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Prevalence of Hypertension and Associated Factors in Patients with Type 2 Diabetes in Tigray Region, Northern Ethiopia: A Cross-Sectional Study

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Abstract

High blood pressure was observed 2 times as common in individuals with diabetes as in those without. The coexistence of hypertension and diabetes substantially increases the risk for micro and macro vascular complications. A fewer studies conducted on the prevalence of hypertensing among type 2 diabetic patients in Ethiopia had some methodological limitations including use of small sample size in single hospital. Moreover, no similar study has been conducted in the study area, despite its unique challenges related to socio-economic factors and healthcare access. This study therefore, aimed at determining the prevalence of hypertension and its associated factors among patients with type 2 diabetes in Tigray region, northern Ethiopia from Sept.2019 to Jan. 2020. Descriptive cross-sectional study was conducted in ten public general hospitals of Tigray. The statistical package for social sciences version 20 was used to analyse data that was obtained through interviewer administered questionnaire of the random sample of 1,158 type 2 diabetes patients. Variables with a p-value less than 0.2 in bivariate analysis were included in a multivariable logistic regression model to identify factors independently associated with hypertension and associated factors were declared at $p < 0.05$. The prevalence of hypertension was 46.0% (95% CI: 43.1–49.0). Of 1,158 type 2 diabetes patients, 32.8 % had pre-hypertensive, 38.4% had stage 1 hypertensive and 5.4% had stage 2 hypertensive. The odds of hypertension were significantly higher among patients who were over 60 years old (AOR=2.84, 95% CI:1.07-7.51), had a BMI over 25 kg/m² (AOR=1.44, 95% CI:1.04-1.97), had diabetes for more than 5 years (AOR=1.39, 95% CI:1.05-1.82), had chronic kidney disease (AOR=1.76, 95% CI:1.23-2.51), had retinopathy (AOR=1.64, 95% CI:1.17-2.28), or were taking more than 4 pills per day (AOR=2.20, 95% CI:1.67-2.90). Conversely, the odds were significantly lower among urban residents (AOR=0.51, 95% CI:0.33-0.77) and those taking anti-platelet (AOR=0.35, 95% CI:0.20-0.60) or anti-dyslipidemia drugs (AOR=0.40, 95% CI:0.25-0.60). The prevalence of hypertension among type 2 diabetes patients was high. Age, residence, BMI, use of anti-platelets drug and anti-dyslipidemia drugs, duration of diabetes, chronic kidney disease and pill burden were the risk factors for hypertension among type 2 diabetic patients. Healthcare providers should implement integrated care models that include regular hypertension screening, lifestyle counseling focused on BMI management, and strategies to reduce the number of medications to lower cardiovascular risk in this population

Keywords: Diabetes, hypertension, complication, Type 2 and prevalence

1. Introduction

Diabetes mellitus is metabolic disorder characterized by hyperglycemia (American Diabetes Association, 2009). The number of people with diabetes is increasing due to population growth, aging, urbanization, and increasing prevalence of obesity and physical inactivity (Wild et al., 2004). Global diabetes prevalence in 2021 was 10.5% (537 million million people). In Africa the prevalence of diabetes in 2021 was 4.5% (24 million). The prevalence of diabetes in Ethiopia was in 2021 was 4.7% (3 million) (International Diabetes Federation, 2021). Hypertension or high blood pressure is a chronic disease in which there is an elevation in the arterial blood pressure (Sweileh et al., 2004). Globally the number of people with hypertension doubled from 1990 to 2019, from 331 million women and 317 million men in 1990 to 626 million women and 652 million men in 2019 (NCD Risk Factor Collaboration, 2021).

Diabetes and hypertension are among the prevalent non communicable diseases and the frequency of both diseases rises with age (Gillow et al., 1999). High blood pressure observed among 70% of individuals with diabetes and is approximately twice as common in individuals with diabetes as in those without (UKPDS Group, 1998; Anwer et al., 2011). Risk factors such as hyperglycaemia, insulin resistance, and dyslipidemia is common to both disease and contribute to the development and progression of atherosclerosis through vascular inflammation, coagulation, endothelial dysfunction and defragment of platelets (Thiruvoipati, 2015). Additionally, autonomic nervous system dysregulation, renin angiotensin aldosterone system (RAAS) activation, renal dysfunction, maladaptive immunity and environmental and socioeconomic factors also contribute to the development of hypertension (Sowers et al., 2001; Oparil et al., 2003).

The coexistence of hypertension and diabetes substantially increases the risk for micro and macro vascular complications such as cardiovascular disease, cerebrovascular accident, retinopathy, and nephropathy (Stamler et al., 1993; Oparil et al., 2003). Furthermore, globally hypertension is the leading major causes of disability and early death (Stamler et al., 1993; Forouzanfar et al., 2016). Evidences showed that 35-75% of diabetes complications can be attributed to hypertension (Bild & Thompson, 1987), hypertension has been associated with 44% of deaths because of diabetes but diabetes is involved in 10% of deaths due to hypertension and high blood pressure attributed to the risk of cardiovascular events by 41%, as compared to 7% and 9% of the these risks in people with diabetes alone (Harris, 1984; Emdin et al., 2015). Moreover, the financial consequences of the two overlapping diseases to patients, family and healthcare system is huge, particularly for the economy of low and middle income countries (Amin et al., 1999).

Despite major advances in healthcare delivery, diabetes continues to be the leading cause of blindness, end stage renal disease (ESRD), and non-traumatic lower limb amputations and the seventh leading cause of death (CDC, 2020). Eventhough, optimal glycemic control is vital in the prevention of diabetes complications, hypertension and dyslipidemia play major role in the initiation and progression of macrovascular disease (DCCT Research Group, 1993). Although good adherence to anti-hypertensive medications and lifestyle modifications result in a significant reduction in cardiovascular and microvascular morbidity and mortality, a significant proportion of diabetes patients still show poorly controlled hypertension (Tsimihodimos et al., 2018).

Therefore, diabetes management should include a multidimensional approach via combining proper control of blood pressure and lipids with appropriate glycemic control (Gaede et al., 2003) and IDF recommended that managing hypertension could significantly reduce the risk of cardiovascular disease outcomes and chronic kidney disease (Saeedi et al., 2019). The need for a reduction of hypertension impact in diabetes is well studied; however, the way how we reduce it in this specific population demands further evidence. Moreover, studies conducted in Ethiopia primarily focused on glycemic control, dyslipidemia, self-care management, diabetes prevalence and diabetes complication among hospitalized/ high risk patients (Padma et al., 2012; Mukeshimana et al., 2015; Ishak et al., 2017; Mariye et al., 2018; Bonger et al., 2018).

Despite the disproportionately high burden of hypertension among diabetes patient as per our knowledge, there are only three studies (Tadesse et al., 2018; Kene et al., 2020; Belsti et al., 2020) conducted on prevalence of hypertension among Type 2 diabetes patients. These few studies have major methodological

limitations, including small sample size, source of data were document review only and done in single institution. Moreover,there was no study conducted on hypertension among T2D in Tigray region, northern Ethiopia. This study therefore, reports the prevalence of hypertension and identifies contributing risk factors in Tigray.

2. Methods and Materials

Study Design and Setting

This was institution-based cross sectional multicentre study conducted in Tigray regional state, Northern Ethiopia. The study was carried out from Sept.2019 to Jan 2020 in 10 public general hospitals that provide basic health services and manage patients with different diseases including diabetes mellitus. About 4,154 patients with type 2 diabetes mellitus received health services at these public general hospitals in 2018/19 (TRHB, 2017).

Population

The study population included all adult diabetes patients attended referral clinics in 10 public general hospitals inTigray. The patients were on routine follow-up during the study period.

Eligibility Criteria

The inclusion criteria were patients with T2DM aged $\geq$ 18 years, and attended follow up DM clinic for at least 1 month. Patients who were severely ill, incomplete medical record and pregnant were excluded from the study.

Sample Size Determination

Sample size was calculated using Epi Info 7.0 StatCalc with the following assumption: 95% confidence intervals (z = 1:96), The 59.5% (P=0.595) proportion of hypertension among T2DM patients of was considered (29) and 3% margin of error. This provides a sample size of 1027, however, a refusal rate was predicted to be 15%, and then the final sample size was 1,181. proportion allocation was employed to allocate the sample size among the selected public general hospitals based on case load (figure 1)

Sampling Procedure

Because of budget constraint we could not include all public hospitals then ten out of 13 were selected using simple random sampling technique. A systematic random sampling technique was used to select the study participants. For each hospital, Ks were calculated by dividing the number of T2D patients of the selected hospital (N) to their respective number of proportionally allocated sample (n) (Figure1). The first patient was selected randomly from the first three by a lottery method, and the next patient was selected every three interval until the required sample was attained.

Variables

Dependent variable: Hypertension status and Independent variables includes the following:
Socio-demographic: Age, Sex, Marital status, Educational status, Occupation, monthly income, residence, family history of DM and BMI.

Clinical: Diabetes treatment, anti-platelets drug, anti-dyslipidemia drug, Duration of diabetes, comorbid disease, FBS, Pill burden, Attend health education on Diabetes.

Behavioral: glucometer, adherence to diabetic diet, vegetable consumption per week, adherence to diabetic medication, glucose test frequency, smoking, alcohol consumption and Physical exercise.

Operational definitions

Hypertension: Patients with systolic blood pressure (SBP) $\geq$ 140 mmHg and /or diastolic blood pressure (DBP) $\geq$ 90 mmHg, (Ekoru et al., 2019) and/or patients on antihypertensive therapy were taken as hypertensive**.** (Muxfeldt et al., 2004).

Staging of Hypertension: BP of 120/80 to 139/89 is prehypertension; BP of 140/90 to 159/99 is Stage 1 HTN; 160/100 to 179/109 is Stage 2 HTN, and BP $\geq$180/110 is hypertensive crisis (Williams et al., 2018).

Follow healthy diet: consuming vegetables, Fruits:, Whole Grains, protein, Low fat Dairy & its product: and low simple carbohydrate , fat/oil, avoid alcohol (NIDDK, 2016)

High fat/oil consumption: eat or consume more than 10% of calories from saturated fat which means about more than 20 grams of saturated fat per day (ANA, 2020).

Alcohol consumption: Adults with diabetes who drink alcohol should do so in moderation (no more than one drink per day for adult women and no more than two drinks per day for adult men) (>2 for women & >3 drinks /day for men) (Gray & Threlkeld, 2019)

Physical activity: At least 150 min of moderate to vigorous physical activity per week was considered as active (Armstrong & Bull, 2006)

The body mass index (BMI): For this study BMI was classified into two categories (< 25 and ≥25) according to their risk of hypertension (Flegal, 2015).

Controlled Fasting Blood Sugar: Fasting blood sugar ≤130 mg/dl.(Liu et al., 2010).

Current Smokers: A person who smoked a cigarette at least once in the last month before the study.

Critically Ill: Patients who are unable to communicate and altered consciousness.

Diabetes Duration: The duration of diabetes was calculated from the time of diabetes melliluse (DM) diagnosis up to time of data collection.

Data Collection Procedure

The data were collected using a pre-tested interviewer administered questionnaire which was developed from the review of relevant literature (Shera et al., 2004; Abejew et al., 2015; Riley et al., 2016; Lebeta et al., 2017; Arambewela et al., 2018). Face to face interviews, review of patient records and physical examination were conducted to obtain data. The interviewer administered questionnaire used had three parts, part I had questions related to participants socio demographic characteristics, part II clinical characteristics and part III behavoural factors. Behavioral variables were assessed based on the WHO STEPwise approach for chronic disease risk factor surveillance (Omer et al., 2021). Clinical data was obtained from patients' records and physical measurements. Body weight was measured using a weight scale machine to an accuracy of 0.1 kg. During measurement, participants. were barefooted and put on light clothes. Height was measured in meters, standing upright on a flat surface by a stadiometer.

Body mass index (BMI) was calculated as the ratio of weight in kilograms (kg) to the square of height in meters (m2). Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured from the left arm at the level of the heart using amercury-based or digital sphygmomanometer after the subjects take a rest for more than 10 minutes and 30 minutes for those who had reported to take hot drinks like coffee. For the participants who had SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg, their blood pressure were measured again and finally the average value was taken. Data was collected by nurses who had Bachelor Degree in Nursing and supervised by the fisrt author (KKB).

Data Quality Assurance

To ensure data quality, the research assistants received one day training about the purpose of the study and the data collection procedure. Moreover, questionnaire was pre-tested to 5% of the sample size in Quiha general hospital two weeks before the actual data collection period for its validity and reliability. The questionnaire was revised based on the information obtained during pretesting. During the actual data collection, all questionnaires were checked for completeness before the patiecuipaqnt was allowed to go home.

Data Management and Analysis

After checking the data for its completeness, consistency, missing values and coding of questionnaires, data were entered into Epi info version 7 and analyzed using SPSS version 20. Binary logistic regression analysis model was used to identify risk factors. Hosmer & Lemeshow and Collinearity tests were done to check for model fitness and effect modifiers respectively. Variables with $p < 0.05$ during the bivariate analysis were then included in the Multivariable logistic regression for further analysis. $P < 0.05$ was considered as cutoff point to declare a variable shows statistically significant association in multivariable analysis. The strength

of association of factors, with hypertension was demonstrated by computing the adjusted odds ratio (AOR) and its 95% confidence interval (CI).

3. Results

Socio-Demographic Characteristics of Participants

Overall, 1158 participants' questioner were fit for final analysis which makes response rate of 98.05 % due to 23 questionairs were excluded because of gross incompleteness. Fourty four percent of the study participants had age greater than 50 years with mean age of 55.9 (SD+ 11.9) years. Of all study participants 54.0% were male, 66.8% were married, 50.5% did not attend formal education and 20.0% had family history of diabetes of which 25.2%, 29.0%, 24.3% and 8.9% had hypertension respectively. However, of the total participantsd 30.0% were unemployed, 72.3% were urban residents and had BMI of less than 25 kg/m2 in which 14.5%, 36.4% and 44.0% of them were normotensive respectively (Table 1).

Table1: Socio-demographic characteristics versus Hypertension among type 2 diabetes (T2D) patients in Tigray region, Northern Ethiopia, 2020 (N=1,158)

Variable	Category	Hypertension status		Total
		Normotensive	Hypertensive	
		625(54.0%)	**533 (46.0%)**	
Age	1. <40 years	53(4.6%)	18(1.6%)	71(6.1%)
	2. 41-45 years	158(13.6%)	61(5.3%)	219(18.9%)
	3. 46-50 years	201(17.4%)	152(13.1%)	353(30.5%)
	4. 51-55 years	130(11.2%)	168(14.5%)	298(25.7%)
	5. 56-60 years	70(6.0%)	108(9.3%)	178(15.4%)
	6. >61 years	13(1.1%)	26(2.2%)	39(3.4%)
Sex	1. Male	333(28.8%)	292(25.2%)	625(54.0%)
	2. Female	292(25.2%)	241(20.8%)	533(46.0%)
Marital status	1. Single	49(4.2%)	28(2.4%)	77(6.6%)
	2. Married	438(37.8%)	336(29.0%)	774(66.8%)
	3. Divorced	61(5.3%)	70(6.0%)	131(11.3%)
	4. Widowed	77(6.6%)	99(8.5%)	176(15.2%)
Educational status	1. No formal education	304(26.3%)	281(24.3%)	585(50.5%)
	3. Primary school (1-8 grade)	135(11.7%)	117(10.1%)	252(21.8%)
	4. Secondary(9-12 grade)	98(8.5%)	71(6.1%)	169(14.6%)
	5. Above secondary education	88(7.6%)	64(5.5%)	152(13.1%)
Occupation	1. Farmer	150(13.0%)	98(8.5%)	248(21.4%)
	2. Government employee	105(9.1%)	60(5.2%)	165(14.2%)
	3. Private work	152(13.1%)	129(11.1%)	281(24.3%)
	4. Retired	50(4.3%)	70(6.0%)	120(10.4%)
	5. Unemployed	168(14.5%)	176(15.2%)	344(29.7%)
Residence	1. Urban	422(36.4%	415(35.8%)	837(72.3%)
	2. Rural	203(17.5%	118(10.2%)	321(27.7%)
Family history of	1.Yes	125(10.8%)	103(8.9%)	228(19.7%)
DM	2. No	500(43.2%)	430(37.1%)	930(80.3%)
BMI	1.< 25 kg/m2	510(44.0%)	376(32.5%)	886(76.5%
	2.> 25 kg/m2	115(9.9%)	157(13.6%)	272(23.5%)

Clinical and Behavioral Characteristics of Participants

Of the total study participants 78.9%, 11.7%, 16.8% and 10.1% were taking oral hypoglycemic agent, anti-coagulant, anti-dyslipidemia drug and had glucometer at home in which 37.7%, 9.6%, 12.8% and 5.7% had hypertension respectively. Similarly of all study participants 22.6%, 60.7%, 42.7%, 90.6% and 50.4% had retinopathy, FBS of >130.00 mg/dl, had pill burden of ≥ 4 pill per day, were adhered to diabetes medication and healthy diet in which 14.2%, 27.2%, 26.0%, 41.8% and 22.9% had hypertension respectively. Regarding behavioral characteristics of the study participants, 68.7, 6.2%, 12.4%, 38.7% and 76.5 were consume vegetable <4 servings per week, ever smoked tobacco products (Smoking), consumed alcohol > 3 drinks per occasion, physically inactive and attend diabetes education in which 32.1%, 3.4%, 5.6% , 18.7% and 33.4% had hypertension respectively. However, 54.6% and 9.0% had diabetes duration of < 5 years and measured their blood glucose 1–2 days per week in which 33.8% and 4.1% were normotensive respectively (Table 2).

Table 2: Clinical and Behavioral characteristics versus Hypertension among type 2 diabetes (T2D) patients in Tigray region, Northern Ethiopia, 2020 (N=1,158)

Variable		Category	Hypertension Status		Total
			Normotensive	Hypertensive	
			625(54.0%)	**533 (46.0%)**	
Diabetes treatment regimen		1. Insulin	91(7.9%)	48(4.1%)	139(12.0%)
		2. Insulin + OHA*	57(4.9%)	48(4.1%)	105(9.1%)
		3. OHA*	477(41.2%)	437(37.7%)	914(78.9%)
Use of anti-platelets drug (e.g. ASA)		1. Yes	25(2.2%)	111(9.6%)	136(11.7%)
		2. No	600(51.8%)	422(36.4%)	1022(88.3%)
Use of anti-dyslipidemia drug		1. Yes	47(4.1%)	148(12.8%)	195(16.8%)
		2. No	578(49.9%)	385(33.2%)	963(83.2%)
Have glucometer at home		1. Yes	51(4.4%)	66(5.7%)	117(10.1%)
		2. No	574(49.6%)	467(40.3%)	1041(89.9%)
Duration of diabetes since it occurred		1. < 5 years	391(33.8%)	241(20.8%)	632(54.6%)
		1. ≥ 5 years	234(20.2%	292(25.2%)	526(45.4%)
Comorbidity	CVD	1. Yes	30(2.6%)	30(2.6%)	38(3.3%)
		2. No	503(43.4%	503(43.4%	1120(96.7%)
	Chronic kidney disease	1. Yes	143(12.3%)	143(12.3%)	222(19.2%)
		2. No	390(33.7%)	390(33.7%)	936(80.8%)
	Retinopathy	1. Yes	164(14.2%)	164(14.2%)	262(22.6%)
		2. No	369(31.9%)	369(31.9%)	896(77.4%)
	Neuropathy	1. Yes	78(6.7%)	78(6.7%)	123(10.6%)
		2. No	455(39.3%)	455(39.3%)	1035(89.4%)
Fasting blood sugar (mg/dl)		1. <130.00 mg/dl	237(20.5%)	218(18.8%)	455(39.3%)
		2. ≥ 130.99 mg/dl)	388(33.5%)	315(27.2%)	703(60.7%)
Pill burden		1. <4 pill / day	432(37.3%)	232(20.0%)	664(57.3%)
		2. ≥ 4 pill /day	193(16.7%)	301(26.0%)	494(42.7%)
Adherence to diabetic diet		1. Adhere	319(27.5%)	265(22.9%)	584(50.4%)
		2. Not adhere	306(26.4%)	268(23.1%)	574(49.6%)
Vegetable consumption per week		1. <4 servings	423(36.5%)	372(32.1%)	795(68.7%)
		2. ≥ 4 servings	202(17.4%)	161(13.9%)	363(31.3%)
Adherence to diabetic Medication		1. Adhere	565(48.8%)	484(41.8%)	1049(90.6%)
		2. Not adhere	60(5.2%)	49(4.2%)	109(9.4%)
		1. Not measured at all	578(49.9%	476(41.1%	1054(91.0%

Variable	Category	Hypertension Status		Total
		Normotensive	Hypertensive	
Days, in which glucose was measured/wk.	2. 1–2 days	47(4.1%)	57(4.9%)	104(9.0%)
Ever smoked tobacco products (Smoking)	1. Yes	33(2.8%)	39(3.4%)	72(6.2%)
	2. No	592(51.1%)	494(42.7%)	1086(93.8%)
Alcohol consumption	1. $\geq$ 3 drinks per occasion	79(6.8%)	65(5.6%)	144(12.4%)
	1. Never & Once a month	546(47.2%)	468(40.4%)	1014(87.6%)
Physical exercise	1. Inactive	231(19.9%)	217(18.7%)	448(38.7%)
	2. Active	394(34.0%)	316(27.3%)	710(61.3%)
Attend health education on Diabetes	1. Yes	412(43.1%)	320(33.4%)	732(76.5%)
	2. No	116(12.1%)	109(11.4%)	225(23.5%)

*OHA=Oral hypoglycemic agent

Prevalence of Hypertension

Using BP cut point of 140/90 mmHg, as recommended by most guidelines of hypertension treatment, 46.0% (533/1158) (95% CI: 43.1–49.0).of the participants in this study had hypertension. Of these 221 (19.0%) of them were diagnosed before DM was diagnosed. Only 146 (12.1%) hypertensive patients properly controlled their blood pressure. Of the total hypertensive patients 445 (38.4%) had stage I hypertension, 63(5.4%) had stage 2 hypertension, 25 (2.2%) had hypertension crisis; and 380 (32.8%) were in pre-hypertension condition (Figure2)

Schematic presentation of sampling technique

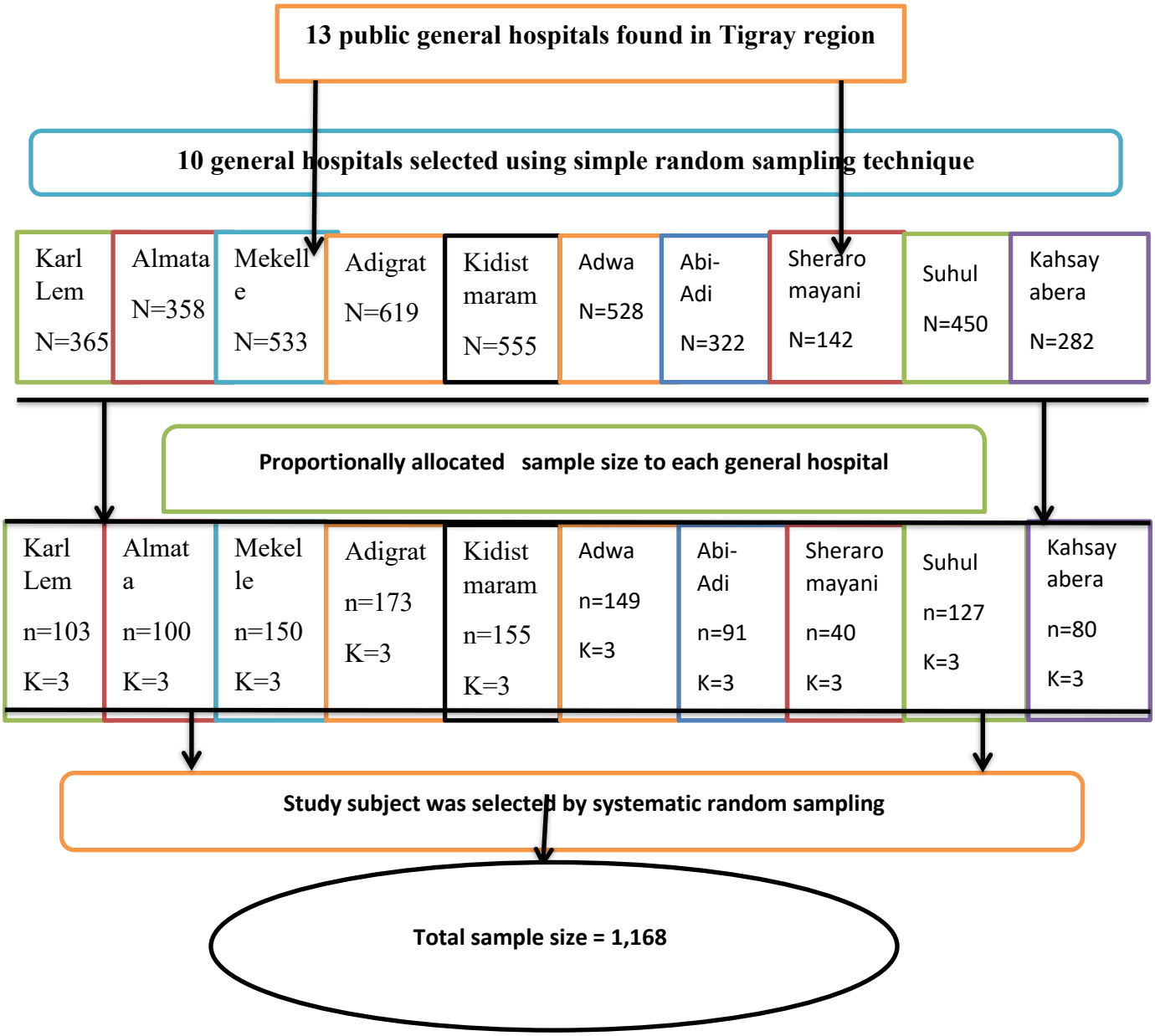

Fig. 1: Schematic presentation of sampling procedure for a study on magnitude and associated factor of chronic diabetes complications among patients with T2DM attending at public general hospitals in Tigray region, Ethiopia 2019/20

Blood pressure levels among T2DM patients

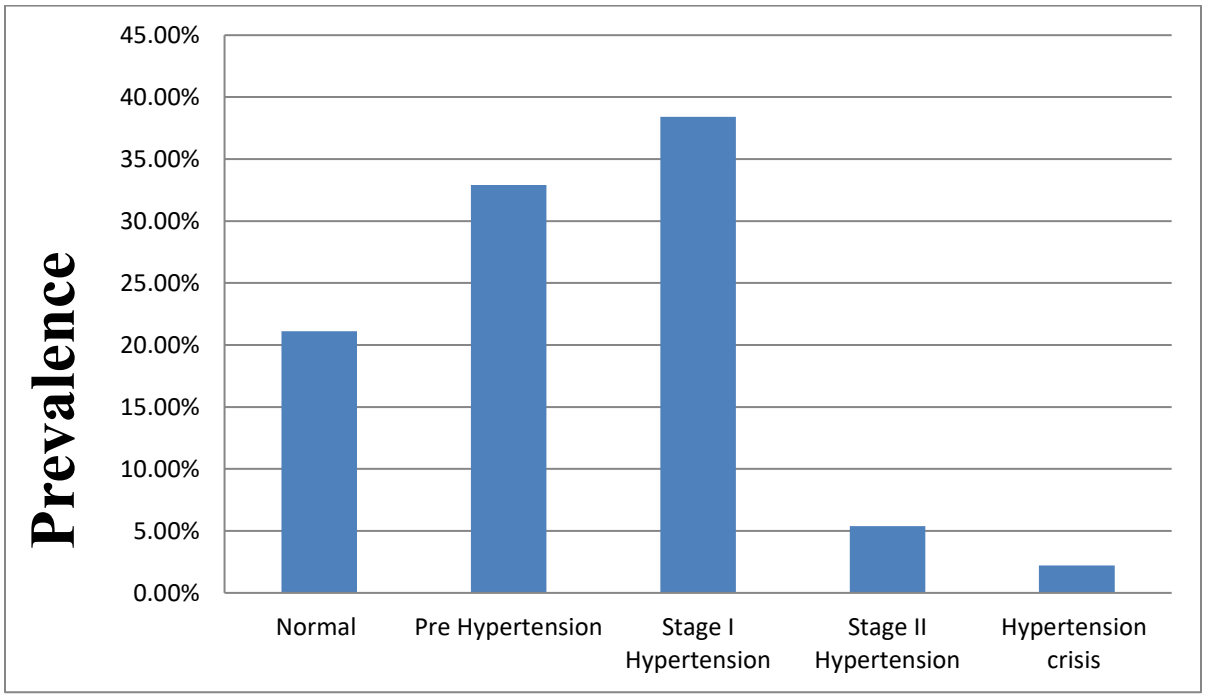

Fig. 2 Blood pressure levels among T2DM patients in Tigray region, 2020.

Factors Associated with Hypertension among Patients with type 2 Diabets (T2D)

Odds ratios were calculated for risk factors found to be associated with hypertension among diabetics. After considering all assumptions of binary logistic regression, based on the p-value (≤ 0.05) of the bivariable analyses, fourteen variables were identified as candidate for analysis in multivariable model. In the multivariable logistic regression analysis, nine variables were found to be risk factors of hypertension among diabetes patients at 5% level of significance.

The odds of having hypertension was 2.841 times higher in age > 60 years old [AOR = 2.841; 95% CI = 1.07, 7.51, P=0.035)] than those below 60 years old. The result showed that being urban resident decrease the probability of developing hypertension by 49.5 % [AOR = 0.505; 95% CI = (0.33, 0.77), P = 0.002] than their counterpart. Those patients with BMI ≥ 25 kg/m2 were 1.4 times more likely to develop hypertension [AOR = 1.436; 95% CI = (1.04, 1.97), P = 0.025] than those with normal BMI.

Taking of anti-platelet or anti-dyslipidemia drug decreased the chance of developing hypertension by 64.7 % [AOR = 0.353; 95% CI = (0.20, 0.60), P < 0.001] and 60.4 % [AOR = 0.396; 95% CI = (0.25, 0.60), P < 0.001] respectively. Those respondents who stayed with diabetes for ≥5 years the probability of hypertension occurance were increased by 38. 7 % [AOR = 1.387; 95% CI = (1.05, 1.82), P =0.019] than their counterpart. Having chronic kidney disease or Retinopathy increased the probability of developing hypertension by 76.2% [1.762; 95% CI = (1.23, 2.51), P =0.002] and by 63.7% [AOR = 1.637; 95% CI = (1.17, 2.28), P =0.004] than their counterpart respectively. Lastly, the diabets patients who took ≥4 pill /day were 2.202 more likely to develop hypertension [AOR = 2.202; 95% CI = (1.67, 2.90), P < 0.001] than their counterpart [Table 3].

Table3: Multivariate logistic regression of factors associated with Hypertension among type 2 diabetes (T2D) patients in Tigray region, Northern Ethiopia, 2020 (N=1,158)

Variable	Category	Hypertension status		Non-adjusted	Adjusted
		Normotensive	Hypertensive	COR (95% CI)	AOR (95% CI)
Age	1. ≤40 years	53(4.6%)	18(1.6%)	1	
	2. 41-45 years	158(13.6%)	61(5.3%)	1.1(0.61, 2.09)	0.734(0.37, 1.45)
	3. 46-50 years	201(17.4%)	152(13.1%)	2.2(1.25, 3.95)	1.189(0.61, 2.31)
	4. 51-55 years	130(11.2%)	168(14.5%)	**3.8(2.12, 6.80)**	1.896(0.95, 3.74)
	5. 56-60years	70(6.0%)	108(9.3%)	**4.5(2.46, 8.39)**	**2.258(1.08, 4.69)***
	6. ≥ 61 years	13(1.1%)	26(2.2%)	**5.9(2.50, 13.83)**	**2.841(1.07, 7.51)***
Marital status	1. Single	49(4.2%)	28(2.4%)	**0.4(0.25, 0.77)**	1.044(0.53, 2.05)
	2. Married	438(37.8%)	336(29.0%)	0.6(0.42, 0.83)	0.934(0.62, 1.38)
	3. Divorced	61(5.3%)	70(6.0%)	0.9(0.56, 1.40)	1.459(0.86, 2.47)
	4. Widowed	77(6.6%)	99(8.5%)	1	
Occupation	1. Farmer	150(13.0%)	98(8.5%)	**0.6(0.44, 0.86)**	1.356(0.84, 2.17)
	2. Gov't employee	105(9.1%)	60(5.2%)	0.5(0.37, 0.79)	0.863(0.54, 1.36)
	3. Private work	152(13.1%)	129(11.1%)	0.8(0.59, 1.11)	0.969(0.66, 1.42)
	4. Retired	50(4.3%)	70(6.0%)	1.3(0.87, 2.03)	1.101(0.68, 1.77)
	5. Unemployed	168(14.5%)	176(15.2%)	1	
Residence	1. Urban	422(36.4%	415(35.8%)	1	
	2. Rural	203(17.5%	118(10.2%)	**1.7(1.29, 2.20)**	**0.505(0.33, 0.77)****
BMI	1. < 25 kg/m2	510(44.0%)	376(32.5%)	1	
	2. ≥ 25 kg/m2	115(9.9%)	157(13.6%)	**1.9(1.40, 2.43)**	**1.436(1.04, 1.97)***
Diabetes treatment regimen	1. Insulin	91(7.9%)	48(4.1%)	1	
	2. Insulin + OHA*	57(4.9%)	48(4.1%)	1.6(0.95, 2.68)	0.703(0.37, 1.30)
	3. OHA*	477(41.2%)	437(37.7%)	**1.7(1.19, 2.52)**	0.890(0.56, 1.41)
Anti-platelets drug	1. Yes	25(2.2%)	111(9.6%)	1	
	2. No	600(51.8%)	422(36.4%)	**0.2(0.10, 0.24)**	**0.353(0.20, 0.60)*****
Anti-dyslipidemia drug	1. Yes	47(4.1%)	148(12.8%)	1	
	2. No	578(49.9%)	385(33.2%)	**0.2(0.014, 0.30)**	**0.396(0.25, 0.60)*****
Duration of diabetes	2. < 5 years	391(33.8%)	241(20.8%)	1	
	3. ≥ 5 years	234(20.2%	292(25.2%)	**2.0(1.60, 2.56)**	**1.387(1.05, 1.82)***
Comorbidity: CVD	1. Yes	8(0.7%)	30(2.6%)	**4.6(2.09, 10.12)**	1.045(0.41, 2.65)
	2. No	617(53.3%)	503(43.4%	1	
Comorbidity: Chronic kidney disease	1. Yes	79(6.8%)	143(12.3%)	**2.5(1.87, 3.43)**	**1.762(1.23, 2.51)****
	2. No	546(47.2%)	390(33.7%)	1	
Comorbidity: Retinopathy	1. Yes	98(8.5%)	164(14.2%)	**2.4(1.80, 3.17)**	**1.637(1.17, 2.28)****
	2. No	527(45.5%)	369(31.9%)	1	
Comorbidity: Neuropath	1. Yes	45(3.9%)	78(6.7%)	**2.2(1.50, 3.25)**	1.058(0.66, 1.68)
	2. No	580(50.1%)	455(39.3%)	1	
Pill burden	1. <4 pill / day	432(37.3%)	232(20.0%)	1	

Variable	Category	Hypertension status		Non-adjusted	Adjusted
		Normotensive	Hypertensive	COR (95% CI)	AOR (95% CI)
	2.≥ 4 pill /day	193(16.7%)	301(26.0%)	**2.9(2.28, 3.69)**	**2.202(1.67, 2.90)*** **

*Veg. vegetable, *Significant at p<0.05; **Significant at p<0.01; ***Significant at p< 0.0001.

4. Discussion

This study was conducted to explore hypertension prevalence and its associated factors among type 2 diabetes patients in Tigray region, Ethiopia. In this study, the overall prevalence of hypertension was found to be 46.0% [95% CI: 43.1, 49.0]. This result was in line with a study conducted in Sudan 47.6% (Chowdhury et al., 2021) but higher than the prevalence rates reported in Bangladesh 31% and Southwest Ethiopia 37.4% (Mubarak et al., 2008; Kene et al., 2020). However, the finding of the current study is lower than studies conducted in Jordan 72% -74.6 % (Mohammad et al., 2017; Kemche et al., 2020Salameh et al., 2022), 86.2% in Cameron (Alsaadon et al., 2022), 59.5% in Northwest Ethiopia (Belsti et al., 2020), 55% in Southern Ethiopia (Tadesse et al., 2018), in Bangladesh 77.5 % (Kabakov et al., 2022) and 85.8% in Israel (Ferrannini et al., 2012). In this study among the hypertensive study participants, Stage 1 hypertention was the highest prevalence, followed by Stage 2 hypertention and hypertension crisis. Similar pattern was observed in studies conducted in Jordan, Ethiopia and Bangladesh (Mubarak et al., 2008; Mohammad et al., 2017; Tadesse et al., 2018; Belsti et al., 2020).

The probable cause for lower prevalence reported in other studies compared to ours could be due to the presence of age difference between the two study populations. For instance a study in Bangladesh reported that 48.4% study participants were aged < 40 years old (Mubarak et al., 2008) but our study showed that 6.5% of study participants were in <40 years old. This may be the possible cause of a higher prevalence of hypertension due to the fact that its frequency increases with increasing age (Berraho et al., 2012; Khanam et al., 2019; Liew et al., 2019; Kotiso et al., 2021).

One of the reasons for higher prevalence rates identified in studies conducted in Jordan, Cameron and Israel (Ferrannini et al., 2012; Kemche et al., 2020; Salameh et al., 2022; Alsaadon et al., 2022) could be most likely due to the cut point for the diagnosis of hypertension used by the authors which was ≥130/80 mmHg but in this study the cut-off point was ≥140/90mmHg. The other possible difference might be due to a difference in BMI of the study populations. Study findings from Jordan, Cameron, Ethiopia and Bangladesh (Mohammad et al., 2017; Belsti et al., 2020; Kemche et al., 2020; Alsaadon et al., 2022; Kabakov et al., 2022) revealed that more than 70% study participants had a BMI of ≥ 25kg/m2, which is higher than the proportion of our study population. Therefore the higher BMI in those studies could be the possible reason higher prevalence of hypertension because high BMI is associated with increased risk of hypertension(Belsti et al., 2020).

Modifiable and non-modifiable risk factors were identified in this study. Under modifiable risk factors, there was BMI, chronic kidney disease, retinopathy, pill burden, residence, anti-platelets and dyslipidemia drug. Age and duration of diabetes were the non-modifiable risk factors. Our study showed that older age (>55Years) was independently associated with hypertension among diabetic patients. This age-related trend of hypertension is consistent with what reported in other studies (Ferrannini et al., 2012; Buford, 2016; Tadesse et al., 2018; Kene et al., 2020; Belsti et al., 2020; Kemche et al., 2020; Chowdhury et al., 2021; Salameh et al., 2022; Alsaadon et al., 2022; Kabakov et al., 2022).

The prevalence of hypertension increases with age, which could be explained by an inrease in age may result in endothelial dysfunction lead to stiffening of the arterial vasculature, changes in vessel lumen elasticity, vascular remodeling, vascular fibrosis, impaired endothelial mediated relaxation, enhanced vascular smooth muscle contraction and resistance, inflammation and oxidative stress are mechanism in which acceleret the development of the hypertension (Weber et al., 1989; Oparil et al., 2018; Hill et al., 2021). Moreover, an incree in age, there is a decrease of baroreceptor sensitivity, an increase of

responsiveness to sympathetic nervous system stimuli and a modification of renin aldosterone relationship, thereby predisposing to high BP (Mariye et al., 2019).

In this study, BMI score was recognized as one of the factors shows significant statistical association with hypertension in people with T2DM. Patients with higher BMI (≥25 kg/m2) had a higher risk for hypertension development than patients with normal BMI. This finding consistent with other studies (Buford, 2016; Takahashi & Oparil, 2017; Belsti et al., 2020; Kemche et al., 2020; Chowdhury et al., 2021; Salameh et al., 2022; Kabakov et al., 2022. The possible explanation for this is might be due to excess fat in patients with higher BMI scor leading to the activation of the angiotensinogen which again increases sodium reabsorption and elevated Intravascular Volume due to water retensuion (Sowers, 2013). The other means by which excess fat in obese individuals leads to hypertension is due to risk of worsening insulin resistance which has been linked in to an increased vascular oxidative stress, inflammation, and endothelial dysfunction characterized by diminished vascular nitric oxide bioactivity, all of which promote vascular stiffness resulting in a persistent elevation of blood pressure (Ritz et al., 2011; Nouh et al., 2017).

This study showed that patients with ≥5 years duration of DM had high hypertension prevalence than patients with < 5 years of DM duration and this is in line with reports from studies conducted in Ethiopia, Cameron, Bangladesh and Jordan (Takahashi & Oparil, 2017; Belsti et al., 2020; Salameh et al., 2022; Alsaadon et al., 2022; Kabakov et al., 2022). This result may be related to chronic hyperglycemia resulting in endothelial suffering leading to thickening of the arterial wall and to a rise in blood pressure later (Li et al., 2015). In relation to residence, this study showed that patients from urban areas seemed to have protective effect against hypertension than those who were from rural areas. This is consistent with the finding of study conducted in Hosanna, Southern Ethiopia (Tadesse et al., 2018) but conterary to study finding from Debre Tabor General Hospital, Northwest Ethiopia (Belsti et al., 2020). This difference might be due to variation in study setting, study population and sample size.

This study revealed that patients who have chronic kidney disease were at greater risk of developing hypertension and this is also reported from studies conducted in Addis Ababa, Ethiopia and Bangladesh (Buford, 2016; Kabakov et al., 2022). The pathophysiological relationship are a patient with renal dysfunction due to kidney disease lead to intravascular volume expansion secondary to increased renal sodium reabsorption and water retension, peripheral vasoconstriction arising from endothelial dysfunction, dysregulated activation of the Renin Angiotensin Aldosterone System (RAAS), up regulation of endothelin1, and down regulation of nitric oxide risk factors for development of hypertension (Wolfrum et al., 2003). However, it is important to note that hypertension is a well-known risk factor for kidney disease, as well as the other way around (Wassmann et al., 2003).

Retinopathy is risk factor that shows statistical association with hypertension in this study. Even though available data did not show a direct causal relationship, the possible reason for coexistence of such co-morbid disease with hypertension might be due to prolonged hyperglycemia. The most important pathogenesis leading to vascular damage is that hyperglycemia damages capillary endothelial cells in the retina, mesangial cells in the renal glomeruli and Schwan cells of the peripheral vasculature (Wassmann et al., 2003). Patient with retinopathy have greater chance for developing hypertension because of similarity in pathogenesis. Moreover patients who took ≥ 4 pills /day were at greater risk for development of hypertension and the reason might be pill burden could lead to poor adherence to diabetes medication in which the occurrence of prolonged hyperglycemia is more likely and result in diabetes complication like hypertension.

Finally findings of this study also showed that patients who took anti platelets or anti-dyslipidemia medication less likely to develop hypertension although we could not find studies with similar result. The possible reason for protective effect of anti-dyslipidemia medication might, this drug reduce bad cholesterol (e.g. LDL-cholesterol) to prevent atherosclerosis, improve endothelial function by increasing the bioavailability of nitric oxide, promoting reendothelialisation, reducing oxidative stress and inhibiting inflammatory responses (71) and down regulatation of angiotensin II type 1 (AT1)-receptor expression

(72). Similarly anti-platelet medications could prevent endothelial dysfaction or damage lead to hypertension through prevention of pathologic blood clot formation.

Some of the major limitations of this study that should be mentioned are: First of all, as it was hospital based cross-sectional in its design, this only allows for the identification of variables that have association with the dependent variable, rather than causation. Second, it may lack generalizability to the entire population and to diabetes patients not receiving care at public hospitals. Finally, some risk factors were not addressed, such as lipid profile, HgbA1C, eating rate per day and family history of hypertension

5. Conclusion

Our study revealed that the prevalence of hypertension among patients with type 2 diabetes in Tigray region, Northern Ethiopia was 46.0%. Stage 1 hypertension was the most common type of hypertension and about one-fourth of patients with previously diagnosed hypertension were uncontrolled. The risk of developing hypertension was associated with older age, residence, BMI, Anti-platelets drug, anti-dyslipidemia drug, duration of DM, chronic kidney disease and pill burden. Therefore, active search for early detection of hypertension and related cardiovascular risk factors should be an important part of diabetes follow-up. Moreover, health education about effective lifestyle modifications and the importance of adherence to self-management (treatment, healthy diet and physical activity) would be of great benefit in controlling high blood pressure and preventing its complications.

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