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Original research

The clinical outcomes of patients with diabetes and hypertension in a peri-urban area, Johannesburg, South Africa

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ABSTRACT

Aim: To describe the clinical outcomes of patients with type 2 diabetes (DM2) and hypertension (HT) who received treatment and care at a specialized primary healthcare facility.
Methods: A cross-sectional study was conducted and data retrieved from 349 patient's records. The clinical outcomes were linked to individual risk factors and demographic profiles. Patients with HT who had at least four blood pressure (BP) measurements and patients with DM2 who had at least two HbA1c measurements in a 12-month period were included.
Results: More females had controlled HT than males. There was no sex difference observed for the control of DM2. Patients with HT visited the clinic for a median period of 96 days (IQR 35–257). Among 59.1% (n = 159) patients who achieved at least one controlled BP measurement, 64.2% (n = 102) had a controlled BP at the last visit. Patients with DM2 visited the clinic for a median period of 851 days (IQR 449.5–1254). From a total of 34 patients (43.5%) who achieved at least one controlled HbA1c measurement, 55.9% (n = 19) had a controlled HbA1c at the last visit.
Conclusion: Despite the difference in patient profiles, more than half of the patients who received specialised DM2 and HT care managed to achieve BP and HbA1c control.
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1. Introduction

Non-communicable diseases (NCDs) are on the increase and are known to be a leading cause of death worldwide [1]. The World Health Organization (WHO) reported that NCDs account for 71% of the 57 million deaths globally, and 78% of these deaths occur in low-and middle-income countries (LMICs) [2]. Non-communicable diseases are included in the Sustainable Development Goals that aim to reduce the premature mortality rate by one third by 2030 [3].

It has been estimated that the quadruple burden of disease in South Africa (SA) is two to three times higher than in developed countries, affecting mostly the poor in urban and peri-urban settings [1]. In SA, NCDs are increasing in both rural and urban populations mainly due to unhealthy lifestyles [4]. In 2016, the HT prevalence rate in SA was 45.5% (for women 15 years and older) and 43.7% (for men 15 years and older) [5]. The overall prevalence rate of DM in SA has drastically increased from 5.4% in 2017 to 12.7% in 2019 [6].

The WHO identified an integrated approach to Primary Health Care (PHC) as the best implementing framework to effectively respond to the burden of chronic diseases [7,8]. The PHC approach has been implemented as part of the SA National Development Plan 2030 [1]. The SA government aims at improving service delivery through re-engineering of PHC with the Integrated Chronic Disease Management (ICDM) model as part of this initiative [9].

Nurse-driven PHC facilities manage over 85% of all patients in communities who rely on the public sector [4]. Nurses in PHC settings have limited access to a doctor, but have tools such as the 'Adult Primary Care' guideline [10], the 'Essential Drug List' [11] and the 'Management of Type 2 diabetes for Adults in PHC level' guideline [12].

Type 2 Diabetes Mellitus (DM2) and Hypertension (HT) frequently present together or follow on one another with substantial overlap in aetiology and disease mechanisms, suggesting either shared genetic or environmental factors, which increase the risks

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for all-cause mortality [13]. Sociodemographic and clinical factors are believed to have an impact on the control of NCDs. The prevalence of HT was reported as being lower in rural SA black men and significantly higher in obese black women [14]. The poorest level of HT control was among uninsured, poor young men aged between 15 and 25 years [14]. A SA study reported a positive linear association between the duration of DM2 and poor HT control. DM2 control was poorer (HbA1c >10%) in patients with a longer duration of diabetes and this was associated with uncontrolled HT [15]. Similar trends of poor blood pressure control in patients treated for hypertension were also found in rural Ghana, Zimbabwe and Morocco [15].

The global burden of disease study suggests that the analysis of risk factors attributable to the disease burden e.g. the demographic and disease profiles can inform the design of specific interventions and programmes [16]. Project HOPE used this approach to design a programme with specific interventions, targeting DM2 and HT in a peri-urban area in SA.

2. Setting

The HOPE Centre, an international non-governmental organisation (NGO), was situated in Zandspruit, City of Johannesburg. The aim of the centre was to provide clinical services for the treatment and management of DM2 and HT and educate the community about these lifestyle diseases over a five-year period [17].

Approximately 90% of the population of Zandspruit live in informal dwellings (shacks). This transient community from diverse backgrounds, live with limited access to basic services such as water and sanitation. Unemployment is high (70%) and people face an array of social challenges, including poverty, poor housing conditions, and limited access to basic health and educational services [17].

This study focused on the effect of individual risk factors and demographic profiles on the clinical outcomes of patients with DM2 and/or HT who attended the clinic.

3. Methods

3.1. Study design

An analytical cross-sectional study was conducted. The study used data from a cohort of clinic patients with DM2 and/or HT (n = 349). Data was collected between September 2012 and October 2017. Inclusion criteria were patients who: (1) had either DM2 and/or HT for at least a year; (2) had at least more than one clinic visit; and (3) had at least two consecutive Hb1Ac measurements for DM2 and at least four consecutive blood pressure measurements for patients with HT in a 12-month period. Patients with HT were included if their average number of days between visits was less than 90 and the maximum difference between visits was less than 100 days.

Data were obtained at different data collection points during the five years of the project and unreliable data were excluded. Baseline data collection included demographic detail such as age, sex, smoking, ethnicity, level of education and employment status (self-reported).

3.2. Physical examination data

Anthropometric measures included height, measured to the nearest 0.1 cm, weight in kilograms (kg) using a digital scale, and waist circumference measured in centimetres (cm). Body mass index (BMI) measurements were obtained using a BMI wheel (kg/m^2) and categorised according to the WHO criteria for BMI values, (Underweight: <18.5 kg/m^2; Normal: ≥18.5 to <25 kg/m^2; Overweight: ≥25 to <30 kg/m^2 and Obese: ≥30 kg/m^2). A DM2 diagnosis was defined as a random blood glucose (RBG) ≥ 11.1 mmol/L and two or more symptoms, or fasting blood glucose (FBG) ≥7.0 mmol/L. Hypertension was defined as systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg. Ambulatory blood pressures (BP) were measured using an electronic automated BP device (Omron/Microlife). Two seated BP readings were done at the level of the heart, one reading per arm, after five minutes of resting. If the BP was high, it was repeated on the same arm after five minutes of rest. Appropriate BP cuffs sizes were used. A BP > 140/90 mmHg obtained at two separate occasions, (two separate visits a minimum of two weeks apart) was significant of a HT diagnosis. A systolic BP of <140 mmHg and a diastolic BP of <90 mmHg in patients with HT, was considered as being controlled.

3.3. Blood tests

Non-fasting blood samples were obtained for HbA1c testing on patients with DM2, analysed by a point-of-care Siemens device or the National Health Laboratory Services. The HbA1c measurements were done twice a year for controlled patients, and every three months for uncontrolled patients. An HbA1c <7% was regarded as controlled.

3.4. Data management and analysis

Data was extracted from the REDCap (Research Electronic Data Capture) system which was used to record patient information [18]. All data was exported into a CSV file and analysed in STATA 15 (Stata Corp. 2017). Descriptive statistics were done on all the data. Analysis was done on two specific clinical outcomes: DM2 (HbA1c) and HT (BP). The DM2 and HT clinical outcomes were linked to individual risk factors, demographic profile and socioeconomic status. The two-sample *t*-test was used to compare means of BMI, age and other continuous variables between groups. The Chi–square test was used to test for associations between categorical variables. Waist circumference, smoking, education and employment status wasn't included in the analyses due to a large percentage of missing values.

The percentage of time in the study with controlled BP was calculated. Days in control were defined as days between a visit where BP was controlled and the subsequent visit. Each control visit to the next day of control were summarised for each patient and calculated as a percentage of the overall days in study. A Lowess curve is used to describe the trend in percentage of patients who had controlled visits for each 30- and 180-day interval, relative to the screening date. Statistical significance was taken as 5%.

3.5. Ethics approval

Ethical approval was obtained from the University of Pretoria, Faculty of Health Sciences Research Ethics Committee (Protocol No:497/2018) and from the Johannesburg Health District (NHRD No: GP_201810_010).

4. Results

4.1. Demographic and Socioeconomic profile

A total of 349 patient's records met the inclusion criteria. (Fig. 1) Seventy-seven percent had HT (n = 269) and 23% (n = 80) had DM2. Among the 269 patients with HT 12% (n = 32) also had DM2. Among the 80 patients with DM2 35% (n = 28) only had DM2.

Table 1
Characteristics of study population by disease at baseline visit.

Variable		HT (n = 269)			DM2 (n = 80)		
	N	Mean (±SD)	Range	N	Mean (±SD)	Range	
Age (years)	Male	84	50.8 (11.8)	28–76	25	51.2(8.0)	35–66
	Female	178	46.9(11.5)	20–82	54	49.0(9.9)	28–77
				N	(%)	N	(%)
Sex		Male		84	32	25	31
		Female		182	68	55	69
Smoking status (self-reported)		Smoker		28	11	12	15
		Non-Smoker		233	89	68	85
Employment status (self-reported)		Income		109	41	34	43
		No income		78	29	21	26
Educational levels (self-reported)		Below grade 6		80	30	22	28
		Grade 7–11		74	28	22	28
		Grade 12 and higher		35	13	11	14
Ethnicity (self-reported)		Zulu		45	17	7	8
		Sotho		35	13	9	11
		Tswana		42	16	13	16
		Pedi		36	14	26	33
		Tsonga		14	5	1	1
		Xhosa		25	9	7	8

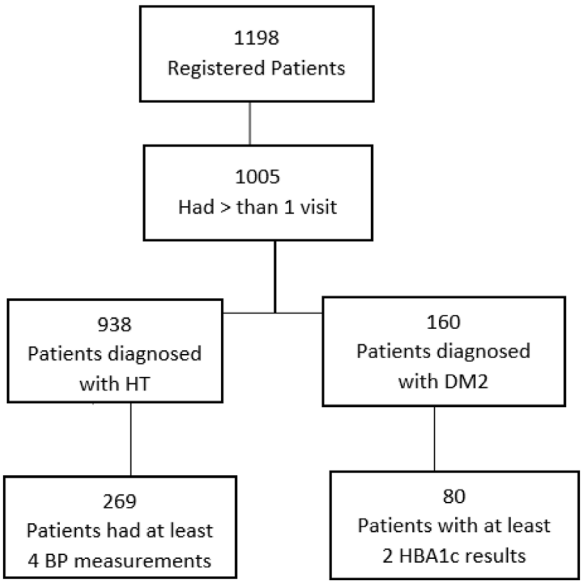

Fig. 1. The flow of HT and DM patients in this study.

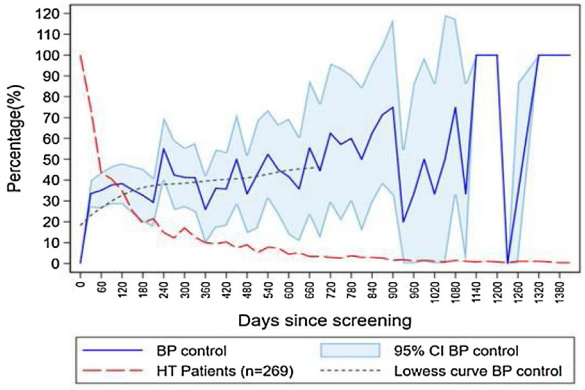

Fig. 2. A Lowess curve for HT control.

Table 1 shows the baseline characteristics of the study population. The mean age (±SD) for male patients with HT was 50.8 (±11.8) years and for female patients with HT was 46.9 (±11.5) years. Patients with DM2 had a mean age (±SD) of 51.2 (±8.0) years for males and 49.0 (±9.9) years for females. There were more female patients (68%; n = 182) with HT than male patients (32%; n = 84). Similarly, there were more female patients (69%; n = 55) with DM2 than male patients (31%; n = 25).

There were more non-smokers (89.3%;n = 233) than smokers (11%;n = 28) in patients with HT. Similarly, in patients with DM2, there were more non-smokers (85%; n = 68) than smokers and (15%; n = 12).

Almost half (41%; n = 109) of patients with HT and patients with DM2 (43%; n = 34) had some form of income. Very few patients with HT (13%; n = 35) and DM2 (14%; n = 11) completed grade 12 or achieved a more advanced qualification.

4.2. Baseline assessments of anthropometric measures and clinical outcomes of HT and DM2

Table 2 reports the baseline assessment of anthropometric measures and the clinical outcomes of patients with HT and/or DM2.

4.3. Description of clinical outcomes and survival analysis

The 269 HT patients had a total of 1237 visits in the study period, ranging from 1 to 26 visits per patient. They were in the study for a median period of 96 days (IQR: 35–257). Patients had controlled BP at 37.3% of the 1237 visits. In total, 59.1% (n = 159) of patients had at least one controlled BP measurement with 27% (n = 43) of those only achieving a controlled BP at the last visit. Among those patients who had at least one controlled measurement, the majority (64.2%; n = 102) had a controlled BP at last visit. Those who never attained control spent a median time of 49 (IQR: 28–98) days in the study. The patients who had controlled BP at least once, spent a median period of 40.4% (IQR: 0%–59.2%) of their days until final screening in control as defined earlier (Fig. 2).

The 80 patients with DM2 had a total of 294 visits in the study period, ranging from 1 to10 visits per patient, for a median period of 851.5 (IQR: 449.5–1254) days in the study. There was a record of controlled DM2 (HbA1c <7%) at only 27.2% of the 294 visits. In total, 43.5% (n = 34) of patients had at least one controlled HbA1c

Table 2
Baseline assessments of anthropometric measures and clinical outcomes by disease.

	HT			DM2		
	N	Male	Female	N	Male	Female
BMI < 25 (kg/m^2)	72	38 (45%)	34 (19%)	14	6 (24%)	8 (15%)
BMI ≥ 25–29(kg/m^2)	64	21 (25%)	43 (24%)	21	7 (28%)	14 (26%)
BMI ≥ 30 (kg/m^2)	129	25 (29.8%)	104 (57.4%)	45	12 (48%)	33 (60%)
		Mean (±SD)	Range		Mean (±SD)	Range
Waist circumferences (cm) (Male)	47	93.5 (12.9)	70–124	14	103.2 (7.9)	90–117
Waist circumferences (cm) (Female)	118	100.3 (17.9)	72–199	35	103.3 (12.8)	79–130
Systolic BP mmHg (Male)	84	168.9 (22.3)	131–235	25	141.0 (21.2)	113.0–199.5
Diastolic BP mmHg (Male)	84	101.5 (15.0)	73–148	25	89.8 (12.6)	60–127.5
Systolic BP mmHg (Female)	182	155.2 (20.6)	112–244	55	142.2 (27.5)	102–209.5
Diastolic BP mmHg (Female)	182	99.5 (12.7)	69–151	55	89.8 (15.6)	65–133.5
HbA1c % (Male)				25	9.8(3.3)	5.2–14
HbA1c % (Female)				55	9.0 (2.8)	5–14

The majority of female patients with HT (57.4%; n = 104) or DM2 (60%; n = 33) were obese. Both male and female patients with DM2 had a higher mean WC than their counterparts with HT.
DM2 control (HbA1c) was similar among the sexes, ranging between 5%–14% and a mean (±SD) HbA1c of 9.8% (±3.3) for male and 9.0% (±2.8) for female patients.

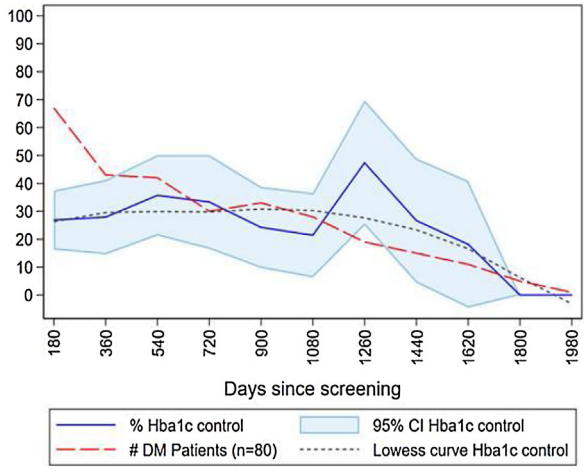

Fig. 3. A Lowess curve for DM2 control.

measurement with 55.9% (n = 19) of those having controlled HbA1c at the last visit (Fig. 3).

There was no statistical significant difference found in the number visits for male and female patients with DM2, between those who were controlled and those who never reached control.

4.4. Individual risk factors and demographic profile in patients with controlled and uncontrolled HT or DM2

Table 3 shows that there were more female patients with controlled HT (66%; n = 120) than female patients with controlled DM2 (21.8%; n = 12). Patients with controlled HT and DM2 were younger, with a mean age (±SD) of 46.5 (±12.7) and 47.1 (±10) years respectively, when compared to patients with uncontrolled HT and DM2 with a mean age of 48.3 (±12.3) and 49.7 (±11.1) years respectively.

5. Discussion

The study focused on the clinical outcomes of patients with HT and DM2 linked to their individual risk factors and demographic profiles.

Although more female than male patients were registered at the clinic for both HT and DM2, both males and females in this study regularly visited the facility because they also received other healthcare services such as reproductive healthcare services (pap smears and prostate blood tests). Male and female patients with DM2 were on average older than patients with HT. This outcome confirmed results reported by Wang et al. who suggested that health seeking behaviours may depend on age and types of condition [19].

Screening for DM2 and HT should be introduced at an earlier age than the suggested age of 45 years, as showed in this study where patients as young as 20 years had HT and 28 years had DM2. In a 15-year old study of people with diabetes, a concern was raised that the younger generation is at risk of losing more life years, due to rapid worsening of conditions found in the increasing number of younger people with diabetes [20].

There was no statistically significant difference in the BMI values amongst patients with controlled or uncontrolled HT and/or DM2, although obesity was found to be associated with both HT and DM2. Patel et al. reported that obesity was a strong predictor for diabetes in men and a weak predictor for hypertension among both men and women [21].

A study conducted in a rural area in SA, demonstrated that with time and routine home visits by community health workers, patients demonstrated a significant improvement in their HT and DM2 control through repeated visits [22]. Despite this finding, patients with DM2 and no comorbidity achieved better control when visiting the clinic rather than being visited at home [22,23]. In this study about a third of HT and DM2 patients managed to achieve control and more than half of those maintained control at their last visit. Both male and female patients with DM2 achieved

Table 3
Individual risk factors and demographic profiles in patients with controlled and uncontrolled HT or DM2 at last visit.

Variable	HT	Uncontrolled		HT	Controlled		DM2	Uncontrolled		DM2	Controlled	
	N	Mea(±SD)	Range	N	Mean(±SD)	Range	N	Mean(±SD)	Range	N	Mean(±SD)	Range
Age	165	48.3 12.3	29–78	102	46.5 12.7	28 82	61	49.7 11.1	30 77	19	47.1 10.0	28 62
				N	(%)	N		(%)	N	(%)	N	(%)
BMI <25				45	61.6	28		38.4	11	78.6	3	21.4
BMI ≥25, <30				40	61.5	25		38.5	16	76.2	5	23.8
BMI ≥30				78	61.9	48		38.1	33	75.0	11	25.0
Sex			Male	59	70.2	25		29.8	18	72.0	7	28.0
			Female	107	58.8	75		66.0	43	78.2	12	21.8

similar control. This result may probably be due to repeated visits, implementation of various activities adopted from both private and public reforms such as the intensive management, treatment and adherence guidelines, and health promotion through access to outreach teams and patient empowerment programs [24]. Although the presence of co-morbidities was not assessed in this study, it is known that patients with DM2 develop co-morbidities and complications over time which makes it more difficult to control their DM2. There is an immediate biological response in patients with HT and the disease itself is not as progressive as DM2, making the management of HT "easier" than patients with DM2.

Managing DM2 is multi-factorial, and needs medical intervention in terms of continuous monitoring and drug titration as well as behaviour changes by the individual: adherence to medication, diet and exercise and weight-loss. Knowledge of the disease and its management is very important and more difficult to control or to manage.

Innovative strategies are needed to assist and support patients with HT and DM2 to achieve control, remain controlled and for patients with DM2 to even improve their long-term health.

Further studies

Future studies should explore innovative strategies empowering patients to self-manage their conditions within reasonable contact time and individualised support from healthcare workers. If self-empowerment is shown to be effective, it could benefit both the health care system and patients. Acknowledging that HT and DM2 are lifestyle conditions and the health system has adjusted its health services delivery over time, it may be worthwhile looking into programs that encourage self-management. With the recognition that the management of patients with DM2 in the public sector is under-resourced, the SA government is aiming to change this through the introduction of the National Health Insurance Bill for Universal Health Coverage. This reform change may provide opportunities to further explore strategies that may potentially benefit patients with DM2.

Limitations and strengths of the study

Limitations: Self-reported variables such as age, smoking, ethnicity, employment status and educational levels could not be validated. Missing values limited potential analyses. There were many patients with DM2 and HT enrolled at the start of the study. As a highly transient community, patients often moved far and outside of their community due to employment, thus resulting in an *ad hoc* visit to the clinic. The numbers declined rapidly when the inclusion and exclusion criteria were applied to the dataset.

Strengths: The study setting as a dedicated PHC facility with special focus on HT and DM2 made it the ideal setting to assess clinical outcomes.

Conflict of interest

None.

Acknowledgments

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