demographic, patients-related factors and good control

Characteristics	Good (n=72)	Poor (n=128)	p-value
Physical activities			
Vigorous activities			
Yes	72 (36.18)	0 (0.0)	1.00[F]
No	0 (0.00)	127 (63.82)	
Moderate			
Yes	69 (35.75)	124 (64.25)	0.74[F]
No	3 (42.86)	4 (57.14)	
Bicycle activities			
Yes	16 (47.06)	18 (52.94)	0.14
No	56 (33.73)	110 (66.27)	
Recreational activities			
Yes	70 (35.53)	127 (64.47)	0.25
No	2 (66.67)	1 (33.33)	
Sedentary hours			
Mild (1-3 hours)	9 (27.27)	24 (72.73)	0.253
Excessive (≥4 hours)	63 (37.72)	104 (62.28)	
Activities that increased heart rate			
Yes	50 (33.33)	100 (66.67)	0.179[F]
No	22 (44.00)	28 (56.00)	
Complications			
Retinopathy	3 (60.00)	2 (40.00)	
Peripheral neuropathy	15 (29.41)	36 (70.59)	
Stroke	3 (50.00)	3 (50.00)	0.486[F]
Heart	0 (0.00)	1 (100.00)	
None	50 (36.76)	86 (63.24)	

- Note the above table shows physical activities, including activities that increased heart rate and complications were not statistically significant as p-values were > 0.05.

Further analysis using logistic regression quantified the relationship between good glycaemic control and age. The odds of having good control of glycaemic increased with age by 8% (Odds ratio=1.08; 95% CI=1.05–1.12). The likelihood of having good glycaemic control increased also with height by 6% (Odds ratio=1.06; 95% CI=1.01–1.11) and not weight (Odds ratio=0.98; 95% CI=0.96–1.00). *(Table 6).*

Additionally, the participants' Human Immunodeficiency Virus (HIV) status was not statistically significant, although HIV positive patients were five (5) times more likely to have good glycaemic control levels compared to HIV negative patients (p-value= 0.153). *(Table 6).*

Table 6. Logistic regression

Characteristics	OR & 95% CI	p-value
Age (mean, std) in years	1.08 (1.05-1.12)	0.001
Height (mean, std) in m	1.06 (1.01-1.11)	0.031
Weight (mean, std) in kg	0.98 (0.96-1.00)	0.095
HIV status		
Negative	1	
Positive	5.46 (0.53-56.13)	0.153
Unknown	1.94 (0.96-3.93)	0.065
Activities that increased heart rate		
No	1	
Yes	2.14 (0.97-4.70)	0.059

- Note the above table shows the mean age was statistically significant with p-value <0.05. However, height, weight, HIV status and activities that increased the heart rate were not.

Discussion

All participants were black Africans which was usual because Daveyton township was a racially demarcated area for black Africans before the dawn of the South African democracy. The township remained predominantly black. This study had a mean age of 58 years old (with a standard deviation of 12 years), which compared well with the Middle East study (Al-Lawati *et al*, 2012). The mean age was considered a positive observation because the lesser the mean age, the worse the glycaemic control. A mean age which was higher than in other studies (Green *et al*, 2013) might be due to the fact that South Africa was a middle-income country more comparable to Middle East than Africa.

The high proportion of females among participants was similar to other studies (Otiniano *et al*, 2012; Angamo *et al*, 2013) and could be attributed to men who were at work while more female participants visited the clinics. Also, the higher female participation gave rise to a higher possibility of a gender bias as females exhibited more help-seeking behavior than males. Hence, it was not surprising to have recruited more females than males.

Majority completed secondary school education and there were relatively better educated participants in this study. Consequently, the unemployment rate in this study was better than in the South African general population because Daveyton township was located in Ekurhuleni which was one of the most industrialized parts of Johannesburg with urbanization of 90% and high levels of formal housing, according to Statistics South Africa (2014).

The above factors were positive for good glycaemic control because Shisana *et al* (2013) reported that the urban population of formal housing had good glycaemic control contrary to informal settlements. This finding was not surprising because Daveyton township had majority of formal housing which had basic amenities such as running water, toilets and electricity. Therefore, the standard of living seemed to facilitate compliance to T2DM. Further, a good glycaemic control or $HbA_1C \leq 7\%$, observed in this study was similar to the Middle East and American studies (Al-Lawati *et al*, 2012; Juarez *et al*, 2012).

Significantly, this study demonstrated that the younger the patient, the poorer the glycaemic control at mean age of 55.66 years (p-value 0.001). The finding could be attributed to the economic development and urbanisation in South Africa, being a middle-income country with more access to fast foods compared to low-income African countries. Besides, some studies conducted more than a decade ago could have different economic outlook from the current one.

Regarding co-morbidities, the HIV status factor was a controversial one because the finding showed that an HIV positive patient was five (5) times more likely to have a good glycaemic control compared to an HIV negative patient. Yet, such a difference was not statistically significant (p-value 0.153). It could be possible that the finding was incidental and should not to be taken seriously because there was no plausible scientific explanation for it. Also, hypertension was not a statistically significant patient factor (p-value 0.054). However, height (p-value 0.031), formal housing (p-value 0.020) and employment status or income (p-value 0.001) were associated with good glycaemic control.

Moderate physical activities which increased the heart rate were relevant and affected the good glycaemic control. However, the finding was not statistically significant (p-value=0.059). The finding was in agreement with the evidence-based recommendations by SEMDSA (2017), ADA (2019) or IDF (2019). Those undergoing exercises were twice (Odds ratio=2.14) more likely to have a good glycaemic control compared to those who did not. However, the risk difference was not statistically significant (p-value 0.059), although in line with reports that had demonstrated regular physical activity and moderate cardiorespiratory fitness were associated with a reduction in cardiovascular and overall mortality of type 2 diabetes mellitus patients (Umpierre *et al*, 2013). The finding was hardly surprising because patient-related factors associated with glycaemic control over the years had been difficult to elucidate from study to study and were sometimes even contradictory.

Otiniano *et al* (2012) found longer duration of disease, lower level of education, frequent use of glucometer, smoking and obesity were all associated with poor glycaemic control. However, Ahmad

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et al (2013) could not find an association of smoking and duration of diabetes with poor glycaemic control in a systematic review. Yet, Otiniano *et al* (2012) showed that obesity was associated with poor glycaemic control. In this study, a lower level of education was not associated with good glycaemic control. Yet, studies conducted by Khan *et al* (2012) in Saudi Arabia found an association between level of education with good glycaemic control. Further, this study could not establish any association between duration of the disease and glycaemic control although Hawaii (Juarez *et al*, 2012) and Otiniano *et al*, 2012) studies did establish that the longer duration of disease was associated with poor glycaemic control. That finding was supported by current evidence from IDF (2019) or WHO (2014).

Another patient-related factor of potential controversy was unemployment (rather than employment), which could not be established to have any association with glycaemic control in this study. However, the observed level of self-reported responses by participants in this study was not related to the glycaemic control. Hence, the finding should be viewed with caution.

Lastly, there was no association between depressive symptoms and glycaemic control. Hence, depression was not a major co-morbidity of T2DM in this study, contrary to findings from other studies (Kendzor *et al*, 2014). Caution must be taken in interpreting the finding because participants tended to underestimate or overestimate situations in self-reported surveys. Further, this study used Patient Health Questionnaire-2 (PHQ-2) which helped to screen for depressive symptoms among participants, but the tool was not appropriate for diagnosis of depression in the primary health care. Consequently, one would argue that the questionnaire was not suitable to determine an association between depressive symptoms and glycaemic control. Hence, depressive symptoms would need further research using newer and relevant tools such as PHQ-9 or the Hamilton Depression Scale, according to Diagnostic and Statistical Manual of Mental Disorders, 5th Edition: DSM-5.

Potential strengths and limitations of the study

The design was appropriate to study patient-related factors with glycaemic control. However, the findings could not be generalized to all peri-urban primary health care facilities in South Africa due to the geography and culture. Sampling method was prone to selection and information bias by researchers. Although sampling was conducted systematically by picking every third T2DM patient presenting for chronic reviews, the convenient round figure of 200 was not the best in determining the size. The questionnaire was self-reported, but researcher administered. Hence, participants could have under-or overestimated their responses to suit the situation. The fact that data was collected over a four-month period meant exposure was not constant. Therefore, caution was needed in inferring temporal effects on the study results. The study was intended to be a snapshot in time with no causal or longitudinal relationships in the associations determined. The PHQ-2 which was utilized was not the appropriate tool to diagnose depression in primary health care. A newer version PHQ-9 or Hamilton Depression Scale could be utilized in future studies.

Conclusion

It was to be expected that majority of participants in this study had poor glycaemic control considering the information on glycaemic control globally (WHO, 2014; IDF, 2019). Nonetheless, this study had better results on glycaemic control in South Africa because it had comparable glycaemic control to some middle-income countries such as Saudi Arabia (Khan, A *et al* 2012; Al-Lawati *et al*, 2012; Khattab *et al*, 2010). Patient factors which influenced glycaemic control were multiple, complex, variable and sometimes contradictory. The patient-related-factors which were associated with good glycaemic control were age, formal housing and earning an income. Hypertension, normal weight and regular physical activities were not significant findings. Neither good nor poor glycaemic control was observed with depression, compliance, other co-morbidities and complications. Depressive symptoms were not associated with glycaemic control in this study. Hence, older patients living in formal housing with an income were more likely to have good glycaemic control. Hence, health promotion and disease prevention efforts should focus on younger T2DM patients (here identified as the population at risk) to prevent poor glycaemic control and complications of T2DM.

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Authors' contributions

JMM was the principal investigator. BP, JMM & JSM were involved in the study conceptualization and manuscript development. JMM & JSM were involved in manuscript revisions and submission. BP was responsible for the data collection and JMM supervised the study.

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