Time to first optimal glycemic control and its predictors among adult type 2 diabetes patients in Amhara Regional State comprehensive specialized hospitals, Northwest Ethiopia

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Abstract

Background Inadequate glycemic management in type 2 diabetes Mellitus patients is a serious public health issue and a key risk factor for progression as well as diabetes-related complications. The main therapeutic goal of preventing organ damage and other problems caused by diabetes is glycemic control. Knowing when to modify glycemic control in type 2 diabetes Mellitus is crucial for avoiding complications and early drug intensifications.

Methods An institutional based retrospective follow-up study was undertaken among 514 eligible adult diabetes patients in Amhara region Comprehensive Specialized Hospitals, Northwest Ethiopia, from January 2017 to January 2022. Simple random sampling technique was used to select study participants. The Kaplan Meier curve was used to assess the survival status of categorical variables, and the log-rank test was used to compare them. The cox proportional hazard model was fitted to identify the predictors of time to first optimal glycemic control. Variables with a p-value < 0.05 were considered to be statistically significance at 95% confidence interval.

Results A total of 514 patient records (227 males and 287 females) were reviewed in this study. The median time to first optimal glycemic control among the study population was 8.4 months IQR (7.6–9.7). The predictors that affect the time to first optimal glycemic control were age group ((AHR = 0.63, 95% CI = 0.463, 0.859 for 50–59 years), (AHR = 0.638, 95% CI = 0.471, 0.865 for 60–69 years), and (AHR = 0.480, 95% CI = 0.298, 0.774 for > = 70 years)), diabetes neuropathy (AHR = 0.629, 95% CI = 0.441,0.900), hypertension (AHR = 0.667, 95% CI = 0.524, 0.848), dyslipidemia (AHR = 0.561, 95% CI = 0.410, 0.768), and cardiovascular disease (AHR = 0.681, 95% CI = 0.494, 0.938).

Conclusion The median time to initial optimal glycemic control in type 2 diabetes Mellitus patients in this study was short. Age between 50 and 59 years and 60–69, diabetes neuropathy, hypertension, dyslipidemia, and cardiovascular

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disease were predictor's of time to first glycemic control. Therefore, health care providers should pay extra attention for patients who are aged and who have complications or co-morbidities.

Keywords Adults, First optimal glycemic control, Type 2 diabetes mellitus, Ethiopia

Background

Diabetes mellitus refers to a group of metabolic disorders characterized by hyperglycemia happens when the body produces insulin that is either resistant or insufficient with the symptoms include thirst, polyuria, polyphagia, blurred vision, and weight loss [1, 2]. Glycemic control is the main goal of treating diabetes. The burden of diabetic consequences is lessened or delayed when blood sugar levels are adequately controlled [3]. Glycated hemoglobin (HgA1c) value is the most advised monitoring measure for an optimal level of glycemic management, according to guidelines from the international diabetes association (IDF) and American diabetes association (ADA), Indicators of patients' glycemic management also include the value of HgA1c within the past three months [4, 5].

Diabetes is a serious public health problem that has epidemic proportions with more than 500 million people worldwide suffer with diabetes today [6]. The complications of diabetes are divided into those that are primarily micro vascular (retinopathy, nephropathy, and neuropathy) or macro vascular (heart attacks, strokes, and peripheral vascular disease) [7]. The proportion of deaths due to high blood sugar or diabetes that happens before age 70 is higher in low- and middle-income countries than in high-income countries [8].

Type 2 diabetes Mellitus affected approximately 462 million people, or 6.28% of the world's population (4.4% of those aged 15–49, 15% of those aged 50–69, and 22% of those aged 70+), for a prevalence rate of 6059 cases per 100,000 [9]. Changes in diet (more energy-dense foods), an increasingly sedentary lifestyle, weight gain, and social issues such as depression, job satisfaction, and poverty are all linked to environmental risk factors in type 2 diabetes Mellitus [10]. Patients in the high mortality group were more likely to be elderly and have diabetes or high blood pressure for a long time [11]. Diabetes patients had a higher all-cause and Cardio vascular diseases (CVD) mortality rate of 7.0 and 3.5 deaths per 1000 person-years, respectively [12].

In Sub-Saharan African countries, metabolic syndrome affects 59.6% of the population, with Ethiopia having the highest prevalence of metabolic syndrome at 61.14%. Metabolic syndrome affects about two out of every three type 2 diabetic patients in Sub-Saharan African countries, indicating that it is common among people with type 2 diabetes Mellitus and raises the risk of heart disease and stroke [13].In Ethiopia, diabetes mellitus affected 6.5% of the population, with the highest prevalence (14%) found

in the Dire Dawa city administration and the lowest prevalence found in the Tigray area (2%) [14].

The level of poor glycemic control is 63.8% found in the west Shewa zone, Ethiopia [15]. In Ethiopia, only 34.4% of individuals with adequate glycemic control supported fasting plasma glucose levels. The percentage of good glycemic control was found to be 33.2% supported by glycosylated hemoglobin readings, almost identical to the studies that employed fasting plasma glucose [16].Age, higher BMI, poor medication adherence, educational status, smoking, insufficient physical exertion, residence, food consumption, raised total cholesterol, chat chewing, monthly income, overweight, and obesity all contributing factors to poor glycemic control [17–20].

Inadequate glycemic control in people with type 2 diabetes Mellitus has become a serious public health problem as well as a major biomarker for further complications. As a result of the unknown time it takes to attain adequate glycemic control, patients develop complications. It is not previously being investigated using hemoglobin AIC measurements, and has not been well researched according to a nationwide scale. In many studies various factors are reported that affect the hemoglobin A1C by raising or reducing the value, but they are not specified by what proportion they affect the hemoglobin A1C value. Determining the period to achieve first glycemic control is critical to monitor diabetes patients' care over time and make necessary treatment adjustments, as well as take prompt action to prevent complications from recurring. Therefore, this study aimed to determine the time to first optimal glycemic control and its predictors among adult type 2 diabetic patients in Amhara Region comprehensive specialized hospitals, Northwest Ethiopia in 2022.

Methods

Study design and setting

A retrospective follow-up study using the prior patients' records was conducted at Felege Hiwot Comprehensive Specialized Hospital, Tibebe Gion Specialized Hospital, and Debre Markos Comprehensive Specialized Hospital in the Amhara Regional State from January 1st, 2017, to January 31st, 2022. The study's participants (227 males and 287 females) were enrolled between 1 January 2017 and 31 January 2022, and the observation period covered the period from their enrollment until the occurrence of the incident. Participants in the study who were unable to be reached for follow-up, passed away, moved before experiencing the event, or were still free of the event at

its conclusion were censored. The baseline data measurement was started at the time of the type 2 diabetes mellitus diagnosis. Patients' medical records at the study hospitals were searched for the research's data between March 2 and May 10, 2022. This study included all adults with type 2 diabetes Mellitus who had followed up at diabetic clinics and patients who had at least two Hgb A1C measurements with a clear date of diagnosis "between" January 1, 2017 and January 31, 2022; it excluded all adult type 2 diabetes Mellitus patients' medical records/charts with incomplete information on HgA1c value; those with less than three months' follow-up throughout the study period; and cases transferred in with an amniotic fluid level.

Sample size and sampling procedures

The required sample size was computed using the freedman method of proportional event allocation, as follow.

Sample size $=\frac{number\ of\ event}{probabillity\ of\ event}$ [21], Number events $=\frac{(Z\frac{\alpha}{2}+Z\beta)2}{pq(logHR)2}$, Probability of an event $=1$-(ps1 (t) +qs2 (t)); Where; n is the sample size; Z $\frac{\alpha}{2}$ a significant level of a of 5%, which is 1.96; the power of (80%), p is the proportion of population allocation for the primary group, q is the proportion of the population allocation for the second group, s1 ($\sqcup$) the survival function at time T1, s2 ($\sqcup$) the survival function at time T2 and HR is that the hazard ratio. A simple random sampling method was used to select study participants. Initially, three specialized hospitals (30% of specialized hospitals found in the Amhara region) were selected using lottery method. Then, proportional allocation of sample was done among selected hospitals based their patient flow by under taking preliminary data ((200 (NTGCSH), 603 (NFHCSH), and 383 (NDMCSH)). Finally, study participants (nTGCSH=87, nFHCSH=261 and nDMCSH=166) were selected by computer generated random sampling technique using their medical registration number as a sampling frame.

Variables

Time to first optimal glycemic control was outcome variable of this study. Socio-demographic variable (age at diagnosis, sex, residence); Diabetes-related variables(history of diabetes-related complications, acute complications, diabetic nephropathy, diabetes neuropathy, diabetes retinopathy, diabetes foot ulcer, more than one complication, and treatment regimen) and Co-morbidity illness variables (History of co-morbid illness, hypertension, dyslipidemia, cardiovascular disease, renal disease, neurologic disease, chronic respiratory disease, and more than one comorbid illness) were the study's predictor variables.

Operational definition

Optimal glycemic control is defined as the three consecutive months of HbA1c<7.5% with more or less stringent glycemic goals for individual clients based on age/life expectancy, comorbid condition, advanced complication, hypoglycemia unawareness, and individual patients consideration [22–24].

Less stringent A1C goals such as <8% [64 mmol/mol] may be appropriate for patients with limited life expectancy or when the harms of treatment are greater than the benefits.

Event Achieving first optimal glycemic control.

Censoring Patients died, lost to follow-up, transferred out, and completed the follow-up period without achieving optimal glycemic control.

Time to the event The time between diagnosis up to achieving first optimal glycemic control or censoring (in months).

Diabetic neuropathy After ruling out other potential explanations, the hospital doctors considered the existence of symptoms and/or indications of peripheral nerve damage among diabetic patients using EMG (Electromyography), nerve conduction velocity (NCV) tests to confirmed diabetic neuropathy [25].

Diabetic retinopathy defined as a microvascular complication of diabetes that was evaluated by clinical examination or indirect ophthalmoscopy by ophthalmologists and classified as present (yes) or absent (no) from the charts based on ophthalmologists decision [26].

Diabetic Nephropathy Defined as an estimated Glomerular Filtration Rate (eGFR)<60 mL/min/1.73 m2 estimated by the Cockcroft-Gault equation [27].

Acute complications Diabetic ketoacidosis (DKA), hyperglycemic hyperosmolar state (HHS), lactic acidosis (LA), and hypoglycemia are all explanations for acute complications [28, 29].

Co-morbidity illness Comorbidity was defined as the presence of at least one other chronic condition other than diabetes mellitus, such as a physical non-communicable disease, a mental health condition, or an infectious disease [28, 30].

Data collection tools and procedure

Secondary data were collected using an adapted structured English version data extraction checklist. The data

was extracted by six nurses who work in the diabetic clinics and they were supervised by three trained public health specialists. Records of all adult type 2 diabetes Mellitus patients who were enrolled between January, 2017 and January, 2022 and who fulfilled the inclusion criteria was used for data collection.

Data quality assurance

Data quality was kept ensured during tool development, data extraction, entry, cleaning and analysis. Prior to data collection, one-day training was given to supervisors and data collectors on objective, data collection procedure, and data collection process and extraction checklist of the study. During data collection, daily monitoring was carried out by supervisors and principal investigator. The consistency and completeness of data were checked by the principal investigator and supervisors on daily basis.

Data processing and analysis

Data were entered using EPI-data 3.1, exported to STATA 14.2, where they were coded, adjusted, and cleaned before being analyzed. Frequencies, proportions, and descriptive statistics that can be displayed in tables and graphs were used to describe the study population. The overall survival rates were commonly described by Kaplan Meier. The log-rank test was employed to compare survival status between categories. The Schoenfeld's residual test was used to determine whether the proportional hazard assumption was met by the variables, and the Cox-Snell residual was used to determine the model's fitness. A multivariable Cox regression model analysis used variables from the bi-variable Cox regression model with a significance level less than 0.20. With a 95% confidence interval, variables in the multivariable Cox model were determined to have actually interfered with the patients' survival.

Results

Socio-demographic characteristics of study participants

We analyzed and included in the final analysis a total of 514 adult type 2 diabetes mellitus patient records from

hospitals in the research area that were enrolled between January 1, 2017, and January 31, 2022. About two hundred eighty-seven (55.84%) of the study participants were females. More than half 326 (63.42%) participants were urban. The mean age of study participants at the time of diagnosis of type 2 diabetes mellitus was 53($\pm$13) years and (24.51%) of patients were in the 30−39 age group (Table 1).

Diabetes-related characteristics of the study participants

More than half (66.15%) of study participants were taking an oral medication and more than one third (35.80%) of the study participants had a history of diabetes-related complications. Eighty-nine (17.32%) of the study participants had diabetic neuropathy followed by acute complications (15.76%). Twenty-eight (5.45%) of the study participants had diabetic nephropathy, and twenty-one (4.09%) of the study participants had diabetic retinopathy (Table 2).

Comorbidity illness variables

More than half of the patients (54.86%) had a history of comorbidities. Among those, the majority of patients had hypertension (40.27%), lipid disorders (dyslipidemia) (19.84%), and cardiovascular disease (17.32%), and the remaining 6.97% were other comorbidity illness. Followed more than a quarter (29.38%) of patients had more than one comorbidity (Table 3).

The glycemic control of adult type 2 diabetes mellitus patients

From the total study participants of type 2 diabetes Mellitus patients 376 (73.15%) were with optimal glycemic control and one hundred thirty-nine (26.85%) were censored (Fig. 1).

Time to optimal glycemic control of type 2 diabetes mellitus patients

In this study 514 type 2 diabetes Mellitus patients were followed for a maximum of 57 months. The mean and median survival time of this study were 7.1, IQR: (4.3,

Table 1 Socio-demographic characteristics of type 2 DM patients at Amhara region Comprehensive Specialized Hospital, Northwest Ethiopia, 2017–2022 ($n = 514$)

Variable	Categories	Optimal glycemic control (%) ($n = 376$)	Censored (%) ($n = 138$)	Total (%)($n = 514$)
Age	30–39	106 (84.13)	20 (15.87)	126 (24.51)
	40–49	89 (79.46)	23 (20.54)	112 (21.78)
	50–59	77 (65.25)	41 (34.75)	118 (22.96)
	60–69	81 (67.50)	39 (32.50)	120 (23.35)
	70 or more	23 (60.53)	15 (39.47)	38 (7.4)
Gender	Male	152 (66.96)	75 (33.04)	227 (44.16)
	Female	224 (78.05)	63 (21.95)	287 (55.84)
Residence	Urban	233 (71.47)	93 (28.53)	326 (63.42)
	Rural	143 (76.06)	45 (23.94)	188 (36.58)

Table 2 Diabetes-related characteristics of type 2DM patients at Amhara region Comprehensive Specialized hospital, Northwest Ethiopia, 2017–2022 (*n* = 514)

Variables	Categories	Optimal glycemic control (%) (*n* = 376)	Censored (%) (*n* = 138)	Total (%) (*n* = 514)
History of Diabetes related complications	Yes	124 (67.39)	60 (32.61)	184 (35.8)
	No	252 (76.36)	78 (23.64)	330 (64.2)
Acute complications	Yes	57 (70.37)	24 (29.63)	81(15.75)
	No	319 (73.67)	114 (26.33)	433 (84.25)
Diabetes nephropathy	Yes	14 (50.00)	14 (50.00)	28 (5.45)
	No	362 (74.49)	124 (25.51)	486 (94.55)
Diabetes neuropathy	Yes	52 (58.43)	37(41.57)	89 (17.31)
	No	324 (76.24)	101 (23.76)	425 (82.69)
Diabetes retinopathy	Yes	13 (61.90)	8 (38.10)	21 (4.08)
	No	363 (73.63)	130 130 (26.37)	493 (95.92)
Diabetic foot ulcer	Yes	12 (66.67)	6 (33.33)	18 (3.5)
	No	364 (73.39)	132 (26.61)	496 (96.5)
More than one Complication	Yes	6 (22.22)	21 (77.78)	27 (5.25)
	No	370 (75.98)	117 (24.02)	487(94.75)
Treatment regimen	Oral (Gliben clamide)	251 (73.82)	89 (26.18)	340 (66.15)
	Insulin	74 (73.27)	27 (26.73)	101(19.65)
	Both	51 (69.86)	22 (30.14)	73 (14.2)

Table 3 Comorbidity illness variables and censoring status at public comprehensive specialized hospitals in Amhara region, Northwest Ethiopia, 2017–2022 (*n* = 514)

Variables	Categories	Optimal glycemic control (%) (*n* = 376)	Censored (%) (*n* = 138)	Total (%)(*n* = 514)
History of Comorbidity illness	Yes	179 (63.48)	103 (36.52)	282 (54.86)
	No	197 (84.91)	35 (15.09)	232 (45.14)
Hypertension	Yes	123 (59.42)	84 (40.58)	207 (40.27)
	No	253 (82.41)	54 (17.59)	307 (59.73)
Dyslipidemia	Yes	53 (51.96)	49 (48.04)	102 (19.84)
	No	323 (78.40)	89 (21.60)	412 (80.16)
Cardio vascular disease	Yes	48 (53.93)	41 (46.07)	89 (17.31)
	No	328 (77.18)	97 (22.82)	425 (82.69)
Renal disease	Yes	8(53.30)	7 (45.70)	15 (2.91)
	No	368 (73.74)	131 (26.26)	499 (97.09)
Neurologic disease	Yes	8 (53.30)	7 (46.70)	15 (2.91)
	No	368 (73.74)	131 (26.26)	499 (97.09)
Chronic respiratory disease	Yes	3 (60.00)	2 (40.00)	5 (0.97)
	No	373 (73.28)	136 (26.72)	509 (99.03)
More than one comorbidity illness	Yes	84 (55.63)	67 (44.37)	151 (29.37)
	No	95 (80.44)	36 (19.56)	131 (25.48)

13.4) and 8.4, IQR: (7.6, 9.7) months, respectively. The overall estimated survival rate of type 2 diabetes Mellitus patients with optimal glycemic control was 73.15%. The optimal glycemic control was observed in type 2 diabetes Mellitus patients at incidence rate of 0.071, or 7.1 per 100 person observed during the observational months (Fig. 2).

Survival experience of Type2 diabetes mellitus patients

Statistical difference in survival time between different categorical variables was tested using the Log-rank test. There was a substantial difference in survival experience among age groups, diabetes neuropathy, hypertension, dyslipidemia, and cardiovascular disease. Regarding age, patients in the age group of 30–39 years showed a shorter median time to achieve the optimal glycemic control (6.3 months) followed by patients in the age group of 40–49 years (7.4 months). Older patients needed much longer time to achieve the first optimal glycemic control, 9.4 months for 50–59 years, 11 months for 60–69 years, and 14.9 months for >=70 years of age. The survival time was significantly different among the five age groups (X^2 (4)=42.61, p-value<0.01. The median survival time to achieve optimal glycemic control among patients with diabetes neuropathy (18.2 months) was longer than the patients with no diabetes neuropathy (7.4 months). The
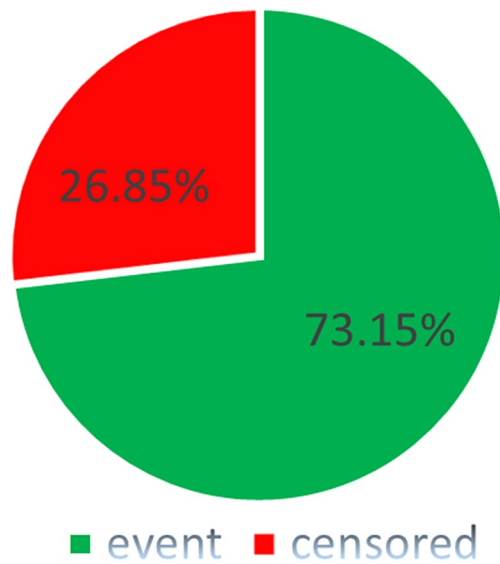
Fig. 1 Outcome of Adult type 2 diabetes Mellitus Patients Amhara region Comprehensive Specialized Hospital, Northwest Ethiopia, 2017–2022 ($n=514$)

survival time was significantly different among the type 2 diabetes mellitus with neuropathy and their counter parts (X^2 (1)=34.71, p-value<0.01) (Fig. 3). The median time to achieve optimal glycemic control was longer among patients with hypertension (14.3 months) when compared to the patients no hypertension (X^2 (1)=57.61, p-value<0.01 (Fig. 4). The median time to achieve optimal

glycemic control was longer among patients with dyslipidemia (17 months) when compared to the patients no dyslipidemia (X^2 (1)=39.09, p-value<0.01 (Fig. 5). The median time to achieve optimal glycemic control was longer among patients with cardiovascular diseases (16 months) when compared to the patients with no cardiovascular disease (X^2 (1)=23.99, p- value<0.01(Fig. 6).

Predictors of time to first glycemic control among type 2 diabetic patients

After fitting the multivariable cox proportional hazard model, adequacy of a fitted model was assessed by using cox Snell residuals. Finally, the graph of Nelson-Aalen cumulative hazard function and the cox Snell residuals variables were compared to the hazard function to the diagonal line. The hazard function follows the 45-degree line, which approximately, indicates that the model fitted the data well (Fig. 7).

Variables like age, sex of the patients, residential area, history of diabetes-related complications, diabetes nephropathy, diabetes neuropathy, diabetes retinopathy, diabetes foot ulcer, more than one complication, history of comorbidity illness, hypertension, dyslipidemia, cardiovascular disease, renal disease, neurologic disease, chronic respiratory disease, and more than one comorbidity illness were having a *p*-value<0.20 in the bi-variable analysis and candidate for multivariable Cox regression analysis. After running the cox regression model, the assumption of proportional hazard was
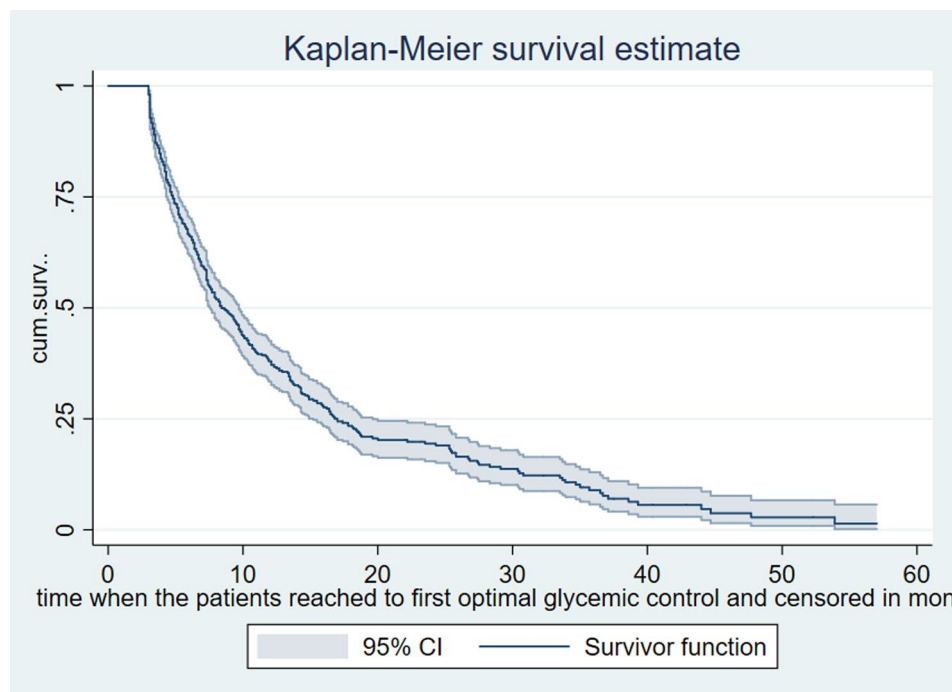

Fig. 2 The overall Kaplan Meier survival curves among type 2 diabetes Mellitus patients in Amhara region public comprehensive specialized hospitals, Northwest Ethiopia, 2017–2022
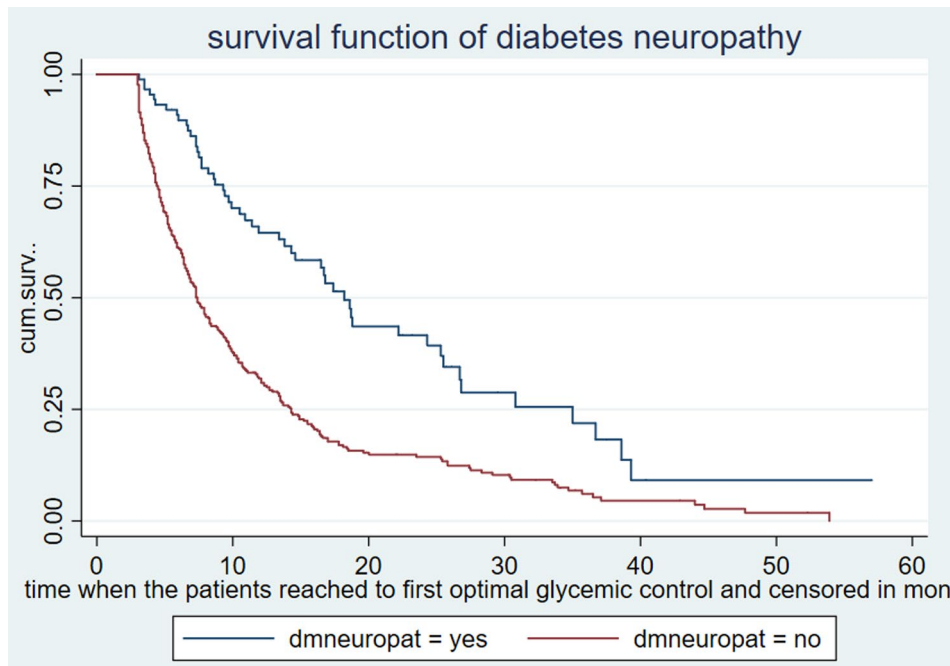
Fig. 3 The survival function of diabetic neuropathy groups among type 2 diabetes Mellitus patients at public comprehensive specialized hospitals in Amhara region, Northwest Ethiopia,2017–2022
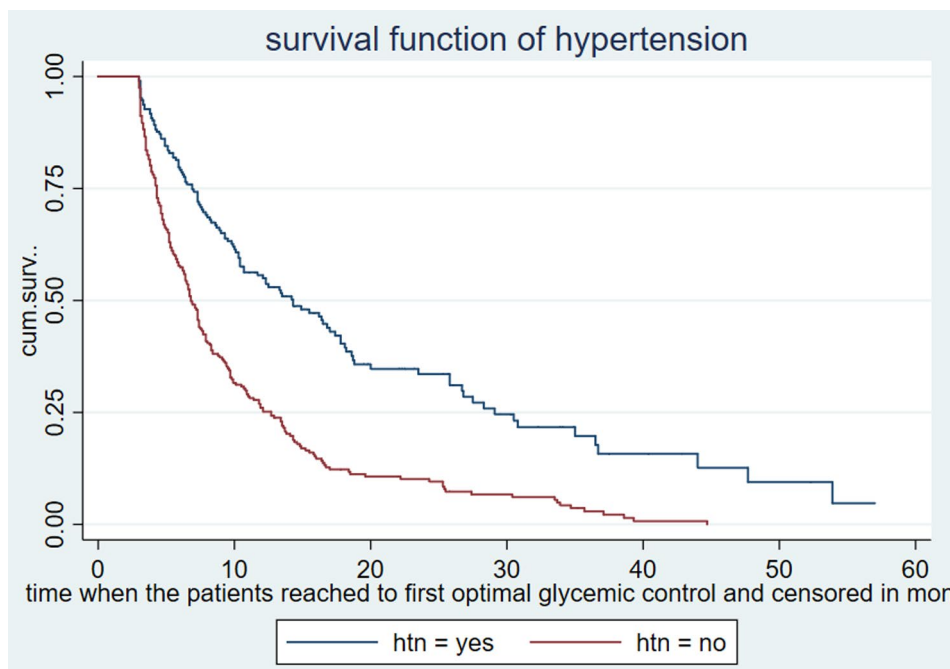

Fig. 4 The survival function of hypertensive group among type 2 diabetes Mellitus patients at public comprehensive specialized hospitals in Amhara region, northwest, Ethiopia, 2017–2022

checked using Schoenfield's residual test (global test was found 0.32), the graphical method, and the variables having p-value>0.05 were considered as full filling the assumption.

Finally, only age group, diabetes neuropathy, hypertension, dyslipidemia, and cardiovascular disease were significantly associated with the time to first optimal glycemic control in the multivariable cox proportional hazard model at 5% level of significance.

As a result, after controlling for other factors, the rates of achieving optimal glycemic control among those in the age groups of 50–59, 60–69, and >=70 years were lower
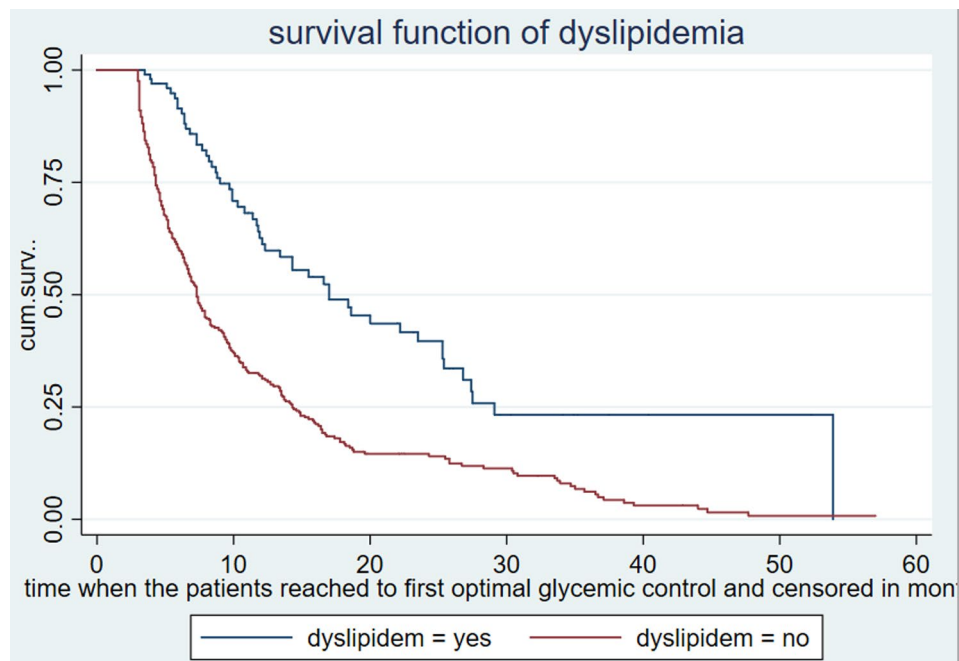
Fig. 5 The survival function of dyslipidemia group among adult type 2 diabetes Mellitus patients at public comprehensive specialized hospitals in Amhara region, Northwest Ethiopia, 2017–2022

Fig. 6 The survival function of cardiovascular disease group among adult type 2 diabetes Mellitus patients at public comprehensive specialized hospitals in Amhara region, Northwest Ethiopia, 2017–2022
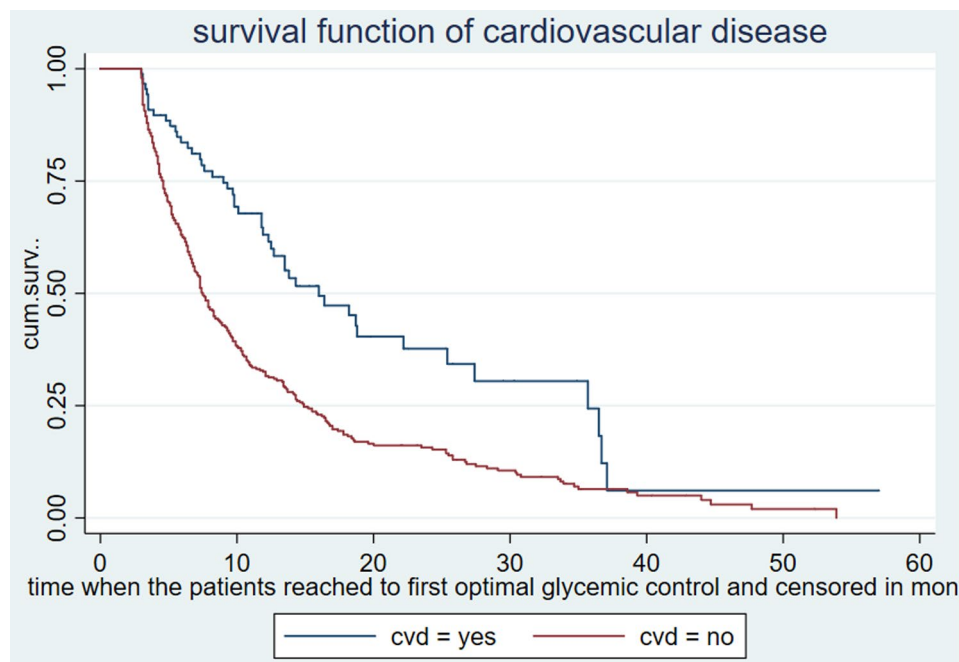
by 37%, 36.2%, and 52, respectively, than those in the age group of 30–39 years.

The rate of achieving optimal glycemic control among patients with diabetes neuropathy was lower by 37.1% compared to patients with no diabetes neuropathy (HR=0.629, 95% CI=0.441, 0.900, p-value=0.011). This means that the time need to reach the optimal glycemic control among patients with no diabetes neuropathy was significantly shorter compared with patients with diabetes neuropathy.

Regarding the presence of comorbidity illness, after adjusting for other covariates, the rate of achieving
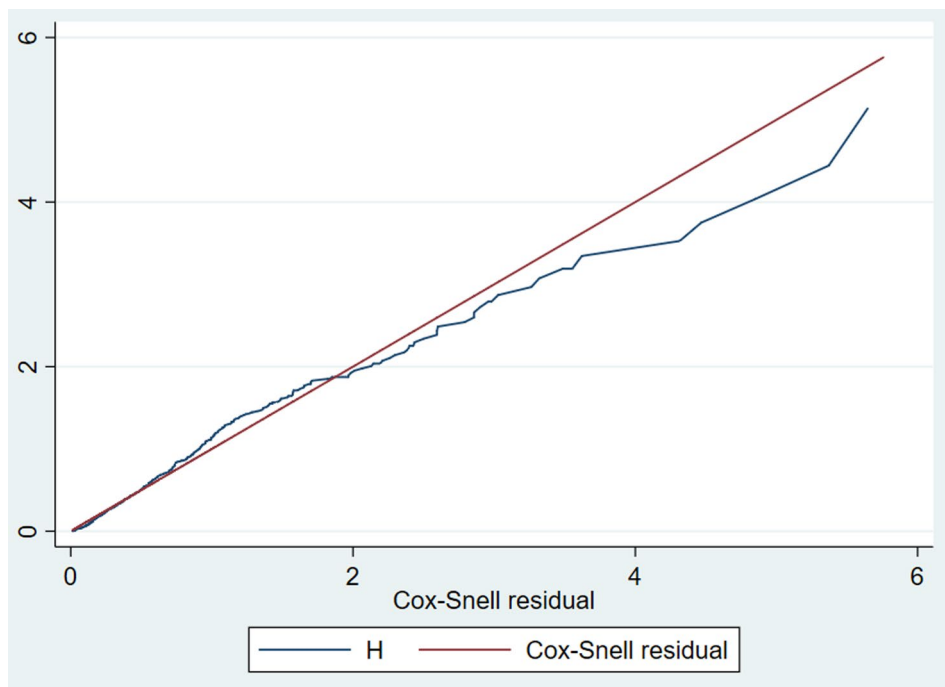
Fig. 7 Cumulative hazards and Cox Snell residual test for overall model adequacy among adult type 2 diabetes Mellitus patients at public comprehensive specialized hospitals in Amhara region, Northwest Ethiopia, 2017–2022

optimal glycemic control among patients with hypertension, dyslipidemia and cardiovascular disease were respectively decreased by 33.4%, 43.9%, and 31.9% compared to patients with no hypertension, no dyslipidemia and no cardiovascular disease (Table 4).

The proportional hazard of diabetes neuropathy group of diabetes mellitus patients were high compared to non –neuropathic group (Fig. 8).

The proportional hazard of hypertensive group of diabetes mellitus patients were high compared to non – hypertensive group (Fig. 9).

The proportional hazard of dyslipidemia of diabetes mellitus patients were high compared to their counter parts (Fig. 10).

The proportional hazard of cardiovascular diseases of diabetes mellitus patients were high compared to their counter parts (Fig. 11).

Discussion
This study was aimed to assess the time to first optimal glycemic control and its predictors among adult type 2 diabetes Mellitus patients in Amhara region comprehensive specialized hospitals. The present study revealed that the median time to first optimal glycemic control was 8.4 (95% CI: 7.6, 9.7) months which means that 50% of the study participants' blood glucose level were controlled within 8.4 months period. This finding was in lined to the study done in public teaching hospitals in Addis Ababa, Ethiopia in which the optimal glycemic control lasted

9.5 months [31]. Due to the scarcity of comparable prior research, the findings of this study were contrasted with cross-sectional investigations on optimal glycemic control and survival analyses focused on death and diabetes-related health outcomes. The identified predictors in this study align with those reported in the existing literature.

The patient's age was one of the risk factor when they were achieving optimal glycemic control for the first time. Furthermore, the study found no significant association in the time required to achieve first optimal glycemic control between the age groups of 30–39 years and 40–49 years. This findings is supported by a study findings conducted in Bahir Dar [32], in West Showa zone [15], in university of Gondar hospital, Ambo hospital, public teaching hospitals in Addis Ababa, in 10 developing countries of Africa, India and Charleston, South Carolina [31, 33–37]. Potential explanations for this difference include lower blood sugar, insulin resistance, and hemoglobin A1C levels in younger patients. Additionally, the combined impact of rising insulin resistance and deteriorating pancreatic islet function with age could be a contributing factor [38].

The hazard of developing poor glycemic control among type 2 diabetes Mellitus mellitus with neuropathy is higher than their counters parts. This finding is supported by studies conducted in West Showa zone [15], in Addis Ababa [31] and Pakistan [39]. This might be due during diabetic neuropathy haemo-dynamic factors that contribute to the development of diabetic nephropathy

Table 4 Results for the final multivariable cox proportional hazard model among type 2 diabetes mellitus patients in Amhara region comprehensive specialized hospitals Northwest Ethiopia, 2017–2022 ($n=514$)

Variables	Categories	CHR(95% CI)	AHR	95% CI for AHR	*p*-value
Age in years	30–39(R)	1	1	1	
	40–49	0.814(0.614, 1.079)	0.823	(0.6148, 1.102)	0.191
	50–59	0.568(0.422, 0.763)	0.630	(0.463, 0.859)	<0.01[*]
	60–69	0.491(0.366, 0.658)	0.638	(0.471, 0.865)	<0.01[*]
	70or more	0.318(0.199, 0.508)	0.480	(0.298, 0.774)	<0.01*
Sex	Male	0.778(0.633, 0.958)	0.910	(0.732, 1.133)	0.400
	Female(R)	1	1	1	
Residence	Urban	0.869 (0.705,1.071)	0.829	(0.664, 1.035)	0.098
	Rural(R)	1	1	1	
History of diabetes related complication	Yes	0.568(0.457, 0.706)	0.878	(0.663 1.163)	0.365
	No(R)	1	1	1	
Nephropathy	Yes	0.443(0.259, 0.757)	0.791	(0.426, 1.469)	0.459
	No (R)	1	1	1	
Neuropathy	Yes	0.425(0.316, 0.570)	0.629	(0.441,0.900)	0.011[*]
	No(R)	1	1	1	
Retinopathy	Yes	0.651(0.374,1.133)	0.862	(0.479, 1.550)	0.621
	No(R)	1	1	1	
Foot ulcer	Yes	0.559(0.314, 0.996)	0.703	(0.377, 1.309)	0.267
	No(R)	1	1	1	
MO complication	Yes	0.172(0.077, 0.386)	0.448	(0.183, 1.094)	0.078
	No(R)	1	1	1	
HC illness	Yes	0.457(0.373, 0.561)	0.7978	(0.631, 1.008)	0.059
	No(R)	1	1	1	
HTN	Yes	0.438(0.352, 0.546)	0.667	(0.524, 0.848)	<0.01[*]
	No(R)	1	1	1	
Dyslipidemia	Yes	0.408(0.305, 0.546)	0.561	(0.410, 0.768)	<0.01[*]
	No(R)	1	1	1	
CVD	Yes	0.478(0.353, 0.648)	0.681	(0.494, 0.938)	0.019[*]
	No(R)	1	1	1	
RD	Yes	0.611(0.379, 0.983)	0.698	(0.426, 1.142)	0.153
	No(R)	1	1	1	
ND	Yes	0.665(0.414, 1.0689)	0.664	(0.407, 1.084)	0.102
	No(R)	1	1	1	
CRD	Yes	0.549(0.272, 1.109)	0.673	(0.319, 1.417)	0.297
	No(R)	1	1	1	
MOC illness	Yes	0.409(0.319, 0.523)	0.801	(0.597, 1.075)	0.140
	No(R)	1	1	1	

MOC illness = more than one comorbidity illness, RD = renal disease, CVD = cardiovascular disease, CRD = chronic respiratory disease, ND = neurologic disease

include increased systemic and intra glomerular pressure, as well as activation of vasoactive hormone pathways including the renin angiotensin system and glucose dependent pathways are also activated within the diabetic kidney and result in enhanced oxidative stress, renal polyol formation and the accumulation of advanced glycation end products (AGEs) results poor glycemic control [40].

Furthermore, having a co-morbidity illness has been discovered to be an important predictor of the time it takes to achieve optimal glycemic control. When compared to patients without hypertension, dyslipidemia, or cardiovascular disease, the rate of achieving optimal glycemic control was reduced by 33.3%, 43.9%, and 31.9%, respectively, indicating that dyslipidemia has a greater negative impact on individual diabetes control, followed by hypertension, and then cardiovascular disease. This is due to the fact that having a comorbid illness, as well as other types of stress, can cause blood glucose (sugar) levels to rise. More glucose is released into the bloodstream as part of the body's defense mechanism against disease.

As a result, hypertension was found to be an independent predictor of time to optimal glycemic control in this study, which is consistent with a study conducted at public teaching hospitals in Addis Ababa, Ethiopia, India, and North china [31, 41, 42]. In study conducted
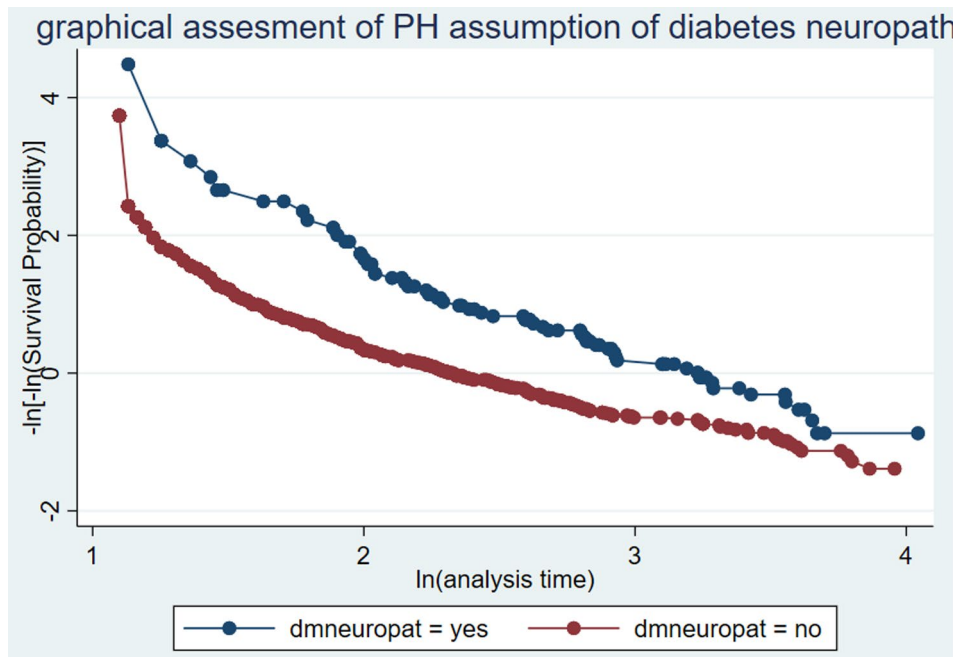
Fig. 8 The proportional hazard of diabetes neuropathy group among type 2 diabetes Mellitus patients at public comprehensive specialized hospitals in Amhara region, Northwest Ethiopia, 2017–2022
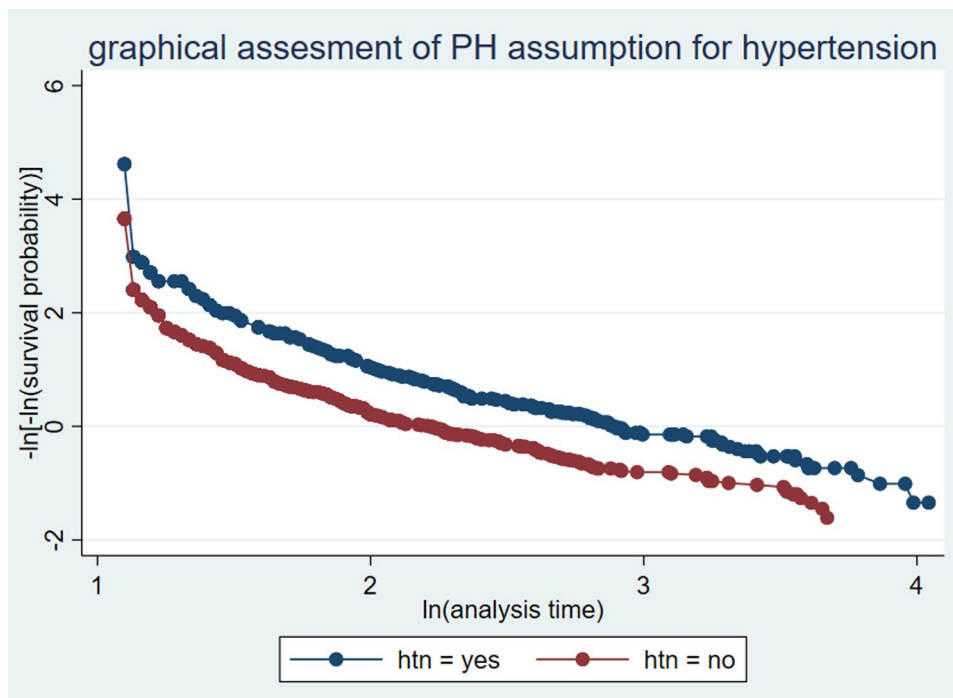

Fig. 9 Implies that the proportional hazard of hypertension group among type 2 diabetes mellitus patients at public comprehensive specialized hospitals in Amhara region, Northwest Ethiopia, 2017–2022

at a multicenter research in Canada, patients with hypertension were proven to be a protective factor for glycemic control [43]. This might be due to maladaptive changes in the autonomic nervous system, vascular endothelial dysfunction, and enhanced activation of the renin-angiotensin-aldosterone system, immune function alterations, and harmful environmental factors [44].

This study found that dyslipidemia was an independent predictor of time to optimal glycemic control, which is consistent with a comprehensive review conducted in
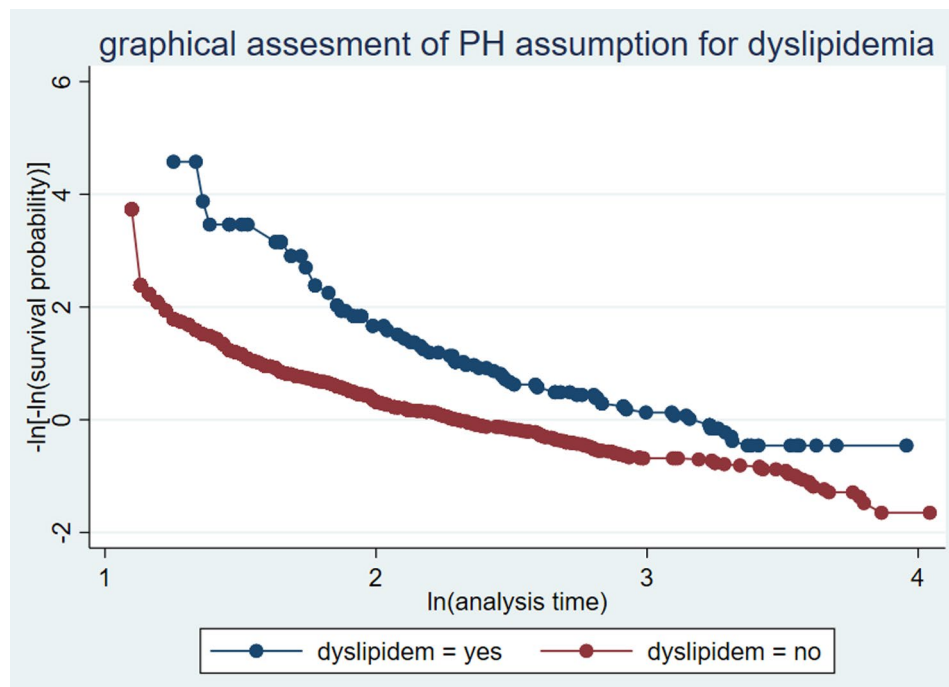
Fig. 10 Implies that the proportional hazard assumption of dyslipidemia group among type 2 diabetes mellitus patients at public comprehensive specialized hospitals in Amhara region, Northwest Ethiopia, 2017–2022
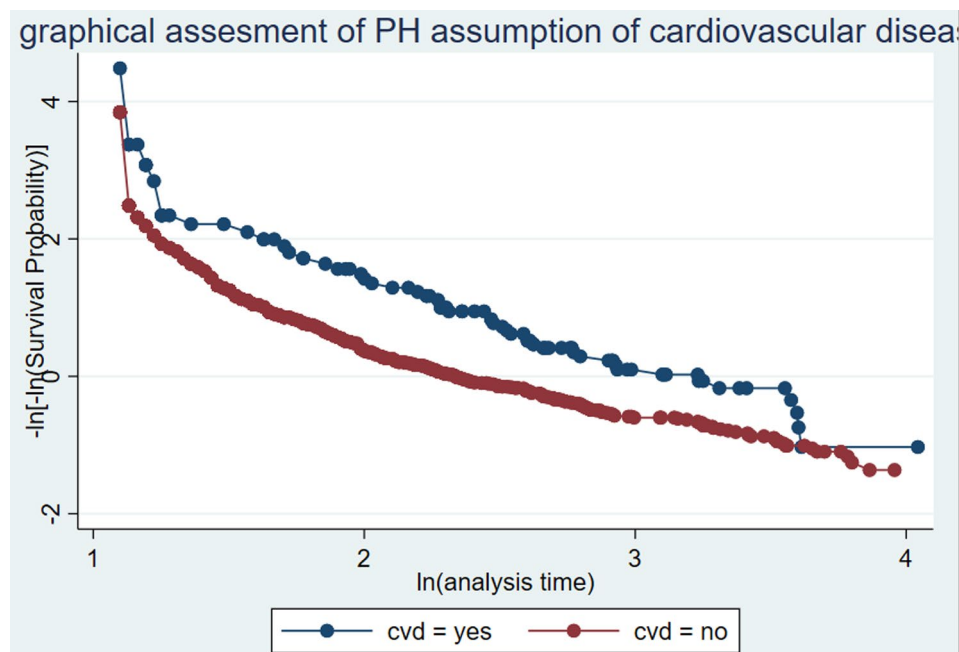

Fig. 11 The proportional hazard of cardiovascular disease group among type 2 diabetes Mellitus patients at public comprehensive specialized hospitals in Amhara region, Northwest Ethiopia, 2017–2022

Ethiopia at Ambo Hospital, West Shewa Zone, at public health teaching hospitals in Addis Ababa, Korea, and California [15, 31, 34, 45–47]. This might be due to high levels of triglycerides in the blood are a common problem for people with diabetes and these levels simply rise with increasing blood sugar, they are actually more closely linked to insulin resistance and the body's overproduction of insulin [48].

Cardiovascular illness was also found to be an independent predictor of time to optimal glycemic control in this study, which is similar with research done at public teaching hospitals in Addis Ababa, Helsinki, and North

China [31, 43, 49]. This might be due to several cellular processes involved in cell growth and survival, including the pAkt, endothelial nitric oxide synthase, and AMP-activated protein kinase pathways, may contribute to the development of cardiovascular disease and results prolonged glycemic control among diabetic patients [50].

Limitation of the study

Despite diligent efforts to minimize the study's potential flaws, there are some limitations in the current study. Because of the retrospective nature of our study and the fact that the data were obtained from secondary sources, this study was unable to investigate some significant predictors, such as sociodemographic, educational, marital, physical activity, smoking, and nutritional status that will have an impact on optimal glycemic control.

Conclusion

Half of type 2 diabetes Mellitus patients attain their first optimum glycemic control within 8.4 months duration. Variables like age in years, diabetes neuropathy, hypertension, dyslipidemia, and cardiovascular disease were significantly associated with first optimal glycemic control. Therefore, Amhara Region Comprehensive Specialized Hospitals need to strengthen the follow-up type 2 diabetes mellitus patients with Hypertension, cardiovascular disease, dyslipidemia, old age, and patients who had diabetic neuropathy to improve individual optimal glycemic control.

Abbreviations

ADA	American diabetes association
AHR	Adjusted hazard rate
CHR	Crude hazard rate
CVD	Cardio Vascular Disease
CRD	Chronic respiratory disease
DM	Diabetes mellitus
FBS	Fasting blood sugar
FHCSH	Felege Hiwot Comprehensive Specialized Hospital
HTN	Hypertension
IDF	International diabetes federation
MOCH	More one complication history
MOCI	More than one comorbidity illness
ND	Neurologic disease
OAD	Oral Antidiuretics Drug
RD	Renal disease
TGSH	Tibebe Gion Specialized Hospital
WHO	World health organization

Author contributions
Atsed alle (Assistance professor), Bekalu Endalew (MPH), Sintayehu Chalie (MPH), Moges Agazhe (Assistance Professor), Friehiwot Molla (MPH), Animut Takele (MPH) and Atalay Liknaw (MPH). All these authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published, have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Data availability
The data is available at the correspondence author as per request.

Declarations

Ethics approval and consent to participate
The research ethics permission letter (Ref. No/ HSR /R/C/Ser/ PG/co/ 108/ 11/ 14) was acquired from the Debre Markos University College of Health Sciences Research and Ethical Review Committee. The particular patient was not harmed because the study was carried out by looking through medical records, and the official letter of cooperation to Felege Hiwot specialized hospital, Tibebe Gion specialized hospital, and Debre Markos specialized hospital was obtained from Debre Markos University. Each study's hospital administrators and medical ward unit heads gave their consent. The College of Health Sciences' study review committee stated that while anonymity and secrecy were strictly upheld, formal consent was not necessary. The names and other identities of patients and medical personnel were not included in the data to maintain confidentiality. Confidentiality was maintained through anonymity and privacy measures were taken to preserve the right of the participants throughout the research work including publication. This study was conducted in accordance with the Declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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References
1. World Health Organization. *Classification of diabetes mellitus.* 2019.
2. American Diabetics Association. *Standards of Medical Care in Diabetes*. 2021.
3. Koro CE, et al. Glycemic control from 1988 to 2000 among US adults diagnosed with type 2 diabetes Mellitus: a preliminary report. Diabetes Care. 2004;27(1):17–20.
4. Association AD. 2. Classification and diagnosis of diabetes: standards of medical care in diabetes—2018. Diabetes Care. 2018;41(Supplement1):S13–27.
5. Aschner P. New IDF clinical practice recommendations for managing type 2 diabetes Mellitus in primary care. Diabetes Res Clin Pract. 2017;132:169–70.
6. Arokiasamy P, Salvi S, Selvamani Y. *Global Burden of Diabetes Mellitus*, in *Handbook of Global Health*. Springer; 2021. pp. 1–44.
7. Vigersky RA. An overview of management issues in adult patients with type 2 diabetes Mellitus mellitus. J Diabetes Sci Technol. 2011;5(2):245–50.
8. Organization WH. *GLOBAL REPORT ON DIABETES*. 2016. 88.
9. Khan MAB, et al. Epidemiology of type 2 diabetes Mellitus–global burden of disease and forecasted trends. J Epidemiol Global Health. 2020;10(1):107.
10. Silink M. II. The economic and social consequences of type 2 diabetes Mellitus. Gac Med Mex. 2009;145(4):290–4.
11. Barkoudah E, et al. Mortality rates in trials of subjects with type 2 diabetes Mellitus. J Am Heart Association. 2012;1(1):e000059.

12. Raghavan S, et al. Diabetes mellitus–related all-cause and cardiovascular mortality in a national cohort of adults. J Am Heart Association. 2019;8(4):e011295.
13. Shiferaw WS, et al. Metabolic syndrome among type 2 diabetic patients in sub-saharan African countries: a systematic review and meta-analysis. Volume 14. Diabetes & Metabolic Syndrome: Clinical Research & Reviews; 2020. pp. 1403–11. 5.
14. Zeru MA, et al. Prevalence and risk factors of type-2 diabetes mellitus in Ethiopia: systematic review and meta-analysis. Sci Rep. 2021;11(1):1–15.
15. Abdissa D, Hirpa D. Poor glycemic control and its associated factors among diabetes patients attending public hospitals in West Shewa Zone, Oromia, Ethiopia: an Institutional based cross-sectional study. Metabolism Open. 2022;13:100154.
16. Gebreyohannes EA, Netere AK, Belachew SA. Glycemic control among diabetic patients in Ethiopia: a systematic review and meta-analysis. PLoS ONE. 2019;14(8):e0221790.
17. Yosef T, Nureye D, Tekalign E. Poor Glycemic Control and its contributing factors among type 2 diabetes Mellitus patients at Adama Hospital Medical College in East Ethiopia. Diabetes Metabolic Syndrome Obesity: Targets Therapy. 2021;14:p3273.
18. Masilela C et al. Factors associated with glycemic control among South African adult residents of Mkhondo municipality living with diabetes mellitus. Medicine, 2020. 99(48).
19. Fekadu G, et al. Challenges and factors associated with poor glycemic control among type 2 diabetes Mellitus mellitus patients at Nekemte Referral Hospital, Western Ethiopia. J Multidisciplinary Healthc. 2019;12:963.
20. Demoz GT, et al. Predictors of poor glycemic control among patients with type 2 diabetes Mellitus on follow-up care at a tertiary healthcare setting in Ethiopia. BMC Res Notes. 2019;12(1):1–7.
21. ryan. t., *sample size determination and power.* 2021.
22. health fm. o., *Guidelines on Clinical and Programmatic Management of Major Non Communicable Diseases.* 2016.
23. Marathe PH, Gao HX, Close KL. American D iabetes a ssociation S tandards of M edical C are in D iabetes 2017. Wiley Online Library; 2017.
24. DiMeglio LA, et al. ISPAD Clinical Practice Consensus guidelines 2018: glycemic control targets and glucose monitoring for children, adolescents, and young adults with diabetes. Pediatr Diabetes. 2018;19 Suppl 27:p105–114.
25. Yu Y. Gold Standard for diagnosis of DPN. Front Endocrinol (Lausanne). 2021;12:719356.
26. Janghorbani M, et al. Incidence of and risk factors for diabetic retinopathy in Isfahan, Iran. Ophthalmic Epidemiol. 2003;10(2):81–95.
27. Tekalign T, Guta MT, Awoke N. *Time to Diabetic Nephropathy and its Predictors Among Diabetic Patients Treated in Wolaita and Dawuro Zone Hospitals, Ethiopia: A Retrospective Cohort Study.* 2023. 16: pp. 163–172.
28. Organization WH. Multimorbidity 2016.
29. Organization WH. *Diagnosis and Management of Type 2 diabetes Mellitus.* 2020.
30. Charlson ME, et al. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis. 1987;40(5):373–83.
31. Leulseged TW, Ayele BT. Time to optimal glycaemic control and prognostic factors among type 2 diabetes Mellitus mellitus patients in public teaching hospitals in Addis Ababa, Ethiopia. PLoS ONE. 2019;14(7):e0220309.
32. Meseret F, et al. Time to first optimal glycemic control and its predictors among type 1 diabetic children in Bahir Dar City public referral hospitals, North West Ethiopia: a retrospective follow up study. BMC Pediatr. 2022;22(1):563.
33. Fasil A, Biadgo B, Abebe M. Glycemic control and diabetes complications among diabetes mellitus patients attending at University of Gondar Hospital, Northwest Ethiopia. Diabetes Metabolic Syndrome Obesity: Targets Therapy. 2019;12:75.
34. Woldu MA, et al. Factors associated with poor glycemic control among patients with type 2 diabetes Mellitus mellitus in Ambo Hospital, Ambo; Ethiopia. Endocrinol Metab Synd. 2014;3(143):2161–1017.
35. Al Mansari A, et al. GOAL study: clinical and non-clinical predictive factors for achieving glycemic control in people with type 2 diabetes Mellitus in real clinical practice. BMJ Open Diabetes Res Care. 2018;6(1):e000519.
36. Ewenighi C, et al. Responses to glycemic control therapy according to age, gender, level of adiposity, and duration of diabetes in type 2 diabetic patients. Indian J Med Sci. 2013;67(3/4):61.
37. Gebregziabher M, et al. Effect of trajectories of glycemic control on mortality in type 2 diabetes Mellitus: a semiparametric joint modeling approach. Am J Epidemiol. 2010;171(10):1090–8.
38. Anioke IC, et al. Predictors of poor glycemic control in adult with type 2 diabetes Mellitus in South-Eastern Nigeria. Afr Health Sci. 2019;19(4):2819–28.
39. Nisar MU et al. Association of diabetic neuropathy with duration of type 2 diabetes Mellitus and glycemic control. Cureus, 2015. 7(8).
40. Soldatos G, Cooper M. Diabetic nephropathy: important pathophysiologic mechanisms. Diabetes Res Clin Pract. 2008;82:S75–9.
41. Borgharkar SS, Das SS. Real-world evidence of glycemic control among patients with type 2 diabetes Mellitus mellitus in India: the TIGHT study. BMJ Open Diabetes Res Care. 2019;7(1):e000654.
42. Mobula LM, et al. Predictors of glycemic control in type-2 diabetes mellitus: evidence from a multicenter study in Ghana. Translational Metabolic Syndrome Res. 2018;1:1–8.
43. Wang J, et al. Status of glycosylated hemoglobin and prediction of glycemic control among patients with insulin-treated type 2 diabetes Mellitus in North China: a multicenter observational study. Chin Med J. 2020;133(01):17–24.
44. Ohishi M. Hypertension with diabetes mellitus: physiology and pathology. Hypertens Res. 2018;41(6):389–93.
45. Teklehaimanot BF, Berhe Akidanemariam, Welearegawi GG. *Poor glycemic control and associated factors among diabetic patients in Ethiopia; A Systemic review and meta-analysis.* medRxiv, 2019: p. 19004986.
46. Anak A, et al. Osong Public Health Res Perspect Osong Public Health Res Perspect Korea. 2021;2233:6052.
47. Benoit SR, et al. Predictors of glycemic control among patients with type 2 diabetes Mellitus: a longitudinal study. BMC Public Health. 2005;5(1):1–9.
48. Hirano T. Pathophysiology of diabetic dyslipidemia. J Atheroscler Thromb. 2018;25(9):771–82.
49. Chen S, et al. Impact of glycemic control on the association of endothelial dysfunction and coronary artery disease in patients with type 2 diabetes Mellitus mellitus. Cardiovasc Diabetol. 2021;20(1):1–9.
50. Rodriguez-Araujo G, Nakagami H. Pathophysiology of cardiovascular disease in diabetes mellitus. Cardiovasc Endocrinol Metabolism. 2018;7(1):4–9.

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