Research Article

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Journal of Obesity & Eating Disorders
ISSN 2471-8203

2025
Vol.11 No.2:116

Uncontrolled Glycemic Level and Its Associated Factors among Adult Diabetes Mellitus Patients Who Visited Diabetic Clinic of Tibebe Ghion Specialized Hospital, Bahir Dar, Northwest Ethiopia, 2023. A Cross Sectional Study

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Received date: September 04, 2024, Manuscript No. IPJOED-24-19590; **Editor assigned date:** September 06, 2024, PreQC No. IPJOED-24-19590 (PQ); **Reviewed date:** September 20, 2024, QC No. IPJOED-24-19590; **Revised date:** February 13, 2025, Manuscript No. IPJOED-24-19590 (R); **Published date:** February 20, 2025, DOI: 10.36648/2471-8205.11.2.116

Citation: Yabebal Y, Genetu A, Wassie GT (2025) Uncontrolled Glycemic Level and Its Associated Factors among Adult Diabetes Mellitus Patients Who Visited Diabetic Clinic of Tibebe Ghion Specialized Hospital, Bahir Dar, Northwest Ethiopia, 2023. A Cross Sectional Study. J Obes Eat Disord Vol:11 No:2

Abstract

Background: Achieving target glycemic control in clinical practice is challenging. As a result, identifying the factors that influence glycemic control is crucial.

Objective: To assess the uncontrolled glycemic level and its associated factors among adult Diabetes mellitus patients on follow up at the Diabetic Clinic of Tibebe Ghion Specialized Hospital, 2023.

Methods: An institution based cross sectional study was conducted among 229 diabetes mellitus patients at Tibebe Ghion specialized hospital from November 2023 to January 2024. The samples were selected using systematic random sampling technique. Pretested, structured, and interviewer-administered questionnaires were used to collect data. Data entered using Epidata Manager version 4.6 and analyzed using SPSS version 27. Multivariable logistic regression analysis was used, considering with a p-value of <0.05 as statically significant, with a 95% confidence interval.

Results: The mean HbA1c of the participants were 8.0% (SD± 1.8547%) and 158 (69.0%) participants were having poor and or inadequate HbA1c (HbA1c ≥ 7.0). Not having access to Self-Monitoring Blood Glucose (SMBG) tools (AOR=5.48, 95% CI 2.21-13.57), polypharmacy (AOR=3.68, 95% CI 1.17-11.59), minimal physical activity (AOR=3.52, 95% CI 1.17-10.53), physical inactivity (AOR=6.55, 95% CI 2.20-19.42), poor medication adherence (AOR=8.05, 95% CI 2.53-25.56) and Body Mass Index (BMI) ≥ 25.0 kg/m^2 (AOR=4.37, 95% CI 1.39-13.73) were factors associated with inadequate and poor glycemic control.

Conclusions: In this study 7 out of 10 participants had inadequate and or poor glycemic control levels. Effective and tailored interventions are needed to mitigate these risk factors.

Keywords: Uncontrolled diabetes; Bahir Dar; Ethiopia

Introduction

World Health Organization (WHO) projected that by 2025 Non-Communicable Disease (NCDs) will account for more than 70% of all deaths globally, with 85% of these occurring in developing countries and Diabetes Mellitus (DM) is one major component of CDs [1].

The American Diabetic Association (ADA) 2023 defines diabetes as group of chronic metabolic disorder that occurs either when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces and classified it primarily based on pathophysiology in to four groups as type 1 diabetes, type 2 diabetes, specific type of diabetes due to other causes diabetes and gestational diabetes [2].

Uncontrolled diabetes and its related complications have significant mortality and economic burden. In 2021, it has resulted about 6.7 million deaths in adults (1 death in every 5 second) between the ages of 20–79 [3]. In Ethiopia a study shows that 5% of adult deaths in Addis Ababa were attributed to diabetes [4]. Globally over 15 years the health expenditure due diabetes and its related complications has increased by 316%, from USD 232 billion in 2007 to USD 966 billion in 2021 for adults aged 20–79 years, representing 11.5% of total global health spending, and it will reach USD 1.03 trillion by 2030 and USD 1.05 trillion by 2045 [2]. In Ethiopia the total health expenditure due to diabetes in 2021 was USD 200million and it is expected to be USD 452 milliion in 2045 [5].

The development of complication and death following diabetes primarily depend on the glycemic control in addition to other factors. As a result, maintaining blood sugar level within the range of ideal blood sugar target control is the most effective way of preventing diabetes related complications development [6].

The prevalence of uncontrolled diabetes is variable in studies conducted in different developing and developed countries. In the developed countries, a prospective cohort study done in Spain by the ESCARVAL-risk study group in 2018 including 19,140 participants showed a total of 11,003 (57%) patients had uncontrolled diabetes defined as HbA1c ≥ 6.5%, and, among those, 5325 participants had HbA1c ≥ 7.5% [6]. The prevalence of uncontrolled diabetes in other developed countries including united states of America (2019), Saudi-Arabia (2016), and India (2019) was 69%, 74.9% and 62.5% respectively [7-9].

In African countries studies the prevalence of uncontrolled diabetes were 49.8%, 70%, 73.52%, 81.6%, 83.3% in Tanzania (2020), Ghana (2018), Uganda (2017), Kenya (2016), and Nigeria (2019) respectively.

In Ethiopia in a meta-analysis of 16 studies in 2019 showed that only one-third of patients (34.4%) achieved a good glycemic control using fasting blood glucose and similar to studies which used fasting plasma glucose, the rate of good glycemic control was found to be only 33.2% using HbA1C.

Despite the development of many effective anti-diabetic medications most of the patients don't achieve the target glycemic control. The reason for poor glycemic control is multifactorial and sophisticated, as many factors affect blood glucose level. It includes patient sociodemographic, diabetes self-care and disease related factor.

Several factors have been identified as associated with uncontrolled diabetes. For instance, in the International Diabetes Mellitus Practice Study (IDMPS) using 11,799 patients from 17 countries in Eastern Europe, Asia, Latin America and Africa. Self-monitoring of blood glucose was the only predictor for achieving the A1C goal in type 1 diabetes while in type 2 diabetes, short disease duration and treatment with few oral glucose-lowering drugs were predictors. Other region-specific factors identified in this study were lack of microvascular and macrovascular complications, old age, health insurance coverage, lack of obesity, self-adjustment of insulin dosages, training by a diabetes educator, self-monitoring of blood glucose in patients who self-adjusted insulin.

Other factors identified in the literature associated with uncontrolled diabetes includes being male, married, rural residency, low income, farmer, physical inactivity, poor medication and diet adherence, alcohol, smoking, khat chewing and dyslipidemia.

Few studies conducted in Ethiopia had identified marital status, income, occupation, health insurance, smoking, alcohol and khat chewing as determinants of glycemic control. However, most of previously done studies used the average fasting blood sugar level to assess the level of glycemic control. The current study used HbA1c, which is the standared glycemic monitering tool and standard validated questionnaires such as MMMAS-8, IPAQ and QF assessment tools for medication adherence, physical activity and alcohol use respectively. This study aimed to assess the uncontrolled glycemic level and its socio-demographic, diabetes self-care and diabetes related factors among adult diabetic patients.

Methods and Materials

Study area and study period

The study was conducted at Tibebe Ghion specialized hospital in Bahir Dar city, Ethiopia. The hospital is a tertiary-level teaching and referral hospital that serves as the referral center for more than 15 district hospitals in the area, providing to a total catchment of 8 million people. It has more than 600 beds and offers health services to patients with various diseases in the outpatient and inpatient departments.

The diabetic unit under department of internal medicine provides different variety of inpatient and outpatient services. There is once weekly diabetic referral clinic service and it provides basic diagnostic tests and treatments for diabetic patients. Serum biochemicals, such as lipid panel, renal function test, random and fasting blood sugar, NGSP certified and DCCT standardized HbA1c, urine analysis (dipstick, microscope, 24 hrs total urine protein), 10 gm monofilament test and in collaboration with ophthalmology unit it provides ophthalmic screening for those patients who do have indication for screening. The diabetic clinic has five rooms and currently there are seven nurses and 10 physicians including medical residents, internist and one endocrinologist who are working there. The study was conducted among adult diabetic mellitus patients who visited TGSH diabetic referral clinic from November 1st, 2023 to January 31st, 2024.

Study design and participants

Facility based cross sectional study was conducted adult diabetic mellitus patients who visited TGSH diabetic clinic during the study period. Patients with diabetes mellitus whose age were greater than 18 years and those who had documented HbA1c within the last 3 months of enrollment or those who were willing it to be measured if it was not documented were included in the study. Participants who were pregnant, anemic or recent blood transfusion, stage ≥ 3b CKD, mentally unstable, critically ill, who were not able to respond or medical records with incomplete data were exclude from the study.

Sample size and sampling procedure

The sample size was calculated using the single population proportion formula with the following assumptions: A confidence level of 95%, a 5% margin of error, and a prevalence of 55.32% from a previous study. Since the total population size was finite and less than 10,000, a correction was applied. With these assumptions and considering a 10% nonresponse rate, the sample size was calculated to be 229. All eligible patients who visited diabetic referral clinic during the study period were recruited using every 2nd sampling fraction until the required sample size is reached. Lottery method was used to choose the first participant.

Study variables

The dependent variable was uncontrolled glycemic level (inadequate/poor=1, good glycemic control=0). The

independent variables were socio-demographic variables such as age, sex, marital status, residency, educational status, income and occupation, health insurance, diabetes self-care factors including Self-Monitoring Blood Glucose (SMBG), knowledge of target blood sugar, adherence to healthy eating plan, adherence to exercise, adherence to antidiabetic medication, alcohol consumption, khat chewing, cigarette smoking and clinical and disease related factors such as type of diabetes, duration of diabetes, mode of therapy, comorbidities, complication, Body Mass Index (BMI) and poly-pharmacy.

Operational definitions

Diabetes mellitus patient: For the purpose of this study diabetes was defined based on If RBS ≥ 200 mg/dl with diabetic symptom, FBS ≥ 126 mg/dl, 2 hours OGTT ≥ 200 mg/dl, HbA1C ≥ 6.5%, a recorded physician diagnosis or use of glucose lowering oral and or injectable anti-diabetic drugs [2].

Glycemic control level: For the purpose of this study patients were categorized based on the American Diabetic Association (ADA) 2023 guideline recommendation into two groups:

Good glycemic control: HbA1C<7%, for non-pregnant adult without significant hypoglycemia

Inadequate and or poor glycemic control: HbA1c ≥ 7.0 % for non-pregnant adult without significant hypoglycemia

HbA1C level: It was determined using the National Glycohemoglobin Standardization Program (NGSP)-certified assays (ngsp.org) and only results within the last three months of patient enrollment were included.

Knowledge of target HbA1C: It was defined as adequate if the participant knew their target HbA1C level and able to tell the level which is set by the treating physician, otherwise they were labeled as inadequate.

Adherence to medication: Participants were asked using Modified Morisky Medication Adherence Scale 8 (MMMAS-8) which has 8 questions. 1 point was given if the respondent says no to the first four questions, sixth and seventh questions, and yes to the fifth question and, never/rarely to the 8th question. If the total sum of the score <6 defined poor adherences, while the score of 6–7 moderate adherence and score of ≥ 8 high adherences.

Adherence to diet: Participants were labeled as adherent to diet, if they had followed the recommended diet for more than 3 days in the last seven days.

Adherence to exercise: It was assessed using International Physical Activity Questionnaire (IPAQ) which has seven questions and the participant were asked what type of physical activity they are having in the past one week (vigorous, moderate, 10-minute walk, sitting) and the duration of each activity. MET-min (Metabolic Equivalent) score was used in result analysis. While calculating the total MET value of the participant, the minutes of sitting (1.5 MET-min), walking (3.3 MET-min), moderate-intensity physical activity (4 MET-min), and vigorous physical activity (8 MET-min) within one week were used. It was categorized as inactive if the total MET-min/week value is below 600, minimally active if 600-3000 MET-min/week is detected, and active if it is above 3000.

Current smoker: For the purpose of this study participants were labeled as current smoker, if they had consumed any amount of cigarate within the last 12 months of enrollment.

Alcohol consumption: Weekly alcohol consumption was calculated using quantitative frequency tool by multiplying the midpoints of the response categories for the quantity, in terms of drinks per occasion, and frequency, in terms of days per week. Based on this weekly volume the respondent were categorized according to NHMRC as 0 ml/week abstaining, 0.1-175 ml/week low risk drinker, 175.1-350 ml/week as risky drinker and >350 ml/week as high-risk drinker.

Standard alcohol: It was defined according to Australian standard drinks guide in survey as 12 ml of pure alcohol which is equivalent to 300 ml of 4% tella, 245 ml of 4.9% beer, 100 ml of 12% wine, 30 ml shot of 40% distilled spirits (gin, rum, tequila, vodka, whisky).

Khat chewer: For the purpose of this study it was defined if respondent had been chewing khat continuously within the last 12 months of enrollment.

Diabetes comorbidities: It was defined as, are conditions that affect people with diabetes more often than age-matched people without diabetes.

Diabetes complications: It was defined as, harmful effects of diabetes, such as damage to the eyes, kidney, nervous system, heart, blood vessels, teeth and gums, feet or skin.

Poly-pharmacy: It was defined as, if the respondent had been taking ≥ 5 medications daily.

BMI: It was classified using kg/m^2 unit as underweight, normal weight, overweight and obese if they had <18.5 kg/m^2, 18.5–24.9 kg/m^2, 25.0–29.9 kg/m^2 and ≥ 30.0 kg/m^2 respectively.

Data collection procedure

Data were collected through outpatient department nurses and laboratory personnel under close supervision by the principal investigator using pretested questionnaire. Patients were interviewed to obtain socio-demographic data, and the patients' medical records were reviewed to obtain information on relevant medical history and laboratory parameters.

Laboratory investigations were performed for biochemical parameters: The level of Glycated Hemoglobin (HbA1c), Renal Function Test (RFT) and lipid profile if it wasn't determined in the past 3 months of enrollment. A 3 ml of freshly drawn venous blood was collected in an EDTA tube for the determination of HbA1c by a turbidimetric immunoinhibition method using the fully automated Beckman Coulter DxC 700 AU (Beckman Coulter, Inc. USA) clinical chemistry analyzer. This technique is NGSP-certified and DCCT standardized and is not affected by common Hemoglobin Variants (HbC, HbS, HbE, and HbD traits) and elevated Fetal Hemoglobin (HbF), decreasing false results for patients with these blood conditions. 5 ml of venous blood samples was drawn from study participants in Serum Separation

Tubes (SST), in which serum was used to measure the Renal Function Test (RFT) and lipid profiles of patients using the same analyzer.

Body weight was measured on an adult weighing scale to the nearest 0.5 kg, with the patient wearing light clothes and in bare feet or stocking feet. Height was measured using a standard height board; the head piece of the height board was gradually lowered until it reaches the patient's head and it was at a 90 angle with the measuring scale. The measurements were approximate to the nearest centimeter. BMI was calculated as weight in kilograms divided by height in meters squared.

Data processing and analysis

The data were entered into EPI data version 4.6 and then transferred to SPSS 27.0 statistical packages for analysis. Data cleaning was conducted before performing the descriptive analysis. The baseline characteristics are presented as numbers and percentages. The findings were summarized in tables and figures. All statistical tests were performed using two-sided tests at the 0.05 level of significance. Odds ratio with 95% confidence intervals and associated p-values were computed to assess the presence and degree of association between dependent and independent variables. All variables with p values less than 0.25 in the bivariate analysis were exported to multivariate analysis and variables were entered hierarchically to fit the logistic regression model. Consequently, statistically significant associations were determined based on the Adjusted Odds Ratio (AOR) with its 95% CI and the P-value<0.05. Hosner-Lemeshow test was used to assess model fitness and multicollinearity test was conducted to check the absence of correlation between independent variables.

Ethical consideration

This study was conducted according to the Helsinki declaration for medical research involving human subjects. Ethical clearance was obtained from the Research Ethical Review Board of College of Medicine and Health Sciences, Bahir Dar University (protocol number 836/2023). Written informed consent was obtained from participants, and patient data confidentiality was respected at all levels from patient interview, chart retrieving and data analysis which was handled by the investigators. During the data collection process, those patients who were found to have uncontrolled diabetes were linked to the treating physicians for any farther management.

Results

Sociodemographic characteristics of study participants

A total of 229 adult diabetic patients were included in the study with response rate of 100%. The mean age of the participants were 46.9 years (SD ± 15.55 years). Majority of the participants were male 124 (54.1%), married 118 (51.5%), from urban 129 (56.3%), non-insured 116 (50.7%) with 95 (41.5%) participants unemployed (Table 1).

Table 1: Sociodemographic characteristics of study participants in TGSH, Bahir Dar, Ethiopia, 2023.

Variables	Category	Frequency	Percent (%)
Age groups, in years	18-44	103	45%
	45-54	48	21%
	55-64	43	18.80%
	≥ 65	35	15.3
Sex	Male	124	54.10%
	Female	105	45.90%
Marital status	Single	72	31.40%
	Married	118	51.50%
	Divorced	14	6.10%
	Widowed	25	10.90%
Educational level	No formal education	46	20.10%
	Primary education (grade1-8)	47	20.50%

	Secondary education (grade 9-12)	41	17.90%
	Collage and above	95	41.50%
Residency	Urban	129	56.30%
	Rural	100	43.70%
Occupation	Unemployed	95	41.50%
	Merchant	41	17.90%
	Government/private employee	55	24.00%
	Farmer	38	16.60%
Monthlyincome (ETB)	<1500	70	30.60%
	1500-5000	61	26.60%
	>5000	98	42.80%
Health care access	Insured	113	49.30%
	Non-insured	116	50.70%

Diabetic self-care activity

Two hundred fifteen (93.9%) of the participant didn't knew their individualized target HbA1c which has been set by the treating physician and 139 (60.7%) of the participants didn't had access to have SMBG. More than three quarter 181 (79%) didn't follow the recommended dietary management and those who came for follow up >3 time per year account for 188 (82.1%). Most of the participant 100 (43.7%) were physically inactive (<600 total MET-min per week), 46 (20.1%) were mildly active (600-3000 total MET-min per week) and 83 (36.2%) were active (>3000 total MET-min per week). One third of the participant 80 (34.9%) had high medication adherence (MMMAS-8 score of 8), 43 (18.8%) had moderate adherence (MMMAS-8 score of 6-8), and 106 (46.3%) had poor adherence (MMMAS-8 score of <6). Around half of the participant 119 (52.0%) were abstaining from alcohol (QF score 0 ml/week), 52 (22.7%) were low risk drinker (0.1-175 ml/week), 51 (22.3%) were risky drinker (175.1-350 ml/week) and 7 (3.1%) were high risk drinker (>350 ml/week). As small as 9 (3.1%) participants were active smoker and 23 (10%) participants were chewing khat.

Clinical and disease related factors

One hundred forty-six (63.8%) participants had type 2 diabetes and the mean duration of diabetes since diagnosis were 7.9 years (SD ± 6.11 years) the lowest being 1 year while the longest was 26 years. Nearly half of the participants, 113 (49.3) had BMI of ≥ 25.0 kg/m^2. The mode of therapy of most of the participants were insulin alone in 86 (37.6%). Polypharmacy was presented in 122 (53.3%) of the participant. Most of the participants, 139 (60.7%) had diabetes related comorbidity and 93 (40.6%) of the participants had diabetes specific complication. Among those who had comorbidities, more than half of the participants, 73 (52.5%) had ≥ 2 comorbidity. In addition, among those who had diabetes specific complication nearly half of the participants had neuropathy (Table 2).

Table 2: Diabetes self-care, clinical and disease related practices in TGSH, Bahir Dar, Ethiopia 2023.

Variables	Category	Frequency	Percent, %
Knowledge of target HbA1c	Yes	14	6.10%
	No	215	93.90%
Access to SMBG	Yes	90	39.30%
	No	139	60.70%

No of visit	≤ 3 times/year	54	23.60%
	>3 times/year	175	76.40%
Diet adherence	Inadequate (≤ 3 days/week)	181	79.00%
	Adequate (>3 days/week)	48	21.00%
Medication adherence (MMMAS-8)	<6 (Poor)	106	46.30%
	6-7 (Moderate)	43	18.80%
	8 (High)	80	34.90%
Physical activity (IPAQ score, total MET-min/week)	<600 (Inactive)	100	43.70%
	600-3000 (Minimally active)	46	20.10%
Alcohol (QF tool, total alcohol ml/week)	> 3000 (Active)	83	36.20%
	0 ml/week (Abstaining)	119	52.00%
	1-175 ml/week (Low risk drinker)	52	22.70%
	170.1-350 ml/week(Risky drinker)	51	22.30%
Smoking	>350 ml/week (High risk drinker	7	3.10%
	Current smoker	9	3.90%
	Ex-smoker (>1 year)	2	0.90%
Khat chewing	Non-smoker	218	95.20%
	Yes	23	10.00%
Type of diabetes	No	206	90.00%
	Type 1	83	36.50%
Duration of diabetes (years)	Type 2	146	63.80%
	<5	76	33.20%
	5-9	50	21.80%
HbA1c in past 3 months (%)	≥ 10	103	45.00%
	<7.0	71	31.00%
Mode of therapy	≥ 7.0	158	69.00%
	OAD alone	62	27.10%
	Insulin alone	86	37.60%
	OAD+insulin	77	33.60%
Diabetes comorbidity	Diet modification/exercise	4	1.70%

	Yes	139	60.70%
Type of diabetes comorbidity	No	90	39.30%
	Hypertension	31	22.30%
	Dyslipidemia	18	12.90%
	Ischemic heart disease	1	0.70%
	Stroke	1	0.70%
	≥ 2 of the above comorbidities	73	52.50%
Diabetes specific complication	Others*	15	10.80%
	Yes	93	40.60%
Type of complication	No	136	59.40%
	Neuropathy	45	48.30%
	Retinopathy	19	20.40%
	Nephropathy	2	2.10%
	≥ 2 of the above complication	19	20.40%
BMI (kg/m^2)	Others**	8	8.60%
	<18.5	20	8.70%
	18.5-24.9	96	41.90%
Polypharmacy presence	≥ 25.0	113	49.30%
	Yes	122	53.30%
	No	107	46.70%

Note: Others*: Epilepsy, major depressive disorder and HIV infection, Others**: Hypothyroidism and diabetic foot ulcer, BMI: Body Mass Index, SMBG: Self-Monitoring of Blood Glucose; HbA1c: Hemoglobin A1c; IPAQ: International Physical Activity Quantification; QF: Quantity Frequency, MMMAS-8: Modified Morisky Medication Adherence Assessment-8

Prevalence of uncontrolled glycemic level

The mean HbA1c of the participant in the past 3 months were 8.0% (SD ± 1.8547%). Nearly half of the participants, 113 (49.0%) had poor glycemic control (HbA1c>8.0%), 45 (19.7%) participants had inadequate control (HbA1c 7.0-8.0%), 71 (31.0%) participants had good glycemic control (HbA1c<7.0%) and 158 (69.0%) participants were having poor and or inadequate HbA1c control (HbA1c ≥ 7.0%).

Factors associate with poor and or inadequate glycemic control

The association between independent and dependent variable, glycemic control level was assessed using both univariable and multivariable logistic regression. On univariable logistic regression having access to SMBG, physical activity, free health care access, diabetes specific complication, diabetic comorbidity, polypharmacy, BMI, duration of therapy, knowledge of target HbA1c and medication adherence were found to be associated with poor and or inadequate glycemic control.

All the factors associate with p value of <0.25 were included in the multivariable logistic regression analysis and resulted medication adherence (p=0.002), physical activity (p=0.002), access to SMBG (p<0.001), polypharmacy (p=0.025) and level of BMI (p=0.029) were found to be statically significant independent factors of poor and or inadequate glycemic control with p value of <0.05.

Those who didn't have access to SMBG were 5.4 times more likely to have poor and or inadequate glycemic control (AOR=5.48, 95% CI 2.21-13.57, p=<0.001). In addition, participants with polypharmacy were 3.6 times more likely to have poor and or inadequate glycemic control (AOR=3.68, 95%CI 1.17-11.59, p=0.025). Respondents who was physically minimally active were 3.5 times more likely to have poor and or inadequate glycemic control compared to their active participants (AOR= 3.52, 95% CI 1.17-10.53, p=0.024), similarly those who were inactive physically were 6.5 times more likely to have poor and or inadequate glycemic control compare to their active participants (AOR=6.55, 95% CI 2.20-19.42, p=<0.001). Participants with poor medication adherence were 8.0 times more likely to have poor and or inadequate glycemic control compared to highly adherent participant (AOR=8.05, 95% CI 2.53-25.56, p=<0.001). Finally, those who had BMI of ≥ 25.0 kg/m^2 were 4.3 times more likely to have poor and or inadequate glycemic control compare to normal BMI participants (AOR=4.37, 95% CI 1.39-13.73, p=0.012) (Table 3).

Table 3: Bivariate and multivariate logistic regression analyses of factors associated with glycemic control among diabetes patients in TGSH, Bahir Dar, Ethiopia, 2023.

Variable	Category	Glycemic control (HbA1c)		Bivariate analysis	Multivariate analysis	
		Good n=71	Inadequate n=158	COR (95% CI)	AOR (95% CI)	P-value
SMBG access	Yes	55	35	1	1	-
	No	16	123	12.08 (6.17-23.64)	5.48 (2.21-13.57)	<0.001*
Polypharmacy	Yes	16	106	7.00 (3.66-13.39)	3.68 (1.17-11.59)	0.025*
	No	55	52	1	1	-
Physical activity	Active	49	34	1	1	-
	Minimally active	14	32	3.29 (1.53-7.09)	3.52 (1.17-10.53)	0.024*
	Inactive	8	92	16.57 (7.12-38.56)	6.55 (2.20-19.42)	<0.001*
Medication adherence	Poor	17	89	5.50 (2.79-10.85)	8.05 (2.53-25.56)	<0.001*
	Moderate	13	30	2.42 (1.10-5.31)	2.94 (0.87-9.95)	0.082
	High	41	39	1	1	-
BMI (Kg/m^2)	<18.5	5	15	1.96 (0.66-5.85)	3.96 (0.80-19.59)	0.091
	18.5-24.9	28	85	1	1	-
	≥ 25.0	38	58	1.98 (1.10-3.59)	4.37 (1.39-13.73)	0.012*
Target HbA1c knowledge	Yes	10	4	1	1	-
	No	61	154	6.31 (1.90-20.88)	4.07 (0.54-30.35)	0.17

DM duration (yrs)	<5	31	45	1	1	-
	5-9	15	35	1.60 (0.75-3.43)	1.09 (0.35-3.60)	0.882
	≥ 10	25	78	2.14 (1.13-4.08)	2.31 (0.83-6.39)	0.106
Comorbidity	Yes	34	105	2.15 (1.21-3.81)	1.04 (0.37-2.92)	0.937
	No	37	53	1	1	-
Complication	Yes	15	78	3.64 (1.90-6.97)	2.35 (0.78-7.00)	0.125
	No	56	80	1	1	-
Health care access	Insured	41	72	1	1	-
	Non-insured	30	86	1.63 (0.92-2.87)	2.13 (0.83-5.45)	0.111

Note: *Statistically significant, COR: Crude Odds Ratio; AOR: Adjusted Odds Ratio; CI: Confidence Interval

Discussion

Measurement of HbA1c is a fundamental diagnostic and treatment response monitoring tool in the management of pharmacologic and non-pharmacologic treatment of diabetes. This study finding showed that 69.0% of the study participants had poor and or inadequate glycemic control (HbA1c ≥ 7.0). This result is comparable with previous studies reported in USA (69%), Ghana (70%), Addis Ababa (68.3%) and Northeast Ethiopia (70.8%). However, the prevalence of poor and inadequate glycemic control was higher than the previous studies conducted in India (37.5%), Tanzania (49.8%), East Ethiopia (45.2%), Amhara region Ethiopia (55.3%) and Northwest Ethiopia (60.5%). The higher proportion of poor and or inadequate glycemic control in this study compared to previous studies partly may be due to most of the patients who referred to this hospital are those who needs advanced care and patients with poor glycemic control.

However, the finding present in this study is also lower than the previous studies conducted in Saudi Arabia (74.9%), Nigeria (83.3%), Kenya (81.6%), Uganda (73.52%), Addis Ababa (80%) and TASH Ethiopia (73.8%). Despite the above-mentioned studies had the same study design, there were variation in the prevalence of inadequate and or poor glycemic control and factors which affects it. The difference in the present and previous studies conducted in Ethiopia may have arisen mainly from variation in the type and methods of glucose measurement tools used. Some researchers used FBG measurement to assess glycemic control while others used HbA1c. In addition, the difference in the assay methods used in HbA1c determination profoundly affect the result by giving falsely high or falsely low reading if they used outside of the NGSP certified and DCCT standardized tool. In addition, clinical and sociodemographic related characteristics of the study participants may also have contributed to the observed high prevalence of poor and or uncontrolled diabetes in this study.

Those who didn't have access to SMBG tend to have poor and or inadequate glycemic control compared to those who had access to SMBG. This finding is consistent with previously reported studies form North California, Cameroon, and two meta-analyses from Ethiopia. This may be due to those who didn't have access to SMBG are less likely to monitor their glycemic level, to adhere standard diabetic care and to consult their physician. In addition, patients who didn't have access to SMBG were less likely to adjust their drug and lifestyle. However, the study conducted in western Kenya showed that there was no association between adherence to SMBG and glycemic control. This difference may be due to the small sample size (116 participants) and most of the participants had poorly controlled HbA1c. Effective strategies and plans has to be implemented in providing affordable SMBG tools to those who are in need, especially *via* diabetic associations.

Those who are physically inactive were more likely to have poor and or inadequate glycemic control compared to their active participants. This result is consistent with previously reported results in Thailand, Saudi-Arabia, Libya and two meta-analyses from Ethiopia. This might be due to physical activity increase insulin receptor number and its sensitivity on muscle cells, since the working muscles have increase glucose uptake than muscles at rest, because of the increased blood flow to the working muscle. Another possible explanation is physical activity

decrease obesity, dyslipidemia, and norepinephrine which leads to low plasma glucose level. Effective education on importance and adherence of exercise programs should be done during their visit. However, this finding is different from the study conducted in Ethiopia. The difference could be due to a variation in exercise assessment tool and sample size.

Respondents who were poorly adherent to their antidiabetic medication were more likely to have poor and or inadequate glycemic control compared to their highly adherent correspondent. This result is in line with studies reported in Libya, Tanzania, and Ethiopia. The possible explanation could be medication non-adherence increase exposure to high serum glucose level due to due to increasing glucose production from the liver, decreasing insulin secretion from the beta-cells, or decreasing glucose uptake by skeletal muscles. To achieve acceptable target glycemic level, obstacles to medication adherence should be addressed, and efficient educational and behavioral intervention programs on adherence to medications need to be conducted. However, in a study conducted at Tikur-Anbessa Specialized Hospital (TASH) medication adherence was not associated with glycemic control. The possible explanation may be due to the different adherence assessment tools, sample size and they used FBS to assess glycemic control, while HbA1c was used in this study.

In this study, overweight and or obese individual are more likely to have poor and or inadequate glycemic control. This study is in line with previous studies conducted from USA, Saudi Arabia, India and a meta-analysis from Ethiopian. One possible explanation may be individuals who are overweight and or obese have high adipose tissue, which alters beta cell function, adipose tissue biology and resulting in multi-organ insulin resistance making it more difficult for person with diabetes to control their serum sugar level. Effective and focused education on the importance of weight reduction should be done during their follow up. Though, a result form TASH showed there was no association between BMI and glycemic control. The possible explanation may be the difference in sample size.

Participants with Poly pharmacy are more likely to have poor and or inadequate glycemic control compared to those participants with no poly pharmacy. This result is in line with studies from Ghana, South Ethiopia. A possible explanation may be poly-pharmacy increases the probability of adverse drug events, including drug-drug and food-drug interactions resulting in decreased compliance to anti-diabetic medications and suboptimal glycemic control. Effective and focused assessment of drug-drug interaction assessment and avoidance of unnecessary medication prescriptions has to be implemented during their follow up.

Strength and limitations of this study

This study is the first to use the NGSP-certified/DCCT standardized HbA1c method to assess the level of glycemic control and the factors associated with it among diabetic patients at TGSH. This study also uses validated and standard tools to assess medication adherence, physical activity and alcohol use. However, the study adopted a cross-sectional study design and comprised a relatively smaller number of participants. Another limitation of this study was that data on some variables like medication adherence, physical exercise and diet adherence were obtained by self-report and may be limited by recall bias.

Conclusions

This study revealed that nearly three-quarters of the study participants had inadequate and or poor glycemic control, which is far below the recommended standards. Inaccessibility of SMBG tools, taking poly-pharmacy, physical inactivity, medication poor adherence and high BMI were significant factors of poor and or inadequate glycemic control. This calls for a focus on the associated factors identified and adjusting management strategies to maintain good glycemic control. Special efforts should be made avail SMBG tools, educate patients about medication adherence, and to promote physical activity.

Consent for Publication

Not applicable.

Availability of Data and Material

The datasets used and/or analyzed during the current study are not publicly available due to confidentiality issues but are available from the corresponding author upon reasonable request.

Competing Interests

The authors declare that they have no competing interests.

Funding

This work was funded by Bahir Dar University. The funder has no role in research design, data collection, result writing and manuscript preparation.

Authors' Contributions

YY conceived and designed the research protocol. AG and GTW approved the proposal with extensive revisions, participated in the data analysis, and wrote the manuscript. All the authors have read and approved the final manuscript.

Acknowledgments

We would like to thank study participants. In addition, we would thank Bahir Dar University and data collectors, particularly Dr. Agerye Kassa.

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