Glycosylated hemoglobin ($HbA1_C$) level as a measure of glycemic control and associated factors among ambulatory diabetic patients in Southwest Ethiopia

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Abstract

Background: Long-term hyperglycemia promotes development of complications and suboptimal well-being in patients with diabetes. A stringent glycemic control is a worldwide standard of diabetes care recommended in order to reduce such adverse health outcomes. The current study was aimed to undertake glycosylated hemoglobin (HbA1c) assay and assess the quality of glycemic control in Ethiopian diabetes care and identify simple patient related factors associated with poor control.

Methods: Hospital-based cross-sectional study with longitudinal components was conducted from October 20 to December 15, 2015 among systematically selected adult ambulatory diabetic patients at the outpatient clinic of Jimma University Medical Center, Southwest Ethiopia. At recruitment, blood samples for $HbA1_C$ determination and sociodemographic characteristics were collected from each patient. In addition, patient charts were reviewed for recorded anthropometric data, diabetic duration and blood pressure. Based on their $HbA1_C$ test values, patients with $HbA1_C \geq 8.0\%$ were considered poor glycemic control. Binary logistic regression was employed to identify factors associated with poor control. A p-value <0.05 was considered statistically significant.

Results: Among 162 diabetic patients included in this analysis, 84 (51.9%) subjects were male and/or Type 1 diabetics; 46 (30.5%) subjects were under 40 years; and every fourth subject was aged 60 years or older. Their diabetic duration ranged from 1 to 22 years with a mean ± SD of 5.4 ± 4.6 years. Sixty-seven (44.7%) subjects had diabetes for five years or longer. Mean ± SD of BMI and $HbA1_C$ was 24.3 ± 4.3 kg/m^2 and 8.76 ± 2.6%, respectively. One-hundred and four (64.2%) patients had $HbA1_C$ values greater than 8.0%, indicating poor glycemic control. Poor glycemic control was associated with age (p= 0.001) in Type 1 diabetic patients. In Type 2 diabetics, prevalence of poor control was significantly higher among hypertensive (p= 0.029), female subjects (p=0.019) with longer duration of diabetes (p= 0.008).

Conclusions: The overall state of glycemic control was unsatisfactory, and the condition was less favorable among hypertensive female subjects with advancing age and a longer history of diabetes. Overall diabetes treatment at the clinic needs to be improved with more intensive management alternatives to the vulnerable groups.

Keywords: Glycosylated hemoglobin, diabetes care, glycemic control, Jimma University Medical Center, Southwest Ethiopia

Background

Diabetes mellitus (DM) is a metabolic disorder diagnosed by long-term hyperglycemia that results from defects in insulin secretion, insulin action, or both [1]. When blood glucose is poorly controlled over a long period of time, diabetes mellitus leads to chronic macrovascular and microvascular complications. The late sequelae of such complications include renal failure, blindness, and non-traumatic lower-limb amputations, non-alcoholic fatty liver disease, heart disease, stroke, depression and adverse pregnancy outcomes [2–7]. Along with other non-communicable diseases, diabetes is responsible for 70% of deaths worldwide [8]. In recent years, death from end-stage diabetic complications is a global health tragedy that could be potentially mitigated or delayed through tight monitoring of glycemia. Therefore, maintaining good glycemic control is the main therapeutic goal for all patients with diabetes to prevent organ damage due to microvascular and macrovascular complications [9, 10].

In clinical management of diabetes, fasting blood glucose and glycosylated hemoglobin ($HbA1_C$) are commonly used as outcome measures of glycemic control [11–13]. Since its introduction to clinical practice in 1980's, $HbA1_C$ has become a cornerstone of diabetes care as a diagnostic tool, as an index of glycemic control, and as screening tool for patients with diabetic complications [14–16]. The use of $HbA1_C$ assay compared with measures of fasting blood glucose avoids the problem of day-to-day variability of glucose values, and importantly removes the need for the person to fast and to have preceding dietary preparations. These qualities have made it the preferred test to judge the adequacy of the ongoing diabetes care and help healthcare providers to decide whether any change in medications or lifestyle is needed [17]. Worldwide recommendations from the World Health Organization (WHO, 2011) and American Diabetes Association (ADA, 2009) also suggest the applicability of HbA1c as a reliable measure of the quality of long-term glycemic control and predict the future risk of diabetic complications.

In spite of these recommendations, utilization of $HbA1_C$ assay in clinical management of diabetes in Ethiopia is extremely low, even at referral hospitals. Instead, fasting plasma glucose testing, with all its limitations such as need for dietary preparations and day-to-day variability, is used as a proxy measure of glycemic control [18–21]. Moreover, patients and their care givers are not very well aware of the $HbA1_C$ test and its implication, probably due to inaccessibility of the test in the public health facilities and unaffordability in some private sectors [22]. Furthermore, $HbA1_C$ is not yet standardized for Ethiopian diabetic patients, and only a few study reports are available regarding the utility of HbA1c assay in diabetic care in Ethiopia [23–25].

Therefore, more thorough knowledge on clinical practice using $HbA1_C$ to meet standard of diabetes care in Ethiopia is needed at all levels. Cognizant of this, several institutions and partners are showing their determination to address such critical issues. Jimma University, a public research university located in Southwest Ethiopia, is among such institutions devoted to address public health problems by undertaking small and large-scale studies in different parts of the country [26]. In this context, a mega research project entitled "Determination of glycosylated hemoglobin ($HbA1_C$) level in association with diabetic complications" hereafter shortened as 'DGHDC', was initiated by staff researchers and generously supported by Jimma University so as to fill the prevailing critical gap of information on diabetes care.

DGHDC was a semi-longitudinal study among ambulatory diabetic patients at the outpatient clinic of Jimma University Medical Center (JUMC) aimed to (i) determine the prevalence of diabetic complications and associated risk factors (ii) assess the level of glycemic control using $HbA1_C$ test and identify the associated factors (iii) evaluate the predictive potential of $HbA1_C$ levels as a screening tool for diabetic patients at increased risk of chronic complications. Baseline characteristics of the study population and prevalence rate of diabetic complications and associated risk factors (Objective i) was already published elsewhere [27], and the outcome of the Objective (iii) will appear in scientific literature sooner. The current paper is a vehicle to disseminate the results of point prevalence of poor glycemic control and associated factors (Objective ii) based on $HbA1_C$ level measured at baseline. These reports will contribute towards enriching local literature on diabetes care in Ethiopia. In more specific terms, the objectives of the this paper is to provide information on the current

quality of glycemic control of people with diabetes in a tertiary care and to identify patient characteristics associated with the quality of glycemic control.

Methods and Participants

Study design and setting

DGHDC was hospital-based cross-sectional study with some longitudinal component among systematically recruited ambulatory diabetic patients at Jimma University Medical Center (JUMC), the former Jimma University Specialized Hospital, which is located in Jimma City, 335 km Southwest of Addis Ababa. The center has many chronic follow-up clinics for both pediatric and adult patients, among which is the diabetes clinic that operates twice a week on Monday and Tuesdays. All ambulatory diabetic patients on diabetes follow-up care at the outpatient clinic of JUMC were our source population. The patients were approached systematically and requested for participation over a two month-period from October 20 to December 15, 2015.

The minimum sample size required for this study was determined by using single population proportion of diabetic patients with diabetic complications and poor glycemic control from previous reports [7, 24]. After all, the final sample size calculated was 258. The study population was all adult ambulatory diabetic patients visiting the outpatient clinic of JUMC during the study period. For the purpose of this study, adult diabetic patients aged 18 years or older on follow up at the clinic for at least the last three months regardless of their DM type, and have at least three consecutive blood glucose measurements and gave their informed consent were included as study subjects. Participants were recruited consecutively and voluntarily. Patients seriously ill and could not give blood sample for $HbA1_C$ assay, and not willing to participate were excluded. Moreover, participants with any known condition affecting red blood cell turnover and influence total hemoglobin and HbA1c level were proposed for exclusion not from the study but from the analysis related to $HbA1_C$. These conditions include history of hemolytic diseases, current pregnancy, significant blood loss, haemoglobinopathies, splenomegaly, rheumatoid arthritis, alcoholism and chemotherapeutic drugs such as antiretrovirals, ribavirin, dapsone, and large doses of aspirin [14].

Data collection procedures and measurement data

After receiving informed verbal consent, the baseline data and blood samples were collected by trained clinical nurses who are providing the health care at the outpatient clinic. From each patient, about 5 ml venous blood was collected into EDTA tubes at the time of the clinic visit with no prior advanced instruction concerning fasting, and used for determination of $HbA1_C$ level. Other demographic and diabetes related data such as current age, sex, residence, diabetic duration and age at onset of DM were gathered through face-to-face interview held in a separate room for privacy. Patient charts were also reviewed through the prepared checklist for types of diabetes; three most recent fasting blood glucose and blood pressure records. Moreover, anthropometric measurements were retrieved for each patient, and used for body mass index (BMI) calculation, as weight (kg)/height $(m)^2$.

Whole blood $HbA1_C$ assay was carried in ABX Pentra 400 Automated Chemistry Machine (Horiba ABX SAS, 34184 Montpellier, France) at JUMC Clinical chemistry core laboratory using ABX pentra $HbA1_C$ WB standard kit for Latex-enhanced immunturbidmetry method provided by the supplier [28]. The resultant $HbA1_C$ value was used to determine the glycemic status of each patient at baseline. The glycemic status was then categorized as good glycemic control if HbA1c <8.0% and poor glycemic control if HbA1c ≥ 8.0%. The use of 8.0% as a cutoff value in HbA1c level in classification of patients into good and poor glycemic level in this analysis was original. This is based on our recent observation [27] that indicated it is the lowest value in the inter-quartile range of $HbA1_C$ that led to significant increase in the odds of microvascular complications in the current population.

Data quality control

Data collectors were trained and adequately oriented and data collection was supervised all the time by the principal investigator. The data collected through interview and information provided by patients was crosschecked with the recorded data for consistency and completeness. Moreover, for laboratory tests, internal

data quality control system was employed using the control kit (ABX Pentra $HbA1_C$ WB Control, Ref. A11A01704; Normal control: 2 x 0.25 ml (lyophilisate) and Pathological control: 2 x 0.25 ml) provided by the supplier. Laboratory guidelines and supplier's instructions on sample handling and processing were also strictly followed so as to guarantee accurate test results.

Statistical Analysis

The statistical analyses were performed with SPSS for windows version 20.0 [29]. Descriptive statistics (mean and standard deviation for continuous variables; and frequencies and percentages for the categorical variables) were computed. Moreover, Pearson product-moment correlation coefficient was used to see if there is correlation between the $HbA1_C$% level and the various sociodemographic and anthropometric characteristics of the study subjects. The level of glycemic control achieved by each study patient, determined using his/her $HbA1_C$ value, was the outcome variable treated as a dichotomous data with good/poor options.

Pearson's correlation, χ^2 test, or Student's t-test was used, as applicable, to test the statistical significance. Binary logistic regression analysis was employed to identify the predictors of poor glycemic control while adjusting for confounders [30]. Those variables appeared with evidence of association with the outcome in the bivariate analysis at $P< 0.25$ were considered candidates in the final model. Multicollinearity between these variables was checked using tolerance and variance inflation factor (VIF) [31]. The result showed no evidence of inter-correlation among the predictor variables in the model. The Odds ratio and 95% confidence interval with a Wald-statistic was reported for each independent variable. All the statistical tests were two-tailed; and a p-value<0.05 was considered significant in the final analysis. Aggregated results were presented in the form of summary Tables.

Ethical Considerations

Before starting the study, the protocol was thoroughly reviewed and received ethical approval and endowment from Jimma University, Health Sciences Institutional Review Board, Ref. No. RPGC/06/2015; Dated March 16, 2015, according to the standardized principle and procedure designed in line with the national and WHO guidelines. In addition, a written permission was sought from the hospital administration to perform the laboratory tests and retrieve patients chart for review. All the study subjects were unpaid volunteers who had informed of the study purpose and gave verbal consent to participate. All the participants' information was kept confidential using coding system and no direct benefit was provided for the participants, except the cost free total hemoglobin and $HbA1_C$ tests performed for each participant. Venous blood collection was performed by experienced laboratory technicians, as routine acceptable clinical practice with no potential risk. The laboratory test result and its implication was communicated with the patients and their care providers immediately on the next clinic visit to assist them improve diabetic care and adjust therapy. Moreover, patients with severe anemia and hyperglycemia were suggested and recommended for intensive care.

Results

Sociodemographic and clinical characteristics of the study participants

Among one hundred and seventy-eight subjects underwent total hemoglobin and $HbA1_C$ determination in DGHDC study, thirteen (13) patients had severe anemia (as evidenced by total hemoglobin test result less than 15.6 µmol/L in the current assay) henceforth excluded from the analysis. Another three patients were also excluded due to missing data on their fasting blood glucose (FBG). As a result the analysis reported here included 162 diabetic patients (84 male and 78 female), aged between 18 to 80 years. The characteristic of the study patients was stratified by the level of glycemic control they achieved and presented in Table 1 and 2. As shown in Table 1, the sample included 84 (51.8%) Type 1 and 78 (48.2%) Type 2 diabetic patients, out of which 105 (64.8%) subjects were urban dwellers. The overall mean (±SD) and median (IQR) age of the participants was 46.7 (±14.8) and 49 (35, 58) years respectively. Moreover, 46 (30.8%) study subjects were below the age of 40 years, and every fourth subject was aged 60 years or older. The age range for Type 1 diabetes was 18–76 years with a mean (±SD) of 41.2 (±15.9) years, while those of Type 2 fall between 27 and 80 years, with a mean (±SD) age of 52.7 (±9.9) years. Moreover, 53.2% of the Type 1 diabetic subjects were aged 40 years or younger, while the majority (54.2%) of Type 2 diabetic patients was aged 50 years or older.

Table 1: Main characteristics of study population in relation to level of glycemic control at outpatient clinic of Jimma University Medical Center, Jimma, Southwest Ethiopia.

Variables	All patients analyzed, n (%)	Patients, n (%) with			
		Good glycemic control (n=58)	Poor glycemic control (n=104)	χ2-statistic*	p-value
Gender					
Male	84 (51.9)	35 (41.7)	49 (58.3)	2.610	0.106
Female	78 (48.1)	23 (29.5)	55 (70.5)		
Age[a]					
18 — 39 years	50 (33.1)	25 (50.0)	25 (50.0)		
40 — 55 years	60 (39.7)	15 (25.0)	45 (75.0)	7.484	0.024
56 years or older	41 (21.2)	14 (34.1)	27 (65.9)		
Residence					
Rural	57 (35.2)	27 (47.4)	30 (52.6)	5.118	0.024
Urban	105 (64.8)	31 (29.5)	74 (70.5)		
Type of diabetes mellitus					
Type-1	84 (51.9)	30 (35.7)	54 (64.3)	0.001	0.981
Type-2	78 (48.1)	28 (35.9)	50 (64.1)		
Diabetic duration[a]					
Shorter than 5 years	83 (55.3)	33 (39.8)	50 (60.2)	4.250	0.039
5 years or longer	67 (44.7)	16 (23.9)	51 (76.1)		
Body mass index[a]					
< 25.0 kg/m^2 (normal)	95 (63.5)	37 (38.9)	63 (61.1)	0.099	0.753
≥ 25.0 kg/m^2 (overweight)	55 (36.7)	20 (36.4)	35 (63.6)		
Systolic blood pressure[a]					
≤ 120 mmHg	89 (56.7)	30 (33.7)	59 (66.3)	0.000	0.988
> 120 mmHg	68 (43.3)	23 (33.8)	45 (66.2)		
Diastolic pressure[a]					
Normal (< 90 mmHg)	111 (70.7)	42 (37.8)	69 (62.2)	2.820	0.093
Hypertensive (≥ 90 mmHg)	46 (29.3)	11 (23.9)	35 (76.1)		
Average FBG level (mg/dl)[a]					
Normal, ≤ 126 mg/dl	52 (38.2)	20 (38.5)	32 (61.5)	0.809	0.368
High, >126 mg/dl	84 (61.8)	26 (31.0)	58 (69.0)		

**= Pearson Chi-Square test unless otherwise specified; [a] indicates totals do not add up to 162 due to missing data; FBG= fasting blood glucose;*

Mean (±SD) of the BMI for the overall data was 24.3 (±4.3) kg/m^2. Majority (60.6%) of the participants had a body mass in a normal range (BMI: 18.0—24.9 kg/m^2), while 35.5% were overweight (BMI≥25.0 kg/m^2). Only six (3.9%) subjects were under weight (BMI <18.0 kg/m^2). The BMI was not significantly different between poor and good glycemic control (Table 2). Mean (±SD) systolic and diastolic pressure for the study population was 123.6 (±20.5) mmHg and 78.5 (±14.4) mmHg, respectively. Duration of diabetes ranged from 1 to 22 years with mean (±SD) duration of 5.4 (±4.6) years. More than half (55.3%) of the participants had the diabetes for shorter duration, less than five years (Table 1). Table 2 shows independent samples t-test results between poor and good glycemic levels with respect to selected clinical variables. As shown in Table 2, current age, diabetic duration, body mass, and blood pressure of the study population was not significantly different between poor and good glycemic levels.

Table 2: Mean scores of demographic and clinical characteristics of diabetic patients by the level of their glycemic control at Jimma University Medical Center, Jimma, Southwest Ethiopia.

Variables	All patients, Mean ± SD	Status of Glycemic Control							
		Good (n=58)		Poor (n=104)					
		Mean	SD	Mean	SD	MD	df	t-static	p-value
Current age (years)	46.72 ± 14.57	43.72	15.78	48.39	13.66	-4.670	149	-1.927	0.059
Age at onset of diabetes (years)	40.53 ± 14.21	36.38	15.83	42.58	12.94	-4.670	140	-2.327	0.014
Diabetic duration (years)	5.38 ± 4.62	4.79	4.52	5.66	4.49	-0.804	149	-0.647	0.282
Body weight (kg)	64.55 ± 11.86	63.70	12.91	65.02	11.28	-1.318	159	0.673	0.502
Body height (meter)	1.63 ± 0.875	1.63	0.07	1.62	0.09	0.006	153	0.420	0.675
Body mass index (kg/m^2)	24.26 ± 4.34	24.02	4.85	24.40	4.02	-0.380	151	-0.523	0.601
Systolic blood pressure (mmHg)	123.58 ± 20.53	124.15	21.52	123.29	20.09	-0.860	154	0.247	0.805
Diastolic blood pressure (mmHg)	78.46 ± 14.43	76.77	10.43	79.36	16.06	-2.639	155	-1.085	0.280
Average FBG (mg/dl)	149.60 ± 54.58	134.75	48.85	157.18	56.28	-22.433	134	-2.296	0.023
$HbA1_C$ concentration (µmol/L)	5.74 ± 2.34	3.32	1.53	7.01	1.56	-3.699	157	-14.259	0.000
$HbA1_C$ percentage (%)	8.76 ± 2.55	6.03	1.25	10.29	1.66	-4.452	160	-16.936	0.000

BP= blood pressure; FBG= fasting blood glucose; HbA1c= glycosylated hemoglobin; SD= standard deviation; MD= mean difference; df= degree of freedom.

Glycosylated hemoglobin level and diabetes related variables

The mean ± SD of total hemoglobin, $HbA1_C$ concentration and $HbA1_C$ percentage for the overall data was 37.23 ± 9.65 µmol/L, 5.47 ± 2.47 µmol/L and 8.76 ± 2.55%, respectively. An independent-samples T-test showed no significant difference ($p>0.05$) between Type 1 and Type 2 diabetic patients. The relationship between the $HbA1_C$% and the various sociodemographic, anthropometric and clinical variables of the study subjects after Pearson product-moment correlation analysis was shown in Table 3. $HbA1_C$% was found to have a positive correlation with the current age of the patients [r=0.159, n=162, p=0.045], age at time of DM onset [r=0.209, n=153, p=0.013], average FBG [r=0.211, n=153, p=0.009], diastolic blood pressure [r=0.166, n=162, p=0.038], and $HbA1_C$ concentration [r=0.774, n=162, p=0.000]. However, $HbA1_C$% was not significantly correlated ($p>0.05$) with the diabetic duration, body weight, body height, body mass, systolic blood pressure, and total hemoglobin concentration. When these datasets were stratified for the types of DM, $HbA1_C$% was still significantly correlated with age [r=0.313, n=70, p=0.008] and age at onset [r=0.337, n= 71, p=0.004] in Type 1 diabetic patients. In T2DM, none of the test variables, except FBG [r=0.296, n=75, p=0.010], showed significant association with the $HbA1_C$ level.

The rate of poor glycemic control

One hundred and four (64.2%; 95% CI: 56.9, 71.6) subjects had $HbA1_C \geq 8.0\%$ (poor glycemic status) with mean (±SD) $HbA1_C$ score of 10.2 (±1.6) percent. The rate of poor glycemic status was not significantly different by Type of diabetes (Table 1). On bivariate analysis, age, place of residence and diabetic duration were significantly ($p<0.05$) associated with the glycemic status, while gender and diastolic pressure show marginal association ($p<0.2$) with the glycemic level (Table 1). Among individuals aged 40 years or older, the rate of poor glycemic control was 70.4%, and this was significantly (p=0.016) higher than the proportion observed among the youngsters (50.0%). The rate of poor glycemic control among patients having diabetes for more than five years (76.1%) was significantly higher than the proportion among those having diabetes for less than five years (60.2%). The 70.5% poor glycemic rate among urban residents was also higher than the proportion among the rural communities (52.6%).the rate of poor glycemic control did not differ significantly among patients with regard to their BMI, systolic blood pressure and fasting blood glucose (Table 1).

Table 3: Pearson Product-Moment Correlations between $HbA1_C$ level and various sociodemographic, anthropometric and clinical characteristics of diabetic patients at the outpatient clinic of Jimma University Medical Center, Southwest Ethiopia.

	$HbA1_C$ % (N=162)	Current age (N=154)	Duration of diabetes (N=153)	Age at the time of onset (N=153)	Body weight in kg (N=162)	Body height in meters (N=154)	Body mass index (N=153)	Systolic BP in mmHg (N=162)	Diastolic BP in mmHg (N=162)	Average FBG in mg/dl (N=153)	Total hemoglobin in µmol/L (N=162)	$HbA1_C$ conc, µmol/L (N=162)
S.N	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1.	1	.159*	.106	.209*	-.110	-.083	-.025	-.019	.166*	.211**	-.102	.774**
2.		1	.266**	.957**	.324**	.111	.236**	.363**	-.025	.001	.023	.222**
3.			1	.012	-.032	.094	-.099	.069	-.152	.188*	-.003	.061
4.				1	.356**	.067	.295**	.356**	.072	-.028	-.008	.262**
5.					1	.241**	.804**	.318**	.200*	-.199*	.090	.007
6.						1	-.362**	-.086	-.143	-.144	.103	-.020
7.							1	.357**	.265**	-.101	.040	.048
8.								1	.459**	.009	-.074	-.025
9.									1	.064	-.067	.084
10.										1	-.010	.160*
11.											.014	.116
12.											1	.423**
13.												1

* Correlation is significant at the 0.05 level (2-tailed); **. Correlation is significant at the 0.01 level (2-tailed).

Multivariate analysis of factors associated with poor glycemic control

Adjusted multivariate direct binary logistic analysis was performed separately for Type 1 and Type 2 diabetic patients to reveal individual level factors contributing to the prevalent poor glycemic control. The model contained five independent variables (sex, age, diabetic duration, place of residence and diastolic blood pressure). As shown in Table 1, BMI and systolic blood pressure had no univariate association with glycemic level, and hence dropped from the multivariate analysis. The final model containing all predictors performed best (as evidenced by the Omnibus Tests of Model Coefficients) and was statistically significant for Type 2 diabetic patients, $\chi^2(5, n=64)= 20.947$; $p=0.001$, indicating the model was able to distinguish between patients who achieved good glycemic level and those who did not. The model as a whole explained between 27.9% (Cox and Snell R square) and 39.7% (Nagelkerke R Square) of the variance in glycemic level and correctly classified 84.4% of the cases, an improvement over the 70.3% in Block 0. Among Type 1 DM patients however, the model was not statistically significant ($\chi^2(5, n=77) = 7.715$; $p=0.173$) and explained only between 9.5% (Cox and Snell R square) and 13.2% (Nagelkerke R Square) of the variance in glycemic level and correctly classified only 70.1% the cases. Summarized results of this analysis are shown in Table 4.

Factors associated with poor glycemic control among Type 1 DM subjects

As shown in Table 4, age of the patient was the only independent predictor of poor glycemic control among Type 1 DM patients. All the other variables in the model showed no significant association with glycemic level of the patients. Regarding the association between the age of the patient and the glycemic level he/she achieved, for every extra calendar year of advancing age, the adjusted odd of poor glycemic control was increased by a factor of 3.6% (AOR= 1.036; 95% CI: 1.001–1.072, p= 0.043). When age was entered into this analysis as a dichotomous variable at a cutoff age of 40 years, it was still the only significant predictor of glycemic control. The occurrence of poor level of glycemic control was 3.7 times (AOR= 3.77; 95% CI: 1.26–11.3; p= 0.018) more likely in individuals aged 40 years or older as compared to subjects younger than 40 years, controlled for other variables in the model.

Factors associated with poor glycemic control among subjects with Type 2 DM

Three (gender, diabetic duration and diastolic pressure) of the five variables in the multivariate model, significantly predicted poor glycemic control in Type 2 DM patients. However, the association between age or residence and glycemic control did not reach significance level (Table 4). The incidence of poor glycemic

control was fourfold higher (AOR=4.39; 95% CI: 1.05–18.49; p=0.019) among female gender as compared to the proportion in male subjects provided that other variables kept the same. After adjustment for other variables including age and gender, longer diabetic duration (5 years or longer) increased the odds of poor glycemic control approximately seven-fold (AOR= 7.44; 95% CI: 1.71 –32.4, p= 0.008). In addition, as compared to the proportion among normotensive patients, the odds of poor glycemic level was six-times higher (AOR= 6.23; 95% CI: 1.21–32.1, p= 0.029) among hypertensive patients (diastolic pressure greater or equal to 90 mm/Hg) when adjusted for other covariates. However, the association between place of residence and baseline age or age at onset of illness and glycemic control did not reach statistically significant level (Table 4).

Table 4: Multivariate predictors of poor glycemic control among Type 1 and Type 2 diabetic patients at Jimma University Medical Center, Jimma, Southwest Ethiopia.

Variables	n (%)	Poor glycemic control, n (%)	Type 1 diabetes			Type 2 diabetes		
			Adjusted OR [95% CI]	Wald statistic	P-value	Adjusted OR [95% CI]	Wald statistic	P-value
Gender								
Male	84 (51.9)	49 (53.7)	1 [Reference]			1 [Reference]		
Female	78 (48.1)	55 (70.5)	1.25 [0.31, 5.06]	0.094	0.759	4.39 [1.05, 18.49]	4.091	0.043
Age (years)[a]	46.7 ± 14.6	48.4 ± 13.7	1.036 [1.00, 1.07]	4.110	0.043	1.054 [0.99, 1.13]	2.525	0.112
Residence								
Rural	57 (35.2)	30 (52.6)	1 [Reference]			1 [Reference]		
Urban	105 (64.8)	74 (70.5)	1.56 [0.54, 4.52]	0.691	0.409	3.58 [0.863, 14.85]	3.088	0.079
Diabetic duration								
Less than 5 years	83 (55.3)	50 (60.2)	1 [Reference]			1 [Reference]		
5 years or longer	67 (44.7)	51 (76.1)	1.06 [0.36, 3.14]	0.011	0.916	7.44 [1.71, 32.39]	7.141	0.008
Diastolic blood pressure								
Normal (< 90 mmHg)	110 (70.1)	69 (66.3)	1 [Reference]			1 [Reference]		
Hypertensive (≥ 90 mmHg)	47 (29.9)	35 (33.7)	0.93 [0.30, 2.88]	0.015	0.902	6.23 [1.21, 32.13]	4.679	0.029
Age among Type 1 DM[b]								
18 — 39 years	39 (47.6)	20 (51.3)	1			-		
40 years or older	43 (52.4)	32 (74.4)	3.77 [1.26, 11.3]	5.601	0.018	-		

[a]= the value is mean ± SD; [b] =entered into the model alternatively with age; CI= confidence interval; DM= diabetes mellitus; OR= odds ratio.

Discussion

In this study, HbA1c test was objectively performed for 178 study patients and the test result and its implication was communicated with the patients and their care providers at the study clinic. The mean $HbA1_C$% for the overall data was 8.7% and this is comparable with earlier study reports from the same clinic, 8.5% and 7.6 % in 2002 [23] and 2012 [24] respectively, and with 7.8% report from Gondar, Northwest Ethiopia [25].However, the mean $HbA1_C$ of 8.7% obtained in this study was slightly higher than similar reports around the world; 7.2% from china [32], 7.8% from Japan [33], 7.4% from Germany [34], 7.2% from European cohort of 2023 [11], and 8.2% from the Diabcare Africa study [35].

It is well-established fact that $HbA1_C$ significantly predicts mortality, with increasing risk throughout the whole range of concentrations above the threshold commonly accepted for diagnosis of diabetes. This effect was found to be consistent and independent of known risk factors [36–39]. In this study, $HbA1_C$% was found to be higher with increasing age (or alternatively with longer history of DM), and chronic hyperglycemia as evidenced by higher FBG level. Therefore, improvement in diabetes care system is essential, especially for elderly subjects with longer duration of DM to minimize its late sequelae: diabetic complications, morbidity and mortality.

Studies have clearly demonstrated that persons with higher level of adherence to their treatment regimens and lower level of $HbA1_C$% have better glycemic control and thus less likely to develop diabetic complications. In contrary, persistently higher levels of $HbA1_C$% indicate poorly controlled DM and hence increased risk of developing diabetic complications [40–43]. In the current study, good glycemic control ($HbA1_C$% <8.0%) was achieved only by 35.8% of the study population. When a threshold of 9.0% and 10.0% are used, the proportion of good glycemic control was 48.1% and 69.9%, respectively. Almost two-third (64.2%) of the patients in the current analysis had poorly controlled diabetes, as defined by HbA1c ≥8.0%, and the condition was not statistically different between Type 1 and Type 2 DM. This proportion is comparable with the 64.7% prevalence reported earlier from Gondar, northern Ethiopia [25], but slightly higher than 59.5% report from Jimma hospital three years ago [24]. A number of studies across the world also reported comparable proportions, including 60% prevalence from China [32], 51.6% from north of Jordan in 2008 [33], 73-80% prevalence in five years European cohort of 2023 [37], 83% from Kenya [40] and 61.3% from Zambia [44]. In contrary to one report from Ethiopia [25], which indicates higher prevalence of poor glycemic control among persons with Type 1 DM than those with Type 2, the level of glycemic control in the current study population was not statistically different between the diabetes types. The substantial proportion of poor glycemic control in the current population underprops the need to scale-up the diabetes care in the country to acceptable standard.

Previous studies [18–21] had reported conflicting results about patient characteristics associated with inadequate glycemic control among Ethiopian diabetic patients. Among other factors, this could be due to differences in the characteristics of the population studied and the variation in the outcome measure used as proxy of glycemic control. In most of such reports from Ethiopia, instead of $HbA1_C$, fasting blood glucose was used as an index of glycemia [45–47]. In the present study, a number of patient and treatment related factors including age or age at DM onset, gender, diastolic blood pressure and diabetic duration were significantly found associated with poor glycemic control. With regard to influence of age on level of glycemia among T1DM patients, adults aged 40 years or older had more odds of poorly controlled DM as compared to the lower age group, which is consistent with other studies [34, 37, 46]. Besides, late T1DM onset (after the age of 25 years) also significantly predicated poor glycemic control and early onset improved glycemic control. The results of our study, like many other reports, did not show an association between gender and diabetic duration and the glycemic level among T1DM patients [24, 25].

Among T2DM patients, gender, duration of illness and diastolic pressure were significant predictors of poor glycemic control. However, the influence of age or age at onset of DM, BMI, systolic blood pressure and place of residence on the level of glycemic control did not attain statistically significant proportion. Increased incidence of poorly controlled T2DM among female subjects is well documented [32]. In concord with literature, the incidence of poor glycemic control among female gender in the current population was double-folded, as compared to their male counterparts. Likewise, patients with long history of T2DM (5 years or longer) revealed increased odds of poor glycemic control in the current study. These findings are consistent with other studies which showed older subjects with a short T2DM have more favorable values for glycemic control [34, 43]. One possible mechanism explained for elevation of $HbA1_C$ with increasing duration of DM was gradual increase in the amount of carbohydrate moieties attached to the HbA1 overtime [48–50]. Diastolic hypertension, as defined as diastolic blood pressure greater than 90 mm/Hg, was also significant predictor of glycemic control in this study population. Literature evidence on the association between diastolic pressure and adequacy of glycemic control is scarce [51].

Although utilization of $HbA1_C$ test as an index for glycemic control could be considered as adequacy of this study, it is not free from all inherent limitations of cross-sectional data. The institutional based nature of the study and the relatively small sample size also limit the generalizability of the findings for all diabetic populations in Ethiopia.

Conclusions

Mean $HbA1_C$ of the study population was high, 8.7%. Regardless of the DM type, the overall status of glycemic control was unsatisfactory, as evidenced by good glycemic goal ($HbA1_C$< 8.0%) achieved by 35.8% of the

diabetic outpatients only. This was by far below any national or international recommendations for good glycemic goal. The adequacy of glycemic control was less favorable among hypertensive female subjects of advancing age and diabetic duration. The findings highlight the need for more intensive management alternatives to these vulnerable groups.

Abbreviations

ADA: American Diabetes Association; BMI: Body mass index; CI: confidence interval; DBP: diastolic blood pressure; DCCT: The Diabetes Control and Complications Trial; DM: Diabetes mellitus; FBG: Fasting blood glucose; $HbA1_C$: glycosylated hemoglobin; IDF: International Diabetes Federation; JUMC: Jimma University Medical Center; SBP: systolic blood pressure; SPSS: Statistical package solution support; T1DM: Type 1 diabetes mellitus; T2DM: Type 2 diabetes mellitus; WHO: World Health Organization

Declaration

The authors declare that this article is our original work and has not been published elsewhere and is not under consideration by any other journal.

Competing interests

The authors declare that they have no competing interests.

Availability of data and material

The datasets supporting the conclusions of this article are included within the manuscript.

Authors' contributions

BZ conceived the research concept and participated in designing the study. TAN led the research team, developed tools, supervised data collection, carried out data analysis, and drafted the manuscript. ADW involved in the research plan, and TGG participated in tool development, WC assisted in the process of $HbA1_C$ determination. Likewise, NH and SG made repeated sensible corrections on the first draft and produced the final document. All authors read and approved the final manuscript.

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