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Determinants of blood pressure and blood glucose control in patients with co-morbid hypertension and type 2 diabetes mellitus in Ghana: A hospital-based cross-sectional study

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Abstract

Hypertension and diabetes are major risk factors for cardiovascular diseases and optimal control of blood pressure (BP) and blood glucose are associated with reduced cardiovascular disease events. This study, therefore, sought to estimate the prevalence and associated factors of controlled BP and blood glucose levels among patients diagnosed with both hypertension and Type 2- diabetes mellitus (T2DM). A quantitative cross-sectional study was conducted in a primary health setting in Ghana among patients 18 years and older diagnosed with both hypertension and T2DM. Pearson's chi-square was used to assess the association between BP and blood glucose levels and the independent variables. The multivariable binary logistic regression model was used to assess the adjusted odds of controlled BP and blood glucose levels. Among the 329 participants diagnosed with both hypertension and T2DM, 41.3% (95% CI: 36.1–46.8%) had controlled BP, 57.1% (95% CI: 51.7–62.4%) had controlled blood glucose whilst 21.8% (95% CI: 17.7–26.7%) had both controlled BP and blood glucose levels. Increased age, non-formal education, non-married, employed, single-dose anti-hypertensives or anti-diabetic medications, and hyperlipidaemia or stroke co-morbidities were positively associated with controlled BP levels. Being female, married, taking 2 or more anti-hypertensive medications, and moderate to high medication-related burden were positively associated with controlled blood glucose levels. In terms of both controlled BP and blood glucose levels, being employed, reduced income level, being registered with national health insurance, single anti-diabetes or anti-hypertensive medications, hyperlipidaemia or stroke co-morbidities, and moderate to high medication-related burden were positively associated with having both controlled BP and blood glucose levels. One in five patients with hypertension and T2DM had both BP and blood glucose levels under control. The benefits and risks of blood pressure and blood glucose targets should thus be factored into the management of patients with hypertension and T2DM.

Abbreviations: BP, Blood pressure; T2DM, Type-2 diabetes mellitus; FBG, Fasting blood glucose; JNC; AOR, adjusted odds ratio; CI, confidence interval; IQR, interquartile range; SBP, systolic blood pressure; DBP, diastolic blood pressure; LMQ, Living with medicines questionnaire.

Introduction

Hypertension and diabetes remain major public health threats worldwide [1,2]. When these cardio-metabolic conditions co-exist in an individual, there is a worsening of both glycaemic and cardiovascular endpoints [3,4]. Both diseases have similarities in risk factors including lifestyle, dyslipidaemia, familial, and racial as well as complications [5,6]. These complications can be categorized into micro and macrovascular complications. Myocardial infarction, stroke, peripheral vascular disease, coronary artery disease, and congestive heart failure are examples of macrovascular problems, while retinopathy, nephropathy, and neuropathy are examples of microvascular complications [7,8].

A significant contributor to the onset and development of diabetes-related illnesses and complications is inadequate and poor glycaemic control. This can significantly increase medical costs, diminish the quality of life, and reduce life expectancy [4]. Research has shown that improving glycaemic control can help patients live longer, have an improved quality of life, and delay the development and progression of diabetic complications [9]. Also, improving glycaemic control significantly lowers expenditures associated with the management of diabetes [10]. Blood glucose levels must be tightly controlled to delay the onset of diabetes and its related complications.

Clinical recommendations in diabetes care support have varied blood pressure (BP) values; nonetheless, most advocate lower levels compared to people without diabetes [11,12]. The lowering of BP in patients with diabetes results in a significant reduction in cardiovascular problems [5]. The target BP for diabetic patients should be less than 140/90 mmHg, according to the Joint National Committee's eighth report (JNC 8), and most patients will need to take two or more antihypertensive drugs to do so [12]. Increased patient and healthcare provider understanding about the illness, access to care, suitable lifestyle changes, evidence-based treatment, high levels of medication adherence, and thorough follow-up are all components of high-quality BP control [13–15]. In addition, studies have shown that old age, chronic renal diseases, longer duration of hypertension, and uncontrolled diabetes mellitus are significant risk factors for poor BP control [16,17].

According to a Ghana Ministry of Health report, diabetes and hypertension are among the top fifteen causes of outpatient visits [18,19]. Effective management of these patient groups requires substantive knowledge of the patient characteristics and other factors affecting their BP control. Even though there have been studies on factors associated with blood pressure in diabetes [20,21]. Literature on factors associated with regulated BP as well as controlled blood glucose levels among persons with co-morbid hypertension and diabetes is limited. This study, therefore, assessed the factors associated with BP and blood glucose control among patients with co-morbid hypertension and type 2 diabetes mellitus (T2DM) at an outpatient department of a lower-middle-income country hospital.

Methods

Study design and context

A hospital-based cross-sectional study was conducted at the Adabraka Polyclinic which is a public primary health facility in Ghana. The clinic provides all essential general healthcare services including assessment and management of chronic conditions such as hypertension and diabetes mellitus. All the commonly prescribed antihypertensive and oral hypoglycaemic agents are included in the national essential drugs list and covered by the National Health Insurance Scheme (NHIS) [22]. This is in line with the national policy on non-communicable diseases (NCDs) which provides guidelines on the primary prevention (e.g., health

promotion), secondary and tertiary prevention (e.g., screening, and early detection, clinical care/case management) of NCDs [19]. The Outpatient Department (OPD) holds twice-weekly clinics for patients with hypertension and T2DM and provides services for an average of eighty patients daily.

Study participants

The study engaged and recruited adults aged at least 18 years known to have both hypertension and T2DM with documented evidence of these clinical diagnoses in their clinical files. Patients who were on anti-hypertension and anti-diabetes medications for at least six months prior to the study were included in the study. Participants excluded from the study include those with Type 1 diabetes mellitus, gestational diabetes, and evidence of impaired cognitive function. Participants provided informed consent prior to their inclusion in the study.

This study is part of a previous study among people with co-morbid hypertension and T2DM, with a sample size of 326 estimated, which was based on a 74.05% prevalence rate of medication adherence [4], 95% confidence interval, 5% error margin and a 10% non-response rate. The study participants were recruited systematically between October 2021 and November 2021.

Patients' medical records were reviewed to validate the diagnosis of hypertension and T2DM diagnosis.

Measures

Data were collected using a validated questionnaire that included general information on socio-demographic characteristics (e.g., age, sex, marital status, religion, education level, occupation, monthly income, payment method for drugs, monthly expenditure), clinical characteristics (number of medications, frequency of daily dose of medication, presence of co-morbidities, blood glucose level, systolic blood pressure (SBP), diastolic blood pressure (DBP), duration since diagnosis and frequency of follow-up visits, and family history of hypertension and T2DM and medication burden.

The patient's BP was measured using a manual mercury sphygmomanometer. Patients were instructed to rest for 3 to 5 minutes before having their BP measured. They sat back in a chair, their back supported. The nurses ensured that the appropriate cuff size was used for BP measurement based on the patient's arm diameter. The readings were taken three times and the average was taken. In this study, participants with SBP below 140mmHg and DBP below 90mmHg were considered to have controlled BP level.

The fasting blood sugar was measured using a certified automated glucometer (GOLD--ACCU). The finger surface was first cleaned with 75% alcohol, and then the sterilised needle was used to prick it. The very first drop of blood was discarded. After 5 seconds, the reading appeared after the blood sample was placed on the strip. These tasks were carried out by well-trained nurses. In this study participants with blood glucose level below 7.0mmol/L were considered to have controlled blood glucose level.

Pill burden was assessed with the 41-item Living with Medicines Questionnaire (LMQ-3) with the overall score ranging from 41 to 205 [23,24]. Pill burden was categorized according to score range as no burden at all (scores in range 41–73); minimum burden (scores in range 74–106); moderate burden (scores in range 107–139); high burden (scores in range 140–172); and Extremely high burden (scores in range 173–205). The LMQ-3 was dichotomized for analysis in this study as moderate/high burden against minimum burden. The scale is reliable with a Cronbach's alpha score 0.9208 computed in this study.

The 5-item medication adherence report scale (MARS-5) measured adherence behaviour [25]. Each item is rated from 1 = always to 5 = never with the composite score ranging from 5 to 25. This study reports a Cronbach's alpha score of 0.8568 for the MARS-5.

Statistical analysis

Stata IC version 16 (StataCorp, College Station, TX, US) was used for analysis. Descriptive statistics were presented using frequency and percentages for categorical variables, the mean and standard deviation for normally distributed continuous variables, and median and interquartile range (IQR) for non-normally distributed continuous variables. The distribution of SBP, DBP, and blood glucose concentration was described using the box and whiskers plots. The percentage of participants with controlled and uncontrolled levels of BP, blood glucose level and both were presented and corresponding 95% confidence interval were estimated using the binomial exact estimation approach.

The Pearson's chi-square test was used to assess the bivariate association between the socio-demographic, clinical and medication-related characteristics observed in the study and the BP and blood glucose levels among the participants. The multiple binary logistic regression model with robust standard errors was used to assess the adjusted odds of controlled BP, controlled blood glucose and controlled levels of both BP and blood glucose among participants across the various characteristics.

Multicollinearity between the variables was assessed using the variance inflation factor (VIF) which recorded a mean VIF of 3.01 (range: 1.72 to 6.98) which is within the acceptable range of less than 10 all three models. The area under the receiver operating characteristics curve was 0.8552 (95% CI: 0.8130 to 0.8975) for the BP level model, 0.7884 (95% CI: 0.7390 to 0.8376) for the blood glucose model and 0.8537 (95% CI: 0.8041 to 0.9033) for both controlled BP and blood glucose model which were all above 70%. The Hosmer-Lemeshow goodness of fit test was insignificant for both the BP level (p-value = 0.073), blood glucose level (p-value = 0.268) and both BP and blood glucose (p-value = 0.636) model indicating models were appropriately fitted. All statistical analysis in this study were considered significant with p-values less than 0.05.

Ethics statement

The study was approved by Ghana Health Service Ethical Review Committee (GHS-ERC 043/09/21). Participants were chosen for the study depending on their willingness to participate. Informed consent for participation was also obtained from each patient.

Results

Background characteristics of study participants

The mean age of the 329 study participants was 57.5 ± 13.2 years. More than half (56.2%) of them were female and 58.4% were married. Less than a fifth (17.9%) had no formal education whilst 21.3% had a tertiary level of education. The median monthly expenditure on medication was 50.0 cedis (thus, 8.00 USD) with a fifth (20.7%) paying for all their medication using the health insurance. Family history of hypertension and diabetes were 68.1% and 49.8% respectively. Most participants (94.2%) of the participants were on amlodipine as an anti-hypertensive medication. The median number of antihypertensive medications taken was 2 (IQR: 1 to 3) with 70.2% of the participants taking at least 2 different medications. The median number of anti-diabetic medications taken was 2 (IQR: 1 to 2) with 51.1% on at least 2 medications (Table 1).

Table 1. Background characteristics of study participants (N = 329).

Characteristics	Frequency (%)
Overall	329 (100.0)
SOCIO-DEMOGRAPHICS	
Sex	
Male	144 (43.8)
Female	185 (56.2)
Age, Mean [±SD]	57.5 [±13.2]
Age group	
<50	80 (24.3)
50–59 years	108 (32.8)
60–69	78 (23.7)
70+	63 (19.1)
Marital status	
Single	84 (25.5)
Married	192 (58.4)
Divorced	25 (7.6)
Others	28 (8.5)
Highest education	
No formal education	59 (17.9)
Primary	72 (21.9)
Secondary	128 (38.9)
Tertiary	70 (21.3)
Occupation	
Unemployed	41 (12.5)
Trader/artisan	176 (53.5)
Professional	53 (16.1)
Retired	48 (14.6)
Others	11 (3.3)
Monthly income	
0–500 cedis (0–80 USD)	150 (45.6)
501–1000 cedis (81.0–160 USD)	121 (36.8)
>1000 (>160 USD)	58 (17.6)
CLINICAL AND MEDICATION RELATED	
Monthly expenditure on drugs, Median (IQR)	50.0 (30.0, 100.0)
Monthly expenditure on drugs	
None/ Health insurance	68 (20.7)
<50 cedis (<8.0 USD)	101 (30.7)
51–100 cedis (8.1–16.0 USD)	88 (26.7)
>100 cedis (>16.0 USD)	72 (21.9)
Number of anti-hypertensive medications, Median (IQR)	2 (1, 3)
Number of anti-hypertensive medications	
<2 medicine	98 (29.8)
2+ medicines	231 (70.2)
Number of anti-diabetes medications, Median (IQR)	2.0 (1.0, 2.0)
Number of anti-diabetes medications	
<2 medicine	161 (48.9)
2+ medicines	168 (51.1)
Other medications	
Dyslipidaemia medications	
No	264 (80.2)

(Continued)

Table 1. (Continued)

Characteristics	Frequency (%)
Yes	65 (19.8)
Soluble aspirin	
No	314 (95.4)
Yes	15 (4.6)
Frequency of daily dose of medication	
Once	145 (44.1)
Twice	181 (55.0)
Three times	3 (0.9)
Have co-morbidities	
No	269 (81.8)
Hyperlipidaemia	57 (17.3)
Stroke	3 (0.9)
Family history of hypertension	
Yes	224 (68.1)
No	105 (31.9)
Family history of diabetes mellitus	
Yes	164 (49.8)
No	165 (50.2)
Duration since diagnosis of hypertension in years, Median (IQR)	5.0 (2.0, 6.0)
Duration since diagnosis of hypertension	
<5 years	151 (45.9)
5+ years	178 (54.1)
Duration since diagnosis of Diabetes Mellitus in years, Median (IQR)	3.0 (1.0, 5.0)
Duration since diagnosis of Diabetes Mellitus	
<5 years	243 (73.9)
5+ years	86 (26.1)
Frequency of follow-up	
Every 2 weeks	22 (6.7)
Monthly	86 (26.1)
Every 2 months	221 (67.2)
Medication related burden	
Minimum burden	228 (69.3)
Moderate/high burden	101 (30.7)
Medication adherence	
Non-adherence	208 (63.2)
Adherence	121 (36.8)

SD: Standard deviation. IQR: Interquartile range. M: Multiple choice respond. USD: United state dollars conversion in November 2021.

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Hyperlipidaemia and/or stroke co-morbidities were prevalent among 17.3% and 0.9% of the participants respectively. A medication-related burden was moderate/high among 30.7% whilst adherence to medication was 36.8% (Table 1).

Blood pressure and blood glucose levels among participants

The median SBP was 140 mmHg (IQR: 128 to 157mmHg), DBP was 85 mmHg (IQR: 77 to 92mmHg) and blood glucose was 6.5 mmol/L (IQR: 5.6 to 8.3 mmol/L). (Fig 1).
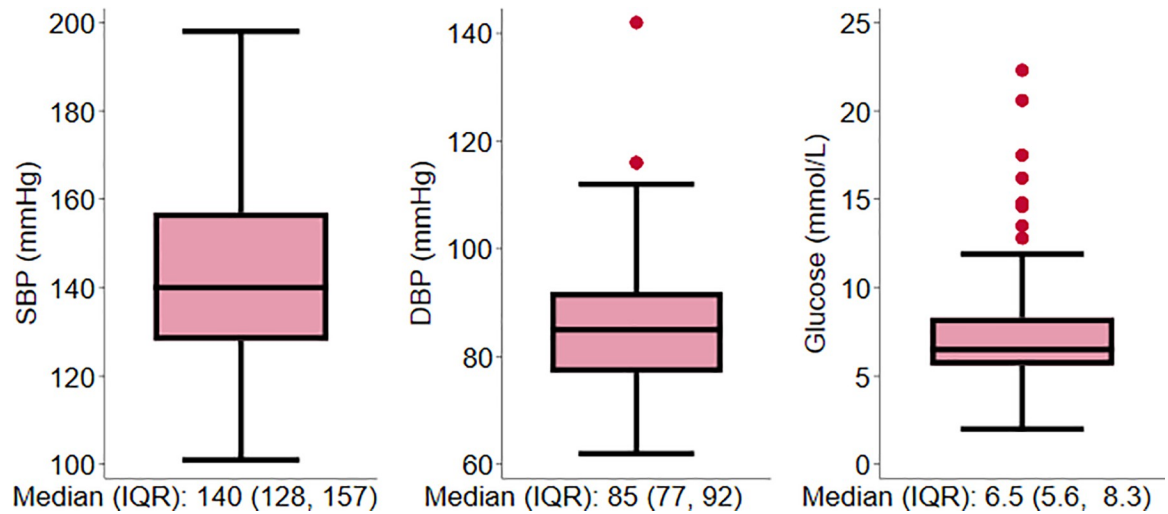
Fig 1. Systolic blood pressure, diastolic blood pressure, and blood glucose levels among study participants.

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Less than half (41.3%) of the participants had controlled BP levels (SBP<140mmHg & DBP<90mmHg) (95% CI: 36.0% - 46.8%) whilst most (57.1%) had controlled blood glucose levels (<7.0 mmol/l) (95% CI: 51.7% - 62.4%). About a fifth (23.4%) had uncontrolled BP and blood glucose levels, 35.3% had uncontrolled blood pressure but controlled blood glucose levels, 19.5% had controlled BP levels but uncontrolled blood glucose levels and 21.8% had controlled BP and blood glucose levels (Table 2).

Bivariate analysis of the association between characteristics of participants and outcomes

Blood pressure control levels only. The bivariate analysis showed that the statistically significant socio-demographic factors associated with the controlled levels of BP among the participants included age group (p = 0.024), marital status (p = 0.001) and the highest level of education (p = 0.001). The statistically significant clinical and medication-related factors associated with BP levels included expenditure on drugs (p = 0.014), number of anti-hypertensive medications (p<0.001), number of anti-diabetic medications (p<0.001), frequency of daily dose of medication (p<0.001), duration of hypertension diagnosis (p = 0.031), and frequency of follow-up visits to clinic (p = 0.021) (Table 3).

Table 2. Blood pressure and blood glucose levels.

Outcomes	Frequency (N = 329)	Percentage	95% CI
Blood pressure level			
Uncontrolled (SBP≥140mmHg or DBP ≥90mmHg)	193	58.7	[53.2, 63.9]
Controlled (SBP<140mmHg & DBP<90mmHg)	136	41.3	[36.1, 46.8]
Blood glucose level			
Uncontrolled blood glucose (7.0+ mmol/L)	141	42.9	[37.6, 48.3]
Controlled blood glucose (<7.0 mmol/L)	188	57.1	[51.7, 62.4]
Blood pressure and blood glucose level			
Uncontrolled BP & uncontrolled blood glucose	77	23.4	[19.1, 28.3]
Uncontrolled BP but controlled blood glucose	116	35.3	[30.3, 40.6]
Controlled BP but uncontrolled blood glucose	64	19.5	[15.5, 24.1]
Controlled BP & controlled blood glucose	72	21.8	[17.7, 26.7]

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Table 3. Bivariate analysis of factors associated with blood pressure level and blood glucose level among hypertensive and type-2 diabetes mellitus co-morbid patients.

Variables & categories	Total	Controlled BP only		Controlled blood glucose only		Controlled BP and blood glucose level	
	N	n (%)	P-value	n (%)	P-value	n (%)	P-value
Overall	329	136 (41.3)		188 (57.1)		72 (21.8)	
SOCIO-DEMOGRAPHICS							
Sex			0.910		0.001		0.140
Male	144	60 (41.7)		68 (47.2)		26 (18.1)	
Female	185	76 (41.1)		120 (64.9)		46 (24.9)	
Age group			0.024		0.023		0.240
<50	80	22 (27.5)		51 (63.7)		13 (16.3)	
50–59 years	108	46 (42.6)		67 (62.0)		29 (26.9)	
60–69	78	36 (46.2)		33 (42.3)		14 (17.9)	
70+	63	32 (50.8)		37 (58.7)		16 (25.4)	
Marital status			0.001		0.820		0.140
Single	84	48 (57.1)		50 (59.5)		24 (28.6)	
Married	192	65 (33.9)		107 (55.7)		35 (18.2)	
Divorced/widowed/separated	53	23 (43.4)		31 (58.5)		13 (24.5)	
Highest education			0.001		0.006		<0.001
No formal education	59	33 (55.9)		36 (61.0)		20 (33.9)	
Primary	72	23 (31.9)		40 (55.6)		13 (18.1)	
Secondary	128	61 (47.7)		84 (65.6)		36 (28.1)	
Tertiary	70	19 (27.1)		28 (40.0)		3 (4.3)	
Employment status			0.340		0.049		0.004
Unemployed/retired	89	33 (37.1)		43 (48.3)		10 (11.2)	
Employed	240	103 (42.9)		145 (60.4)		62 (25.8)	
Monthly income			0.310		0.011		0.280
0–500 cedis (0–80 USD)	150	61 (40.7)		93 (62.0)		38 (25.3)	
501–1000 cedis (81.0–160 USD)	121	46 (38.0)		72 (59.5)		25 (20.7)	
>1000 (>160 USD)	58	29 (50.0)		23 (39.7)		9 (15.5)	
CLINICAL AND MEDICATION RELATED							
Source of expenditure on drugs			0.014		0.160		0.092
Health insurance only	68	37 (54.4)		44 (64.7)		20 (29.4)	
Out-of-pocket	261	99 (37.9)		144 (55.2)		52 (19.9)	
Number of hypertensive medications			<0.001		0.015		<0.001
<2 medicine	98	63 (64.3)		46 (46.9)		34 (34.7)	
2+ medicines	231	73 (31.6)		142 (61.5)		38 (16.5)	
Number of diabetes medications			<0.001		0.660		<0.001
<2 medicine	161	85 (52.8)		94 (58.4)		51 (31.7)	
2+ medicines	168	51 (30.4)		94 (56.0)		21 (12.5)	
dyslipidaemia medications			0.970		0.280		0.023
No	264	109 (41.3)		147 (55.7)		51 (19.3)	
Yes	65	27 (41.5)		41 (63.1)		21 (32.3)	
Soluble Aspirin			0.240		0.400		0.036
Does not take medication	314	132 (42.0)		181 (57.6)		72 (22.9)	
Takes medication	15	4 (26.7)		7 (46.7)		0 (0.0)	
Frequency of daily dose of medication			<0.001		0.002		0.460
Once	145	43 (29.7)		97 (66.9)		29 (20.0)	
Twice/thrice	184	93 (50.5)		91 (49.5)		43 (23.4)	

(Continued)

Table 3. (Continued)

Variables & categories	Total	Controlled BP only		Controlled blood glucose only		Controlled BP and blood glucose level	
	N	n (%)	P-value	n (%)	P-value	n (%)	P-value
Have co-morbidities			0.350		0.026		0.002
None	269	108 (40.1)		146 (54.3)		50 (18.6)	
Hyperlipidaemia /Stroke	60	28 (46.7)		42 (70.0)		22 (36.7)	
Family history of hypertension			0.530		0.056		0.570
Yes	224	90 (40.2)		136 (60.7)		51 (22.8)	
No	105	46 (43.8)		52 (49.5)		21 (20.0)	
Family history of diabetes mellitus			0.620		0.950		0.810
Yes	164	70 (42.7)		94 (57.3)		35 (21.3)	
No	165	66 (40.0)		94 (57.0)		37 (22.4)	
Duration since diagnosis of hypertension			0.031		0.950		0.430
<5 years	151	72 (47.7)		86 (57.0)		36 (23.8)	
5+ years	178	64 (36.0)		102 (57.3)		36 (20.2)	
Duration since diagnosis of T2DM			0.095		0.120		0.960
<5 years	243	107 (44.0)		145 (59.7)		53 (21.8)	
5+ years	86	29 (33.7)		43 (50.0)		19 (22.1)	
Frequency of follow-up			0.021		0.007		0.060
2 weeks/monthly	108	35 (32.4)		73 (67.6)		17 (15.7)	
Every 2 month	221	101 (45.7)		115 (52.0)		55 (24.9)	
Medication related burden			0.200		0.430		0.046
Minimum burden	228	89 (39.0)		127 (55.7)		43 (18.9)	
Moderate/high burden	101	47 (46.5)		61 (60.4)		29 (28.7)	
Adherence to medication			0.810		0.180		0.210
Non-adherence	208	87 (41.8)		113 (54.3)		41 (19.7)	
Adherence	121	49 (40.5)		75 (62.0)		31 (25.6)	

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Blood glucose control levels only. The bivariate analysis showed that sex (p = 0.001), age group (p = 0.023), highest education (p = 0.006), employment status (p = 0.049) and monthly income (p = 0.011) were the statistically significant socio-demographic factors associated with the blood glucose levels of participants. The statistically significant clinical and medication related factors associated with blood glucose level included number of anti-hypertensive medications (p = 0.015), frequency of daily dose of medication (p = 0.002), presence of hyperlipidaemia or stroke co-morbidity (p = 0.026) and frequency of follow-up visits to clinic (p = 0.007) (Table 3).

Blood pressure and blood glucose control levels. The bivariate analysis showed that highest level of education (p<0.001) and employment status (p = 0.004) were the only socio-demographic characteristics associated with controlled BP and blood glucose levels. Number of anti-hypertensive medications (p<0.001), number of anti-diabetic medication (p<0.001), dyslipidaemia medication (p = 0.023), soluble aspirin (p = 0.036), presence of hyperlipidaemia/stroke comorbidities (p = 0.002), and medication related burden (p = 0.046) were the clinical- and medication- related factors associated with controlled BP and blood glucose level (Table 3).

Multivariable binary logistic regression model of factors associated with outcomes of the study

Blood pressure control levels. In the multivariable binary logistic regression model, the adjusted odds of controlled BP compared to those less than 50 years old was over 5 times high

among the 60–69 years old (AOR: 5.16, 95% CI: 1.77–15.02, p = 0.003) and over 9 times higher among the 70 years and older (AOR: 9.44, 95% CI: 3.06–29.16, p<0.001). Compared to the married, the odds of controlled BP were over 5 times high among the single (AOR: 5.70, 95% CI: 2.45–13.26, p = 0.003). Also, compared to those with no formal education, the odds of controlled BP was 86% less among those with primary school education (AOR: 0.14, 95% CI: 0.05–0.35, p<0.001) and 68% less among those with tertiary education (AOR: 0.32, 95% CI: 0.12–0.82, p = 0.018). The adjusted odds of controlled BP was over 5 times high among the employed (AOR: 5.47, 95% CI: 2.30–12.97, p<0.001) (Table 4).

The odds of controlled BP was 84% less among those on 2 or more anti-hypertensive medications (AOR: 0.16, 95% CI: 0.07–0.37, p<0.001) and 70% less among those on 2 or more anti-diabetic medications (AOR: 0.30, 95% CI: 0.15–0.59, p = 0.001). Participants who take two or three daily doses of medications had increased odds of having controlled BP compared to those taking a single dose (AOR: 7.00, 95% CI:2.88–17.01, p<0.001). The odds of controlled BP were 54% less among those who had been diagnosed with hypertension for at least 5 years (AOR: 0.46, 95% CI: 0.23–0.91, p = 0.027) (Table 4).

Blood Glucose control levels. In the multivariable binary logistic regression model, the odds of controlled blood glucose levels were 2 times higher among females compared to males (AOR: 2.04, 95% CI: 1.04–4.00, p = 0.038). The odds of controlled blood glucose levels were 50% less among the single compared to the married (AOR: 0.50, 95% CI: 0.27–0.96, p = 0.037). Also, participants with the highest monthly income levels (>1000 cedis) had 66% reduced odds of controlled blood glucose level (AOR: 0.34, 95% CI: 0.14–0.78, p = 0.012) (Table 4).

The odd of controlled blood glucose level was 2 times among those on 2 or more anti-hypertensive medications (AOR: 2.52, 95% CI: 1.34–4.74, p = 0.004). Participants who took two or three daily doses of medications had reduced odds of having controlled blood glucose levels compared to those taking a single dose (AOR: 0.52, 95% CI: 0.29–0.93, p<0.027). The odds of controlled blood glucose levels were 53% less among those with follow up visits every 2 months (AOR: 0.47, 95% CI: 0.26–0.85, p = 0.012) (Table 4).

Both controlled blood pressure and blood glucose levels. In the multivariable binary logistic regression model, the adjusted odds of controlled BP and blood glucose levels compared to those with no formal education was 84% less among primary school holders (AOR: 0.16, 95% CI: 0.05–0.49, p = 0.001) and 89% less among the tertiary school educated (AOR: 0.11, 95% CI: 0.03–0.44, p = 0.002). The adjusted odds of controlled BP and blood glucose were 10 times high among the employed (AOR: 10.12, 95% CI: 3.28–31.25, p<0.001). Increased monthly income level was associated with decreased odds of controlled BP and blood glucose level, thus compared to those with 0–500 cedis of monthly income, the odds of controlled BP and blood glucose were 75% less for those with 501–1000 cedis monthly income (AOR: 0.25, 95% CI: 0.10–0.60, p = 0.002) and 93% less among those earning more than 1000.00 cedis (AOR: 0.07, 95% CI: 0.02–0.25, p<0.001) (Table 4).

The odds of controlled BP and blood glucose level was 56% less among those whose expenditure on medications were out-of-pocket (AOR: 0.44, 95% CI: 0.20–0.98, p = 0.046). Compared to those on single medications, the odds of controlled BP and blood glucose was 60% less among those taking 2 or more antihypertensive medications (AOR: 0.40, 95% CI: 0.17–0.94, p = 0.036) and 73% less among those taking 2 or more anti-diabetic medications (AOR: 0.27, 95% CI: 0.13–0.56, p<0.001). The odds of controlled BP and blood glucose were over 3 times high among those having co-morbid hyperlipidaemia/ stroke (AOR: 3.35, 95% CI: 1.50–7.48, p = 0.003). Controlled BP and blood glucose levels were significantly high among participants with moderate or high medication related burden (AOR: 2.42, 95% CI: 1.17–5.05, p = 0.018). Adherence to medication was associated with over 2 times higher odds of having both controlled BP and blood glucose level (AOR: 2.12, 95% CI:1.03, 4.34, p = 0.040) (Table 4).

Table 4. Multivariable binary logistic regression model of factors associated with controlled levels of blood pressure, glucose and both blood pressure and glucose among hypertensive and type 2 diabetes mellitus co-morbid patients.

	Multiple binary logistic regression model					
	Controlled blood pressure level		High blood glucose level		Controlled Blood pressure and blood glucose level	
Variables and categories	AOR [95% CI]	P-value	AOR [95% CI]	P-value	AOR [95% CI]	P-value
SOCIO-DEMOGRAPHICS						
Sex						
Male	1.00 [reference]		1.00 [reference]		1.00 [reference]	
Female	0.93 [0.47, 1.84]	0.828	2.04 [1.04, 4.00]	0.038	1.31 [0.49, 3.48]	0.588
Age group						
<50	1.00 [reference]		1.00 [reference]		1.00 [reference]	
50–59 years	0.97 [0.37, 2.56]	0.952	1.38 [0.65, 2.92]	0.401	1.09 [0.36, 3.35]	0.877
60–69	5.16 [1.77, 15.02]	0.003	0.65 [0.27, 1.55]	0.331	1.25 [0.31, 5.00]	0.753
70+	9.44 [3.06, 29.16]	<0.001	1.22 [0.37, 3.99]	0.743	2.33 [0.66, 8.20]	0.188
Marital status						
Married	1.00 [reference]		1.00 [reference]		1.00 [reference]	
Single	5.70 [2.45, 13.26]	<0.001	0.50 [0.27, 0.96]	0.037	0.88 [0.41, 1.88]	0.736
Divorced/widowed/separated	2.25 [0.96, 5.29]	0.063	0.91 [0.35, 2.33]	0.837	1.97 [0.78, 4.98]	0.151
Highest education						
No formal education	1.00 [reference]		1.00 [reference]		1.00 [reference]	
Primary	0.14 [0.05, 0.35]	<0.001	0.48 [0.21, 1.09]	0.081	0.16 [0.05, 0.49]	0.001
Secondary	0.68 [0.30, 1.56]	0.361	1.81 [0.88, 3.71]	0.104	0.82 [0.28, 2.34]	0.705
Tertiary	0.32 [0.12, 0.82]	0.018	0.58 [0.24, 1.40]	0.226	0.11 [0.03, 0.44]	0.002
Employment status						
Unemployed/retired	1.00 [reference]		1.00 [reference]		1.00 [reference]	
Employed	5.47 [2.30, 12.97]	<0.001	1.88 [0.79, 4.50]	0.156	10.12 [3.28, 31.25]	<0.001
Monthly income						
0–500 cedis (0–80 USD)	1.00 [reference]		1.00 [reference]		1.00 [reference]	
501–1000 cedis (81.0–160 USD)	0.64 [0.32, 1.28]	0.208	0.83 [0.43, 1.59]	0.573	0.25 [0.10, 0.60]	0.002
>1000 (>160 USD)	0.75 [0.28, 2.01]	0.564	0.34 [0.14, 0.78]	0.012	0.07 [0.02, 0.25]	<0.001
CLINICAL AND MEDICATION RELATED						
Source of expenditure on drugs						
Health insurance only	1.00 [reference]		1.00 [reference]		1.00 [reference]	
Out-of-pocket	0.68 [0.33, 1.41]	0.302	0.56 [0.28, 1.11]	0.095	0.44 [0.20, 0.98]	0.046
Number of hypertensive medications						
<2 medicine	1.00 [reference]		1.00 [reference]		1.00 [reference]	
2+ medicines	0.16 [0.07, 0.37]	<0.001	2.52 [1.34, 4.74]	0.004	0.40 [0.17, 0.94]	0.036
Number of diabetes medications						
<2 medicine	1.00 [reference]		1.00 [reference]		1.00 [reference]	
2+ medicines	0.30 [0.15, 0.59]	0.001	0.79 [0.45, 1.39]	0.419	0.27 [0.13, 0.56]	<0.001
Frequency of daily dose of medication						
Once	1.00 [reference]		1.00 [reference]		1.00 [reference]	
Twice/thrice	7.00 [2.88, 17.01]	<0.001	0.52 [0.29, 0.93]	0.027	2.40 [0.92, 6.25]	0.073
Have co-morbidities						
None	1.00 [reference]		1.00 [reference]		1.00 [reference]	
Hyperlipidaemia /Stroke	1.06 [0.38, 2.92]	0.911	2.40 [0.96, 5.99]	0.061	3.35 [1.50, 7.48]	0.003
Duration since diagnosis of hypertension						
<5 years	1.00 [reference]		1.00 [reference]		1.00 [reference]	
5+ years	0.46 [0.23, 0.91]	0.027	1.70 [0.92, 3.12]	0.089	1.29 [0.64, 2.58]	0.474

(*Continued*)

Table 4. (Continued)

	Multiple binary logistic regression model							
	Controlled blood pressure level			High blood glucose level			Controlled Blood pressure and blood glucose level	
Variables and categories	AOR [95% CI]	P-value		AOR [95% CI]	P-value		AOR [95% CI]	P-value
Duration since diagnosis of Diabetes Mellitus								
<5 years	1.00 [reference]			1.00 [reference]			1.00 [reference]	
5+ years	0.42 [0.16, 1.07]	0.069		0.75 [0.37, 1.52]	0.424		1.75 [0.78, 3.95]	0.177
Frequency of follow-up								
2 weeks/monthly	1.00 [reference]			1.00 [reference]			1.00 [reference]	
Every 2 month	1.94 [0.99, 3.79]	0.054		0.47 [0.26, 0.85]	0.012		1.86 [0.83, 4.19]	0.132
Medication related burden								
Minimum burden	1.00 [reference]			1.00 [reference]			1.00 [reference]	
Moderate/high burden	1.37 [0.73, 2.57]	0.328		2.77 [1.59, 4.85]	<0.001		2.42 [1.17, 5.05]	0.018
Adherence to medications								
Non-adherence	1.00 [reference]			1.00 [reference]			1.00 [reference]	
Adherence	0.99 [0.56, 1.75]	0.983		1.65 [0.96, 2.87]	0.071		2.12 [1.03, 4.34]	0.040

AOR: Adjusted odds ratio. CI: Confidence interval.

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Discussion

The current study sought to assess the BP and blood glucose levels among persons with co-morbid hypertension and T2DM, and the factors associated with these outcomes. The research observed that less than half (41.3%) of patients with hypertension and diabetes comorbidity had their BP under control. These findings are similar to findings a from South African study (42%) [26] and the Jimma University Medical Center (43.51%) [4]. Though BP control levels from this research is better compared to other studies conducted in Addis Ababa (19.4%) [27], and Malaysia (23.5%) [28], this was relatively lower than a study conducted in the Ho municipality in Ghana which reported BP control of 58.7% among people living with diabetes. Furthermore, this study showed the median SBP and DBP were 140 mmHg (IQR: 128–157) and 85 mmHg (IQR: 77–92) respectively. The SBP and DBP estimates from this study were higher than the 135.4 mmHg and 83.3 mmHg estimates from a study among out-patients in two diabetic clinics in Ghana [29]. However, recommendations for managing BP, such as the JNC 8, typically call for lower systolic and diastolic levels in diabetics [12]. Maintaining sufficient BP control is the primary therapeutic goal; hence these findings point to the need for greater attention to the optimum care of patients with co-morbid hypertension and T2DM. Also, in line with the objectives of the Ghana NCD policy, which aims to strengthen early detection and management of NCDs including co-morbid hypertension and T2DM, maintaining BP and blood glucose control will lead to a reduction in morbidity and mortality from NCDs [19,24].

Compared with some patients with diabetes in Ghana, the blood glucose levels in this study was higher [30–32]. Generally, in low-resourced settings like Ghana, and especially in public health facilities where this study was conducted, glycaemic control was assessed using the fasting blood sugar. This is due to the high costs associated with more robust measures like the glycated haemoglobin (HbA1c) which measures average glycaemia over three months.

Also, a fifth of the participants had uncontrolled BP and blood glucose levels whilst another one-fifth had controlled levels for both BP and blood glucose. Without effort from patients, achieving target BP and fasting blood glucose (FBG) will be a difficult challenge. However,

when patients ensure optimal adherence to recommended treatment, which can also be based on patients' adherence to dietary and lifestyle changes. In cases when the initial aims are not met, it is advised to alter the medicines and to regularly evaluate patients [33]. Additionally, it has been demonstrated that following clinical guidelines when prescribing drugs for T2DM and hypertension improves clinical outcomes [34].

The findings from this study also showed that controlled BP levels were high among the older age groups which is inconsistent with the findings from a similar study conducted in Ethiopia where patients who fell among the older age groups had two times uncontrolled BP compared to patients among the younger age groups [4] This observed result may be due to the fear in the prevalence of worse clinical outcomes in the elderly who present with comorbid hypertension and diabetes and hence a better rate of adherence to treatment. Although other studies did not find any significant association between marital status and control of BP levels [4,35], this study showed that those who were not currently married had controlled BP levels. Patients taking two or three doses of medications daily, had controlled BP levels which is inconsistent with other studies which have showed that multiple daily dosing of medications leads to a higher rate of non-adherence and consequently unfavourable clinical outcomes [36–38]. The differences in results may be due to a better understanding of the co-morbid nature of their disease condition and therefore a better rate of adherence to their treatment. This study further revealed that those who were employed had controlled BP levels which disagrees with a similar study in Addis Ababa where patients who were employed had uncontrolled BP levels [35]. This may be due to the strains of their jobs and therefore a recognition of the need to adhere to treatment to prevent a worsened clinical outcome. On the other hand, the study findings showed that controlled BP levels were low among those with some form of formal education. This disagrees with studies that have shown formal education to have a positive association with BP levels [4,35]. The differences in observed results may be due to the differences in health seeking behaviours. Participants taking 2 or more different anti-hypertensive and anti-diabetic medications had controlled BP levels which is inconsistent with other studies which have shown that patients who take two or more different medications for their chronic diseases feel burdened and therefore do not adhere to their treatment [36–38]. The observed results may be due to an understanding of the need to adhere to treatment. This study also revealed that those who have been diagnosed with hypertension for at least 5 years had controlled BP levels which is inconsistent with studies which have shown that patients who have been diagnosed with hypertension for over 5 years have uncontrolled BP levels due to a reduction in their health-seeking behaviour [35].

In terms of blood glucose control, the study findings agree with other studies which have shown that two or more medications, and moderate to high medication related burden were significantly associated poor blood glucose control levels [39,40]. Patients taking two or more medications may feel burdened by the number of pills they have to take which consequently leads to non-adherence to treatment and poor blood glucose control outcome [36]. On the other hand, although other studies disagree with the study findings which showed that two or three daily doses of medications were associated better blood glucose control levels, they agree that bi-monthly clinic follow-up periods were implicated blood glucose control levels [36,39,40]. The observed results may be due to an understanding of the disease nature and therefore an increase in health seeking behaviour. Though this study showed that being married and being female has a significant association with increased odds of blood glucose control levels and increased monthly income has significant association with decreased odds of blood glucose control levels, other studies found no association with blood control levels [39,40].

In terms of combined BP and blood glucose control, this study further found that being employed, having hyperlipidaemia or stroke co-morbidity, and moderate to high medication related burden were associated with high controlled BP and blood glucose levels. This is inconsistent with other studies which have shown that being employed, having other co-morbidities and moderate to high medication related burden are associated with uncontrolled BP and blood glucose levels [35,39,40]. In order to prevent unfavourable outcomes due to the presence of other co-morbidities and the strains of their jobs, these patients may have adhered to their treatment regimen which is probably the reason for the observed results. On the other hand, this study showed that having some form of formal education is associated with decreased chances of having both BP and blood glucose levels controlled, which is inconsistent with studies which have shown significant association between formal education and controlled levels of BP and blood glucose [4,35]. This may be due to a decrease in health seeking behaviour. Consistent with other studies [36–38], this study has also shown two or more anti-hypertensive and anti-diabetic medications to be associated with decreased chances of having both BP and blood glucose levels controlled. This is due to the pill burden these patients feel which may lead to non-adherence to treatment and a deterioration of their condition. Socio-behavioural interventions may be needed for encouraging such patients to adhere to their medications. Although other studies found no association between income and BP and blood glucose, this study showed that increased monthly income level and out-of-pocket payment for medications were associated with decreased chances of having both BP and blood glucose control levels and these have implications for medicines availability, affordability and adherence behaviour [4,35].

Study limitations

This study is a cross-sectional study hence cannot establish causal inferences but rather associations. Interpretation of findings should therefore be done cautiously. Since this was a hospital-based study, information on the estimates of BP levels and blood glucose were facility specific and may not reflect what pertains within the general community exhibit. Also, because this study measured the BP and blood glucose level of participants at one time point during the interview, it is unable to determine the fluctuations at different time points to establish consistencies in these parameters. Nonetheless, this study provides some estimates on the extent of BP and blood glucose controls among patients with hypertension and T2DM to inform the development of interventions. Again, the rigorous nature of the analytical procedure also reduces the potential biases that are likely to occur. The sample size of 339 is also large enough to draw valid conclusions from a single centre study.

Conclusion

In this study, two in five patients with hypertension and T2DM had controlled BP levels, three in five had controlled blood glucose levels and one in five had both BP and blood glucose levels under control with factors such as employment status, hyperlipidaemia or stroke co-morbidity, adherence to medication, and moderate to high medication related burden being associated with the control. Identifying patients at risk of poor BP and blood glucose control can lead to targeted interventions in line with the Ghana NCD policy on strengthening management especially among high-risk groups to reduce morbidity and mortality from NCDs. In addition, policy makers should institute measures to ensure that health promotion and education on long-term diseases such as hypertension and T2DM form part of the routine management and care practices. Potential drawbacks to poor control of BP and blood glucose

parameters should also be included in these policy documents to guide clinical practice and ensure better health outcomes for patients with co-morbid hypertension and T2DM.

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References

1. Alsaadon H, Afroz A, Karim A, Habib SH, Alramadan MJ, Billah B, et al. Hypertension and its related factors among patients with type 2 diabetes mellitus–a multi-hospital study in Bangladesh. BMC Public Health. 2022; 22: 1–10. https://doi.org/10.1186/S12889-022-12509-1/TABLES/2

2. Correia JC, Lachat S, Lagger G, Chappuis F, Golay A, Beran D, et al. Interventions targeting hypertension and diabetes mellitus at community and primary healthcare level in low- and middle-income countries:a scoping review. BMC Public Health 2019 19:1. 2019; 19: 1–20. https://doi.org/10.1186/s12889-019-7842-6 PMID: 31752801

3. Salameh AB, Hyassat D, Suhail A, Makahleh Z, Khader Y, EL-Khateeb M, et al. The prevalence of hypertension and its progression among patients with type 2 diabetes in Jordan. Annals of Medicine and Surgery. 2022;73. https://doi.org/10.1016/j.amsu.2021.103162 PMID: 34917355

4. Muleta S, Melaku T, Chelkeba L, Assefa D. Blood pressure control and its determinants among diabetes mellitus co-morbid hypertensive patients at Jimma University medical center, South West Ethiopia. Clin Hypertens. 2017; 23. https://doi.org/10.1186/s40885-017-0085-x PMID: 29299337

5. Petrie JR, Guzik TJ, Touyz RM. Diabetes, Hypertension, and Cardiovascular Disease: Clinical Insights and Vascular Mechanisms. Canadian Journal of Cardiology. 2018; 34: 575–584. https://doi.org/10.1016/j.cjca.2017.12.005 PMID: 29459239

6. Kim MJ, Lim NK, Choi SJ, Park HY. Hypertension is an independent risk factor for type 2 diabetes: the Korean genome and epidemiology study. Hypertension Research. 2015; 38: 783. https://doi.org/10.1038/hr.2015.72 PMID: 26178151

7. Yamazaki D, Hitomi H, Nishiyama A. Hypertension with diabetes mellitus complications. Hypertens Res. 2018; 41: 147–156. https://doi.org/10.1038/s41440-017-0008-y PMID: 29353881

8. Perreault L, Pan Q, Aroda VR, Barrett-Connor E, Dabelea D, Dagogo-Jack S, et al. Exploring residual risk for diabetes and microvascular disease in the Diabetes Prevention Program Outcomes Study (DPPOS). Diabet Med. 2017; 34: 1747–1755. https://doi.org/10.1111/dme.13453 PMID: 28833481

9. Rodríguez-Gutiérrez R, Montori VM. Glycemic Control for Patients With Type 2 Diabetes Mellitus: Our Evolving Faith in the Face of Evidence. Circ Cardiovasc Qual Outcomes. 2016; 9: 504–512. https://doi.org/10.1161/CIRCOUTCOMES.116.002901 PMID: 27553599

10. Banerji MA, Dunn JD. Impact of Glycemic Control on Healthcare Resource Utilization and Costs of Type 2 Diabetes: Current and Future Pharmacologic Approaches to Improving Outcomes. Am Health Drug Benefits. 2013; 6: 382. Available: /pmc/articles/PMC4031727/. PMID: 24991370

11. American Diabetes Association. Introduction: Standards of Medical Care in Diabetes—2021. Diabetes Care. 2021; 44: S1–S2. https://doi.org/10.2337/dc21-Sint PMID: 33298409

12. Armstrong C. JNC8 guidelines for the management of hypertension in adults. Am Fam Physician. 2014; 90: 503–504. PMID: 25369633

13. Bakris GL, Williams M, Dworkin L, Elliott WJ, Epstein M, Toto R, et al. Preserving renal function in adults with hypertension and diabetes: A consensus approach. American Journal of Kidney Diseases. 2000; 36: 646–661. https://doi.org/10.1053/ajkd.2000.16225 PMID: 10977801

14. Kwakye AO, Buabeng KO, Opare-Addo NAM, Owusu-Dabo E. Clinical pharmacists education and counselling in patients with co-morbid hypertension and diabetes in a Municipal hospital in Ghana. Afr J Pharm Pharmacol. 2021; 15: 183–190. https://doi.org/10.5897/ajpp2021.5267

15. Carey RM, Whelton PK, Aronow WS, Casey DE, Collins KJ, Himmelfarb CD, et al. Prevention, detection, evaluation, and management of high blood pressure in adults: Synopsis of the 2017 American College of Cardiology/American Heart Association Hypertension Guideline. Ann Intern Med. 2018; 168: 351–358. https://doi.org/10.7326/M17-3203 PMID: 29357392

16. Dedefo MG, Gemechu DB, Fekadu G, Dibessa TT. Blood Pressure Control among Hypertensive Diabetic Patients on Follow-Up at Chronic Clinic of Nekemte Referral Hospital in West Ethiopia. Int J Hypertens. 2020. https://doi.org/10.1155/2020/7526257 PMID: 32637172

17. Baynouna LM, Nagelkerke NJD, Al Ameri TA, Zein Al Deen SM, Ali HI. Determinants of Diabetes and Hypertension Control in Ambulatory Healthcare in Al Ain, United Arab Emirates. Oman Med J. 2014; 29: 234. https://doi.org/10.5001/omj.2014.58 PMID: 24936278

18. Ghana Health Service. Ghana Health Service 2016 Annual Report. 2017.

19. Ministry of Health (MOH). Republic of Ghana National Policy for the Prevention and Control of Chronic Non-Communicable Diseases in Ghana. 2012 Aug.

20. Serra N, Oliveras A, Bergoñon S, Sans L, Cobos A, Martínez P, et al. Factors associated with blood pressure control in diabetic patients treated in nephrology units. PRESDIAB Study. Nefrologia. 2011; 31: 313–321. https://doi.org/10.3265/Nefrologia.pre2011.Apr.10556 PMID: 21629337

21. Abougalambou SSI, Abougalambou AS, Sulaiman SAS, Hassali MA. Prevalence of hypertension, control of blood pressure and treatment in hypertensive with type 2 diabetes in Hospital University Sains Malaysia. Diabetes and Metabolic Syndrome: Clinical Research and Reviews. 2011; 5: 115–119. https://doi.org/10.1016/J.DSX.2012.03.001 PMID: 22813562

22. National Health Insurance Scheme (NHIS)—Ghana. Medicines List. 2022 [cited 14 Oct 2022]. Available: https://www.nhis.gov.gh/medlist.

23. Awad A, Alhadab A, Albassam A. Medication-Related Burden and Medication Adherence Among Geriatric Patients in Kuwait: A Cross-Sectional Study. Front Pharmacol. 2020; 11. https://doi.org/10.3389/fphar.2020.01296 PMID: 32973523

24. Zidan A, Awisu A, El-Hajj MS, Al-Abdulla SA, Figueroa DCR, Kheir N. Medication-Related Burden among Patients with Chronic Disease Conditions: Perspectives of Patients Attending Non-Communicable Disease Clinics in a Primary Healthcare Setting in Qatar. Pharmacy. 2018; 6: 85. https://doi.org/10.3390/pharmacy6030085 PMID: 30104554

25. Horne R, Weinman J. Patients' belief about prescribed medicines and their role in adherence to treatment in chronic physical illness. J Psychosom Res. 1999.

26. Adebolu FA, Naidoo M, Adebolu F. Blood pressure control amongst patients living with hypertension presenting to an urban district hospital outpatient clinic in Kwazulu-Natal. 2014. https://doi.org/10.4102/phcfm.v6i1.572 PMID: 26245402

27. Shimels T, Abebaw M, Bilal AI, Tesfaye T. Treatment Pattern and Factors Associated with Blood Pressure and Fasting Plasma Glucose Control among Patients with Type 2 Diabetes Mellitus in Police Referral Hospital in Ethiopia. 2018. https://doi.org/10.4314/ejhs.v28i4.12 PMID: 30607059

28. Chew BH, Mastura I, Shariff-Ghazali S, Lee PY, Cheong AT, Ahmad Z, et al. Determinants of uncontrolled hypertension in adult type 2 diabetes mellitus: an analysis of the Malaysian diabetes registry 2009. Cardiovasc Diabetol. 2012; 11: 1–8. https://doi.org/10.1186/1475-2840-11-54/TABLES/2

29. Apini R, Annan R, Apprey C, Asamoah-Boakye O. Predictors of Glycaemic Control among Ghanaian Type 2 Diabetic Patients Using Diabetes Self-management Approach. Int J Biochem Res Rev. 2018; 23: 1–18. https://doi.org/10.9734/IJBCRR/2018/42976

30. Afaya RA, Bam V, Azongo TB, Afaya A, Kusi-Amponsah A, Ajusiyine JM, et al. Medication adherence and self-care behaviours among patients with type 2 diabetes mellitus in Ghana. PLoS One. 2020; 15: e0237710. https://doi.org/10.1371/journal.pone.0237710 PMID: 32822381

31. Djonor SK, Ako-Nnubeng IT, Owusu EA, Akuffo KO, Nortey P, Agyei-Manu E, et al. Determinants of blood glucose control among people with Type 2 diabetes in a regional hospital in Ghana. PLoS One. 2021; 16: e0261455. https://doi.org/10.1371/journal.pone.0261455 PMID: 34936668

32. Osei-Yeboah J, Lokpo SY, Owiredu WKBA, Johnson BB, Orish VN, Botchway F, et al. Medication Adherence and its Association with Glycaemic Control, Blood Pressure Control, Glycosuria and Proteinuria Among People Living With Diabetes (PLWD) in the Ho Municipality, Ghana. Open Public Health J. 2019; 11: 552–561. https://doi.org/10.2174/1874944501811010552

33. Davies MJ D'Alessio DA, Fradkin J, Kernan WN, Mathieu C, Mingrone G, et al. Management of Hyperglycemia in Type 2 Diabetes, 2018. A Consensus Report by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD). Diabetes Care. 2018; 41: 2669–2701. https://doi.org/10.2337/dci18-0033 PMID: 30291106

34. De Boer IH, Bangalore S, Benetos A, Davis AM, Michos ED, Muntner P, et al. Diabetes and Hypertension: A Position Statement by the American Diabetes Association. Diabetes Care. 2017; 40: 1273–1284. https://doi.org/10.2337/dci17-0026 PMID: 28830958

35. Amare F, Nedi T, Berhe DF. Blood pressure control practice and determinants among ambulatory hypertensive patients attending primary health care facilities in Addis Ababa. SAGE Open Med. 2020; 8: 2050312120946521. https://doi.org/10.1177/2050312120946521 PMID: 32821388

36. Bernhard J, Maibach R, Thürlimann B, Sessa C, Aapro MS. Patients' estimation of overall treatment burden: why not ask the obvious? J Clin Oncol. 2002; 20: 65–72. https://doi.org/10.1200/JCO.2002.20.1.65 PMID: 11773155

37. Gallacher K, May CR, Montori VM, Mair FS. Understanding patients' experiences of treatment burden in chronic heart failure using normalization process theory. Ann Fam Med. 2011; 9: 235–243. https://doi.org/10.1370/afm.1249 PMID: 21555751

38. Krska J, Katusiime B, Corlett SA. Patient experiences of the burden of using medicines for long-term conditions and factors affecting burden: A cross-sectional survey. Health Soc Care Community. 2018; 26: 946–959. https://doi.org/10.1111/hsc.12624 PMID: 30058749

39. Mariye T, Girmay A, Tasew H, Teklay G, Ayele E, Gerensea H, et al. Determinants of hypertension among diabetic patients in public hospitals of the central zone, Tigray, Ethiopia 2018: Unmatched case-control study. Pan African Medical Journal. 2019; 33. https://doi.org/10.11604/pamj.2019.33.100.17094 PMID: 31489078

40. Yimam M, Desse TA, Hebo HJ. Glycemic control among ambulatory type 2 diabetes patients with hypertension Co-morbidity in a developing country: A cross sectional study. Heliyon. 2020; 6. https://doi.org/10.1016/J.HELIYON.2020.E05671 PMID: 33319113