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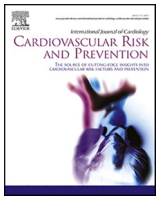

Predictors of uncontrolled hypertension among type 2 diabetic patients in Ethiopia: Multicenter cross-sectional study

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ABSTRACT

Background: Hypertension (HTN) is the commonest comorbidity among people with type 2 diabetes mellitus (T2DM). Uncontrolled HTN is a major risk factor for several diseases. This study aimed to determine the magnitude and predictors of uncontrolled HTN among T2DM patients.

Methods: A multicenter cross-sectional study was conducted among hypertensive from September 19, 2021 to 17 December 2021. Logistic regression model was conducted to identify predictors of uncontrolled HTN. Uncontrolled BP was defined by systolic BP of ≥130 mmHg and/or diastolic BP of ≥80 mmHg.

Results: A total of 400 study participants were included in the analysis, of which 208 (52 %) were females. The mean age of the participants was 60.6 with SD of 10.25 years. The target blood pressure achieved in 156 (39 %) of participants. Age, non-adherence to medications (OR; 2.0; 95 % CI: 1.1–3.6; P = 0.02), not reducing dietary salt (OR; 2.4; 95 % CI: 1.5–3.8; P < 0.001), uncontrolled blood sugar (OR:2.4; 95 % CI: 1.4–4.3; P = 0.002), obesity (OR; 3.2; 95 % CI:1.2–8.7; P = 0.03) and having every fourth month and above follow up (OR; 2.3; 95 % CI:1.3–4.3; P = 0.049) were significantly associated with uncontrolled blood pressure.

Conclusions: The target blood pressure achieved was suboptimal. Hypertensive T2DM patients who were younger, non-adherent to their medications, not reducing dietary salt, obese, with a longer frequency of follow-up, and with poor glycemic control were more likely to have uncontrolled blood pressure. Improving medication adherence, dietary salt reduction, frequent follow up and glycemic control are important to control hypertension.

1. Introduction

Hypertension is a chronic non-communicable disease (NCD) in which the blood pressure (BP) in the arteries is persistently elevated. There is no sharp demarcation between normal BP and HTN. However, for clinical purposes, it is defined as systolic blood pressure (SBP) of ≥140 mm of mercury (mmHg) and/or diastolic blood pressure (DBP) of ≥90 mmHg or any prior diagnosis of HTN made by a health professional and taking the antihypertensive medications [1].

HTN contributes to the development and progression of micro-vascular and macro-vascular complications of diabetes and is a major risk factor for cardiovascular mortality and morbidity through its effects on target organ [2].

HTN is the commonest comorbidity among people with T2DM. Its prevalence in these populations is sharply increasing in all regions of the world with a prevalence of 50 %–75 % [3] and affecting around 20–60 % of patients with diabetes, depending on obesity, ethnicity, and age [4]. The co-existence of the two conditions carries an excessive risk of severe complications and mortalities [5] and leads to a dramatically increased risk (2–4 folds) of cardiovascular disease, end-stage kidney disease, and death, compared with the normotensive and non-diabetic adults [6]. Nonetheless, adequate treatment of HTN may reduce cardiovascular-related mortality and morbidity [7].

Several lifestyle interventions have been shown to reduce BP and these strategies are beneficial in managing most of the other CVD risk factors [8]. Lifestyle modifications like; smoking cessation, weight

Abbreviations: ACC, American College of Cardiology; BMI, body mass index; CVD, cardiovascular disease; DM, diabetes mellitus; HTN, hypertension; JNC, Joint National Committee.

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management, reduction of dietary sodium intake, physical activity, and moderation of alcohol consumption should be encouraged for all patients, regardless of the stage of HTN [9] and should be regarded as a complement to drug therapy rather than an alternative [8]. Unluckily, the majority of T2DM patients with HTN don't achieve the target BP and most patients with normal renal and hepatic function require aggressive treatment with a combination of two or three drugs from different antihypertensive classes [10].

The annual death of Ethiopia's population due to non-communicable diseases such as uncontrolled HTN was still high (39 %) [11] and its prevalence is rising due to increased risk factors [12].

Recent guidelines agree on the necessity for early, aggressive reduction of BP, with a goal of <130/80 mmHg, in patients with HTN with diabetes [13].

Despite effective antihypertensive therapies, achieving target BP control remains a challenge for diabetics even worse in resource-limited settings [14].

Even though there's inconsistency among studies, multiple factors were found to contribute to uncontrolled HTN. Various predictors of uncontrolled hypertension have been identified in previous studies. These include poor medication adherence, complications, and being overweight [5,15–17] in Kenya, Tanzania, India, and China; excessive alcohol consumption and unemployment in South Africa [18]; young age and urban dwelling [16] in China; and older age and longer duration of illness [17] in India. In addition, studies conducted elsewhere revealed non-adherence to anti-hypertensive therapy and dietary approach to prevent HTN, high salt intake, alcohol intake, cigarette smoking, physical inactivity, being men, advanced age, disease duration, comorbidities, and overweight/obesity are among the main contributing factors to uncontrolled HTN [19–22].

Recognizing associated factors of HTN among diabetic patients is important for healthcare professionals, to successfully minimize its impact on patients, and policy-makers to design appropriate strategies. However, there is a limited of data in Ethiopia to provide evidence-based recommendations to clinical practice and policy makers.

Therefore, this study aimed to determine the level of BP control and identifying predictors of uncontrolled BP among comorbid hypertensive diabetic patients.

2. Methods

2.1. Study design, setting, and participants

A cross-sectional study design was conducted from September 19, 2021 to 17 December 2021, at Tikur Anbessa Specialized Hospital (TASH) and St. Paul's Hospital Millennium Medical College (SPHMMC) located in Addis Ababa, Ethiopia. All adult patients of HTN with diabetes who attended chronic clinics of TASH and SPHMMC were the source of population, and all adults patients of HTN with T2DM in follow-up clinic at TASH and SPHMMC during the study period and fulfilling the inclusion criteria were the study population. All adult patients of HTN with T2DM taking antihypertensive drugs for at least six months in TASH and SPHMMC who came for follow-up during the study period and willing to give informed consent were included in the study. Mentally disabled, those who are unable to hear, seriously ill patients, and pregnant women were excluded from this study.

2.2. Sample size determination and sampling Procedure

The required sample size was calculated using single population proportion formula, and the following assumptions were used to calculate the required sample size, 44.1 % prevalence of uncontrolled BP among T2DM patients [23], 95 % confidence interval, and marginal error of 5 % to get a sample size of 379. Considering a 10 % contingency, 417 hypertensive T2DM patients were included in the study. A systematic random sampling technique was used.

2.3. Data collection procedure and quality control

Data were collected using an interviewer-administered pretested questionnaire adopted from different literature [8,23] and a medical chart review was conducted. Pre-test was done on 5 % of the sample at saint Peter comprehensives hospital.

2.4. Adherence measurement tool

Self-reported medication adherence assessment tool was used. The study participants were asked whether in the past 7 days they missed, skipped, or did not take a dose of their antihypertensive medications. The five answer choices were "none of the time," "a little of the time," "some of the time," "most of the time," and "every time." Participants who responded with an answer other than "none of the time" were classified as having non adherence [24].

2.5. Data processing and analysis

Data were entered using Epi Data version 4.6 and exported to the Statistical Package for Social Science (SPSS) version 25.0 for analysis. Both univariate and multivariate binary logistic regression analyses were done. Variables which had p-value of less than 0.25 in the univariate binary logistic regression analysis were included in multivariate binary logistic regression analysis. Hence, the covariates adjusted in the multivariate analysis included age category, gender, occupation, physical activity, lack of dietary salt reduction, family history of hypertension, blood glucose levels, medication adherence, BMI, types of antidiabetic medication, duration of diabetes, and frequency of follow-up.

The odds ratio (OR) and 95 % confidence interval (CI) was estimated to identify factors associated with uncontrolled BP by using multiple stepwise logistic regression models. The level of statistical significance was declared at p value < 0.05.

2.6. Operational definitions

Uncontrolled blood pressure: systolic and diastolic blood pressures were recorded during patients' visits, in a seated position, after resting for at least 5 min. Two measurements were recorded at 5-min intervals, and then uncontrolled BP was determined by the average BP of the two measurements. Uncontrolled BP was defined by Systolic BP of ≥130 mmHg and/or diastolic BP of ≥80 mmHg [13].

Salt intake measurement: the extent of salt intake was measured based on WHO recommendations. Accordingly, optimal salt intake is defined as consumption below 5 g per day or equivalent to one teaspoon full. Not reducing dietary salt represents a daily salt consumption of more than one teaspoonful or 5 g per day. Patients were told to report their salt consumption in terms of grams or teaspoons based on their level of understanding [25].

3. Results

3.1. Socio-demographic characteristics

Among 417 study participants approached, 400 were eligible for analysis. Of which 192 (48 %) were males. The mean (±SD) age of the participants was 60.6 ± 10.25 years. More than half, 230 (57.5 %), of the study participants were 60 years and above. Among the study participants, 147 (36.8 %) completed secondary education and 314 (78.5 %) were unemployed as shown (Table 1).

3.2. Clinical characteristics of participants

As presented in Table 2, 156 (39 %) were having a family history of HTN. The majority, 316 (79 %), of study participants have uncontrolled

Table 1
Socio-demographic characteristics of hypertensive T2DM patients, Addis Ababa, Ethiopia (N = 400).

Variable		TASH, N (%)	SPHMMC, N (%)	Total, N (%)
Gender	Male	128 (32.0)	64 (16.0)	192 (48.0)
	Female	140 (35.0)	68 (17.0)	208 (52.0)
Age (years)	18–39	5 (1.3)	7 (1.7)	12 (3.0)
	40–59	102 (25.5)	56 (14.0)	158 (39.5)
	≥60	161 (40.3)	69 (17.3)	230 (57.5)
Marital status	Single	16 (4.0)	3 (0.8)	19 (4.8)
	Married	213 (53.3)	107 (26.7)	320 (80.0)
	Divorced	9 (2.3)	6 (1.5)	15 (3.8)
	Widowed	30 (7.5)	16 (4.0)	46 (11.5)
Religion	Orthodox	201 (50.3)	94 (23.5)	295 (73.8)
	Muslim	43 (10.8)	25 (6.2)	68 (17.0)
	Protestant	24 (6.0)	13 (3.3)	37 (9.3)
Educational status	No-formal education	44 (11.0)	27 (6.8)	71 (17.8)
	Primary education	45 (11.3)	24 (6.0)	69 (17.3)
	Secondary education	98 (24.5)	49 (12.3)	147 (36.8)
	College and above	81 (20.3)	32 (8.0)	113 (28.2)
Occupational status	Unemployed	216 (54.0)	98 (24.5)	314 (78.5)
	Government employed	34 (8.5)	17 (4.3)	51 (12.8)
	Self-employed	12 (3.0)	13 (3.3)	25 (6.3)
	NGOs	4 (1.0)	6 (1.5)	10 (2.5)
Residence	Urban	254 (63.5)	118 (29.5)	373 (93.3)
	Rural	14 (3.5)	14 (3.5)	27 (6.8)

NGO: non-governmental organizations; TASH: Tikur Anbessa Specialized Hospital; SPHMMC: St. Paul's Hospital Millennium Medical College.

blood sugar. The mean (±SD) duration since diagnosis of HTN was 9.51 ± 7.48 years with a range of 1–40 years. Of those patients with complications, 26 (57.7 %) had nephropathy. More than half of the study participants had good knowledge about HTN, 52.8 %. Almost half of the study participants had controlled systolic blood pressure 175 (43.8 %); while about 255 (63.7 %) had controlled diastolic blood pressure. The overall control of blood pressure was achieved by only 156 (39 %) of the study participants (Table 2).

About 38 % patients were on monotherapy for their hypertension management, of which 100 (64.5 %) were on enalapril monotherapy. Slightly above one third (37.8 %) of the study participants were on dual therapy. Oral anti-diabetic agents alone, 193 (48.3 %), were the most prescribed medications; while 68 (17.0 %) patients were on insulin alone. The majority, 317 (79.3 %), of the participants were adherent to their treatment (Table 3).

3.3. Determinants of uncontrolled blood pressure

The association of independent variables with uncontrolled HTN was investigated using logistic regression model. In the multivariate analysis, age range of 18–39 years (OR; 5.4; 95 % CI:1.1–28.2; P = 0.047) and 40–59 years (OR; 2.7; 95 % CI: 1.6–4.6; P < 0.001), non-adherent to medication (OR; 2.0; 95 % CI:1.1–3.6; P = 0.021), not reducing dietary salt (OR; 2.4; 95 % CI:1.5–3.8; P = 0.000), uncontrolled blood sugar (OR:2.4; 95 % CI: 1.4–4.3; P = 0.002), obesity (OR; 3.2; 95 % CI:1.2–8.7, P = 0.026) and having four and above months of follow up period (OR; 2.3; 95 % CI:1.3–4.3, P = 0.049) were found to be predictors of uncontrolled BP (Table 4).

Table 2
Clinical characteristics of hypertensive T2DM patients, Addis Ababa, Ethiopia (N = 400).

Variables		TASH, N (%)	SPHMMC, N (%)	Total,N (%)
Not reducing dietary salt		94 (23.5)	53 (13.3)	147 (36.8)
Alcohol drinkers		12 (3.0)	7 (1.8)	19 (4.8)
Smokers		10 (2.5)	4 (1.0)	14 (3.5)
Perform regular physical exercise		236 (59.0)	112 (28.0)	348 (87.0)
Family history of hypertension		111 (27.8)	46 (11.5)	156 (39.0)
Knowledge of hypertension	Good	150 (37.5)	61 (15.0)	211 (52.8)
	Poor	118 (29.5)	71 (17.8)	189 (47.3)
Follow-up frequency	≤1 month	28 (7.0)	5 (1.3)	33 (8.3)
	Every 2 months	27 (6.8)	17 (4.3)	44 (11.0)
	Every 3 months	80 (20.0)	50 (12.5)	130 (32.5)
	Every 4 months and above	133 (33.3)	60 (15.0)	193 (48.3)
BMI	Normal weight	140 (35.0)	85 (21.3)	225 (56.2)
	Over-weight	101 (25.3)	40 (10.0)	141 (35.3)
	Obese	27 (6.8)	7 (1.8)	34 (8.5)
Duration of HTN	<5 years	74 (18.5)	48 (12.0)	122 (30.5)
	5–10 years	103 (25.8)	50 (12.5)	153 (38.3)
	>10 years	91 (22.8)	34 (8.5)	125 (31.3)
Duration of diabetes	<5 years	65 (16.3)	30 (7.5)	95 (23.8)
	5–10 years	76 (19.0)	52 (13.0)	128 (32.0)
	>10 years	127 (31.8)	50 (12.5)	177 (44.3)
Availability of BP apparatus at home		88 (22.0)	19 (4.8)	107 (26.8)
Home BP measurement		89 (22.3)	19 (4.8)	108 (27.0)
Blood glucose control	Controlled	51 (12.8)	33 (0.8)	84 (21.0)
	Uncontrolled	217 (54.3)	99 (24.8)	316 (79.0)
Blood pressure	Controlled	98 (24.5)	58 (14.5)	156 (39.0)
	Uncontrolled	170 (42.5)	74 (18.5)	244 (61.0)
Presence of comorbidity		166 (41.5)	62 (15.5)	228 (57.0)
Types of Comorbidities	Dyslipidemia	41 (10.3)	9 (2.3)	50 (12.5)
	HHD	24 (6.0)	10 (2.5)	34 (8.5)
	IHD	18 (4.5)	3 (0.8)	21 (9.2)
	Peripheral neuropathy	11 (2.8)	6 (1.5)	17 (7.0)
	CKD	6 (1.5)	5 (1.3)	11 (4.8)
	Ischemic stroke	7 (1.8)	1 (0.3)	8 (3.5)
	PAD	4 (1.0)	4 (1.0)	8 (2.0)
	HHD and Dyslipidemia	3 (0.8)	5 (1.3)	8 (2.0)
	HHD and peripheral neuropathy	3 (0.8)	4 (1.0)	7 (1.8)
	CKD and HHD	5 (1.3)	–	5 (1.3)
	HIV	–	5 (1.3)	5 (1.3)
	CKD and Dyslipidemia	4 (1.0)	–	4 (1.0)
	Asthma	3 (0.8)	1 (0.3)	4 (1)
	DVT	3 (0.8)	–	3 (0.8)
	AF and HHD	2 (0.5)	1 (0.3)	3 (0.8)
	Others[a]	32 (8.0)	2 (0.5)	36 (9.0)

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Table 2 (*continued*)

Variables		TASH, N (%)	SPHMMC, N (%)	Total,N (%)
Presence of complication		38 (9.5)	6 (3.0)	44 (11.0)
Common Complications	Nephropathy	22 (50.0)	4 (9.0)	26 (59.0)
	Retinopathy	4 (9.0)	1 (0.3)	5 (11.1)
	Retinopathy and nephropathy	3 (6.8)	1 (0.3)	4 (8.9)
	Neuropathy	3 (6.8)	1 (0.3)	4 (8.9)
	Retinopathy and neuropathy	3 (7.5)	–	3 (7.5)
	Others ***	3 (0.8)	–	3 (0.8)

ACEIs: Angiotensin-converting enzyme inhibitors; AF: Atrial fibrillation; BMI: body mass index; BP: blood pressure; CKD: Chronic kidney disease; DM: diabetes Mellitus; DVT: deep venous thrombosis; HHD: Hypertensive heart disease; HIV: human immune deficiency virus; HTN: Hypertension; IHD: ischemic heart disease; PAD: peripheral arterial disease; TASH: Tikur Anbessa Specialized Hospital; SPHMMC: St. Paul's Hospital Millennium Medical College**Nephropathy and ACEIs induced cough, foot ulcer and neuropathy 3.3. Types of medications prescribed and adherence.

[a] IHD and PAD, AKI, CKD and Dilated cardiomyopathy, IHD, and HHD.

4. Discussion

This study determined the prevalence of uncontrolled HTN and identify its predictors among diabetic patients at the two tertiary hospitals of the capital, TASH and SPHMMC. Our study specifically targeted individuals with uncontrolled hypertension among diabetic patients, a group at higher risk for cardiovascular complications. In our study, we identified multiple factors predicting uncontrolled blood pressure, including younger age, non-adherence to medications, lack of dietary salt reduction, obesity, longer frequency of follow-up, and poor glycemic control.

The findings revealed that from a total of 400 hypertensive DM patients, merely 39 % achieved the currently recommended BP goal [13]. This result is consistence with the report of systematic review and meta-analysis of findings from Sub-Sahara Africa [26].

The level of uncontrolled BP found in this research contrasts with the results reported in previous studies in Ethiopia [8,23], and Portugal [27]. This discrepancy may stem from a revision in the criteria for BP control. Previous literature used joint national committee 8 (JNC8) (which used a cutoff point ≥140/90 for diabetic patients' BP target) [28], but the current study is based on the American College of Cardiology (ACC) 2019 guidelines [29]. In addition, the inconsistency could also be due to the differences in the magnitude of co-morbidities [30,31] and the age of study participants [32].

The magnitude of uncontrolled BP in this study (61 %) was found to be lower than results from studies conducted in Tanzania (84.5 %) [5], South Africa (75.5 %) [15], and Kenya (79 %) [33]. This variation could be potentially be ascribed to the high percentage of complications [34] and low adherence level to medication [35,36] and lack of adherence to lifestyle modifications [37,38] in those studies.

The result of multivariate binary logistic analysis showed age to be significantly associated with uncontrolled BP. The odds of uncontrolled BP were 5.4 times higher among age range of 18–39 years than age ≥60 years (OR; 5.4; 95 % CI: 1.1–28.2; P = 0.047) and 2.7 times higher among age 40–59 years (OR; 2.7; 95 % CI: 1.6–4.6; P < 0.001) than age ≥60 years. Similar results were reported from previous studies in Ethiopia [19,21], Brazil [39], and China [16]. This might be due to poor awareness of the disease and medication experiences in the younger patients [40], and increased prevalence of comorbidities in elderly leading to accessing better treatment [41]. Moreover, the refusal to acknowledge the presence of illness or engaging in external activities can lead to young patients neglecting to adhere to their medication regimen [42].

Table 3
Medication therapy and adherence level among hypertensive T2DM patients, Addis Abba, Ethiopia (N = 400).

Variables		TASH, N (%)	SPHMMC, N (%)	Total, N (%)
Adherence	Good	219 (54.7)	98 (24.5)	317 (79.3)
	Poor	49 (12.3)	34 (8.5)	83 (20.8)
Number of medications prescribed	One	90 (58.0)	65 (41.9)	155 (38.8)
	Two	104 (68.9)	47 (31.0)	151 (37.8)
	Three	57 (77.0)	17 (22.9)	74 (18.5)
	Four	17 (22.9)	3 (4.0)	20 (27.0)
Monotherapy	Enalapril	61 (39.4)	39 (25.0)	100 (64.5)
	Amlodipine	21 (13.5)	18 (11.6)	39 (25.0)
	Hydrochlorothiazide	2 (1.2)	5 (3.0)	7 (4.5)
	Nifedipine	4 (2.5)	1 (0.6)	5 (3.2)
	Others[a]	2 (1.3)	2 (1.3)	4 (2.5)
Dual therapy	Enalapril + amlodipine	53 (35.0)	22 (14.5)	75 (49.6)
	Enalapril + Hydrochlorothiazide	15 (10.0)	7 (4.6)	22 (14.5)
	Enalapril + nifedipine	4 (2.6)	8 (5.2)	12 (8.0)
	Losartan + amlodipine	5 (3.3)	–	5 (3.3)
	Enalapril + metoprolol	4 (2.6)	1 (0.6)	5 (3.3)
	Atenolol + amlodipine	1 (0.6)	3 (2.0)	4 (2.6)
	amlodipine + Hydrochlorothiazide	3 (2.0)	2 (1.3)	5 (3.3)
	Atenolol + enalapril	4 (2.0)	–	4 (2.0)
	Others[b]	15 (10.0)	4 (2.0)	19 (12.5)
Triple therapy	Enalapril + amlodipine + Hydrochlorothiazide	17 (22.9)	3 (4.0)	20 (25.6)
	Enalapril + amlodipine + furosemide	7 (9.5)	3 (4.0)	10 (13.5)
	Atenolol + Enalapril + amlodipine	8 (10.8)	1 (1.3)	9 (12.0)
	Nifedipine + Enalapril + Hydrochlorothiazide	4 (5.4)	2 (2.7)	6 (8.0)
	Metoprolol + enalapril + furosemide	5 (6.7)	2 (2.7)	7 (9.5)
	Enalapril + metoprolol + amlodipine	3 (4.0)	1 (1.3)	4 (5.4)
	Enalapril + atenolol + furosemide	2 (2.7)	1 (1.3)	3 (4.0)
	Others[c]	11 (14.8)	4 (5.4)	15 (20.3)
Quadra therapy	Enalapril + amlodipine + atenolol + Hydrochlorothiazide	7 (35.0)	–	7 (35.0)
	enalapril + amlodipine + Hydrochlorothiazide + metoprolol	4 (20.0)	1 (5.0)	5 (25.0)
	enalapril + furosemide + metoprolol + spironolactone	3 (15.0)	1 (5.0)	4 (20.0)
	Others[d]	3 (15.0)	1 (5.0)	4 (25.0)
Number of antidiabetic medications	One	101 (25.2)	60 (15.0)	161 (40.3)
	Two	167 (41.8)	72 (18.0)	239 (59.8)
Types of antidiabetic medications prescribed	Metformin	49 (30.4)	43 (26.7)	92 (57.0)
	Insulin	51 (31.7)	17 (10.5)	68 (42.2)
	Dapagliflozin	1 (0.6)	–	1 (0.6)
	Metformin and insulin	90 (37.6)	43 (18)	133 (55.6)

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Table 3 (*continued*)

Variables		TASH, N (%)	SPHMMC, N (%)	Total, N (%)
	Metformin and glibenclamide	58 (24.2)	27 (11.3)	85 (35.6)
	Others[e]	19 (8.0)	2 (0.8)	21 (8.7)
On statin therapy		218 (54.5)	94 (23.5)	312 (78.0)
Type of statins	Atorvastatin	192 (48.0)	90 (22.5)	282 (70.4)
	Simvastatin	23 (5.8)	4 (1.0)	27 (6.7)
	Rosuvastatin	3 (0.8)	–	3 (0.8)
On aspirin		115 (28.8)	46 (11.5)	161 (40.3)

[a] Candesartan, losartan, atenolol, lisinopril.

[b] Enalapril + propranolol, Hydrochlorothiazide + atenolol and metoprolol + telmisartan.

[c] amlodipine + atenolol + Hydrochlorothiazide, amlodipine + atenolol + lisinopril, amlodipine + enalapril + carvedilol, amlodipine + furosemide + Hydrochlorothiazide, amlodipine + furosemide + spironolactone, amlodipine + lisinopril + furosemide, amlodipine + losartan + atenolol, amlodipine + metoprolol + furosemide, atenolol + enalapril + Hydrochlorothiazide and carvedilol + felodipine + furosemide.

[d] metoprolol + Hydrochlorothiazide + nifedipine + carvedilol, losartan + nifedipine + amlodipine + Hydrochlorothiazide, enalapril + furosemide + atenolol + spironolactone, enalapril + furosemide + bisoprolol + spironolactone, enalapril + Hydrochlorothiazide + atenolol + nifedipine, enalapril + amlodipine + furosemide + spironolactone, amlodipine + losartan + metoprolol + Hydrochlorothiazide and enalapril + amlodipine + furosemide + spironolactone.

[e] Metformin and sitagliptin, vildagliptin and metformin, dapagliflozin and insulin, dapagliflozin and metformin, metformin and glimepiride, vildagliptin, metformin and glibenclamide.

Adherence to treatment is found to be one of the critical factor associated with uncontrolled BP. Poor adherence reduces optimal clinical benefits, and therefore reduces the overall effectiveness of treatment outcomes. This study showed that non-adherent patients were two times more likely to have uncontrolled BP than adherent patients (OR; 2.0; 95 % CI: 1.1–3.6; P = 0.021). This result is consistent with the result obtained from previous studies conducted in Ethiopia [23], Zimbabwe [43], South Africa [15,44], Tanzania [5], and USA [45]. The reason for non-adherence may potentially stem from unaffordability of medications; patients might stop taking their medication when their symptoms were under control; unavailability of medicines within the health facilities and medication side effects [23]. Non-adherence is a major cause of uncontrolled BP over the world leading to inappropriate drug dose or class changes, which can cause increased adverse effects and medical costs [46].

This study also revealed that the status of glycemic control is predictor for uncontrolled BP. The odds of uncontrolled BP among patients with uncontrolled blood glucose was increased by 2.4 times as compared to patients with controlled blood sugar (OR:2.4; 95 % CI: 1.4, 4.3; P = 0.002). This finding is in line with previous findings in Ethiopia [8,23]. This might be due to oxidative stress associated with increased blood glucose is closely related to increased arterial stiffness. Chronic hyperglycemia can increase free radicals through glucose auto-oxidation, protein glycation, and activation of the polyol pathway resulting in lipid peroxidation and protein oxidation of cellular structures [47]. The other explanation could be that the impaired regulation of the renin-angiotensin system, the sympathetic nervous system, and possibly, endothelial factors in patients with poor glycemic control could be a contributing factors for uncontrolled BP [48].

Weight reduction is one of the important lifestyle modifications recommended for individuals with hypertension and diabetes. The findings of this study showed that obesity has a notable association with BP control. Obese individuals have 3.2 times more likely to have uncontrolled blood pressure (OR; 3.2; 95 % CI:1.2–8.7; P = 0.026). This result was consistent with studies conducted in Tanzania [5] and India [17].

Nonadherence to life style modification aimed at reducing dietary salt intake has also been identified as factor associated with uncontrolled BP. Patients who were unable to reduce dietary salt intake had 2.4 times more likely to have uncontrolled BP as compared to their counterparts (OR; 2.4; 95 % CI: 1.5–3.8; P < 0.001). This finding aligned with studies conducted in China [49] and Ethiopia [21]. The observed association may be attributed to the effect of high-salt diets on the function of the renin-angiotensin system leading to fluid retention which increases the cardiac workload contributing to uncontrolled BP. An alternative explanation could be high sodium intake associated with fluid retention that increase in systemic peripheral resistance, alterations within the endothelial function, changes in the structure and performance of large elastic arteries, modification in sympathetic activity, and the autonomic neuronal modulation of the cardiovascular system causing uncontrolled BP [50].

The frequency of follow-up was also observed to be linked with uncontrolled BP. Individuals followed-up every four months or more exhibited 2.3 times higher likelihood of uncontrolled BP than their counterparts (OR; 2.3; 95 % CI: 1.3–4.3; P = 0.049). This result is consistent with a report from USA, indicating frequent visits to the primary care units were associated with better BP control [51]. It is also consistent with a result obtained from a study done in Ethiopia [8], where a monthly follow-up is protective for BP control.

The present study was conducted in two tertiary hospitals unlike the previous single centered studies in Ethiopia. Glycated hemoglobin (HgA1c) is used to determine blood glucose control status. However, this study was not without limitations. Recall bias from self-reporting of adherence and lack of objective findings related to lifestyle modification measurements may underestimate or overestimate the result. Difficult to know the temporal relationship between uncontrolled BP and its predictors since it is a cross sectional study design.

5. Conclusion

In the current study, BP control was suboptimal and achieved only about one-third of the study participants. Hypertensive T2DM patients who were younger than 60 years, non-adherent to medication and lifestyle modification, uncontrolled blood glucose, obese and longer frequency of follow-up period had higher likelihood of uncontrolled BP. Improving medication adherence, dietary salt reduction, glycemic control, weight reduction, age specific counseling and frequent follow-up are recommended to achieve target BP control.

Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Informed Consent Statement Informed consent was obtained from all subjects involved in the study.**Data Availability Statement** The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Table 4
Multivariate logistic regression analysis among hypertensive T2DM patients, Addis Ababa, Ethiopia (N = 400).

Variables		Uncontrolled BP, N (%)	Controlled BP, N (%)	Crude OR (95%CI)	Adjusted OR (95%CI)
Age category	18–39	10 (83.3)	2 (16.7)	4.8 (1.0–22.5)	5.4 (1.1, 28.2)[a]
	40–59	117 (74.1)	41 (25.9)	2.8 (1.8–4.3)	2.7 (1.6–4.6) **
	≥60	117 (50.9)	113 (49.1)	1	1
Gender	Male	107 (55.7)	85 (44.3)	1	1
	Female	137 (65.9)	71 (34.1)	1.5 (1.0–2.3)	1.3 (0.8–2.1)
Occupation	Unemployed	186 (59.2)	128 (40.8)	1	1
	Self-employed	13 (52.0)	12 (48.0)	0.8 (0.3–1.7)	0.6 (0.2–1.6)
	Governmental	37 (72.5)	14 (27.5)	1.8 (0.9–3.5)	1.3 (0.6–2.9)
	NGO	8 (80.0)	2 (20.0)	2.8 (0.6–13.2)	2.9 (0.6–15.2)
Physical activity	No	28 (53.8)	24 (46.2)	1.4 (0.8–2.5)	0.8 (0.4–1.5)
	Yes	216 (62.1)	132 (37.9)	1	1
Not reducing dietary salt	No	171 (67.6)	82 (32.4)	1	1
	Yes	73 (49.7)	74 (50.3)	2.1 (1.4–3.2)	2.4 (1.5–3.8)[a]
Family history of HTN	No	141 (57.8)	103 (42.2)	1	1
	Yes	103 (66.0)	53 (34.0)	1.4 (0.9–2.2)	1.4 (0.9–2.3)
Blood sugar	Uncontrolled	209 (66.1)	107 (33.9)	2.7 (1.7–4.5)	2.4 (1.4–4.3)[a]
	Controlled	35 (41.7)	49 (58.3)	1	1
Medication adherence	Non-adherent	58 (69.9)	25 (30.1)	1.6 (0.9–2.7)	2.0 (1.1–3.6)[a]
	Adherent	186 (58.7)	131 (41.3)	1	1
BMI	Normal	122 (54.5)	102 (45.5)	1	1
	Overweight	93 (66.0)	48 (34.0)	1.6 (1.0–2.5)	1.5 (0.9–2.4)
	Obese	28 (82.4)	6 (17.6)	3.8 (1.5–9.7)	3.2 (1.2–8.7)[a]
Antidiabetic medication	Oral	111 (57.5)	82 (42.5)	1	1
	Insulin alone	34 (50.0)	34 (50.0)	0.7 (0.4–1.3)	1.4 (0.7–2.7)
	Oral and insulin	99 (71.2)	40 (28.8)	1.8 (1.148–2.911)	0.7 (0.4–1.3)
Duration of DM	<5 years	52 (54.7)	43 (45.3)	1	1
	5–10 years	80 (62.5)	48 (37.5)	1.4 (0.8–2.4)	1.4 (0.7–2.5)
	>10 years	112 (63.3)	65 (36.7)	1.4 (0.9–2.4)	1.5 (0.8–2.9)
Frequency of follow up	≤1 month	16 (48.5)	17 (51.5)	1	1
	2 months	23 (52.3)	21 (47.7)	1.2 (0.5–2.9)	1.9 (0.7–5.8)
	3 months	78 (60.0)	52 (40.0)	1.6 (0.7–3.4)	2.2 (0.9–5.4)
	4≥months	127 (65.8)	66 (34.2)	2.0 (0.9–4.3)	2.3 (1.3–4.3)[a]

Abbreviations: OR: odds ratio; BMI: body mass index; CI: confidence interval; DM: diabetes mellitus; NGO: non-governmental organizations.
[a] p-value <0.05; **p-value <0.001.

CRediT authorship contribution statement

Leteslase Hagos Gebreziher: Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Melak Gedamu Beyene:** Writing – review & editing, Writing – original draft, Validation, Software, Investigation, Formal analysis. **Desalew Mekonnen:** Writing – review & editing, Validation, Supervision, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Assefa Mulu Baye:** Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

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