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REVIEW ARTICLE

Prevalence and treatment-related outcome of hospitalised type 2 diabetes mellitus patients with comorbidities at an academic hospital in Johannesburg

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Background: Diabetic patients with comorbidities face increased risks of morbidity, mortality, and hospitalisation, leading to higher healthcare costs. Despite compliance with treatment, many do not achieve desired glycaemic control (HbA1c < 7%). Identifying comorbidities in T2DM patients can enable more comprehensive care. This study aimed to investigate T2DM control in hospitalised T2DM patients with and without comorbidities.
Method: A retrospective chart review of 246 T2DM patients aged ≥ 18 admitted in 2019 to Helen Joseph Academic Hospital was conducted. Files were randomly selected and data summarised using descriptive statistics.
Results: The mean age was 52 ± 13.4 years. Comorbidities were present in 73% (179) of patients, with a majority being female (51%, 126). Among those with comorbidities, 30% (74) had complications. Hypertension was the most common concordant disease, and HIV the most common discordant disease. Diabetes-related conditions led to hospitalisation in 63% (155) of T2DM patients.
Conclusion: A high prevalence of comorbidities was observed in hospitalised T2DM patients. Although there was no significant association with some cardiac risk factors (blood glucose, cholesterol, HbA1c), blood pressure was higher in T2DM patients with comorbidities compared with those without.

Keywords: comorbidities and modifiable risk factors, type 2 diabetes

Introduction

Diabetes mellitus (DM) is a metabolic chronic illness, characterised by high random plasma glucose levels of ≥ 11.1 mmol/L or a fasting plasma glucose of ≥ 7.0 mmol/L.[1] There are two types of DM (Type 1 and Type 2).[2] Type 1 DM (T1DM), accounts for 10% of all DM cases, and is caused by insufficient production of insulin.[2] Type 2 DM (T2DM) is responsible for 90% of all DM cases, and is characterised by insulin resistance and altered tissue sensitivity.[2] This results in some patients having normal insulin levels but manifesting high blood glucose levels.[2]

Globally, it is estimated that 422 million people are currently living with T2DM according to the latest statistics by WHO (2023).[3] In South Africa, 4.2 million people are estimated to be living with diabetes as provided by the International Diabetes Federation.[2]

Furthermore, it is projected that, by 2030, the number of cases of DM worldwide will reach 570 million.[20] The main disease burden of DM is in low- and middle-income countries.[3] In South Africa, 2019 epidemiological prevalence data suggests that, of adults aged 20–79 years, 12.7% are living with T2DM.[2]

An indicator of glycaemic control is the measure of the percentage of HbA1c checked over the last three months.[1] HbA1c levels higher than 7.5% are linked to an increased risk of microvascular complications (life-threatening diseases due to uncontrolled diabetes).[4] This includes retinopathy, neuropathy, and nephropathy.[4] The progression of these pathologies can be slowed by reducing blood glucose levels.[5]

It is estimated that 6.7 million people died from diabetes worldwide in 2021.[2] The majority of the deaths were due to cardiovascular complications.[2] It is also known that elevated cholesterol, high blood pressure, and hyperglycaemia are modifiable risk factors, which impact both microvascular and macrovascular outcomes.[1,6]

Furthermore, an increased risk of cardiovascular morbidity and mortality is associated, when hypertension and hyperlipidaemia are both not adequately controlled in T2DM.[7] Studies also show that for T2DM there is a higher hospitalisation rate for patients with comorbidities (presence of an additional one or more chronic diseases), than without comorbidities.[8] Common comorbidities associated with T2DM include cardiovascular diseases, arthritis, cancer, mental disorders, respiratory diseases, and HIV.[4] These comorbidities generally increase healthcare expenditure.[8]

Aim

The objective was to investigate the control of T2DM in hospitalised T2DM patients, with and without comorbidities.

Methods

Study design and study site

This quantitative study took place at the 636-bed Helen Joseph Academic Hospital in Johannesburg, South Africa. The hospital provides tertiary services and specialised services such as oncology, HIV, breast, pain, and endocrinology clinics. Inpatient records were retrospectively reviewed.

Study population and sample

T2DM patients, aged 18 years or older, who were admitted to hospital between January 1, 2019 and December 31, 2019 were included in the study. The year 2019 was chosen as

patients admitted in 2020/21 could have been affected by SARS-CoV-2, which could have been a potential confounder in the study.[9]

A total of 246 patients' records were obtained using a systematic sampling method. Starting with the first identified patient in 2019, every second file was selected thereafter. In the case where the required data were not recorded in the patient file, that file was excluded and the next sequential file was selected until the total number of required files was attained.

Data collection

The data from each patient record were transcribed onto a data collection form. This form consisted of two sections. In Section 1 (demographics and characteristics), demographics included: age, sex, weight, height, length of hospital stay, BMI, and waist circumference. Characteristics included: a reason for admission, level of care (ICU, high care, specialist care, normal care [general]), previous hospitalisation and the number of admissions, and hospitalisation outcome (discharged, death, referral).

Section 2 consisted of clinical indicators, diabetic management history, diabetic complications, and comorbidities. Clinical indicators included: fasting/random blood glucose (mmol/l), blood pressure (mmHg), HbA1c (%), total cholesterol (mg/dl), triglycerides (mg/dl), high-density lipoprotein (HDL-C) (mg/dl), and low-density lipoprotein (LDL-C) (mg/dl). Diabetic management history variables included: the date of first diagnosis for T2DM, T2DM medication used up to 6 months before hospitalisation, prescribed T2DM medication on admission, prescribed T2DM medication used in hospital, prescribed T2DM medication on discharge, and a history of cardiovascular procedures such as stenting and coronary artery bypass grafting (CABG).

Diabetic complications such as retinopathy, nephropathy, neuropathy, gastroparesis, and amputations (peripheral vascular disease) were included. The following comorbidities were included: hypertension, hyperlipidaemia, coronary artery disease, hypothyroidism, glaucoma, dysrhythmia, cardiac failure, chronic kidney failure disease, stroke, and deep vein thrombosis, asthma, chronic obstructive pulmonary diseases (COPD), HIV, cancer, major depressive disorder (MDD), schizophrenia, bipolar disorder, anxiety, epilepsy, Parkinson's disease, Alzheimer's diseases, rheumatoid arthritis and other arthropathies.

Data management and analysis

Data were collected and transcribed into an Excel version 2019 spreadsheet (Microsoft Corp, Redmond, WA, USA) and analysed with Statistica version 14.0 (https://www.statistica.com/en/software/tibco-data-science-/-tibco-statistica). Data were presented as follows: continuous variables were presented as means and standard deviations (SD), and categorical variables were presented as frequencies and percentages. To compare variables between two groups (T2DM with comorbidities and T2DM without comorbidities) the *t*-test was used where data were normally distributed, and the Mann–Whitney U test was used where data were not normally distributed.

To measure objectives, comparing comorbidities (and their prevalence) in T2DM patients who have been hospitalised, percentages of comorbidities were analysed together with the percentage of each comorbidity present. To compare cardiac risk factors (blood glucose, blood pressure, and cholesterol) in hospitalised T2DM patients, T2DM patients with and without comorbidities were evaluated using the *p*-values of each of the risk factors to establish any statistical significance. To compare the length of hospital stay, the mean and standard deviation were used and compared in T2DM patients with and without comorbidities. Reasons for hospitalisations were measured using the percentage of disease that led to admission, whether it was related to diabetes or not. Levels of care received for these T2DM patients were recorded. To assess adherence to the South African National Standard Treatment Guidelines 2019 in the treatment of T2DM patients, diabetes medications prescribed were assessed to see if they were prescribed in line with the guidelines.

Ethics

An ethic clearance certificate (reference number M210814) was obtained from the University of the Witwatersrand Human Research Ethics Committee (HREC). Permission to do the study was obtained from the CEO of the hospital. Patients' confidentiality was protected by the exclusion of any identifiable characteristics and the allocation of a participant study number to each data collection form (Protection of Personal Information Act no. 4. 2013 s.19 of South Africa).

Results

Two hundred and forty-six T2DM patients with a mean (SD) age of 52 ± 13.4 formed part of the data set. The majority 51% (n = 126) were females. The mean (±SD) of blood sugar levels, blood pressure glycated haemoglobin, and cholesterol levels on admission and discharge respectively are summarised (Table 1).

Fifty-four (22%) patients had a history of previous hospitalisation, whilst 192 (78%) were hospitalised for the first time. One hundred and forty-three (58%) of the T2DM patients had no complications compared with 103 (42%) T2DM patients who presented with complications. One hundred and seventy-nine (73%) of the T2DM patients had comorbidities, whereas 67 (27%) of the T2DM patients had no comorbidities. All patients in this study cohort were discharged and no file was assessed to ascertain if any patient(s) had died in the hospital. No patient was referred out.

Table 1: Basic characteristics of T2DM patients (continuous variables)

	Basic characteristics	
Variable	**Number of patients**	**Mean ± SD**
Age	246	52 ± 13.4
Length of stay	246	5 ± 4.3
BSL1	246	18 ± 7.5
BSL2	245	9 ± 2.1
SBP1	246	138 ± 22.1
DBP1	246	82 ± 15.7
SBP2	242	126 ± 14.4
DBP2	242	75 ± 10.8
HbA1c	65	12 ± 3.5
TC	19	3 ± 1.7
HDL-C	16	1 ± 0.8
LDL-C	19	2 ± 1.1

BSL 1&2 = blood sugar level on admission and discharge respectively.
SBP 1&2 = systolic blood pressure on admission and discharge respectively.
DBP 1&2 = diastolic blood pressure on admission and discharge respectively.

Table 2: Level of care received by T2DM patients whilst in hospital

	Comorbidity present		No comorbidity	
Level	**Total number of patients (*n*)**	**Percentage (%)**	**Total number of patients (*n*)**	**Percentage (%)**
ICU	1	0.6	0	0
High care	128	71.5	25	37.3
Specialist care	20	11.2	3	4.5
Normal care	30	16.8	39	58.2
Total	179	100	67	100
Test:	Fisher's exact test.			
P-value:	< 0.0001.			

The level of care that T2DM patients received whilst in hospital

Table 2 indicates the level of care T2DM patients with and without comorbidities received whilst in hospital. One hundred and twenty-eight (71.5%) patients with comorbidities required high care, 1 (1%) had been in ICU, and 20 (11.2%) had been in specialised care, with only 30 (16.8%) requiring normal care. Of those without comorbidities, no patient was in ICU while 25 (37.3%) were in high care, 3 (4.5% were in specialised care, and the majority ($n = 39$; 58.2%) were in normal care.

Reasons for admission

Figure 1 shows reasons for admission indicating that the majority 63% ($n = 155$) were related to diabetes.

Comorbidity profile of T2DM

For concordant diseases, the most prevalent disease is hypertension at 54.9% ($n = 135$) followed by dyslipidaemia at 17.5% ($n = 43$). Dysrhythmia and angina are the least prevalent, both at 0.4% ($n = 1$) as summarised in Figure 2.

For discordant diseases, the most prevalent disease is HIV (10.2%; $n = 25$) followed by arthritis, COPD, and epilepsy (2.9%; $n = 7$), then asthma (2.0%; $n = 5$). The least prevalent diseases were cancer, MDD, schizophrenia, and Alzheimer's disease (0.8%; $n = 2$), as summarised in Figure 3.

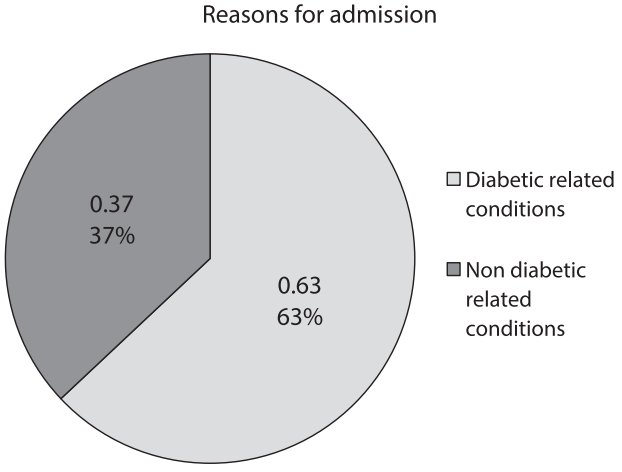

Figure 1: Percentages of diseases that led to T2DM patients being hospitalised. Diabetic-related conditions: hyperglycaemia, diabetic foot, hypoglycaemia, diabetic ketoacidosis, and eye infection. Non-diabetic conditions: major depressive disorder, chronic obstructive pulmonary diseases, cancer, asthma, human immunodeficiency virus, epilepsy, arthritis, schizophrenia and Alzheimer diseases.

Association of cardiovascular risk factors to comorbidities

Table 3 summarises the association of cardiovascular risk factors with comorbidities. Blood sugar levels on both admission and discharge had no correlation with comorbidities, whereas blood pressure (BP) of patients with comorbidities was higher

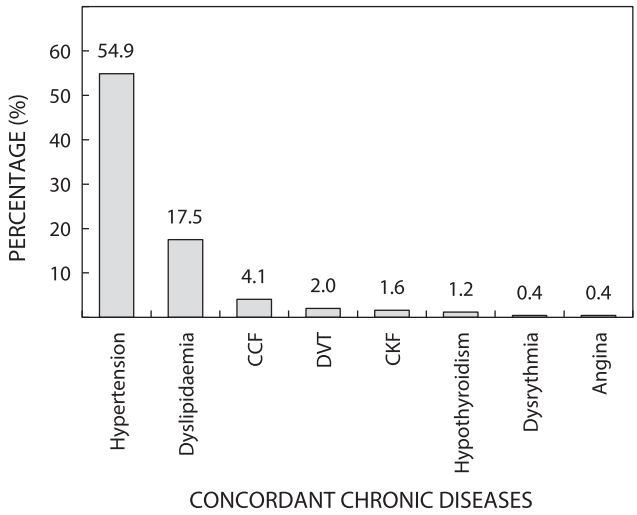

Figure 2: Concordant diseases present in T2DM patients. Definitions: CCF: congestive cardiac failure. DVT: deep vein thrombosis. CKF: chronic kidney failure.

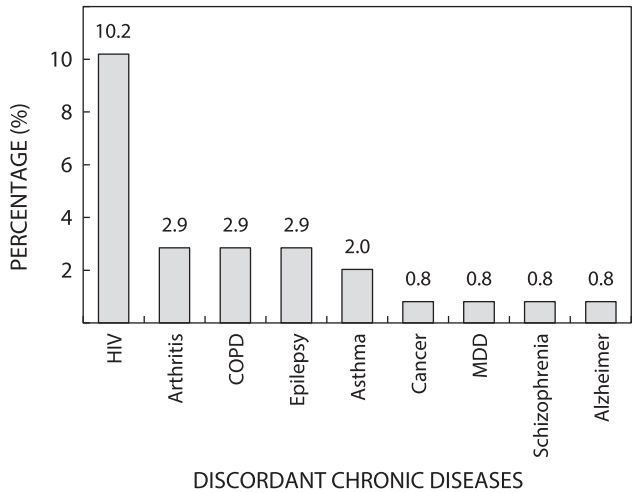

Figure 3: Discordant diseases present in T2DM patients. Definitions: HIV: human immunodeficiency virus. COPD: chronic obstructive pulmonary diseases. MDD: major depressive disorder.

Table 3: Association of cardiovascular risks factors with comorbidities

Factor	No comorbidity Mean ± SD	Comorbidity present Mean ± SD	*p*-value
BSL1	17.6 ± 4.6	17.4 ± 8.3	0.368
BSL2	9.1 ± 2.6	9.0 ± 1.9	0.690
SBP1	131.1 ± 17.7	141.1 ± 23.0	0.001*
DBP1	79.7 ± 13.0	82.7 ± 16.5	≤ 0.000*
SBP2	119.7 ± 10.1	127.8 ± 15.1	0.000*
DBP2	72.5 ± 8.9	75.3 ± 11.3	0.065
HbA1c	11.4 ± 3.5	12.58 ± 4.2	0.209

BSL 1&2 = blood sugar level on admission and discharge respectively.
SBP 1&2 = systolic blood pressure on admission and discharge respectively.
DBP 1&2 = diastolic blood pressure on admission and discharge respectively.
HbA1c = glycated haemoglobin.
*Statistically significant.

both on admission and discharge with a *p*-value less than 0.05, compared with that of patients without comorbidities.

Complications present in T2DM patients

Seventy-four T2DM patients (30%) had both complications and comorbidities whilst 29 (12%) had comorbidities without any complications. Figure 4 shows complications identified in this patient cohort. Diabetic ketoacidosis (DKA) (23.2%, *n* = 57) was the most prevalent followed by neuropathy (9.4%, *n* = 23) and amputation being the least prevalent (2.0%, *n* = 5).

Length of hospital stay of patients with and without comorbidities

Patients with comorbidities stayed longer in the hospital with a mean (SD) hospital stay (days) of 6.0 ± 4.7 compared with 3.6 ± 2.0 of the patients without comorbidities. Eighty-four of these patients (34%) were male and 95 (39%) were female.

Adherence to South African standard treatment guidelines for diabetic medications prescribed for T2DM patients

Figure 5 shows the medications that were prescribed to the T2DM patients with metformin being the most prescribed, having been used by 63.0% (*n* = 155). There were only 6.9% (*n* = 17) on glimepiride. For patients on injectables, Actraphane

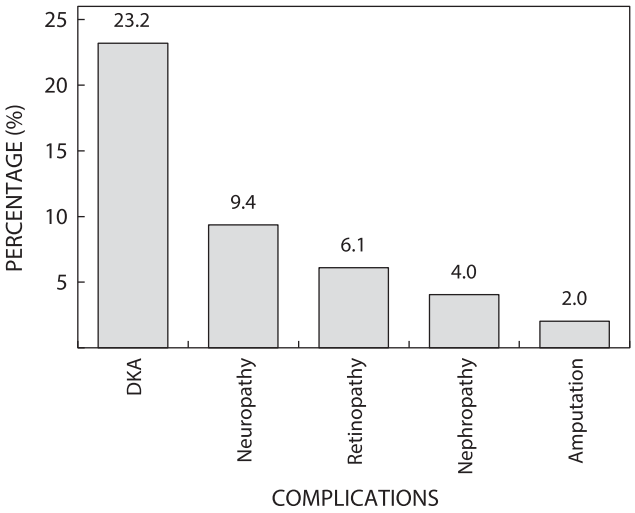

Figure 4: T2DM complications identified in hospitalised patients.

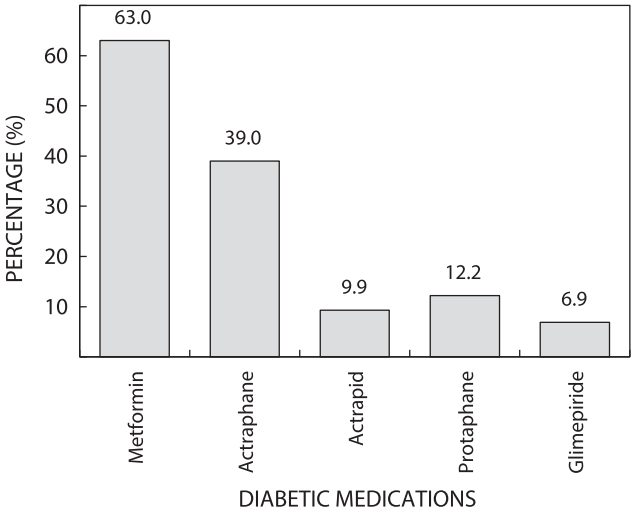

Figure 5: Diabetic medications prescribed to T2DM patients.

accounted for about 39.0% (*n* = 96) of the cases, followed by Protaphane at 12.2% (*n* = 30) and then Actrapid at 9.3% (*n* = 23).

Discussion

T2DM is known to be associated with a reduced quality of life due to a high prevalence of comorbidities and complications.[10] This study is important as it assesses the influence of different T2DM patients' characteristics and comorbidities on successful glycaemic control of T2DM patients hospitalised at Helen Joseph Academic Hospital in 2019.

The analysis of the comorbidity profile was done according to concordant comorbidities, these being diseases that have similar pathophysiology to diabetes and discordant comorbidities, i.e., diseases that are not directly related to the diabetes classification. Factors such as level of care (Table 3), length of hospital stay, hospitalisation outcome, complication profile, the reason for admission, and the diabetic medication prescribed were also investigated and analysed revealing results as discussed below.

This study revealed that almost three-quarters of T2DM patients had one or more chronic diseases. This is a similar finding to other national and international studies.[7,11,12] This study found that 79% had one or more chronic diseases.[12] In general, there was a high prevalence of comorbidities in T2DM patients who were hospitalised.[12]

Almost three-quarters of the patients with comorbidities in our study required high level of care whilst in the hospital. This study also showed that T2DM patients with comorbidities had a prolonged stay (days), with a mean (SD) of 6.0 ± 4.7 compared with those without comorbidities with a mean (SD) stay of 3.6 ± 2.0. These findings are similar to other national and international studies.[11,13] These respective studies therefore concur that T2DM patients with comorbidities require high care in hospital and generally spend more days in hospital than those without comorbidities.

In this study, hypertension was observed in more than half of the T2DM patients assessed, followed by dyslipidaemia. This is similar to studies conducted in South Africa and India respectively, which both established hypertension as the dominant concordant disease among T2DM patients.[9,10,14] Factor(s) that

may contribute to the consistency in hypertension being a dominant concordant disease may point to the lack of intensive screening on each T2DM review visit, as healthcare providers often find it too exhausting and time-consuming.[11,21] On the contrary, the current study could not establish the reason for hypertension dominance in this patient cohort.

Patients with T2DM have the highest prevalence of cardiovascular diseases (CVDs) due to similar pathophysiological traits shared by these two diseases.[16,17] A cross-sectional household survey of 25 532 participants from the South African 2012 national health and nutrition statistics showed that in T2DM patients hypertension was also a common condition in most patients, followed by stroke, heart disease, and then dyslipidaemia.[14]

For discordant diseases, this study found HIV as the leading disease followed by arthritis, COPD, and epilepsy. The estimated overall HIV prevalence rate is approximately 13.7% among the South African population. The total number of people living with HIV (PLWHIV) was estimated to be approximately 8.2 million in 2021. For adults aged 15–49 years, an estimated 19.5% of the population is HIV positive.[18] The high rate of HIV in South Africa could therefore account for the high prevalence of HIV in T2DM patients in this study.

Many patients in the current study who have T2DM were elderly with a mean (SD) age of 52 ± 13.4. Furthermore, a majority of T2DM patients were found to have been admitted due to diabetic-related conditions such as hyperglycaemia, diabetic foot, hypoglycaemia, diabetic ketoacidosis, and eye infection, among others.

In this study, the T2DM patients did not reach the HbA1c target of $6.5\% \leq x \geq 7\%$ as stipulated in the South African treatment guideline (2019 update). There was no statistically significant relationship between HbA1c in patients with and without comorbidities with a p-value of > 0.05 (Table 2). The study further shows no difference in cardiac risk factors of T2DM patients with and without comorbidities.

In this study, less than a quarter of T2DM patients had multiple admissions to hospital before 2019. Among the T2DM patients with comorbidities, almost a third had complications. The dominant complication was diabetic ketoacidosis. This could be due to poor adherence to medication or the presence of competing chronic illnesses causing difficulty in administering medication.[11,19]

A cross-sectional study of 373 185 participants conducted in Catalonia, Spain, pointed out that the presence of comorbid chronic conditions may affect the therapeutic targets of diabetes, thereby leading to increased emergency and unnecessary recurring hospital admissions.[7] Readmissions become more expensive for diabetic patients with comorbid chronic conditions than those without comorbidities.[20] These findings could be a possible reason as to why patients in this study did not reach the target HbA1c.

An analysis of prescribed medications showed that the T2DM patients in this study were predominantly treated with metformin (Figure 5). The current South African treatment guideline (2019 update), recommends the use of metformin tablets as the first-line treatment in patients diagnosed with T2DM if there are no contraindications or allergies.[5] Metformin is a well-accepted, efficacious antidiabetic drug with side effects that are minimal, compared with other anti-diabetic drugs.[16] Metformin is recommended because it also promotes weight loss among people living with T2DM.[10] This shows that there was compliance with national guidelines.

To the best of our knowledge, the study is the first to be conducted in a South African public hospital focusing on the effect of comorbidities in the control of T2DM. This is important, as it highlights the need for proper screening for comorbidities in T2DM patients at each visit at the community level so that proper intervention can be implemented on time, and before complications could arise and lead to hospitalisations.

Conclusion

The study showed that, in this cohort of T2DM patients, the prevalence of one or more comorbidities was 73%. The main concordant disease was hypertension and the main discordant disease was HIV. T2DM patients with comorbidities generally stayed longer in the hospital in comparison with those without comorbidities. The study found that there was no statistically significant association between comorbidity and BSL even though clinically comorbid T2DM patients had higher mean values of BSL. HbA1c as the measure of glucose control over three months could not show any significant difference in patients with and without comorbidities. BP was higher in T2DM patients with comorbidity than in those without. The majority of T2DM patients had diabetic ketoacidosis as the reason for their admission. Moreover, patients with comorbidities required high care and specialist services more than those without comorbidities. Metformin was the most widely used antidiabetic medication. This demonstrates adherence to the latest South African STGs.

Limitations

Files of patients who had died could not be assessed as the files could not be located. Some of the patients' parameters such as cholesterol, BMI, and waist circumference were not routinely done, and therefore could not be evaluated. The study was conducted in one public hospital in Gauteng and may not give a true reflection of the whole province and/or the country. Some of the patient files selected could not be found on the shelves due to filing challenges, which could contribute to selection bias.

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Ethical considerations – An ethics clearance certificate (reference number M210814) was obtained from the University of the Witwatersrand Human Research Ethics Committee (HREC). Permission to do the study was obtained from the CEO of the hospital. Patients' confidentiality was protected by the exclusion of any identifiable characteristics and the allocation of a

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