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Diabetic complications and healthy diets are related to glycemic levels among type 2 diabetes patients in Nairobi County, Kenya; A 3-month follow-up study

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Abstract

Introduction: Diabetes is a chronic metabolic disease, caused by prolonged high blood sugars, resulting from inadequate insulin or reduced sensitivity to its action. Understanding the longitudinal trends of glycemic levels among Type 2 Diabetes (T2DM) patients could improve their quality of care and reduce the related-costs. **Methods:** This study was conducted from August to November 2023. We assessed glycemic trends among patients with Type 2 Diabetes Mellitus (T2DM) using a longitudinal study design. Two public health hospitals in Nairobi city County were purposively selected due to their high burden of T2DM. Through a convenient sampling we enrolled all the eligible patients during the study period from the diabetes clinics in the two hospitals resulting to a total of 122 participants (31 from Mbagathi and 91 Mama Lucy Kibaki hospital. These were followed up for three months. This sample size was verified through a post- hoc power analysis to ensure adequate power for our study analysis. Using an interviewer-administered questionnaire we gathered patients' characteristics, while their Hemoglobin A1C (HbA1c) levels, determining their glycemic levels, were measured through blood tests. Multilevel logistic regression analysis was performed at $p<0.05$ to identify predictors of glycemic levels. **Results:** In the 3-month follow-up, we obtained 323 hemoglobin A1C (HbA1c) test reports from 122 T2DM patients. 237 (74%) of these HbA1c reports had elevated glycemic levels defined as HBA1C of >7.0, regardless of the follow-up month. Elevated glycemic level were frequent among females (70%) and patients aged above 50 years (68%). Over time, proportion of patients with elevated glycemic levels increased from 66% to 79%. Additionally, the use of combination therapies that included Metformin, Glibenclamide, or insulin rose from 47% to 80%. Diabetes complications (Odds ratio (OR) = 9.4, 95% confidence interval (CI) 1.04, 85.2), daily fruits and vegetable servings (OR=0.2, 95% CI 0.04, 0.6) were independently related to elevated glycemic levels among T2DM patients. **Conclusion:** We establish association between elevated glycemic levels with diabetes complications and fruits and vegetable diets, underscoring the importance of implementing patient centered interventions promoting earlycomplications detection, effective treatment, and optimal glycemic control for T2DM patients while improving their quality of life.

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Introduction

Globally, Type 2 Diabetes (T2DM) poses a significant public health challenge, with approximately 462 million cases reported [1]. T2DM is associated with increasing morbidity rates, premature deaths, and decreased life expectancy, particularly in developing countries. These issues are often associated with rapid urbanization, shifts in lifestyle, unhealthy diets, high Body Mass Index (BMI), poor medication adherence, and limited access to healthcare [2-5]. Patients with T2DM face a higher risk of complications, including neuropathies, retinopathies, diabetic foot problems, leg amputations, kidney disease, hypoglycemia, hyperglycemia, and various heart-related complications. These complications are all worsened by patients' low economic status and educational levels [6,7]. Such health challenges significantly impact patients' quality of life, diminishing their physical, psychological, and social well-being [8,9]. Maintaining a Hemoglobin A1C (HbA1c) level of less than 7% is critical for managing diabetes effectively and reducing the risks of complications associated hospital visits and healthcare costs [10-14].

Patients with T2DM consuming unhealthy diets and not adhering to their prescribed diabetic medications are at an increased risk of having elevated glycemic levels, often reflected by an HbA1c greater than 7% [15-18]. In Sub-Saharan Africa, particularly in Kenya, awareness of T2DM management is further hampered by several barriers to patient care. These include limited access to quality healthcare services, incomplete prescriptions, inadequate knowledge about diabetes care, and poor record-keeping, which limits follow-up data on patient management [19]. Recognizing these gaps and understanding the longitudinal trends in glycemic levels among T2DM patients provide valuable insights for designing effective, patient-centered interventions aimed at achieving optimal glycemic control [20-22]. This study aimed to achieve two interconnected objectives: 1) to identify longitudinal patterns of glycemic status over time and (2) determine associated independent variables for elevated glycemic levels.

Methods

Study site

This study was conducted at Mbagathi and Mama Lucy Kibaki hospitals in Nairobi City County, among the largest urban centers in Kenya. These hospitals are the largest public Level 4 facilities in Nairobi County and operate specialized outpatient clinics for diabetes patients, handling the highest volume of diagnosed diabetes cases in the area. Mbagathi Hospital has a bed capacity of 227, while Mama Lucy Kibaki Hospital has a capacity of 197. Each facility hosts a monthly specialized diabetic outpatient clinic, serving to a range of 30 to 50 patients weekly at Mbagathi Hospital and 100 to 150 patients at Mama Lucy Kibaki Hospital. Mbagathi Hospital is in the Lang'ata constituency, while Mama Lucy Kibaki Hospital is situated in the Embakasi central constituency of Nairobi city County.

Study design and sampling

This study adopted a longitudinal study design to follow up 122 censured T2DM patients over the age of 18 years, and followed them for 3 months, all sampled using a sampling frame obtained from the patients records from Mbagathi and Mama Lucy Kibaki hospitals. During follow up, all patients were evaluated for diabetes complications and their glycemic levels monitored.

Study variables

We collected data on demographic and economic characteristics from patients using an interviewer-administered questionnaire. This included details such as age, sex, occupation, education level, income, and marital status. Additionally, we documented clinical factors related to the patients, including the duration of diabetes treatment, the medications used, their dosages, and any side effects experienced. Other characteristics obtained included the patient's body mass index, family history of diabetes, and complications associated with the condition. We obtained behavioral factors including physical exercise categorized into short or long intensity, diet, self-blood sugar monitoring, and medication adherence.

A clinical assessment included measuring Blood Pressure (BP) in mm/Hg using a sphygmomanometer. Body Mass Index (BMI) was calculated based on the weights and heights obtained from a weighing machine. For glucose monitoring, Glycosylated Hemoglobin (HbA1c) levels were assessed to determine glycemic control. During each follow-up for three months, 2 ml of venous blood was drawn from patients and placed into an EDTA bottle labeled with the patient's code. This blood was then analyzed for HbA1c levels using a cobas analyzer with a cobas Integra hemolyzing reagent, employing a turbidimetric inhibition immunoassay for hemolyzed whole blood [23,24]. Results for HbA1c are provided as a percentage, calculated as the ratio of HbA1c to hemoglobin. A HbA1c level of 7% or more is considered to indicate elevated glycemic levels for patients with type 2 diabetes [25,26]. All laboratory tests investigations were conducted at Mama Lucy Kibaki and Mbagathi Hospitals which are registered and certified by the Laboratory Board of Kenya, employing trained laboratory professionals.

Data analysis

Clustering analyses of glycemic measurements: We collected repeated measures data monthly from the same subjects, allowing us to define each patient as a cluster that consists of multiple temporal observations. To quantify these correlations, we estimated Intra-cluster Correlation Coefficients (ICC) using the residual variance, which is approximately 3.29, a value commonly used in the standard logistic distribution. This was assumed to represent the Level 1 variance component, along with the patient-level variance, which was derived from fitting mixed-effects multilevel logistic regression models [27].

Estimating the association between elevated glycemic level and independent variables: Adjusting for patient-level clustering, we fitted Generalized Mixed Effect Models (GLMM) with a binomial distribution and a logit function to examine how independent variables affect glycemic level. In the first step, we constructed multilevel univariable models using a less stringent significance level of $P \leq 0.1$ to identify individual significant variables associated with elevated glycemic levels. In the next step, we evaluated the assumption that the log-odds of glycemic status occurrence increases with a variable, we created a quadratic term for continuous variables such as fruit servings and age (the variable squared) and assessed whether the linearity assumption was violated.

In the second step, we extended these models to create multilevel-multivariable models that control independent variables related to glycemic levels. All GLMMs were fitted using the maximum likelihood method with Laplace approximation, incorporating patient identification as random effects. In the

multivariable analysis we included sex and age in the models to account for their potential confounding effects. The final model was selected through a backward-stepwise selection process, during which variables not significantly predicting risks associated with glycemic levels were gradually removed based on low values of the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC), indicating a better-fitting model. All analyses were conducted using R software version 4.5.0.

Ethical review statement

We sought ethical clearance for this study from AMREF Health Africa Ethics and Scientific Review Committee, approval number ESRC P1416/2023. Research permits were also sought from the National commission for science technology and innovation (NACOSTI) under License number NACOSTI/P/23/26755. All the patients aged above 18 years provided their consent to participate in the study.

Results

Type 2 Diabetic (T2DM) patient characteristics

Of the 122 patients with Types 2 Diabetes (T2DM), a majority (64%) were females. The average patient's age was 57±13 years, ranging between 25 and 85 years. Most (62%) of the patients attained secondary or post-secondary education. About two-thirds (77%) of the patients were married, while the remaining patients were either single, divorced or widowed. Additionally, most (55%) of the patients were employed in informal employment, while the rest worked in formal occupations, retired, or unemployed. About 68% of the participants were earning less than 10,000 Kenya shillings (Table 1).

The median and Interquartile range in years for patients living with diabetes was 7 and 8 respectively. These patients were on diabetes treatment for a median and Interquartile range in years 10 and 12, respectively. The monthly median and interquartile range for diabetes treatment costs in Kenya Shillings (KES) was 1800 and 2000, respectively, ranging to a maximum of 25,000.

Diabetes status among T2DM patients

Table 2 describes diabetes status of the 122 T2DM patients. Half of the patients (52%) came from families with a history of diabetes. One in five (21%) of the patients were admitted to the hospital due to diabetes-related complications, with a median admission time of 2 months and an interquartile range of 4 months, extending to a maximum of about one year. Most (69%) of the patients were using oral medication, while the rest using insulin injections or a combination of both. Additionally, 70% of patients could identify their medications by color, shape, and labels. In terms of storage, 40% of patients kept their medications in cupboards, 23% in bags, and 9% in the fridge, with the rest using a combination of these locations. Almost all patients (97%) were aware of their daily medication doses and the timing for taking them. Most patients (83%) had been taking their medication for more than three months prior to the start of this study. However, one in three patients (34%) reported occasionally forgetting to take their medication, with a median of two days and an interquartile range of one day for missed doses. Only 9 patients (7%) reported experiencing side effects from their diabetes medications, which included diarrhea, dizziness, general body itchiness, nausea and vomiting, heartburn, hypoglycemia, and increased thirst. Moreover, more than half

Table 1: T2DM patient characteristics (n=122).

Variable	Levels	Frequency	%
Sex	Female	78	63.9
	Male	44	36.1
Age in years	Below 50	37	33.1
	50 to 65	56	45.9
	Above 65	29	23.8
Education level	No education, Primary	46	37.7
	Secondary	51	41.8
	Post secondary	25	20.5
Marital status	Divorced, single, widowed	28	23.0
	Married	93	77.0
Occupation	Formal employment	14	11.5
	Informal employment	68	55.7
	Unemployed, retired	40	32.8
Monthly income	<10,000	82	67.8
	≥10,000	39	32.2

(50%) of the patients were diagnosed with hypertension with a majority (95%) receiving treatment. Other chronic conditions identified in the patients' clinical records included heart disease, hyperlipidemia, and osteoarthritis, among others. Most patients (52%) followed healthy diet plans involving cutting or reducing sweet carbohydrates and fatty meals. Additionally, a majority (62%) of these patients were obese or overweight, while the remaining patients having normal body weight. Over 55% of the patients engaged in physical activity. Notably, only one patient smoked cigarettes and seven patients (6%) consumed alcohol. Fewer than 14% of the patients reported diabetes complications including nerves complication (35%), eye and dyslipidemia (17%), and diabetic foot (12%) among others. Of the 17 patients with current complications, only 3 (18%) required hospitalization. The diabetes status of patients during follow-up is shown in Table 2.

Longitudinal follow up and retention of patients

During the 3-month follow-up period, from August to November 2023, we collected a total of 323 reports out of the expected 366, resulting in a response rate of 88%. We received reports consistently each week, with data obtained from 89 out of the 122 participants (73%). Only 10 participants were lost to follow-up (Figure 1).

Longitudinal glycemic levels

During the 3-month follow-up, we obtained 323 reports of glycemic measurements (HbA1c). Of these, 86 reports (27%) indicated good glycemic levels, while 237 reports (73%) showed elevated glycemic levels. Among the reports of good glycemic levels, 44 (51%) came from females, and the majority, 70 reports (81%), were from individuals aged under 65 years (Figure 2). Over time, the number of good glycemic measurement reports slightly decreased among females and males (Figure 2A). For the 237 reports of poor glycemic level, 166 (70%) were from females, and 176 (70%) were from participants aged under 65 years. At the patient level, the proportion of patients with low glycemic levels decreased from 34% to 23% over time, regardless of age or sex. Conversely, the proportion of patients with elevated glycemic levels increased from 66% to 79% over

Table 2: Diabetes (DB) status among patients.

Variable	Levels	Baseline (n=122)		1 st follow up (n=109)		2nd follow up (n=92)	
		Freq[1]	(%)	Freq[1]	(%)	Freq[1]	(%)
Treatment mode of payment	Cash payment	54	44	44	40	38	41
	Insurance	68	56	65	60	54	59
Family member with DB	No, don't know	58	48	53	49	43	47
	Yes	64	52	56	51	49	53
Ever admitted for DB complication	No	97	80	85	78	72	78
	Yes	25	20	24	22	20	22
DB Complications admitted for	Uncontrolled sugar	15	84	14	79	11	80
	Diabetic coma, foot	6	24	6	25	6	30
	Stroke	2	8	2	8	2	10
	Hyperglycemia, BP[2]	1	4	1	4	1	5
	Eye problem	1	4	1	4		0
DB treatment	Oral medication	85	70	78	71	63	68
	injection	15	12	16	15	14	15
	Combined Insulin and orals	22	18	15	14	15	16
Name DB medications	No	36	30	30	27	21	23
	Yes	86	70	79	73	71	77
Identify their medication	Label	39	32	48	44	38	41
	Shape color	23	19	12	11	1	1
	Color	17	14	16	15	17	18
	Shape color label	12	10	10	9	7	8
	Depend on others	10	8	6	6	4	4
	Color label	9	7	6	6	8	9
	Shape	6	5	9	8	12	13
	Shape label	6	5	2	2	5	5
Where to store DB meds	Cupboard	49	40	47	41	34	37
	Bag	28	23	29	27	25	27
	Fridge	11	9	10	9	9	10
	Tin	4	3	4	4	4	4
	Combined	30	25	21	19	20	22
Dose taking daily	No	4	3	3	3	1	1
	Yes	118	97	106	97	91	99
Aware time take meds	No	4	3	1	1		0
	Yes	114	97	105	99	91	100
How long taking DB medication	<3 months	21	18	8	7	18	20
	>3 months	100	83	101	93	74	80
Forgot taking DB medication	No	80	66	91	83	75	82
	Yes	42	34	18	17	17	18
Current DB complication	No	105	86	101	93	88	96
	Yes	17	14	8	7	4	4
Complication	Uncontrolled sugars	4	22	1	13		0
	Neuropathy	3	17	4	50	4	100
	Retinopathy	2	11	1	13		0
	Dyslipidemia	2	11		0		0
	Other complications[3]	7	39	2	25	0	0

Hypertensive	Yes	62	59	68	62	51	55
	No	44	41	41	38	41	45
	Missing	16					
Have glucometer strips	No	59	48	47	43	35	38
	Yes	63	52	62	57	57	62
Chronic condition	Heart disease	4	3		0	2	2
	hyperlipidemia	5	4	3	3	16	17
	Osteoarthritis	17	14	13	12	13	14
	Cancer	1	1		0		0
	Other conditions[4]	23	19	19	17	20	22
	No condition	72	59	74	68	41	45
Follow healthy diet plan	No	34	28	20	18	18	20
	Yes	88	72	89	82	74	80
Healthy diet plan involve.	Cutting sweet carbs and fatty meals	46	52	-	0	69	93
	Reducing sweet carbs	31	36	8	9	3	4
	Cutting fatty meals	11	13	81	91	2	3
	Missing	34		20		18	
Engage in physical activity	No	55	45	49	45	37	40
	Yes	67	55	60	55	55	60
Smoke cigarettes	No	121	99	108	99	90	98
	Yes	1	1	1	1	2	2
Take alcohol	No	115	94	106	97	91	99
	Yes	7	6	3	3	1	1
BMI[5]	Healthy weight	45	37	31	28	35	38
	Obese	30	25	33	30	27	29
	Overweight	47	38	45	42	30	33

[1]Freq refers to Frequency; [2]Blood pressure; [3]Other complications include diabetic foot, heart complications, kidney complications, leg amputation and nephropathy each with less than ≤2 occurrences; [4]Other conditions include asthma, eye problem, HIV, stroke, skin condition, Kidney disease, Neuropathy, Prostate hypertrophy, Stroke and Thyroid each with less than ≤3 occurrences; [5]BMI refers for body mass index.

the same period (Figure 2). Elevated glycemic levels were frequent among females compared to males and among those aged below 65 years. On the other hand, good glycemic levels were frequent among male compared to female and those aged above 50 years.

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Distribution of diabetes medication and their comorbidity

The commonly used antidiabetic medications among patients included Metformin, insulin, and Glibenclamide, among others. Over time, the proportion of patients using insulin or combination therapy, which consists of Metformin and other medications, increased. Conversely, the number of patients primarily using Metformin decreased from 36% to 17%. Among the various insulin prescriptions, Insulin Mixtard was the most frequently prescribed, accounting for 70% of prescriptions, while Humulin was prescribed in less than 18%. The use of Insulin Mixtard increased from 71% to 83%, while the prescription rate for Humulin rose from 2% to 18% over time (Table 3). Overall, more than 85% of diabetes patients were prescribed more than two types of medications. The percentage of patients prescribed only one diabetes drug slightly decreased from 15%

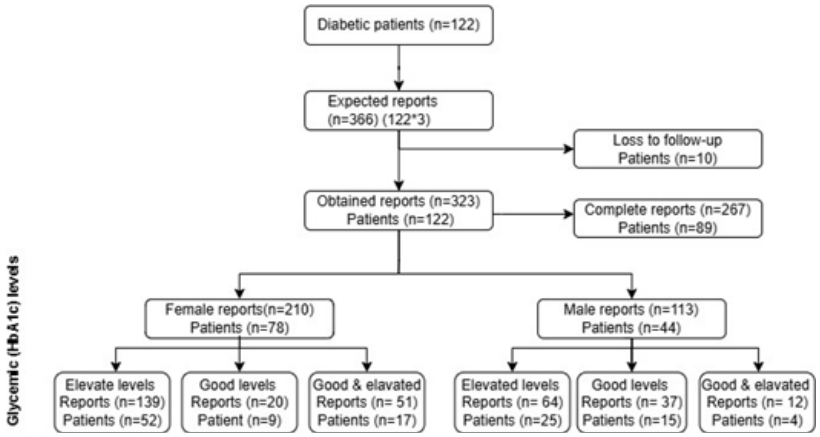

Figure 1: Schematic diagram showing the flow of the descriptive profile of diabetic patients.

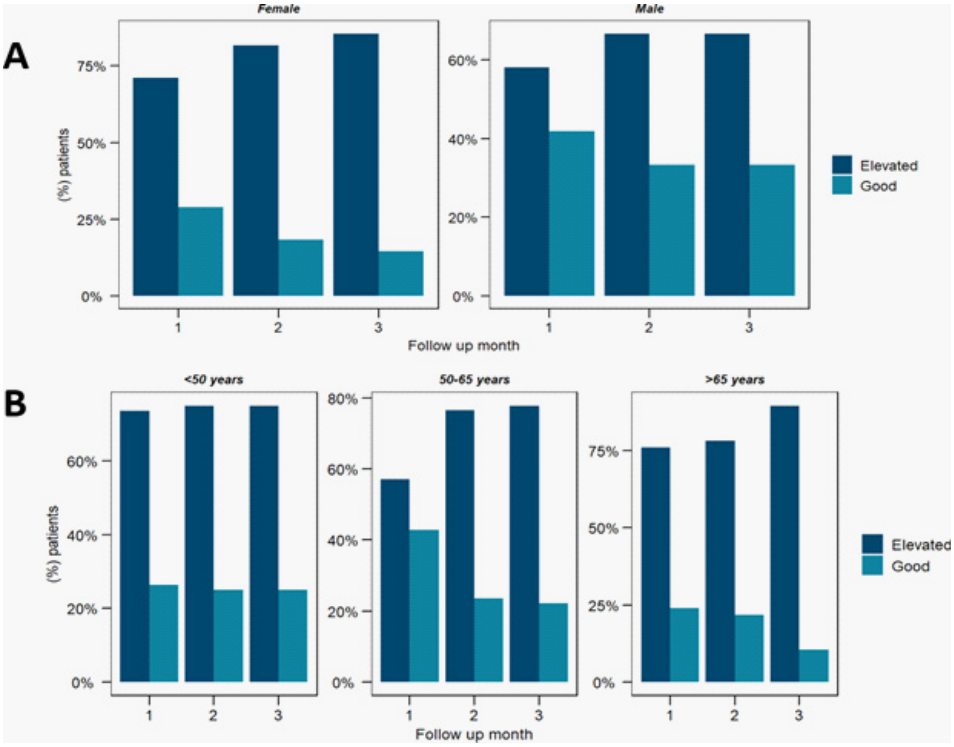

Figure 2: Longitudinal distribution of glycemic control among diabetes patients by age and sex.

Table 3: Distribution of diabetes comorbidity and prescribed medication.

Variable	Level	Baseline (n=122)				2nd follow up (n=92)	
		Freq	(%)	Freq	(%)	Freq	(%)
Comorbidity	No	91	75	59	54	38	41
	Yes	31	25	50	46	54	59
Antidiabetic medication	Metformin	44	36	22	20	16	17
	Metformin, glibenclamide	38	31	35	32	25	27
	Insulin	13	11	12	11	13	14
	Metformin, other[1]	9	7	17	16	23	25
	Metformin, insulin	7	6	14	13	9	10
	Metformin, glibenclamide, insulin	3	2	4	4	4	4
	Glibenclamide	1	1	1	1		0
	None	4	3	3	3	2	2
	Other[1]	3	2	1	1		0

Insulin prescribed	Insulin mixtard	10	71	9	82	10	83
	Humulin	2	14	2	18	-	0
	Regular insulin humulin	1	7	-	0	-	0
	Soluble insulin	1	7	-	0	-	0
	Humulin insulin mixtard	-	0	-	0	2	17
Taking comorbidity medication	No	75	61	71	65	50	54
	Yes	47	38	38	35	42	46
No. prescribed drugs	1	18	15	13	12	12	13
	2 to 4	76	62	66	61	57	62
	>5	28	23	30	27	23	25
HBA1AC	Good	40	34	25	23	19	21
	Poor	79	66	85	77	73	79

[1]Other antidiabetic medications include dapagliflozin, Diamicron, Empiget, Sitagliptin, Trevi met, Amlodipine, pregabalin, Rovista, Varinil and Losartan.

to 13%, while those prescribed more than two drugs increased slightly. Additionally, the incidence of comorbidities among patients rose significantly, from 25% to 59% during the follow-up period. Patients receiving medication for comorbidities also increased, from 38% to 46% over time (Table 3).

Univariate analysis

Univariate analysis associated months of diabetes medication use, diabetes complications, daily fruit and vegetable servings, and type of diabetes medication to glycemic levels, with significance at $p<0.1$ (Table 4).

Multivariate analysis

In multivariate analysis, glycemic level is independently associated with diabetes complication and daily fruit servings at $p<0.05$. Patients with diabetes who experienced complications were nine-fold likely to have elevated glycemic levels when controlling for other factors. Additionally, patients taking daily fruit and vegetable servings were at 85% reduced risk of elevated glycemic levels holding all factors constant (Table 5). While the risk of elevated glycemic levels decreases among female patients, it increases with age when controlling for other factors, though this finding is not statistically significant at $p>0.05$.

Considering significant risk factors, the variance estimate that measured the variation in the frequency of the outcome among the 122 patients was 180.1. In contrast, the residual variance (Level 1), which accounted for the variation in repeated measures of the outcome over time, was 3.29. Only 2% of the overall variation occurred across the repeated measures, resulting in an Inter-cluster Correlation Coefficient (ICC) of 0.02. This was calculated using the formula 3.29 / (180.1+3.29) for Level 1. On the other hand, 98% of the overall variation was observed at the patient level, yielding an ICC of 0.98, calculated as 180.1 / (180.1+3.29) for Level 2. This latter ICC represents the correlation of the outcome for a random subject at two different time points, t and t', where $t \neq t'$.

Discussion

This study established a longitudinal trend of glycemic levels among type 2 diabetes patients in an urban setting. Elevated glycemic levels are associated with diabetes complications and intake of fruits and vegetables. Risks of elevated glycemic levels increases with age, highlighting the need for age- and sex-specific interventions for better glycemic control, similar to findings from a study conducted in Ethiopia [28]. Given that half of the patients reported neuropathies, retinopathies, diabetic foot, among other complications from diabetes, a holistic approach integrating complication management is essential. To improve or maintain glycemic targets for diabetics, patient-centered interventions are necessary. These should include early diagnosis, treatment of complications, and nutrition counseling promoting healthy food choices and eating patterns rich in fruits and vegetables [29,30].

Diabetes complications were associated with elevated glycemic levels among diabetics by ninefold, suggesting a likelihood of high pill burden for complications treatment. Consequently, this raises the risk of medication non-adherence. Indeed, three in ten diabetes patients with complications used combined therapy medication often forgot to take their medications. Consistent with our findings, studies in Turkey and Ethiopia show high pill burden is linked to elevated glycemic levels among patients with type 2 diabetes [31,32]. Moreover, diabetes complications lead to additional healthcare costs, which included expenses for dialysis, renal transplants, hospital admissions, emergency visits, and medications. These costs affect the overall accessibility of diabetes healthcare services [33,34]. Providing timely diabetes care while addressing medication costs and side effects is essential for ensuring medication adherence. This approach promotes patient-centered therapy combinations and appropriate prescriptions for maintaining recommended glycemic levels, as well as improving access to quality care [35,36].

Consuming daily servings of fruits and vegetables was associated with reduced risk of elevated glycemic levels by 85%, suggesting their protective role in managing blood glucose. These foods are rich sources of soluble dietary fiber, which slows down the digestion and absorption of sugar in the body's cells. This slows metabolism, aiding in blood sugar regulation and lowering cholesterol levels [37-39]. Most patients with good glycemic control reported consuming fruits and vegetables daily, which is consistent with findings from a study conducted in Saudi Arabia [40]. Promoting access to and adherence to a healthy diet rich in fruits and vegetables is crucial for managing type 2 diabetes. Additionally, it helps reduce the risk of metabolic diseases such as obesity and cardiovascular disease, supports intestinal health, and decreases incidence of certain types of cancer [41,42] Fruits and vegetables serve as functional foods to alleviate symptoms of diabetes [43].

Table 4: Univariate analysis of factors associated with glycemic control among type two diabetes patients.

Variable	Level	OR	OR 95% CI	P-value
Month		0.21	0.09, 0.50	0.000
Sex	Male	Ref.	-	-
	Female	0.32	0.03, 3.53	0.353
Age in years	≤50	Ref.	-	-
	50-65	1.03	0.08, 13.91	0.984
	≥65	0.83	0.04, 18.66	0.908
Education level	Primary	Ref.	-	-
	Secondary	0.86	0.07, 10.75	0.906
	Tertiary	1.13	0.05, 24.28	0.936
Marital status	Divorced, single, widowed	Ref.	-	-
	Married	1.29	0.09, 19.60	0.853
Occupation	Unemployed, retired	Ref.	-	-
	Formal	1.62	0.03, 87.15	0.811
	Informal	0.63	0.05, 7.50	0.712
Income cat	≤10000	Ref.	-	-
	>10000	0.88	0.08, 9.83	0.916
Years taking DB treatment		0.92	0.77, 1.09	0.331
Years of living with DB		0.91	0.74, 1.11	0.349
DB treatment payment	Cash payment	Ref.	-	-
	Insurance	1.39	0.14. 13.58	0.776
Diabetic family member	Don't know, no	Ref.	-	-
	Yes	0.75	0.08, 7.14	0.804
DB complication admittance	No	Ref.	-	-
	Yes	0.74	0.05,11.85	0.832
Weight (Kgs)	Mean=73.4±13.6	0.97	0.90,1.05	0.436
Height (M)	Mean=1.61±0.09	758.6	337.6, 1704	0.1946
BMI	Mean= 27.2±4.5	0.82	0.65, 1.03	0.09
Systolic BP		0.98	0.94,1.02	0.234
Diastolic BP		0.99	0.94, 1.06	0.904
Diabetic treatment type	Injection and oral	Ref.	-	-
	Injection	0.08	0.001, 5.05	0.232
	Oral	1.61	0.17, 14.88	0.0674
Months taking medications	<3 months	Ref.	-	-
	≥3 months	8.05	0.78, 83.16	0.080
Forgot taking medication	No	Ref.	-	-
	Yes	0.53	0.09, 3.11	0.485
Medication side effect	No			
	Yes	8.74	0.64, 0.01	0.103
DB complication reports	No			
	Yes	6.52	1.02, 41.68	0.048
Complication admittance	No	Ref.	-	-
	Yes	1.67	0.13, 21.73	0.697
Hypertensive	No	Ref.	-	-
	Yes	4.84	0.60, 39.35	0.14
Test blood sugar	No			
	Yes	0.15	0.01, 2.34	0.175

Have glucometer strips	No	Ref.	-	-
	Yes	0.65	0.15, 2.86	0.57
Follow healthy diet plan	No	Ref.	-	-
	Yes	0.32	0.07, 1.54	0.155
Daily fruits vegetable servings		0.17	0.05, 0.66	0.010
Engage physical activity	No	Ref.	-	-
	Yes	3.36	0.76,14.92	0.111
Take alcohol	No	Ref.	-	-
	Yes	1.73	0.02, 0.01	0.807
No. prescribed drugs	>1	Ref.	-	-
	2-4	0.49	0.07, 3.52	0.480
	>5	0.53	0.04, 6.46	0.622
Fasting blood sugar	Diabetic	Ref.	-	-
	Normal	0.67	0.24, 1.90	0.457
	Pre-diabetic	1.89	0.48, 7.39	0.362

DB: Diabetes.

Table 5: Multivariate analysis of factors associated with glycemic levels among diabetes patients.

Variable	Level	OR1	OR (95% CI2)	P-value
Diabetes complication reports	No	Ref	-	-
	Yes	9.39	1.04, 85.23	0.047
Daily fruits vegetable servings		0.15	0.04, 0.61	0.008
Age categories	<50	Ref	-	-
	50-65	1.19	0,05, 30.6	0.915
	>65	1.53	0.03, 78.6	0.832
Sex	Female	0.28	0.02, 5.45	0.404
	Male	Ref	-	
Parameters	AIC	277		
	BIC	303.5		
	Log-Likelihood	-131.5		
Variance	Patients (Level 2)	180.1		
	Residual (Level 1)	3.29		

[1]OR: Odds ratio; [2]CI: Confidence interval

Patients who have been on diabetes medication for over three months are more likely to experience elevated glycemic levels, perhaps indicating disease progression. This advancement is often associated with the long duration of medication use or the choice of treatment, such as oral medications and injections, which can lead to side effects and issues with treatment compliance. These factors have been linked to higher glycemic levels, as indicated by studies conducted in Sub-Saharan Africa [44-46]. Additionally, fewer patients (7%) with poor glycemic control reported experiencing side effects from their medications, including nausea, vomiting, flatulence, and diarrhea. These side effects can negatively impact their treatment adherence [46]. Strengthening of the healthcare systems and facilities providing timely care, addressing treatment intensification, managing medication costs or side effects ensuring medication compliance while improving overall quality of care [35].

We acknowledge several limitations in our study. First, since our study sites being the primary referral hospitals in the county, our findings may not fully represent the entire population, as we cannot rule out missing population-level representation. However, the three-month follow-up period assessed the relationship between associated factors linked to elevated glycemic levels. Second, the weekly self-reported data on diet, physical activity, and self-care may be subject to recall bias. Nevertheless, the weekly data collection has been found to be relatively credible and reliable. Third, although we lost 10% of patients during the study period, our high response rate of 88% significantly minimized non-responder and selection bias. Moreover, the multilevel analysis statistically accounted for the missing data.

In conclusion, this study found that glycemic levels increase with age among type 2 diabetes patients in an urban setting. Elevated glycemic levels are linked to diabetic complications and unhealthy dietary practices. Implementing appropriate patient-centered interventions is essential for maintaining optimal glycemic control and improving the quality of life, as well as for preventing and facilitating early detection and treatment of diabetes complications.

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References

1. Khan MAB, Hashim MJ, King JK, Govender RD, Mustafa H, Al Kaabi J. Epidemiology of Type 2 Diabetes - Global Burden of Disease and Forecasted Trends. J Epidemiol Glob Health. 2020; 10: 107-111.
2. Moradi-Lakeh M, Forouzanfar MH, El Bcheraoui C, et al. High Fasting Plasma Glucose, Diabetes, and Its Risk Factors in the Eastern Mediterranean Region, 1990-2013: Findings From the Global Burden of Disease Study 2013. Diabetes Care. 2017; 40: 22-29.
3. Zheng Y, Ley SH, Hu FB. Global aetiology and epidemiology of type 2 diabetes mellitus and its complications. Nat Rev Endocrinol. 2018; 14: 88-98.
4. Tancredi M, Rosengren A, Svensson AM, et al. Excess Mortality among Persons with Type 2 Diabetes. N Engl J Med. 2015; 373: 1720-1732.
5. Sun H, Saeedi P, Karuranga S, et al. IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. Diabetes Res Clin Pract. 2022; 183.
6. Saeedi P, Salpea P, Karuranga S, et al. Mortality attributable to diabetes in 20-79 years old adults, 2019 estimates: Results from the International Diabetes Federation Diabetes Atlas, 9th edition. Diabetes Res Clin Pract. 2020; 162.
7. Harding JL, Pavkov ME, Magliano DJ, Shaw JE, Gregg EW. Global trends in diabetes complications: a review of current evidence. Diabetologia. 2019; 62: 3-16.
8. Bazpour M, Rostampour S, Kamel-Khodabandeh A. Assessment of Quality of Life and Self-care Behaviors in Patients with Type 2 Diabetes Mellitus in Mashhad, Iran. Jundishapur J Chronic Dis Care. 2021; 10.
9. E.K G, C.F O, E.N O, M.C M. Assessment of the Perceived Quality of Life of Non insulin Dependent Diabetic patients attending the Diabetes Clinic in Kenyatta National Hospital. IOSR J Pharm. 2014; 4: 15-21.
10. Laiteerapong N, Ham SA, Gao Y, et al. The Legacy Effect in Type 2 Diabetes: Impact of Early Glycemic Control on Future Complications (The Diabetes & Aging Study). Diabetes Care. 2019; 42: 416-426.
11. Laiteerapong N, Ham SA, Gao Y, et al. The Legacy Effect in Type 2 Diabetes: Impact of Early Glycemic Control on Future Complications (The Diabetes & Aging Study). Diabetes Care. 2019; 42: 416-426.
12. Fiseha T, Alemayehu E, Kassahun W, Adamu A, Gebreweld A. Factors associated with glycemic control among diabetic adult out-patients in Northeast Ethiopia. BMC Res Notes. 2018; 11: 1-6.
13. Haghighatpanah M, Nejad ASM, Haghighatpanah M, Thunga G, Mallayasamy S. Factors that correlate with poor glycemic control in type 2 diabetes mellitus patients with complications. Osong Public Health Res Perspect. 2018; 9: 167-174.
14. American Diabetes Association. Standards of Medical Care in Diabetes-2014. Diabetes Care. 2014; 37 Suppl 1: S14-S80.
15. Farrell B, French Merkley V, Ingar N. Reducing pill burden and helping with medication awareness to improve adherence. Can Pharm J. 2013; 146: 262-269.
16. Forde AT, Crookes DM, Suglia SF, Demmer RT. The weathering hypothesis as an explanation for racial disparities in health: a systematic review. Ann Epidemiol. 2019; 33: 1-18.e3.
17. Edelman SV, Polonsky WH. Type 2 Diabetes in the Real World: The Elusive Nature of Glycemic Control. Diabetes Care. 2017; 40: 1425-1432.
18. Moradi-Lakeh M, Forouzanfar MH, El Bcheraoui C, et al. High Fasting Plasma Glucose, Diabetes, and Its Risk Factors in the Eastern Mediterranean Region, 1990-2013: Findings From the Global Burden of Disease Study 2013. Diabetes Care. 2017; 40: 22-29.
19. Mwavua SM, Ndungu EK, Mutai KK, Joshi MD. A comparative study of the quality of care and glycemic control among ambulatory type 2 diabetes mellitus clients, at a Tertiary Referral Hospital and a Regional Hospital in Central Kenya. BMC Res Notes. 2016; 9: 1-8.
20. Kamuhabwa AR, Charles E. Predictors of poor glycemic control in type 2 diabetic patients attending public hospitals in Dar es Salaam. Drug Healthc Patient Saf. 2014; 6: 155-165.
21. Kakade AA, Mohanty IR, Rai S. Assessment of factors associated with poor glycemic control among patients with Type II Diabetes mellitus. Integr Obes Diabetes. 2018; 4.
22. Aro AK, Karjalainen M, Tiihonen M, et al. Glycemic control and health-related quality of life among older home-dwelling primary care patients with diabetes. Prim Care Diabetes. 2017; 11: 577-582.
23. Sinha B, Ghosal S. A Target HbA1c Between 7 and 7.7% Reduces Microvascular and Macrovascular Events in T2D Regardless of Duration of Diabetes: a Meta-Analysis of Randomized Controlled Trials. Diabetes Ther. 2021; 12: 1661.
24. Sinha B, Ghosal S. A Target HbA1c Between 7 and 7.7% Reduces Microvascular and Macrovascular Events in T2D Regardless of Duration of Diabetes: a Meta-Analysis of Randomized Controlled Trials. Diabetes Ther. 2021; 12: 1661.
25. Adjei SK, Adjei P, Nkrumah PA. Poor Glycemic Control and Its Predictors Among Type 2 Diabetes Patients: Insights From a Single-Centre Retrospective Study in Ghana. Health Sci Rep. 2025; 8: e70558.
26. American Diabetes Association. Introduction and Methodology: Standards of Care in Diabetes-2024. Diabetes Care. 2024; 47: S1-S4.
27. Chweya RN, Mambo SN, Gachohi JM. Longitudinal analyses suggest a higher burden of self-reported influenza-like illness among women and girls in a rural community in western Kenya. Glob Epidemiol. 2021; 3: 100059.
28. Kautzky-Willer A, Kosi L, Lin J, Mihaljevic R. Gender-based differences in glycaemic control and hypoglycaemia prevalence in patients with type 2 diabetes: results from patient-level pooled data of six randomized controlled trials. Diabetes Obes Metab. 2015; 17: 533-540.
29. Szczerba E, Barbaresko J, Schiemann T, Stahl-Pehe A, Schwingshackl L, Schlesinger S. Diet in the management of type

2 diabetes: umbrella review of systematic reviews with meta-analyses of randomised controlled trials. BMJ Med. 2023; 2: e000664.

30. Evert AB, Dennison M, Gardner CD, et al. Nutrition therapy for adults with diabetes or prediabetes: a consensus report. Diabetes Care. 2019; 42: 731-754.

31. Sheleme T, Mamo G, Melaku T, Sahilu T. Glycemic Control and its Predictors among Adult Diabetic Patients attending Mettu Karl Referral Hospital, Southwest Ethiopia: A Prospective Observational Study. Diabetes Ther. 2020; 11: 1775-1788.

32. Dawite F, Girma M, Shibiru T, et al. Factors associated with poor glycemic control among adult patients with type 2 diabetes mellitus in Gamo and Gofa zone public hospitals, Southern Ethiopia: A case-control study. PLoS One. 2023; 18.

33. Alijanzadeh M, Hashemipour S, Attaran F, et al. Availability and affordability of diabetes healthcare services associated with the frequency of diabetes-related complications. BMC Health Serv Res. 2024; 24: 1-10.

34. Oyando R, Njoroge M, Nguhiu P, et al. Patient costs of diabetes mellitus care in public health care facilities in Kenya. Int J Health Plann Manage. 2020; 35: 290-308.

35. Otieno FCF, Ogola EN, Kimando MW, Mutai K. The burden of unrecognised chronic kidney disease in patients with type 2 diabetes at a county hospital clinic in Kenya: implications to care and need for screening. BMC Nephrol. 2020; 21.

36. Alijanzadeh M, Hashemipour S, Attaran F, et al. Availability and affordability of diabetes healthcare services associated with the frequency of diabetes-related complications. BMC Health Serv Res. 2024; 24: 1-10.

37. Sui W, Wang S, Chen Y, et al. Insights into the Structural and Nutritional Variations in Soluble Dietary Fibers in Fruits and Vegetables Influenced by Food Processing Techniques. Foods. 2025; 14: 1861.

38. Weickert MO, Pfeiffer AFH. Impact of Dietary Fiber Consumption on Insulin Resistance and the Prevention of Type 2 Diabetes. J Nutr. 2018; 148: 7-12.

39. Wang PY, Fang JC, Gao ZH, Zhang C, Xie SY. Higher intake of fruits, vegetables or their fiber reduces the risk of type 2 diabetes: A meta-analysis. J Diabetes Investig. 2015; 7: 56-69.

40. Elfaki FA, Chandika RM, Kahlani SH, et al. Dietary patterns and their associations with glycemic control among type 2 diabetic patients in Jazan, Saudi Arabia: A cross-sectional study. Medicine (Baltimore). 2023; 102: e34296.

41. Lattimer JM, Haub MD. Effects of Dietary Fiber and Its Components on Metabolic Health. Nutrients. 2010; 2: 1266-1289.

42. Ioniță-Mîndrican CB, Ziani K, Mititelu M, et al. Therapeutic Benefits and Dietary Restrictions of Fiber Intake: A State of the Art Review. Nutrients. 2022; 14: 2641.

43. Sui W, Wang S, Chen Y, et al. Insights into the Structural and Nutritional Variations in Soluble Dietary Fibers in Fruits and Vegetables Influenced by Food Processing Techniques. Foods. 2025; 14: 1861.

44. Jemeli Rutto P, Ng'ambwa TO, Jepkemei Chirchir I. Influence of Duration of Diabetes, Presence of Comorbidities, and Medication Adherence Contributing to Poor Glycemic Control Among Clients at Kapkatet Sub-County Hospital, Kericho County Kenya. Int J Res Sci Innov. 2025; 12: 1299-1313.

45. Fina Lubaki JP, Omole OB, Francis JM. Glycaemic control among type 2 diabetes patients in sub-Saharan Africa from 2012 to 2022: a systematic review and meta-analysis. Diabetol Metab Syndr. 2022; 14: 134.

46. Vijan S, Sussman JB, Yudkin JS, Hayward RA. Effect of patients' risks and preferences on health gains with plasma glucose level lowering in type 2 diabetes mellitus. JAMA Intern Med. 2014; 174: 1227-1234.