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Journal of Endocrinology and Disorders
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Research Article

Factors Affecting Glycemic Control Among Type 2 Diabetes Mellitus Patients at Yekatit 12 Hospital Medical College. 2024

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Received Date: January 18, 2025 | **Accepted Date:** January 30, 2025 | **Published DATE:** February 10, 2025

Citation: Kidist K. Madessa, Mekdes T. Ambaye, Zemene Y. Afework, Eyerusalem W. Nimane, Nahom A. Bekele, et al., (2025), Factors Affecting Glycemic Control Among Type 2 Diabetes Mellitus Patients at Yekatit 12 Hospital Medical College. 2024, *J. Endocrinology and Disorders,* 9(1); DOI:**10.31579/2640-1045/207**

Abstract

Objectives: The report aims to examine the effects of serum creatinine (SCT) on heart, diabetes, anaemia and normal study units, and along with the other biological factors. The study is based on the relationship of serum creatinine with heart, diabetes, anaemia patients and many other factors.

Materials & Methods: A real data set of 299 heart patients with 13 study characters is taken in the current study, the data set is available herein: https://archive.ics.uci.edu/ml/datasets/Heart+failure+clinical+records, and the serum creatinine probabilistic model has been developed applying statistical joint generalized linear models.

Results: From the fitted Log-normal model, the mean serum creatinine (SCT) is positively associated with age (P<0.0001). It is partially negatively associated with ejection fraction (EFT) (P=0.0974) and partially positively associated with the joint interaction effects (JIEs) of EFT and the death-event (DEE), i.e., EFT*DEE (P=0.1168). It is negatively associated with creatinine phosphokinase (CPK) (P<0.0001) and serum sodium (SNa) (P<0.0001), while it is positively associated with their JIEs, i.e., CPK*SNa (P<0.0001). It is negatively associated with high blood pressure (BP) (P=0.0030). It is partially negatively associated with the JIEs of anaemia status (ANS) and time up to the end of the follow-up period (TFP) i.e., ANS*TFP (P=0.1299), while it is independent of both the ANS and TFP. It is negatively associated with the smoking status (SMS) (P=0.0007), and positively associated with the JIEs of SMS and TFP, i.e. SMS*TFP (P=0.0016). Variance of SCT is negative associated with age (P=0.0543) and ANS (P=0.0044), while it is positively associated with their JIEs, i.e. AGE*ANS (P=0.0070). SCT variance is negatively associated with CPK (P=0.0001), while it is partially positively associated with the JIEs of CPK and ANS i.e., CPK*ANS (P=0.1482). Variance of SCT is negatively associated with diabetes mellitus status (DMS) (P=0.0199), while it is positively associated with the JIEs of CPK and DMS i.e., CPK*DMS (P=0.0086). There are many more significant effects in the SCT variance model.

Conclusions: From this data set, it is clear that mean and variance of serum creatinine is associated with the heart, diabetes and anaemia patients. It affects age, EFT, CPK, SNa, PLC, BP, ANS, DMS, SMS, SEX, TFP, DEE and their many joint interaction effects.

Key words: Creatinine phosphokinase (CPK); Ejection fraction (EFT); Hypertension; Joint generalized linear models (JGLMs); Serum creatinine (SCT); Serum sodium (SNa)

1 Introduction

Globally, the prevalence of DM is increasing significantly. In 2000, 151 million people in the world had diabetes. With this increase, it has been projected that 221 million people will have diabetes in 2010 and 324 million by 2025 [1]. Type 2 diabetes accounts for 90 to 95% of the incidence of diabetes, and the current epidemic outbreak of diabetes reflects the high prevalence of type 2 diabetes. The Centers for Disease Control and Prevention (CDC) reported that in 2002, more than 18 million Americans, about 6.9% of the United States population, had diabetes [2].

The global statistics indicate that the burden of DM, precisely type II diabetes, is not restricted to developed nations but is also a problem for developing countries. Several studies in China, India, and Mauritius have indicated that the prevalence of type II DM is significantly high and steadily increasing. [3,4,5] Approximately 7.1 million Africans were said to be suffering from diabetes at the end of 2000. This figure was expected to rise to 18.6 million by 2030. [3, 4] Only a little data regarding the status of DM in Ethiopia is available. WHO estimated the number of diabetic cases in Ethiopia to be 800,000 by the year 2000, and this number is expected to increase to 1.8 million by 2030 [6] A study done in Jimma town has shown the prevalence of type II DM to be 5.3%, and 14.8% of participants in the survey had prediabetes? [7]

Diabetes is a significant cause of mortality worldwide, although several studies indicate that diabetes is likely underreported as a cause of death. In the United States, diabetes was listed as the sixth-leading cause of death in 2002. [2] A recent estimate suggested that diabetes was the fifth leading cause of death worldwide and was responsible for almost 3 million deaths annually (1.7–5.2% of deaths worldwide). [1] There are several well-established risk factors for type II DM, among which family history of type II DM, obesity, chronic physical inactivity, previously identified IGT or IFG, history of GDM or delivery of baby >4 Kg, HPN and dyslipidemia are prominent. The ADA recommends screening all individuals >45 years every 3 years and screening individuals at an earlier age if they are overweight and have one of the additional risk factors for diabetes.

Diabetes mellitus, both type I & II, is associated with acute and chronic complications. Acute complications include diabetic ketoacidosis, which is more common in type I, and hyperglycemic hyperosmolar state, which is primarily seen in type II DM. The chronic complications of DM affect many organ systems and are responsible for the majority of morbidity and mortality associated with the disease. Chronic complications can be divided into vascular and nonvascular complications. The vascular complications of DM are further subdivided into microvascular (retinopathy, neuropathy, and nephropathy) and microvascular complications (coronary artery disease (CAD), peripheral arterial disease (PAD), cerebrovascular disease). Nonvascular complications include problems such as gastroparesis, infections, and skin changes. Although glycemic control is central to diabetes management, diabetes care should be comprehensive, detect and manage DM-specific complications, and modify risk factors for DM-associated diseases. Significant components of DM management are diabetes education, medical, nutritional therapy, exercise, blood glucose monitoring, and pharmacotherapy. Insulin and oral glucose-lowering agents are the primary drugs for glycemic control [10].

Diabetes mellitus is a disease associated with different complications and significant morbidity and mortality worldwide, although the precise figures are lacking in Ethiopia up to the principal investigator's knowledge. Glycemic control is the primary target of diabetes management. It is essential for preventing and progressing complications, as several trials have indicated a strong correlation between glycemic control and complications in type II DM. One of these trials is a small study conducted in 110 lean Japanese subjects, which showed that multiple insulin injections, which resulted in better glycemic control (HgbA1c = 7.1%) compared with conventional treatment (HgbA1c = 9.4%), significantly reduced the microvascular complications of diabetes. [8] The United Kingdom Prospective Diabetes Study (UKPDS) trial is the largest trial conducted regarding the effect of glycemic control on the complications of type II DM. The results showed that retinopathy, nephropathy, and possibly neuropathy are benefited by lowering blood glucose levels in type 2 diabetes with intensive therapy, which achieved a median HbA1c of 7.0% compared with conventional treatment with a median HbA1c of 7.9% and the overall micro-vascular complication rate was decreased by 25%. It also showed a continuous relationship between the risks of microvascular complications and glycemia. For every percentage point decrease in HgbAlc (e.g., 9 to 8%), there was a 35% reduction in the risk of complications. The other finding of this trial was that there was no significant effect of lowering blood glucose on cardiovascular complications. However, there is a 16% reduction in the risk of combined fatal or nonfatal myocardial infarction and sudden death [9].

Another study in Menelik II Hospital in Addis Ababa indicated the association between glycemic control and complications. It found that 75% of diabetic patients with complications had poor control of FBS [12]. The American diabetic association (ADA) guideline also states that lowering hemoglobin A1C values has been associated with reducing microvascular complications of diabetes [9]. The general hemoglobin A1C goal for patients is less than 7%. It also recommends that more stringent goals, such as a standard hemoglobin A1C value of less than 6%, be considered in individual patients if they are achievable without significant hypoglycemia. Less stringent goals may be appropriate for patients with limited life expectancies, very young or older adults, and individuals with comorbid conditions [10].

Different studies show that glycemic control is affected by several factors: age, compliance to therapy, exercise, diet, obesity, cigarette smoking, self-monitoring of blood glucose levels, presence of comorbid conditions, duration of DM and medications used. Only a little has been done in JUSH regarding the level of glycemic control and its associated factors, which is the primary reason for conducting this study. This study will provide essential information regarding the attainment of glycemic control and factors contributing to it among type 2 diabetes patients having follow-ups in the hospital.

This study aims to determine the level of glycemic control and associated factors among patients with type 2 diabetes who had follow- at Yekatit 12 Hospital Medical College. 2024.

2 Methods and Materials

2.1 Study area

The study was conducted at Yekatit 12 Hospital and Medical College's Internal Medicine Department. Yekatit 12 Hospital was established in 11923G. Until the Ethiopian revolution of the 11970s, it was known as Haile Selassie I Hospital, named after Emperor Haile Selassie I. In addition, Yekatit 12 Hospital Medical College maintains electronic medical record systems, which streamline the process of collecting data for this study. These records contain detailed information on patient demographics, medical history, investigation results, diagnoses and disease progress over time. The hospital serves over 5 million people in its central 5 Departments in the catchment area. Addis Ababa was chosen as the study setting due to its diverse population, representing various socioeconomic backgrounds and cultural contexts. The city is known for its well-established healthcare infrastructure, making it a suitable location to access a significant number of emergency patients. An institutional-based cross-sectional study will be carried out in Yekatit 12 hospital medical colleges from May 1 to June 30, 2024.

2.2 Study Period

This study was conducted from May 1 to June 30, 2024.

2.3 Study Design

An institutional-based cross-sectional study design was applied

2.4 Population

2.4.1 Source population: All type 2 DM patients having follow-ups in Yekatit 12 Hospital Medical College.

2.4.2 Study Population: type 2 DM patients who attended at Yekatit 12 Hospital Medical College. From May 1 to June 30, 2024.

2.4.3 Sample population: 318 type 2 DM patients attending the Yekatit 12 Hospital Medical College from May 1 to June 30, 2024.

Eligibility Criteria

Patients included in this study were those who had at least two previous visits to the clinic

2.5 Sample size and Sampling method

$$n = \frac{Z^2 P(1-P)}{d^2}$$

$$n = \frac{(1.96)^2 (0.5)(1-0.5)}{(0.05)^2}$$

$$n = 384$$

Taking the level of significance α to be 95% and the margin of error d = 0.05 with P →0.5

$$\frac{n}{1+\frac{n}{N}}$$

After correcting the formula and using N=1800 (the total number of type 2 DM patients), the corrected sample size will be 318.

A systematic sampling technique was applied to select each study subject included in the study.[28]

2.6 Type of data and method of data collection

Both qualitative and quantitative data were collected. The principal investigator and a trained data collector who is a student in one of the health science disciplines accomplished data collection. Data were collected by interviewing using a questionnaire, measuring weight and height, and reviewing follow-up sheets, particularly for variables like FPG, medications used and comorbidity. Then, the data were filled out on a well-designed English-formatted questionnaire and a checklist.

2.7 Variables

2.7.1 Dependent

- FPG

2.7.2 Independent

- Age
- Compliance
- Exercise
- Obesity
- Cigarette smoking
- Medications
- Duration of DM
- Comorbidity
- Self-monitoring of blood glucose

2.8 Data quality assurance

A clear and well-designed questionnaire was prepared. The data collector was adequately trained before data collection and supervised by the principal investigator during the data collection. The questionnaire was pre-tested in about 50 subjects to ensure that its contents were appropriate for the subjects included in the study.

2.9 Data Analysis and Interpretation

The data was analyzed using computer software, Statistical Package for Social Studies version 21.0(SPSS 21.0). Results were presented in tables and pie charts, and a test of association (chi-square test) was performed among variables. A P-value of less than 0.05 was taken as significant. Finally, the study results were interpreted and presented in this final written report form, which will be submitted to the Medicine and Health Officer Coordinating Office.

2.10 Problems encountered

- Language barrier
- Inadequate budget
- Incomplete patient charts, especially difficulty in getting documented evidence of comorbid conditions.

2.11 Limitation

Unavailability of HbA1c in Yekatit 12 Hospital Medical College.

2.12 Ethical considerations

A formal approval letter was obtained from the Ethical Review Committee of the Yekatit 12 Hospital Public Health Department. Consent to the study participants was provided. All information collected from patients was kept confidential and used only for the intended purpose. If the participants are unwilling to respond, they can declare that they will discontinue participation during data collection at any time. Personal information, including names of patients, was not included in the questionnaire.

Definition of terms

Diabetes mellitus: the presence of one of the following:

- Symptoms of DM plus RBS concentration >11.1 mmol/L (200 mg/dL)
- FPG >7.0 mmol/L (126 mg/dL)
- Two-hour plasma glucose >11.1 mmol/L (200 mg/dL) during an oral glucose tolerance test (38)

Reasonable glycemic control: when target FPG of 90-130 mg/dl is achieved (10).

Poor glycemic control: when the level of FPG exceeds 130 mg/dl.

Noncompliance: less than 80% compliance with the prescribed regimen, calculated as the number of doses taken divided by the number specified [21].

Adequate physical exercise: 150 min/week (distributed over at least 3 days) of aerobic physical activity [10].

Obesity: BMI > 30 Kg/m2 (38).

Comorbid condition: documented evidence of one or more diabetes-associated conditions (HPN, dyslipidemia, cardiovascular diseases) (38).

Annual income (in Birr)

Low: < 9,515

Medium: 9,515 – 33,660

High: > 33,660 (39)

3 Results

Socio-demographic characteristics			Frequency	%
Age	<50		133	45.5
	50-65		124	42.5
	>65		35	12.0
Sex	Male		172	58.9
	Female		120	41.1
Educational status	Illiterate		92	31.5
	Read-and-write only		25	8.6
	Grade	1-4	36	12.3
		5-8	62	21.2
		9-12	24	8.2
	Coll. / University		53	18.2
Occupation	Unemployed		22	7.5
	Farmer		100	34.2
	Health Professional		6	2.1
	Government employee		67	22.9
	Merchant		97	33.2

Table 1: Frequency distribution of socio-demographic characteristics of type 2 DM patients having follow-up at Yekatit 12 Hospital Medical College, diabetes clinic, May 1- June 30, 2024

Factor affecting glycemic control			Glycemic control		Total	*P-value*
			Good	Poor		
Age (years)	<50		50(37.5%)	83(**62.5%**)	133	*0.006*
	50-65		59(47.5%)	65(52.5%)	124	
	>65		7(20%)	28(**80%**)	35	
Sex	Male		86(50%)	86(50%)	172	
	Female		30(25%)	90(**75%**)	120	*0.001*
Compliance	Yes		115(39.6%)	175(60.4%)	290	
	No		1 (50%)	1(50%)	2	
Regular physical exercise	Yes	Adequate	26(43.3%)	34(57.7%)	60	*0.6*
		Inadequate	20(34.4%)	38(**65.6%**)	58	
	No		70(40.2%)	104(**59.8%**)	174	
Smoking	Yes		4(50%)	4(50%)	8	
	No		112(39.4%)	172(60.6%)	284	
Comorbid condition	Yes		46(39.3%)	71(**60.7%**)	117	
	No		70(40%)	105(60%)	175	*0.8*
SMBG	Yes		26(39.4%)	40(60.6%)	66	
	No		90(39.8%)	136(60.2%)	226	*0.9*
Duration of DM (years)	0-1		20(37.7%)	33(**62.3%**)	53	*0.01*
	2-5		67(48.2%)	72(51.8%)	139	
	> 5		29(29%)	71(**71%**)	100	

Table 2: Frequency distribution of factors affecting glycemic control versus glycemic control among patients attending at Yekatit 12 Hospital Medical College, May 1- June 30, 2024

Anti-diabetic medication used	Glycemic control		Total
	Good	Poor	
Biguanide	11	18	29
Sulfonylurea	4	15	19
Insulin	**42**	**47**	89
Biguanide + Sulfonylurea	53	93	146
Biguanide + Insulin	**6**	**3**	9

Table 3: Frequency distribution of anti-diabetic agent used versus glycemic control among type 2 DM patients attending at Yekatit 12 Hospital Medical College, May 1- June 30, 2024

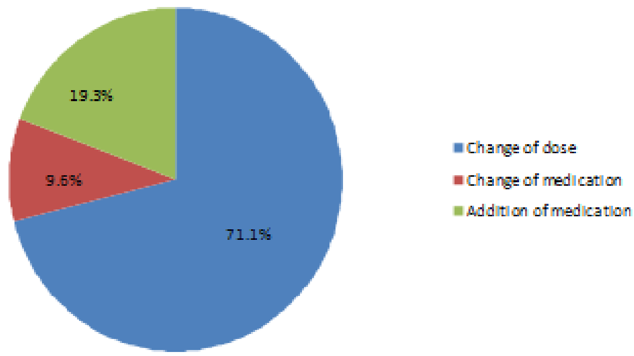

Figure 1: Distribution of types of modification of pharmacotherapy among patients of type 2 DM patients having follow-up at Yekatit 12 Hospital Medical College, May 1-June 30, 2024 G.C

Duration of DM (yrs)	Medication				
	Sulfonylurea	Biguanide	Insulin	Biguanide + Sulfonylurea	Insulin + Biguanide
0-1	7	7	6	29	2
2-5	6	5	54	67	7
>5	6	15	29	50	0

Table 4: Frequency distribution of medications versus duration of disease among patients of type 2 DM having follow-up in Yekatit 12 Hospital Medical College, May 1- June 30, 2024 G.C

4 Discussion

This study was conducted among 292 type 2 diabetes mellitus patients, making the response rate about 92%. It was seen that glycemic control was achieved in 39.3% of the patients, which is low but better than the

finding of a study conducted in an outpatient clinic in Gondar, which showed that only 23% of type 2 DM patients had reasonable glycemic control. [11] This study investigated the effect of several well-established factors on glycemic control among type 2 diabetes patients who had follow-ups at Yekatit 12 Hospital Medical College diabetes clinic. Glycemic control is achieved in 37.6%, 47.6% and only 20% of type 2 DM patients in the age groups less than 50, 50 to 65 and older than 65 years, respectively. It is seen that glycemic control is most difficult to achieve in elderly type 2 DM patients, particularly those older than 65. This supports the findings of several similar studies, which showed that glycemic control is challenging in this age group. [14, 27] There is also a statistically significant association between age and glycemic control (P=0.006) as opposed to the results of a longitudinal study conducted in California, which didn't find a significant association between the two. [13]

About 59% of the patients attending the clinic are male. It has been seen that glycemic control is far better in males than in females; it is achieved in 50% of male patients but only in 25% of female patients. There is also a statistically significant association between sex and glycemic control (p=0.001). This aligns with the result of a cross-sectional study conducted among Indian American type 2 diabetes patients.[27] Several studies have clearly shown that noncompliance significantly impacts morbidity, mortality and quality of life in diabetic patients, and improvement in compliance has a significant positive correlation with glycemic control. [13 .14. 15] However, this study showed that the compliance rate in the clinic is very high (more than 99%), minimizing its role as a significant determinant of glycemic control. Exercise is one of the integral components of diabetes management.[10] Several studies have also indicated a significant improvement in glycemic control with exercise. [18,19

Successful management of weight loss in obese patients with type 2 diabetes is capable of correcting many of the metabolic abnormalities associated with type 2 diabetes. [21, 22] Studies conducted in Greece and Ethiopia (Gondar) have also implicated BMI as one of the predictors of glycemic control, i.e., glycemic control improves with decreasing BMI. [11, 20] The findings of this study also support this fact. Glycemic control is achieved in 40.9% and 20% of overweight and obese type 2 diabetic patients, respectively, whereas it is attained in 41.2% of type 2 diabetics with normal BMI. Hypertension is the primary comorbid condition seen among patients of type 2 DM who have follow-up appointments in the clinic. Some studies have indicated that the presence of comorbid conditions may affect glycemic control, mainly because it may increase medication burden and indirectly affect compliance. A Gondar Hospital outpatient clinic study also indicated a negative correlation between HPN and glycemic control. [11] However, this study didn't indicate a significant difference in glycemic control in those with/out comorbid conditions. Glycemic control is attained in 39.3% of those with comorbid conditions and 40% without comorbid conditions. No statistically significant association exists between comorbid conditions and glycemic control (p=0.9).

It has been found that about 22.6% of type 2 diabetes patients attending the clinic practice SMBG, and the majority do this during physical exercise only. A study conducted in California revealed that frequent self-monitoring of blood glucose levels was associated with clinically and statistically better glycemic control regardless of diabetes therapy, and glycemic control is directly proportional to the monitoring intensity.[23] However, this study showed that SMBG, particularly during physical exercise only, doesn't significantly change glycemic control. Glycemic control is achieved in about 39% of patients in both groups, i.e., those who practice SMBG and those who do not. There is also no statistically significant difference in glycemic control between the two groups (p=0.95).

The majority (47.6%) of the patients included in the study had a disease of 2 to 5 years duration, and glycemic control was best achieved in this group; 48.2% had good glycemic control. Glycemic control was the most difficult to achieve in those with more than 5 years of disease; it was achieved in only 29%. A statistically significant association exists between the duration of type 2 DM and glycemic control (p=0.01). This result supports studies conducted in Ethiopia, Libya, and India, which showed a significant correlation between the two variables. [11,24,25]

A pharmacologic approach is essential for most type 2 DM patients. While various drugs are available, no single medication is proven superior for glycemic control. The most common regimen, metformin plus glibenclamide, is used by 50% of patients but achieves control in only 36.3%. In contrast, the least prescribed combination—insulin and metformin (3% of patients)—yields the best control at 66.7%. Insulin monotherapy also shows better outcomes, with 47% achieving glycemic control. These findings contradict a German study, which reported lower glycemic control in patients on insulin-based therapies.[26]

5 Conclusion

The incidence of glycemic control among type 2 diabetic patients in the hospital is low, although there is tremendous room for improvement. Several modifiable and non-modifiable factors were discovered to have a substantial impact on achieving glycemic control. The non-modifiable ones include age, gender, and disease duration, whereas the adjustable ones are physical exercise, obesity, drug selection, and pharmacotherapy change in cases of uncontrolled hyperglycemia. This study found that achieving glycemic control is difficult for elderly individuals, particularly those over 65 years old. It has also been demonstrated that noncompliance is not a significant barrier to achieving glycemic control because almost all of the patients are compliant with pharmacotherapy, implying that with the appropriate medication selection and therapy modification in uncontrolled cases of hyperglycemia, glycemic control can be significantly improved.

It has also encouraged a number of patients to engage in health-promoting behaviors and diabetes treatment components such as physical activity and smoking cessation. Still, the majority of people do not engage in physical activity, and even if they do, many of them do not meet the ADA's suggested intensity and frequency, which may be improved. The other conclusion is that practically all patients who practice SMBG do so only during physical activity, which was not shown to significantly improve glycemic control in the long run. Another noteworthy conclusion of this study is that as type 2 diabetes progresses, it becomes more difficult to maintain glycemic control. It was also discovered that there is some reluctance to start insulin or an insulin-containing combination regimen in patients with long-standing disease and poor glycemic control, as the majority of these patients have poor glycemic control but are on metformin/glibenclamide combination therapy. Compared to other mono/combination pharmacotherapeutic treatments, insulin alone or insulin/metformin combination therapy has shown greater results when it comes to anti-diabetic drugs. The achievement of glycemic control was also found to be adversely affected by the failure to correctly alter medication in uncontrolled cases of hyperglycemia.

List of abbreviations

ADA: American Diabetes Association

BMI: Body mass index

CAD: Coronary artery disease

CDC: Center for Disease Control

DM: Diabetes mellitus

FPG: Fasting plasma glucose

GDM: Gestational diabetes mellitus

HbA1c: Hemoglobin A1c

HEPA: Health-enhancing physical activity

HPN: Hypertension

IFG: Impaired fasting glucose

IGT: Impaired glucose tolerance

JUSH: Jimma University specialized hospital

PAD: Peripheral arterial disease

RBS: Random blood sugar

SMBG: Self-monitoring of blood glucose

WHO: World Health Organization

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DOI: 10.31579/2640-1045/207