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DIETARY PATTERN AND ITS ASSOCIATION WITH GLYCEMIC CONTROL AMONG CHILDREN AND ADOLESCENTS WITH T1DM AT TIKUR ANBESSA SPECIALIZED HOSPITAL, ADDIS ABABA, ETHIOPIA, 2025/26, A CROSS-SECTIONAL STUDY.

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A RESEARCH PAPAR TO BE SUBMITTED TO ADDIS ABABA UNIVERSITY, COLLEGE OF HEALTH SCIENCES; DEPARTMENT OF PEDIATRICS AND CHILD HEALTH FOR PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE SPECIALTY CERTIFICATE PROGRAM IN PEDIATRICS AND CHILD HEALTH.

April, 2026 GC ADDIS ABABA, ETHIOPIA.

APPROVAL SHEET

ADDIS ABABA UNIVERSITY COLLEGE OF HEALTH SCIENCES SCHOOL OF MEDICINE
DEPARTMENT OF PEDIATRICS AND CHILD HEALTH

I, the undersigned Pediatrics and Child Health Resident declare that I have submitted my original research paper on the investigating the association between dietary practice and glycemic control among children and adolescents with type 1 DM at TASH, Addis Ababa, Ethiopia, Cross-Sectional study in partial fulfillment of the specialty program.

Submitted by:

Dr. HANNA YIRDAW ---------- ----------

Name of resident Signature Date

This proposed work has been submitted with my approval as an advisor,
Approved by:
Dr. SEMINEW ---------- ----------

Advisor Signature Date

ADDIS ABABA UNIVERSITY

COLLEGE OF HEALTH SCIENCES

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Title of research	Dietary Pattern and its Association with Glycemic Control Among Children and Adolescents with T1DM at Tikur Anbessa Specialized Hospital, 2025/6.
Duration of research	3 months
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ACRONYMS AND ABBREVIATIONS

ADA… ..... **American diabetic association**

CGM..... **continuous glucose monitoring**

DM..... **Diabetes mellitus**

EDA .....**Ethiopian diabetes association**

HbA1c.....**glycated hemoglobin**

IDF…..... **International diabetes federation**

ISPAD….....**International Society for Pediatric and Adolescent Diabetes**

T1DM .....**Type 1 Diabetes mellitus**

TASH..... **Tikur Anbesa specialized hospital**

SUMMARY

Background: One common long-term metabolic condition is diabetes mellitus (DM). One unique biochemical feature of this illness is elevated blood sugar levels. The term "diabetes mellitus" refers to a complex metabolic disorder in which an individual has persistently high blood sugar due to a malfunction in the production or secretion of insulin.

Objectives: To evaluate the relationship between glycemic control and dietary habits in kids and teenagers with type 1 diabetes**.**

Methodology: The current study was conducted using a cross-sectional study design that involved a hospital-based approach between October, 2025 and January, 2026 G.C among patients in the follow-up clinics for diabetic children of the Tikur Anbessa specialized hospital. Sample size calculation was done by using a single population proportion formula with 95% confidence level and 5% precision which resulted in 129 respondents. The collected data was first analyzed using excel, and then entered to SPSS version 27 for data analysis. Both bivariable and multivariable linear regression analysis were used. All variables were considered in bivariable linear regression analysis while those with p-values <0.2 were considered for multivariable linear regression analysis**.**

Results; The study involved a sample size of 129 subjects who were aged between 10 and 18 years. They accounted for 77.5% of the total sample population. Majority (93%) of the patients dwelled in urban settings. The nutritional state of most of the participants was within acceptable limits with 89.1% being well-nourished. However, their glycemic control was not satisfactory, evident in the higher average HbA1c (10.25 ± 2.35%). Multivariate regression analysis revealed that poor adherence to diet, low education level of care-givers, and reduced frequency of insulin administration were predictors of increased HbA1c levels. Other variables like age, disease duration, and exposure to glycemic index were not associated independently with HbA1c.

Conclusion: Many children and adolescents with type 1 diabetes visiting Tikur Anbessa Specialized Hospital are faced with inadequate glycemic control. This condition is highly influenced by modifiable risk factors such as dietary intake, insulin administration, and educational level of the care providers. Despite the general adequacy of the nutritional status among those affected, the study revealed problems in diabetic-related dietary intake and insufficient patient empowerment. These results imply the necessity of specific actions towards improving dietary knowledge among patients and their caregivers, as well as enhancing diabetes

management methods.

1. INTRODUCTION

1.1. Background

Diabetes mellitus (DM) is a prevalent condition that affects the metabolism system. It is defined by an excess of glucose in the blood stream as one of its biochemical features (1). "Diabetes mellitus" refers to the complicated metabolic disorder that causes persistent hyperglycemia due to the lack of sufficient production of insulin or resistance to insulin (2). Deficiency in the production of insulin, as well as resistance to insulin, causes inadequate effect of insulin in the target tissues leading to disturbances in carbohydrates, fats, and protein metabolism (3).

T1DM makes up for 85% or more of diabetes among people below the age of 20, as per global statistics (4). The number of young patients who developed T1DM in 2021 was estimated at 108,300 individuals with T1DM under the age of 15 years globally, while the number of those living with the disease stood at 651,700 (5) (6).

The complications and mortality associated with diabetes are caused not only by the acute metabolic disturbance but also by the complications of diabetes such as retinopathy, nephropathy, neuropathy, cardiovascular disease, and obstructive arterial disease causing gangrene in the limbs (7). Despite several risk factors for chronic complications from diabetes among children, glycemic control stands out as the single strongest predictor (8) (9).

Glycemic control is said to delay the onset and progression of complications associated with diabetes, based on findings from the DCCT study (10). Glycated hemoglobin (HbA1c) measures glycemic control over the past two to three months, and provides a reliable measure of long-term glycemic control (7).

As per ISPAD and American Diabetes Association guidelines, children and adolescents who have complete access to diabetic care should aim at achieving an HbA1c level lower than 7.0% (53 mmol/mol). But when it is not possible to provide analog insulin, advanced insulin delivery devices, frequent checking of blood glucose levels, and constant glucose monitoring, then a relatively higher HbA1c goal (less than 7.5%, [58 mmol/mol]) should be considered (11) (12).

Nutrition is one of the key considerations in managing T1D in children. According to the ISPAD guidelines, children suffering from diabetes are supposed to have similar nutritional requirements as their peers. This includes consuming 45–50% carbohydrates, 30–35% fat (less than 10% saturated fat), and 15–20% protein daily (13).

In the diet, the major macro-nutrient is carbohydrates, and they contribute 45-50% of the body's energy in a day, with 4 Kcal/g of energy yield (14). It should also be known that apart from processed foods and sweet beverages that have high or moderate GI values and that cause obesity, there are other fruits that lead to high blood sugar levels more slowly than others (15). 30-35% of the total calorie intake should comprise fats, which will provide 9 kcal/g of energy. There are two types of fats – the first one being unsaturated fats that are mainly found in vegetables, and the second one is saturated fats that are found in animal foods. Due to their association with maintaining a healthy lipid profile and reducing the risks related to cardiovascular diseases, unsaturated fats, especially polyunsaturated fats, (PUFA) including omega-3 and omega-6 should always be taken into consideration. Moreover, fats induce the slow passage of the stomach, thereby avoiding any sort of glycemic peaks (16). Finally, proteins constitute 15–20% of the daily intake and provide 4 Kcal/g of energy, compared to other macronutrients. Both plant-based food sources, such as lentils, and animal sources, such as meat, fish, and eggs, provide proteins. Proteins are mainly used for growth; however, in some cases, they can be used as an energy source, like in type 1 diabetes (17).

1.2. Statement of the problem

Children with type 1 diabetes should practice a healthy lifestyle to avoid peaks of hyperglycemia that cause greater inflammation of tissues and arteries. Two indices that measure the quality and quantity of food consumed at meals are the glycemic index and the glycemic load. Because the effects of the main macronutrients in the diet on postprandial blood glucose levels differ, children with diabetes should eat meals that characterize a slower and more stable glycemic peak (18).

1.3. Significance of the study

To our knowledge, no such studies have been conducted in children and adolescents with type 1 diabetes; therefore, this will be the first such study in Ethiopia, allowing for clinicians to prescribe evidence-based nutrition recommendations based on which dietary habits promote stable blood glucose and ideal HbA1c and to find beneficial dietary patterns that can support

early intervention to reduce the risk of micro vascular and macro vascular complications (retinopathy, nephropathy, neuropathy, and cardiovascular disease) later in life .

2. LITERATURE REVIEW

A worldwide modeling study on the incidence of type 1 diabetes in children and adolescents aged 0 to 19 years between 1990 and 2050 found that globally in 2021, 355,900 (95 percent UI 334,200-377,300) children and adolescents will be diagnosed with the disease, of which 56 percent (200,400 cases, 95 percent UI 180,600-219,500) will be diagnosed. Under diagnosis ranges from less than 35 percent of new cases in West Africa, South and Southeast Asia, and Melanesia to over 95 percent in Australia and New Zealand, western and northern Europe, and North America (19).

Thirty of the forty-three potential candidates from the initial cohort were enrolled in the long-term study of 30-year follow-up research on HbA1c and diabetes complications, which was carried out in Australia on children with type 1 diabetes mellitus diagnosed before the age of six (mean age at diagnosis = 2.9 years; female = 56 percent). Following an average follow-up of 29.7 years (SD = 3.9 years), 13 patients (33 percent) experienced neuropathy, 19 patients (63 percent) experienced eye complications, and 3 patients (10 percent) experienced nephropathy. Compared to the HbA1c values during childhood (8.2 percent [66.1 mmol/mol], 95 percent CI 7.8–8.5 [61.7–69.4], $p < 0.001$) and adulthood (8.2 percent [66.1 mmol/mol], 95 percent CI 7.8–8.5 [61.7–69.4]), the mean HbA1 percent [74.9 mmol/mol], 95 percent 8.6-9.3 [70.5-78.1]. An increased risk of neuropathy was found to be statistically correlated with a larger deviation from the mean childhood HbA1c (RRR = 7.8, 95 percent 1.1–57.4, $p = 0.009$) (20).

A cross-sectional study was conducted to examine the association between dietary patterns and glycemic control in Jordanian children and adolescents with type 1 diabetes (n=107, 53 males and 54 females). Data were collected through in-person interviews using three validated and reliable questionnaires. Only 25.7% of children and adolescents with type 1 diabetes had good glycemic control and nearly 51% had poor glycemic control. Three dietary patterns were identified: \"High-Vegetables,\" \"Unhealthy,\" and \"High-Fruits.\" The \"High-Vegetables\" dietary pattern had a protective association with glycated hemoglobin (odds ratio, CI: 0.07 (0.005–0.826); 0.06 (0.005–0.741) at the second and third tertiles, respectively (21).

A randomized clinical trial was conducted at an outpatient, multidisciplinary tertiary diabetes center in Boston, Massachusetts, USA, to test the hypothesis that improved glycemic control was related to better diet quality. A randomized clinical trial was conducted to evaluate a behavioral nutrition intervention with 136 participants (baseline glycated hemoglobin (HbA1c) 8.1% ± 1.0%, average age 12.8 ± 2.6 years, 69.1% using insulin pump) who completed 3-day diet records and used masked continuous glucose monitoring (CGM) data using the Medtronic iPro CGM system at baseline, and at months 3, 6, 9, 12, and 18. 1,5-anhydroglucitol levels were assessed every six months, whereas HbA1c levels were measured every three months. Linear mixed-effects regression models were used to estimate associations between time-varying dietary intake variables and time-varying glycemic control indicators, adjusting for (22).

This study evaluated the effect of insulin treatment on the interaction between nutrient intake and glycemic control in a cohort of youth with type 1 diabetes, and used 3-day dietary questionnaires to assess the nutritional intake of 252 young people with type 1 diabetes (52% male, 13.2±2.8 years old, mean z-BMI [z-BMI]: 0.7±0.8) and determined the probability of poor glycemic control (A1C level of ≥8.5 percent) using the logistic regression model based on fat, protein, and fiber intake as a function of insulin delivery method (pump vs. injection), age, gender, years of diabetes diagnosis, z-BMI, amount of insulin intake, glucose self-monitoring, and TEI (mean TEI: 40.9±15.4 kcal/kg/day) (23).

A cross-sectional study of 231 patients with type 1 diabetes mellitus at Jugol and Hiwot Fana Compressive Specialized University Hospitals in Harar showed that children who consumed less than three meals had a 3.28 times greater odds of developing poor glycemic control than those who consumed three or more meals and snacks (aOR 3.28; 95 percent CI: 1.25–8.62), and that those who consumed foods that were forbidden had a 3.17 times greater odds of poor glycemic control than their peers (aOR 3.17; 95 percent CI: 1.21–8.29) (24).

The A non-experimental, cross-sectional study of diabetics ages seven to eighteen years old at a two-day camp in Bogor, Indonesia in December 2010. The two-day camp covered insulin injection techniques, dietary practices, physical activity, and the dangers of type 1 diabetes. Twenty-eight patients (five boys and twenty-three girls) participated, and eighteen met the inclusion criteria to provide data for the study. Glycosylated hemoglobin (HbA1c) was measured before and three months after the camp, and the Pediatric Quality of Life (PedsQL) surveys were administered. Using Stata 19, the researchers conducted a paired t test for HbA1c before and

three months after the camp. HbA1c was 9.18 percent (SD 2.48) before the camp and 8.67 percent (SD 1.62) three months later (P=0.004) (25).

3. OBJECTIVE

3.1. General objective

- To assess the association between dietary habit and glycemic control among children and adolescent with T1DM at TASH, Addis Ababa.

3.2. Specific objectives

- To assess common dietary patterns among children and adolescents with T1DM.
- To measure glycemic control among children and adolescents with T1DM.
- To determine the relationship between dietary adherence and glycemic outcomes.

4. METHOD AND MATERIALS

4.1. Study setting

The study was conducted at the pediatric DM follow-up clinic at Tikur Anbessa Specialized Hospital (TASH). TASH is the largest and oldest teaching hospital in Ethiopia, founded in 1974 and run by Addis Ababa University, educating hundreds of medical students and residents and treating approximately 400,000 patients annually. The pediatric diabetic follow-up clinic has two open rooms throughout the day and averages of 167 cases are seen per month at the pediatric diabetic clinic. The pediatric endocrinologists and pediatric residents participate in the pediatrics DM clinic every Thursday morning.

I selected Tikur Anbessa Specialized Hospital (TASH) for several reasons: it had pediatric endocrinologists working in its pediatric diabetes clinics, which allowed me to access the patient group I sought; data collection was easier at that hospital; and I could recruit a broad spectrum of patients from across the country because of its locations.

4.2. Source population

All children and adolescents with confirmed DM who are registered for follow-up at the pediatric diabetes clinics of TASH, Addis Ababa, Ethiopia during the study period.

4.3. Study population

Every child and adolescent between the ages of 6 and 18 who has had diabetes for at least a year and is receiving insulin therapy at the Tikur Anbessa Specialized Hospital DM clinic.

4.4. Study design

To evaluate the relationship between dietary pattern and glycemic control in children and adolescents with type 1 diabetes, an institutional cross-sectional study was carried out.

4.5. Study Period

The study was conducted from October 2025 to January 2026 G.C.

4.6. Sampling method

A convenient sampling method was used and children and adolescents whose age are between 6 and 18yrs with T1DM at TASH are included.

4.7. Sample size

- Step 1: determine the initial sample size using this formula $n = \frac{(Z\ \alpha/2)^2\ P\ (1-P)}{d^2}$

Where:

•**n** is sample size,

•**Zα/2** is the value under the standard normal table for a given confidence interval (1.96 for 95% CI),

•**d** is the margin of error (0.05).

•**p** is the best estimate of prevalence since we do not have a previously performed study in our country, we took 50% to increase the strength of the study

Sample size = 384

- Step 2 — corrected sample size using finite population correction (FPC) formula

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

where: - **n** = corrected (final) sample size

n_0 = initial calculated sample size (without correction)-384

N = total population size (in our DM clinic an estimated number of cases to be seen are around 167).

Corrected sample size = **117** participants

- Step 3 Add contingency

Add 10% for contingencies: - contingency= 117x0.1=12

Final sample size= 117+12= 129

Participant were selected by convenient sampling techniques.

4.8. Inclusion and exclusion criteria

4.8.1. Inclusion criteria

All children included in this study received follow-up care at the pediatric DM clinic with the onset of diabetes to be at least 1 year and less than 10 years, age between 6 and 18 years of age, with HgA1c level, be on insulin, and to provide consent through signed consent forms by the children's caregivers, At Tikur Anbessa Specialized Hospital (TASH).

4.8.2. Exclusion criteria

This study excluded participants who met any of the following criteria:

- Those whose age is less than 6yrs and more than 18yrs and can't give consent
- Those who are newly diagnosed and have no HgA1c level.

4.9. Study Variables

4.9.1. Dependent variables

- Glycemic control

4.9.2. Independent variables

- Socio-demographic variables (age, sex, residence, educational level)
- Anthropometric variables (weight, height, BMI, MUAC)
- Dietary related variables (dietary pattern, glycemic index, meal frequency)
- Clinical and diet related variables (age at diagnosis, insulin regimen, insulin frequency)

4.10. Data collection and measurement

4.10.1. Settings

This study's data collection was conducted at Black Lion Hospital. Data was gathered at the pediatric diabetes clinic's outpatient department. The hospital's institutional ethical board granted the researcher ethical approval prior to the study's execution.

4.10.2. Data collection

During the first meeting, the researcher explained the goals of the study and the participant read and signed the consent form. The researcher supervised two general practitioners to collect data using a structured, pretested interview questionnaire modified and adapted from related literature, translated by language experts into the local languages and again into English. The researcher assigned each participant a unique ID and only the researcher accessed personal data, maintaining confidentiality by having the matching participant ID on each questionnaire. All questionnaires were in Amharic.

4.10.3. Instrument

To accomplish the study's goals, a three-part package was used for data collection. Three structured questionnaires are included in this package. The data collection method involves in-person interviews with the child, their caregiver, and the care system.

- **The Personal Information Questionnaire: -** It included information on the parents (age, education level, marital status, occupation, household income, smoking status, and history of Type 1 Diabetes Mellitus [T1DM]) and on the child (age, gender, school grade, the onset of the disease, daily activities, anthropometric information [weight, height, body mass index [BMI]], and information about the type and amount of insulin administered.
- **Dietary assessment:** In Tayyem et al., the authors modified 120-item food frequency questionnaires (FFQ) to collect dietary data from children and teenagers in Jordan. They reduced the 30 food items to 28 food items and divided the food list into six categories, whereas in our setup, we will divide the food list into five categories, and the frequency

response options ranged from \"never\" to \"≥6/day,\" which provided six different options. Dietary information collected from the FFQ was analyzed using the Food Processor program.

- **Biochemical tests: -** we are going to use already measured and recorded level of HgbA1c from the I care system.

4.10.4. Data handling

The investigator verified the cleanliness and completeness of the data. The physical documents was digitized, saved onto a hard drive, and prepared for analysis, while a backup was maintained on a different drive.

4.11. Data Quality Control

The questionnaire was originally created in English, and then translated into Amharic and then back into English by several qualified people to ensure consistency in the data. Data collectors received two days of instruction on how to fill out the questionnaire and the entire data collection process before the actual time to collect data. A pretest was given to 5% of the sample size in a similar population and any corrections were made. As the data was being collected, it was checked for consistency and completeness every day.

4.12. Data Analysis and interpretation

The completed data were coded and entered into Excel by the principal investigator and then exported to SPSS version 27 for analysis, with careful cleaning of data to ensure validity and accuracy. Bivariable linear regression models were fit to assess the association between each study outcome (glycemic control) and the dietary practice and related variable, and multivariable linear models were fit to determine the independent determinants of glycemic control. The multivariable regression modeling included covariates based on the bivariable association with the outcome variables with P-value <0.25. The normality of the outcome variable was tested using the Shapiro-Wilk test (P> 0.05), histograms, and Q-Q plots. The results of the degree of association between the various associated factors and the study outcomes are reported as crude and adjusted odd ratios and p-val is used to determine whether an association is statistically sign.

Ethical considerations

No identifying information, such as names of the participants, was included in the anonymous data collected; the caregivers provided consent prior to data collection; and the TASH research and publication committee, as well as the pediatrics and child health departments, issued a formal letter and ethical clearance, as well as assigned code numbers and omitted patient identifiers to ensure confidentiality.

4.13. Plan for dissemination of results

The study's results were presented on the day of the research defense, and both soft and hard copies of the formal report will be sent to the Department of Pediatrics and Child Health. Additionally, the research findings will be published in regional or global scientific journals.

4.14. Operational Definition

glycemic control

Glycemic control Is a medical term referring to levels of blood glucose in a person with diabetes mellitus which were categorized by American Diabetic Association (ADA) recommendation based on the value of glycosylated hemoglobin. (26, 27).

Good glycemic control is when HbA1c below 7% (28).

Poor glycemic control is when HbA1c is to be more or equal to 7% (28).

Dietary pattern

Dietary pattern refers to the overall combination, frequency, and quality of foods and beverages consumed by an individual, assessed using a validated dietary assessment tool (e.g., Food Frequency Questionnaire (29).

5. RESULTS

5.1. Socio-demographic Characteristics of the Study Participants

A total of **129 children and adolescents with type 1 diabetes mellitus** were included in the analysis. Regarding age distribution, **100 participants (77.5%)** were aged **10–18 years**, while **29 (22.5%)** were aged **6–9 years**.

The sex distribution was nearly equal, with **66 (51.2%) females** and **63 (48.8%) males**. The majority of participants were **urban residents (120, 93.0%)**, whereas only **9 (7.0%)** resided in rural areas.

In terms of educational status, **78 participants (60.5%)** were attending **grades 1–4**, **44 (34.1%)** were in **grades 5–8**, and **7 (5.4%)** were not enrolled in formal schooling at the time of the study.

Most caregivers were aged **35–44 years (62, 48.1%)**, followed by those aged **45–54 years (34, 26.4%)**. Regarding caregiver education, **67 (51.9%)** had **secondary education**, while **40 (31.0%)** had attained **tertiary education**. Only **1 caregiver (0.8%)** had no formal education.

The majority of caregivers were **married (103, 79.8%)**, while **14 (10.9%)** were single, **11 (8.5%)** divorced, and **1 (0.8%)** widowed. Concerning household income, **49 households (38.0%)** reported a monthly income of **10,000–19,999 ETB**, followed by **28 (21.7%)** earning **≥20,000 ETB**.

A family history of type 1 diabetes mellitus was reported in **16 participants (12.4%)**, while **113 (87.6%)** had no such history. With regard to caregiver relationship, the primary caregiver was most commonly the **mother (66, 51.2%)**, followed by the **father (31, 24.0%)**. In **11 cases (8.5%)**, the child was self-caring, while **15 (11.6%)** were cared for by both parents.

Table 1. Socio-demographic characteristics of children and adolescents with type 1 diabetes mellitus attending Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia (n = 129)

Variable	Category	Frequency (n)	Percentage (%)
Age group	6–9	29	22.5

Variable	Category	Frequency (n)	Percentage (%)
(years)	10–18	100	77.5
Sex	Male	63	48.8
	Female	66	51.2
Place of residence	Urban	120	93.0
	Rural	9	7.0
School grade/level	Not in school	7	5.4
	Grade 1–4	78	60.5
	Grade 5–8	44	34.1
Age of caregiver (years)	<18	4	3.1
	18–24	7	5.4
	25–34	17	13.2
	35–44	62	48.1
	45–54	34	26.4
	55–64	4	3.1
	≥65	1	0.8
Educational status of caregiver	No formal education	1	0.8
	Primary	21	16.3
	Secondary	67	51.9
	Tertiary	40	31.0
Marital status of caregiver	Single	14	10.9
	Married	103	79.8
	Divorced	11	8.5
	Widowed	1	0.8
Monthly household income (ETB)	<2,000	14	10.9
	2,000–4,999	16	12.4
	5,000–9,999	22	17.1
	10,000–19,999	49	38.0
	≥20,000	28	21.7
Family history	Yes	16	12.4

Variable	Category	Frequency (n)	Percentage (%)
of T1DM	No	113	87.6
Relationship of caregiver to child	Mother	66	51.2
	Father	31	24.0
	Both parents	15	11.6
	Self	11	8.5
	Other relative	6	4.7

5.2. Clinical and Anthropometric Characteristics

Duration of Diabetes:

Among the 129 participants, the mean duration of diabetes was 7.21 ± 3.39 years, ranging from 1 to 15 years. Most participants (81.4%) had diabetes for ≤10 years, while 18.6% had diabetes for more than 10 years (Table 2).

Age at Diagnosis:

The mean age at diagnosis was 5.35 ± 3.33 years, with a range of 1 to 14 years. Over half of the participants (51.9%) were diagnosed at ≤5 years, 32.6% between 6–9 years, and 15.5% at ≥10 years.

Anthropometric Characteristics:

The mean weight was 38.19 ± 12.58 kg (range 19–68 kg), mean height was 144.48 ± 16.60 cm (range 110–180 cm), and the mean mid-upper arm circumference (MUAC) was 20.10 ± 3.32 cm (range 13–30 cm). The mean BMI was 17.87 ± 3.03, indicating that most participants were within normal nutritional ranges.

Nutritional Status:

Based on height-for-age, 88.4% had normal growth, 10.1% were moderately stunted, and 1.6% were severely stunted.

Based on BMI-for-age, 89.1% were well-nourished, 9.3% had moderate acute malnutrition, and 1.6% had severe acute malnutrition.

Glycemic Control:

The mean HbA1c was 10.34 ± 2.20%, ranging from 6.2% to 15.3%, reflecting suboptimal glycemic control in many participants.

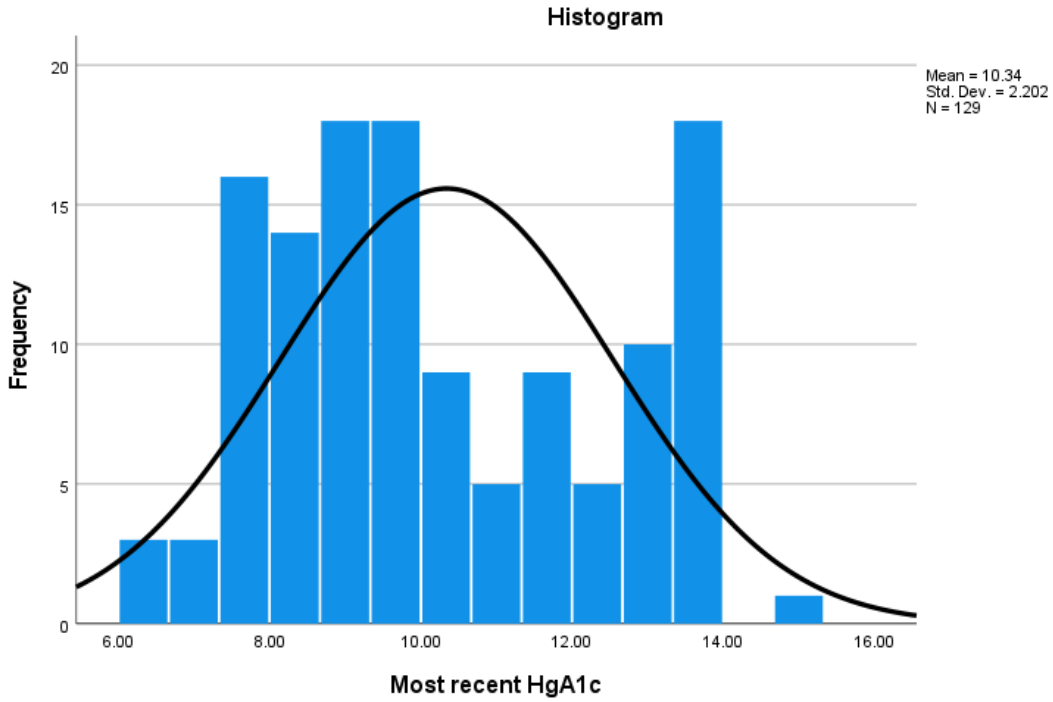


Fig 1: Most recent HgA1c reports

Insulin Therapy:

The majority (93.8%) were on NPH and regular insulin (RI) regimen, while a few were on RI and Glargine combination (6.2%).

Most participants administered insulin twice daily (93.0%), with fewer taking it three times (3.9%) or four times (2.3%) per day. Only 0.8% used a once-daily regimen.

Self-Monitoring of Blood Glucose:

68.2% of participants monitored their blood glucose 1–2 times daily, 27.1% monitored 3–4 times daily, while 4.7% never monitored their blood glucose.

History of Hospital Admission for DKA:

In the past year, 76.0% of participants had never been admitted for DKA, 16.3% had one admission, and 7.8% had two or more admissions.

Table 2. Clinical and Treatment-Related Characteristics of Participants (N = 129)

Characteristic	Category / Measure	n (%) or Mean ± SD (Range)
Duration of diabetes (years)	≤10	105 (81.4)
	>10	24 (18.6)
Age at diagnosis (years)	≤5	67 (51.9)
	6–9	42 (32.6)
	≥10	20 (15.5)
Weight (kg)	–	38.19 ± 12.58 (19–68)
Height (cm)	–	144.48 ± 16.60 (110–180)
MUAC (cm)	–	20.10 ± 3.32 (13–30)
BMI	–	17.87 ± 3.03
Nutritional status (Height-for-age)	Normal	114 (88.4)
	Moderate stunting	13 (10.1)
	Severe stunting	2 (1.6)
Nutritional status (BMI-for-age)	Well-nourished	115 (89.1)

	Moderate malnutrition	12 (9.3)
	Severe malnutrition	2 (1.6)
Insulin regimen	NPH+RI	121 (93.8)
	RI+ Glargine	8 (6.2)
Frequency of insulin administration	Once daily	1 (0.8)
	Twice daily	120 (93.0)
	Three times daily	5 (3.9)
	Four times daily	3 (2.3)
Self-monitoring of blood glucose	Never	6 (4.7)
	1–2 times/day	88 (68.2)
	3–4 times/day	35 (27.1)
DKA admissions in past year	Never	98 (76.0)
	Once	21 (16.3)
	≥2	10 (7.8)

5.3. Dietary Characteristics of Participants

Dietary glycemic index (GI) exposure was assessed by ranking participants and categorizing them into **tertiles** using the NTILE function in SPSS. Participants were classified into **low (lower tertile), medium (middle tertile), and high (upper tertile) GI exposure** groups for yellow (medium GI) and red (high GI) food categories.

For **yellow (medium GI) food exposure**, **41 participants (31.8%)** were in the **lower tertile**, while **44 (34.1%)** and **44 (34.1%)** were classified in the **middle** and **upper tertiles**, respectively.

Regarding **red (high GI) food exposure**, **47 participants (36.4%)** fell into the **lower tertile**, whereas **39 (30.2%)** and **43 (33.3%)** were in the **middle** and **upper tertiles**, respectively.

Assessment of **green (low GI) food intake** showed that the majority of participants (**82, 63.6%**) had a **medium intake**, corresponding to the consumption of **two low-GI food items per day**. In contrast, **24 participants (18.6%)** had **low intake (≤1 low-GI food)**, and **23 (17.8%)** achieved **high intake (≥3 low-GI foods)**.

Overall, these findings demonstrate that a substantial proportion of children and adolescents were exposed to **moderate to high levels of medium- and high-GI foods**, while **optimal intake of low-GI foods was observed in fewer than one-fifth of participants**.

Table 3. Dietary pattern characteristics of children and adolescents with type 1 diabetes mellitus attending Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia (n = 129)

Dietary variable	Category	Frequency (n)	Percentage (%)
Yellow GI exposure (medium GI foods)	Low–medium intake	41	31.8
	Medium intake	44	34.1
	High–medium intake	44	34.1
Red GI exposure (high GI foods)	Low exposure	47	36.4
	Moderate exposure	39	30.2
	High exposure	43	33.3
Green GI intake (low GI foods)	Low intake (≤1 low-GI food/day)	24	18.6
	Medium intake (2 low-GI foods/day)	82	63.6
	High intake (≥3 low-GI foods/day)	23	17.8

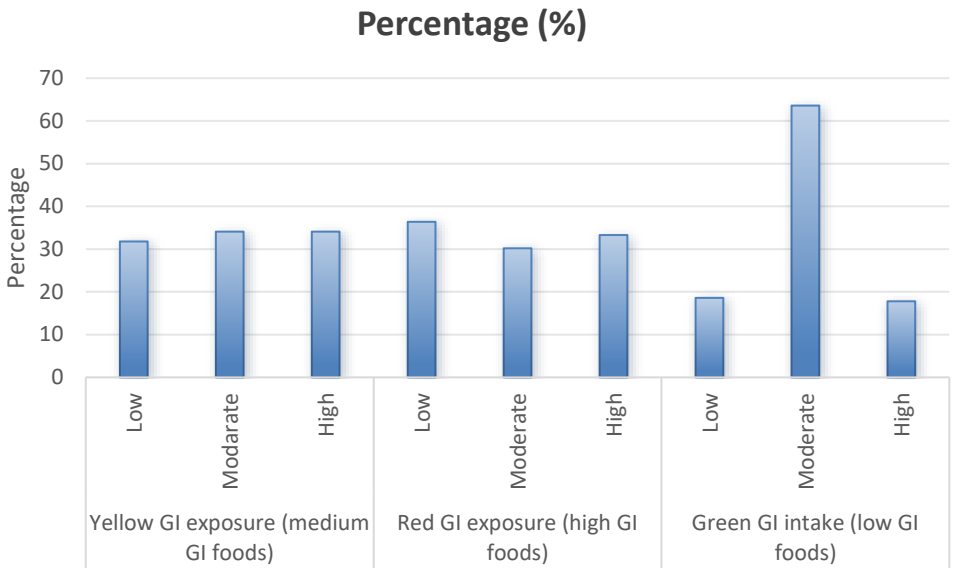


Fig 1: Percentage of dietary intake and exposure to different GI foods

Dietary recommendation habits were categorized based on adherence frequency, where **good habit** represented participants who **always followed all dietary recommendations**, **moderate habit** included those who followed recommendations **rarely, sometimes, or often**, and **poor habit** referred to participants who **never followed recommendations**.

Among the participants (n = 129), the majority demonstrated **moderate dietary adherence** (**76.7%, n = 99**). **Good dietary habits**, defined as consistent adherence to all recommendations, were observed in **21.7% (n = 28)** of participants. Only **1.6% (n = 2)** reported **poor dietary habits**, indicating that complete non-adherence to dietary recommendations was uncommon in this population.



Fig 2 : Habit of participant in following the dietary recommendations

Insulin adjustment practices were similarly classified according to adherence frequency, with **good habit** representing participants who **always followed insulin adjustment recommendations**, **moderate habit** including those who followed recommendations **rarely, sometimes, or often**, and **poor habit** referring to participants who **never adhered** to the recommended insulin adjustments.

Most participants demonstrated **good insulin adjustment practices** (**62.0%, n = 80**), indicating consistent adherence to recommendations. **Moderate adherence** was observed in **32.6% (n = 42)** of participants, while **poor adherence** was reported by **5.4% (n = 7)**. These findings suggest that the majority of the study population exhibit generally favorable insulin management behaviors.

5.4. Bivariable Linear Regression Analysis

Bivariable linear regression analysis was performed to explore the preliminary association between each independent variable and the most recent HbA1c level. At this stage, only the **Tests of Between-Subjects Effects** were examined, which assess whether a variable explains a statistically significant amount of variation in HbA1c. Parameter estimates (β) and confidence intervals were not generated at this step, so the direction and magnitude of associations could not yet be determined.

A total of **sociodemographic, clinical, anthropometric, and dietary variables** were tested. Variables that **passed the preliminary selection criterion (p < 0.25)** and were eligible for inclusion in the multivariable model included:

- **Sociodemographic:** age of the child (categorical), age at diagnosis (categorical), caregiver age, caregiver education, relationship with the child, monthly income
- **Clinical/therapeutic:** duration of diabetes (categorical), doses of insulin, hospital admission for DKA
- **Dietary:** green, yellow, and red GI intake

These variables were therefore included in the subsequent multivariable linear regression analysis to determine independent predictors of HbA1c.

Note: Since this is a preliminary analysis, the **direction and magnitude** of associations are not reported here. The multivariable model will provide β coefficients, 95% confidence intervals, and p-values for each predictor.

Table 4. Preliminary bivariable analysis of factors associated with most recent HbA1c (Tests of Between-Subjects Effects)

Variable	F	p-value	Eligible for multivariable analysis (p < 0.25)
Age of child (categorical)	9.019	0.003	Yes
Age at diagnosis (categorical)	3.779	0.025	Yes
Relationship with child	2.542	0.043	Yes
Duration of diabetes	2.367	0.126	Yes

(categorical)			
Doses of insulin	3.256	0.024	Yes
Hospital admission for DKA	3.763	0.026	Yes
Age of caregiver	2.932	0.010	Yes
Caregiver education	2.829	0.041	Yes
Monthly income	1.697	0.155	Yes
Green GI intake	4.347	0.015	Yes
Yellow GI intake	2.223	0.113	Yes
Red GI intake	1.694	0.188	Yes
Habit towards recommendations	3.417	0.067	Yes

Variables not passing the preliminary selection ($p \geq 0.25$) are excluded from this table, including sex, residency, school grade, marital status, family history of T1DM, weight, height, BMI, MUAC, BMI-for-age, height-for-age, insulin regimen, frequency of monitoring, and continuous age or duration of diabetes.

5.5. Multivariable Linear Regression Analysis

Multivariable linear regression was conducted to identify independent predictors of the most recent HbA1c level, adjusting for potential confounders. All variables with $p < 0.25$ in the preliminary bivariable analysis were included in the model. Adjusted regression coefficients (β), 95% confidence intervals, and p-values were obtained to determine the independent effects of each variable.

Independent predictors of HbA1c

After adjustment, the following factors were significantly associated with HbA1c:

1) **Doses of insulin administration:** Higher frequency of insulin doses was positively associated with HbA1c. Compared to the reference category (4 doses per day), participants receiving **1, 2, or 3 doses per day** had higher HbA1c, with the largest effect observed in the 3-dose group:

1 dose: β = 4.89, 95% CI: 0.29, 9.50; p = 0.038

2 doses: β = 2.94, 95% CI: 0.54, 5.34; p = 0.017

3 doses: β = 4.64, 95% CI: 1.44, 7.84; p = 0.005

2) **Caregiver education level:** Children whose caregivers had **primary education** had higher HbA1c compared to those whose caregivers had tertiary education (β = 1.38, 95% CI: 0.05, 2.72; p = 0.042).

Other variables included in the model, child age, age at diagnosis, caregiver age, relationship with child, duration of diabetes, hospital admissions for DKA, monthly income, and dietary GI indices, **were not independently associated** with HbA1c (p > 0.05).

Table 5. Multivariable linear regression analysis of independent predictors of most recent HbA1c

Variable	**β (Adjusted)**	**95% CI (Lower, Upper)**	**p-value**	**Significant**
Doses of insulin administration (1 vs ref)	4.894	0.286, 9.503	0.038	Yes
Doses of insulin	2.939	0.542,	0.017	Yes

administration (2 vs ref)		5.337		
Doses of insulin administration (3 vs ref)	4.639	1.438, 7.841	0.005	Yes
Caregiver education (primary vs tertiary)	1.384	0.052, 2.715	0.042	Yes
Green GI index (0 vs ref)	-0.459	-1.865, 0.946	0.518	No
Green GI index (2 vs ref)	-0.949	-1.951, 0.053	0.063	No
Yellow GI index (1 vs ref)	-0.246	-1.281, 0.790	0.639	No
Yellow GI index (2 vs ref)	0.445	-0.519, 1.409	0.362	No
Red GI index (1 vs ref)	-0.376	-1.357,	0.449	No

		0.606		
Red GI index (2 vs ref)	0.545	-0.453, 1.543	0.281	No

N.B: Reference for each variable is the last category (eg. For Dose of insulin = 4 times daily dose)

5.6. Model Diagnostics and Assumptions

Prior to interpreting the multivariable linear regression results, key model assumptions were evaluated. Normality of residuals was assessed using the Shapiro–Wilk test and Q–Q plots, indicating no significant deviation from normality. Linearity and model specification were supported by visual inspection of residual plots, and homoscedasticity was confirmed both graphically and using the Breusch–Pagan test ($p = 0.551$). Multicollinearity was evaluated using Variance Inflation Factor (VIF), with all values < 2, indicating no evidence of problematic multicollinearity. The overall model was statistically significant ($F(33,95) = 2.323$, $p = 0.001$), explaining 44.7% of the variance in HbA1c levels ($R^2 = 0.447$; adjusted $R^2 = 0.254$). These assessments support the validity and robustness of the multivariable model.

6. DISCUSSION

The primary objective of this study was to assess the association between dietary pattern and glycemic control among children and adolescents with type 1 diabetes mellitus (T1DM) at Tikur Anbessa Specialized Hospital. Glycemic control remains the most important modifiable predictor of long-term diabetes complications (8,9), and strict glycemic control has been shown to delay the onset and progression of microvascular complications as demonstrated in the DCCT trial (10). In the present study, the mean HbA1c was 10.34 ± 2.20%, indicating overall suboptimal glycemic control compared to ISPAD and ADA recommendations (<7–7.5%) (11,12). This finding is consistent with reports from other low-resource settings where optimal glycemic targets are difficult to achieve due to limited access to advanced insulin regimens, structured education, and continuous glucose monitoring (19,24).

In the bivariable analysis, several sociodemographic, clinical, and dietary variables showed preliminary associations with HbA1c. These included child age, age at diagnosis, caregiver age, caregiver education, relationship with the child, duration of diabetes, insulin doses, hospital admission for DKA, monthly income, and green, yellow, and red glycemic index (GI) food intake. However, after adjusting for potential confounders in the multivariable linear regression model, only frequency of insulin administration and caregiver education level remained independently associated with HbA1c.

Regarding insulin administration, children receiving fewer daily insulin doses (1–3 doses) had significantly higher HbA1c compared to those receiving four daily doses. This finding aligns with evidence that intensified insulin regimens improve glycemic outcomes, as supported by long-term follow-up data emphasizing the importance of sustained glycemic control (20). In resource-limited settings where most patients are on NPH and regular insulin twice daily, achieving optimal glycemic control may be challenging compared to regimens that allow greater flexibility and tighter glucose monitoring.

Caregiver education also emerged as an independent predictor. Children whose caregivers had only primary education had significantly higher HbA1c compared to those with tertiary-educated caregivers. This underscores the critical role of caregiver literacy and understanding in diabetes self-

management, including insulin adjustment, dietary planning, and glucose monitoring. Similar observations have been reported in studies highlighting the importance of family involvement and structured education in achieving better glycemic outcomes (22,25).

Although dietary variables (green, yellow, and red GI intake) were significantly associated with HbA1c in the bivariable analysis, these associations did not remain significant after adjustment for confounders. This suggests that the apparent effect of dietary GI exposure on glycemic control may be mediated or confounded by other factors such as insulin dosing patterns, caregiver education, and overall self-management practices. Previous studies have demonstrated significant associations between healthier dietary patterns and improved glycemic control (21–23). For example, a "High-Vegetables" dietary pattern showed protective effects on HbA1c in Jordanian children with T1DM (21), and higher fiber intake was associated with lower odds of suboptimal control in Australian youth (23). The discrepancy between those findings and the present study may be explained by contextual differences, dietary assessment methods, and treatment regimens.

Additionally, other variables that were significant in the bivariable analysis—such as age of the child, age at diagnosis, caregiver age, relationship with caregiver, duration of diabetes, DKA admission history, and monthly income—lost statistical significance in the multivariable model. This indicates that their initial associations with HbA1c were likely confounded by stronger predictors, particularly insulin dosing frequency and caregiver education. It also highlights the multifactorial nature of glycemic control, where interrelated clinical and socioeconomic factors influence outcomes.

Overall, while dietary GI exposure showed a trend toward association with HbA1c, insulin regimen intensity and caregiver educational status were the dominant independent determinants of glycemic control in this population.

This study has several limitations. First, its cross-sectional design precludes establishing causal relationships between dietary patterns and glycemic control. Second, dietary intake was assessed using a food frequency questionnaire based on caregiver or participant recall, which is subject to recall bias and social desirability bias. Respondents may have over-reported adherence to recommended foods (e.g., low-GI items) and under-reported consumption of high-GI or "forbidden" foods, potentially attenuating true associations. Third, measurement of dietary quality did not quantify portion sizes with high precision, which may have reduced sensitivity in detecting

associations with HbA1c. Furthermore, most participants were on similar insulin regimens (predominantly NPH + RI twice daily), limiting variability in treatment exposure. Residual confounding from unmeasured factors such as physical activity intensity, carbohydrate counting accuracy, and psychosocial influences may also have affected the results. These limitations may partly explain why nutritional patterns and GI categories were not independently associated with glycemic control in the multivariable analysis.

7. CONCLUSION AND RECOMMENDATIONS

This study demonstrates that children and adolescents with Type 1 Diabetes Mellitus (T1DM) at Tikur Anbessa Specialized Hospital experience a high burden of suboptimal glycemic control, with a mean HbA1c of 10.34 ± 2.20%, considerably above the recommended targets of <7.0% (11,12). These findings highlight a substantial gap between international glycemic standards and the current level of control in this setting.

Although several sociodemographic, clinical, and dietary factors showed associations with HbA1c in the bivariable analysis, only frequency of insulin administration and caregiver educational status remained independent predictors after adjustment for confounders. Children receiving fewer daily insulin doses had significantly higher HbA1c compared to those receiving four daily doses, underscoring the importance of treatment intensification in achieving optimal glycemic control. Additionally, children whose caregivers had only primary education demonstrated higher HbA1c levels compared to those with tertiary-educated caregivers, emphasizing the critical role of caregiver capacity in diabetes self-management.

Dietary glycemic index categories and dietary adherence showed preliminary associations in bivariable analysis but were not independently associated with HbA1c in the multivariable model. This suggests that the effect of dietary patterns on glycemic control may be mediated through treatment-related and educational factors, particularly insulin dosing practices and caregiver knowledge.

To improve glycemic outcomes, interventions should prioritize optimization of insulin therapy, including consideration of more intensive regimens where feasible, and strengthening structured Diabetes Self-Management Education (DSME) programs tailored to caregiver educational level. Educational interventions should focus on practical insulin adjustment skills, glucose monitoring interpretation, and context-appropriate dietary guidance. In addition, improving access to glucose monitoring supplies and supporting consistent follow-up care are essential system-level strategies to bridge the gap between current outcomes and recommended glycemic targets.

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ANNEX

Annex 1

Information and consent form.

Dear Participant,

My name is Dr. Hanna Yirdaw and I am a pediatric and child health final year resident at TASH. I am currently doing my research on dietary pattern and its association with glycemic control among children and adolescents with type T1D at TASH. The purpose of this study is to assess and investigate the association between diet and glycemic control among children and adolescents with T1DM at TASH. The data collected will only be used for the purpose of this study. Confidentiality will be strictly protected and none of your responses will affect you in any way. Your participation will significantly help increase the body of knowledge in this area and is vital for the success of this study but is purely voluntary. You may decline to participate in the study at any point if you choose to do so. I would like to thank you in advance for your participation. If you have any questions or need to contact the researcher, please use the following contact information.

Respectfully,

Dr. Hanna yirdaw

+251-910849838

E-mail; hanishayirdaw@gmail.com

Consent form

I declare that the purpose, procedure as well as, the risks and benefits of the study have been explained to me and that I understand. I hereby agree to take part in the study.

Annex 2

Questionnaire

Part 1:

Socio-demographic Data

1. Study Id no: _____, MRN: _____
2. Age (Years**):** Current age (years)_____, Age at diagnosis (years)_____
3. Sex: - ☐ Male ☐ Female
4. Place of Residency: - ☐Urban ☐Rural
5. School grade/level: _____
6. Anthropometric measurements: -Weight (kg):_____, Height (cm): _____BMI**:** _____
7. Nutritional status (Height for Age):- ☐well-nourished ☐moderate stunting ☐severe stunting
8. Weight for Height (W/H): ☐normal ☐moderate wasting ☐severe wasting
9. Relationship of the Care Giver of the Child: _____

Family History

10. **Age of the care giver (years): _____**
11. **Gender**

    ☐ Male ☐ Female

12. Income (monthly)…….
13. Educational Status of Parents**:**

    ☐Cannot read and write, ☐ Primary, ☐ Secondary, ☐ Diploma and above

14. Marital status: ☐Single ☐Married ☐Divorced ☐Widowed

15. Family history of T1DM: - ☐yes ☐No

Part 2: Dietary Patterns & Meal Habits

Variable	**Response Options / Format**
Duration of diabetes (years/months)	_____
Meals and snacks per day	_____
Most recent HbA1c (%)	_____ Date: _____
Insulin regimen	☐ NPH ☐ Mixed ☐RI
Doses of insulin	☐ once daily ☐ 3/day ☐ 2/day
Frequency of self-monitoring blood glucose	☐0/day ☐1–2x/day ☐3–4x/day ☐>5x/day
Hospital admissions for DKA in the past year	A. 1 time B. 2 times C. 3 times D. >3 times

Part 3: Food Frequency Questionnaire

Please tick the number that best represents usual intake: -

0 = Never or <1/month

1 = 1-3/month

2 = 1-3/week

3 = 4-6/week

4 = 1/day

5 = 2+/day

Variable	Food items	Never or <1/month	1-3/month	1-3/week	4-6/week	1/day	>2/day
Cereals and staples	White bread						
	Whole-grain bread / brown bread						
	Kocho bread						
	Rice						
	Pasta / noodles						
	Maize/corn porridge (injera/porridge)						
	Red/white teff injera						
Fruits and vegetables	Fresh fruit (banana, apple, orange, etc.)						
	Citrus fruits such us lemon, grape						
	Leafy green vegetables(broccoli, cabbage, cauli flower, and etc…)						
	Other vegetables (tomato, carrot, onion,)						
	Fruit juices (commercial, with sugar)						

Variable	Food items	Never or <1/month	1-3/month	1-3/week	4-6/week	1/day	>2/day
Diary and proteins	Milk (cow/goatcamel) or yogurt						
	Cheese						
	Eggs						
	Legumes (beans, lentils)						
Snacks and Sweets	Sugary snacks (chocolates, candy)						
	Sweet biscuits / cakes						
	Sugary breakfast cereals						
	Ice cream / dessert						
Beverages	Sugar-sweetened beverages / soda						
	Sweetened tea/coffee						
	Plain water (number of cups/day) - write number						
Fast food and processed	Fried fast food (chips, fried chicken)						

Variable	Food items	Never or <1/month	1-3/month	1-3/week	4-6/week	1/day	>2/day
	Processed meats (sausages, hotdogs)						
	Takeaway/restaurant meals (frequency/week) - write number						

Thank you for offering your time to participate in this research study!