DOI: 10.51745/najfnr.9.19.118-128

ORIGINAL ARTICLE

Nutrition, Metabolism, and Prevention of NCDs

Impact of food security, dietary diversity, and nutritional status on glycemic control among adults with type 2 diabetes mellitus in Fako Division, Cameroon

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ABSTRACT

Background: Diabetes mellitus (DM) represents a prevalent metabolic disease that has been increasingly recognized as a global health priority. However, the precise influence of food security, dietary diversity, and nutritional status on glycemic control among individuals with type 2 diabetes mellitus (T2DM) remains inadequately characterized.

Aims: This study aimed to assess the association between food security, dietary diversity, nutritional status, and glycemic control in adults diagnosed with T2DM undergoing treatment at Buea and Limbe Regional Hospitals within the Fako Division, Cameroon.

Patients and Methods: A cross-sectional study design was employed to recruit individuals with T2DM from the aforementioned hospitals. Data collection was conducted using a structured questionnaire, encompassing sociodemographic characteristics, food security status, dietary diversity, nutritional status, blood pressure measurements, and glycemic control assessments. Glycemic control was determined using a glucometer. Data were analyzed using statistical package for the social sciences version 27.0.

Results: The study revealed that 28.8% of respondents exhibited a normal Body Mass Index (BMI), while 41.1% were classified as overweight and 30.1% as obese. Additionally, 12.7% of household experienced food insecurity, compared to 87.3% who were food secure. A majority of respondents (77.9%) reported consuming a diverse diet (≥ 6 food groups), 19.1% consumed 4 – 5 food groups and only 3.0% exhibited a low dietary diversity score (1 – 3 food groups). Additionally, 77.9% of participants presented with poor fasting blood glucose levels, whereas 22.1% demonstrated good fasting blood glucose control. Participants residing in household with ≤ 4 family members were approximately two times more likely to exhibit poor fasting blood glucose compared to those residing in household with > 4 family members (Adjusted Odds Ratio [AOR]: 1.83, 95% Confidence Interval [CI]: 1.02 – 3.28, p = 0.042). However, no significant associations were observed between food insecurity (p = 0.539), low dietary diversity (p = 0.854), high BMI (p = 0.782), fasting blood glucose levels (p > 0.05).

Conclusions: The majority of individuals with T2DM in the study population were classified as overweight or obese, resided in food-secure households, and reported diverse dietary intake. Small family size was identified as a significant factor negatively impacting glycemic control among adult diabetic patients. Educational and dietary interventions aimed at improving nutritional status and blood glycemic control are recommended.

Keywords: Body mass index, food group, food security, fasting blood glucose.

ARTICLE INFORMATION

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Received: September 19, 2024
Revised: January 08, 2025
Accepted: March 02, 2025
Published: March 27, 2025

Article edited by:
Prof. Khaled Méghit Boumédiène
Article reviewed by:
Dr. Tonderayi Mathew Matsungo
Dr. Nkereuwem Ekerette

Cite this article as: Tambe B. A., Nkopi Nneh S. A., Djikeng F. T., Dhlamini T., Chipili G., G Mbhenyane X. (2025). Impact of food security, dietary diversity, and nutritional status on glycemic control among adults with type 2 diabetes mellitus in Fako Division, Cameroon. *The North African Journal of Food and Nutrition Research*, 9 (19): 118 – 128. https://doi.org/10.51745/najfnr.9.19.118-128

1 INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder that has become increasingly prevalent over the past few decades. T2DM is characterized by persistent hyperglycemia, which, if inadequately managed, can lead to a spectrum of severe health complications. One of the key aspects of managing T2DM is maintaining a healthy and balanced diet. Nutritional management is critical in the therapeutic regimen for patients with T2DM as dietary intake directly influences glycemic control, weight management, and overall physiological well-being (Frayne *et al.,* 2010).

T2DM constitutes approximately 90 to 95% of all diagnosed diabetes cases (Cioana *et al.,* 2023). Epidemiological evidence from Saudi Arabia indicates that diabetes mellitus (DM) has emerged as a leading cause of morbidity and underscoring the rapid escalation of the epidemic within the Middle East region (Alzaheb & Altemani, 2018). The Western Pacific islands continue to exhibit disproportionately high diabetes prevalence rates, attributable to a confluence of ethnic predispositions and evolving lifestyle patterns (Bakr, 2015).

The African continent, historically characterized by low diabetes prevalence, is currently witnessing a marked surge in diabetes prevalence. The adult (20–79 years) prevalence rate is estimated at 4.7%, with global projections indicating a further increase to 5.1% and 5.2% by 2030 and 2045 respectively (Saeedi *et al.,* 2019). In 2019, global reports documented 366,227 diabetes-related deaths, with 73.1% occurring in individuals under 60 years of age, a rate exceeding that of any other global region (Saeedi *et al.,* 2019). Data from sub-Saharan Africa (Hall *et al.,* 2019) suggest a substantial unmet need for diabetes care and diagnosis, encompassing access to complications screening, counselling, and pharmacological interventions. Several low-income countries possess healthcare systems that are already overburdened with multiple competing health care issues.

The etiological factors associated with T2DM are multifarious, including both genetic and environmental determinants. These include a familial predisposition to diabetes, advanced age, obesity (particularly abdominal obesity), and physical inactivity (Kyrou *et al.,* 2020). Adiposity and prolonged obesity are recognized as potent risk factors for T2DM, while a sedentary lifestyle has also been implicated in increased disease susceptibility (Webb *et al.,* 2006). Deficiencies in patient education, health care professional availability, and health healthcare facility access significantly elevate the risk of diabetes-related complications. Prophylactic interventions are resource-intensive, and some countries rely on international aid to facilitate screening and educational initiatives (Hall *et al.,* 2019).

The medical management of T2DM includes the monitoring of blood glucose levels and laboratory assessments, alongside pharmacological interventions, including sulfonylureas, non-sulfonylurea secretagogues, biguanides, α-glucosidase inhibitors and thiazolidinediones. Concomitantly, nutritional management and lifestyle strategies are critical components of a comprehensive therapeutic approach, aimed at improving glycemic control, dyslipidemia, and blood pressure, associated with education on dietary principles (Webb *et al.,* 2006). Dietary management has been demonstrated to be crucial in the primary prevention of DM, the management of established cases, and the mitigation of associated complications (Sultana *et al.,* 2020). The assessment of dietary quality in individuals with DM is beneficial in the development of effective diabetes management strategies, requiring a proper evaluation of their nutritional status, particularly in the context of secondary and tertiary prevention to decelerate the progression of diabetes-related complications (Duvenage, Gericke & Muchiri, 2023; Kyrou *et al.,* 2020; Wong & Sabanayagam, 2020). Enhanced dietary status has been correlated with a range of protective effects on health outcomes. Dietary intake is a recognized determinant of BMI and BMI control is key metric in the management of glycemic control among patients with T2DM (Alzaheb & Altemani, 2018). The consumption of a diverse array of foodstuffs, incorporating servings from all food groups, is beneficial to the maintenance of healthy body weight.

Fasting plasma glucose (FPG) is a diagnostic criterion of T2DM, reflecting plasma glucose levels after an eight-hour fast. According to the World Health Organization WHO (2003), normal glucose metabolism refers to 6.1 mmol/L > FPG ≥ 3.9 mmol/L; impaired fasting glucose (7.0 mmol/L > FPG ≥ 6.1mmol/L) indicates prediabetes and diabetes mellitus is defined as FPG ≥ 7.0 mmol/L. A two-hour plasma glucose (2h–PG) value of ≥ 11.1 mmol/L in a 75 g oral glucose tolerance test (OGTT) is closely associated with an FPG level of 7.0 mmol/L, both of which are predictive of retinopathy development. This study aims to assess the association between food security, dietary diversity, nutritional status, and the management of T2DM in patients receiving treatment at two healthcare facilities in the Fako Division.

2 Patients and Methods

2.1 Study area

This study was carried out in Buea and Limbe Regional Hospitals, situated in the Fako Division, located between latitude 4º 14 north of the equator and longitude 9º 23 east of the Greenwich Meridian. The Buea Regional Hospital is approximately 2 kilometers from the Mile 17 motor park positioned between the delegations of education and the army barracks, along the Bokwango neighborhood highway.

Limbe Provincial Hospital (formerly Limbe Provincial Hospital, also called Mile 1 Hospital), a 200-bed healthcare facility in the Southwest Region of Cameroon, serves as the primary referral hospital for the region and is operated by the Cameroon Ministry of Public Health. Both hospitals maintain established diabetes units staffed by diabetologists.

2.2 Study design and population

A cross sectional study was conducted from November 2021 to August 2022 at the Buea and Limbe Regional Hospitals, involving patients diagnosed with diabetes. Participants who had received treatment for a minimum of six months at these healthcare facilities met the inclusion criteria. An exhaustive sampling method was employed to recruit all eligible participants attending the selected hospitals. The minimum sample size of 299 was calculated using the formula $n = Z^2 \times P (1-P) / d^2$, where: n = minimum sample size, Z = confidence value = 1.96 for a 95% confidence interval, P = estimated prevalence of key diabetes indicators (8%) from a study in the Center and North-west regions (Bigna *et al.,* 2018), and d = 5% of precision. An additional 49 participants were included to account for potential attrition, ensuring the minimum sample size was achieved. Ethical approval was obtained from the Institutional Review Board of the University of Buea (No: 2021/1467-05/UB/SG/IRB/FHS), Cameroon and all participants provided written informed consent prior to enrollment.

2.3 Data collection and procedure

Data were collected using a pre-tested, structured interview questionnaire, including sociodemographic information, anthropometric measurements (body weight, height, BMI), dietary assessment via 24-hour food recall and household food security status.

Sociodemographic data

This section included patient age, marital status, educational attainment, income level, household size, and duration of T2DM, among other relevant demographic characteristics.

Anthropometric measurement

Height was measured to the nearest 0.1 cm using UNICEF wooden height and length boards, while body weight was measured to the nearest 0.1 kg using a UNICEF Seca 762 classic mechanical medical weighing scale. BMI was calculated as weight (kg) / height (m²) and categorized according to the World Health Organization (Bull *et al.,* 2020) standards: underweight (BMI ≤ 18kg/m²), normal range (18.5 ≤ BMI < 24.9 kg/m²), overweight (BMI = 25 ≤ BMI < 29.9 kg/m²) and obese (BMI = ≥ 30 kg/m²).

Dietary diversity

Participants were asked to recall all foods and beverage items consumed within the 24 hours preceding the interview. This 24-hour dietary recall, an opened-ended structured interview, is considered a reliable method for assessing dietary diversity due to its comprehensive capture of recent consumption and reduced recall bias compared to longer recall periods (FANTA & FAO, 2016; FAO, 2010). According to FAO report, there are no conventional cut-off points in terms of number of food groups to indicate adequate or insufficient dietary diversity for HDDS or IDDS (FAO, 2010; FANTA & FAO, 2016). Based on FAO guidelines, food items were categorized into nine different food groups: cereals, white tubers and roots, vegetables, fruits, meat, eggs, fish and other seafood, legumes, nuts and seeds, milk and milk products, oils and fats, and sweets. These were then recategorized into 9 broader groups for analysis: starchy staples, green leafy vegetables, vitamin A-rich fruits/vegetables, other fruits/vegetables, organ meats, meat/poultry/fish, eggs, legumes/nuts/seeds, and milk/milk products. Dietary diversity was assessed based on the consumption of these nine food groups, emphasizing micronutrient intake and food access. Participants consuming six or more food groups were classified as having high dietary diversity, those consuming four to five groups as having moderate diversity, and those consuming three or fewer groups as having low dietary diversity.

Food security

Household food security status was measured using Household Food Insecurity Access Scale (HFIAS), a nine-item questionnaire. Participants were classified as food secure if they reported ‘no’ to all items and food insecure if the they reported ‘yes’ to at least one item. The HFIAS assesses food insecurity experiences during the preceding 30 days (FAO, 2010; FANTA & FAO, 2016). Households were categorized in four groups based on HFIAS scores: food secure (0–1), mildly food insecure (2–7), moderately food insecure (8–14), and severely food insecure (15–27).

Physical activity

Physical activity levels were assessed using a structured questionnaire according Bull *et al.* (2020). These guidelines recommend that individuals, including those with chronic conditions and disabilities, engage in at least 150–300 min of moderate-intensity physical activity, 75–150 min of vigorous-intensity, or a combination of moderate-to-vigorous-intensity physical activity for a minimum of 150 min per week to achieve substantial health benefits. Participants were subsequently categorized into low (sedentary), moderate, or high physical activity levels based on these minimum recommendations.

Blood pressure

Blood pressure measurements were obtained using an electronic sphygmomanometer on the non-dominant arm. Three consecutively readings were recorded, with a one-minute interval between each measurement, after a five-minute rest period in a quite environment. The average of these three readings was utilized for data analysis. Arterial hypertension was defined as a systolic blood pressure (SBP) of ≥ 140 mmHg and/or a diastolic blood pressure (DBP) of ≥ 90 mmHg.

Diabetes and glycemic control

In the current study, DM was defined as the prescription of hypoglycemic medication for ≥ 28 days within the preceding two years or a FPG ≥ 126 mg/dL at screening (Coates, Swindale & Bilinsky, 2007). Glycemic control was evaluated using the hemoglobin A1c (HbA1c) test in conjunction with physician consultation. Participants were categorized into two groups, based on the American Diabetes Association (ADA, 2011) recommendations: good glycemic control (FPG ≤ 130 mg/dL) and poor glycemic control (FPG > 130 mg/dL). Blood glucose levels were measured using a glucometer (OneTouch Verio Reflect meter, Zug-Switzerland). Information regarding treatment regimens and the presence of diabetes-related complications was also collected.

2.4 Statistical analysis

All data were coded, entered, cleaned, and analyzed using the Statistical Package for Social Sciences (SPSS, V.26.0). Descriptive and inferential statistical methods were employed. Descriptive statistics, including means, standard deviation, minimum and maximum values for continuous variables, and frequencies and percentages for categorical variables, were presented in tables and figures. Inferential statistical analysis, including Pearson's chi-square test and logistic regression analyses, were conducted. Pearson correlations were utilized to determine the relationship between food security and dietary diversity. Bivariate analysis was performed to identify factors associated with poor glycemic control, using Pearson's Chi Square tests. Variables demonstrating significance ($p < 0.20$) in the bivariate analysis were included in a multivariate logistic regression model, to identify independent associations with poor diabetes control. Furthermore, variables identified in preceding studies as significant predictors of poor diabetes control were incorporated into the multivariate analysis. A manual backward stepwise selection method was used to determine the optimal model, based on the Bayesian Information Criterion (BIC). Collinearity among predictors was assessed using tolerance values. Potential confounding variables were evaluated by iteratively removing and inserting plausible variables, with a change of ≥ 25% in odds ratios considered indicative of confounding. Significant interactions between final model variables were also assessed. Statistical significance was set at $p < 0.05$.

3 RESULTS

3.1 Characteristics of the study participants

This study included a cohort of 299 participants with T2DM. The sample comprised 53.8% males and 46.2% females, with participant ages ranging from 45 to 75 years. The mean age of the participants was 61.9 ± 7.6 years. Furthermore, 80.3% of the participants were married and cohabiting with their spouses, and 71.2% resided in households where two or more income-earning members. The majority of participants (48.5%) reported household sizes of 4 – 6 individuals, with a mean household size of 4.4 ± 2.0 persons. In 93.7% of households, females were the primary decision-makers regarding food procurement and consumption. A high proportion (44.5%) of participants reported household income levels between 110,000 and 200,000 FCFA (Table 1).

Table 1. Socio-demographic and socioeconomic characteristics of the study population (n = 299)

Variables Categories	Frequency	Percentage
Regional hospitals		
Buea	191	63.9
Limbe	108	36.1
Sex		
Female	138	46.2
Male	161	53.8
Marital status		
Single	2	.7
Married	240	80.3
Widow(er)	51	17.1
Divorce	6	2.0
Age (years)		
≥75	13	4.3
65 – 74	108	36.1
55 – 64	127	42.5
45 – 54	51	17.1
Level of education		
No formal education	15	5.0
Primary education	12	4.0
Secondary education	26	8.7
Tertiary education	246	82.3
Household family size (persons)		
1 – 3	115	38.5
4 – 6	145	48.5
≥ 7	39	13.0
Household number of earning hands		
1	86	28.8
2	206	68.9
3	7	2.3
Who makes decisions about food purchase and consumption		
Household head (male)	20	6.7
Spouse (female)	279	93.7
Household income level (FCFA)		
≥ 210,000	131	43.8
110,000 – 209,000	133	44.5
≤ 100,000	35	11.7

3.2 Household food insecurity

Regarding household food insecurity, the majority of participants (87.3%) were classified as food secure, while 12.7% were classified as food insecure. Detailed analysis revealed that 7.7% of participants experienced moderate food insecurity, 4.7% while experienced mild food insecurity, and 0.3% experienced severe food insecurity.

3.3 Dietary diversity score

Dietary diversity was assessed using 17 food groups (cereals, vitamin A-rich vegetables/ tubers, white tubers, dark green leafy vegetables, other vegetables, vitamin A-rich fruits, other fruits, organ meats, flesh meats, eggs, fish, legumes/nuts/seeds, milk and milk products, oils /fats, red palm products, sweets, species/condiments). These 17 food groups were subsequently recategorized into nine broader food groups: starchy staples, dark green leafy vegetables, vitamin A-rich fruits/vegetables, other fruits/vegetables, organ meats, meat/poultry/fish, eggs, legumes/ nuts/seeds, milk/milk products. The most frequently consumed food groups were fish (92.6%), other vegetables (88.3%), species /condiment (81.9%), cereals (80.3%) and white tuber (78.9%), while vitamin A rich vegetables/tubers (8.7%), eggs (10.7%), sweets (2.3%) and organ meat (0.7%) were the least frequently consumed (Figure 1). Overall, 77.9% of participants exhibited high dietary diversity, consuming six or more food groups, 19.1% consumed 4 – 5 food groups and 3.0% consumed 1 – 3 food groups. The mean number of food groups consumed was 6.7 ± 1.9.

Results displayed on Table 2, indicate that 77.9% of participants revealed poor FPG, and 31.4% exhibited stage 1 hypertension. Regarding diabetes management, 53.9% of participants were treated with oral hypoglycemic agents alone, 34.0% with insulin alone, 10.1% with a combination of oral agents and insulin, and 2.0% were under clinical follow-up. The majority of participants (89.7%) reported no diabetes-related complications, while 4.6% experienced stroke, 3.0% leg ulcer, and 0.3% blindness. A significant proportion (62.9%) of participants reported a sedentary lifestyle, and 30.1% were classified as obese.

Table 3 presents the results of bivariate analysis examining the relationship between glycemic control in diabetic patients and selected sociodemographic characteristics. A statistically significant association was observed between family size and glycemic control (p = 0.036). Table 4 presents the results of bivariate analysis examining the relationship between glycemic control in diabetic patients and selected health-related factors, dietary diversity, food insecurity, and nutritional. No statistically significant associations were identified for any of these variables within the study population ($p > 0.05$).

Table 2. Health related characteristics of participants

Variables	Frequency	Percentage
Body mass index (BMI)		
Normal	86	28.8
Overweight	123	41.1
Obese	90	30.1
Fasting blood glucose		
Good (FPG ≤ 130 mg/dL)	66	22.1
Poor (FPG >130 mg/dL)	233	77.9
Duration of diabetes (years)		
1–5	172	57.5
6–10	97	32.5
11–20	29	9.7
21–30	1	0.3
Type of diabetes medication		
Insulin only	101	34.0
Insulin and medication	30	10.1
Medication only	162	53.9
Clinical follow up	6	2.0
Diabetes complications		
None	268	89.7
Stroke	14	4.6
Leg ulcer	9	3.0
Blindness	1	0.3
Others	7	2.4
High blood pressure (HBP)		
HBP Stage 1	94	31.4
HBP Stage 2	86	28.8
Normal	32	10.7
Pre-hypertensive	87	29.1
Physical activity level		
Low (Sedentary)	188	62.9
Moderate	111	37.1

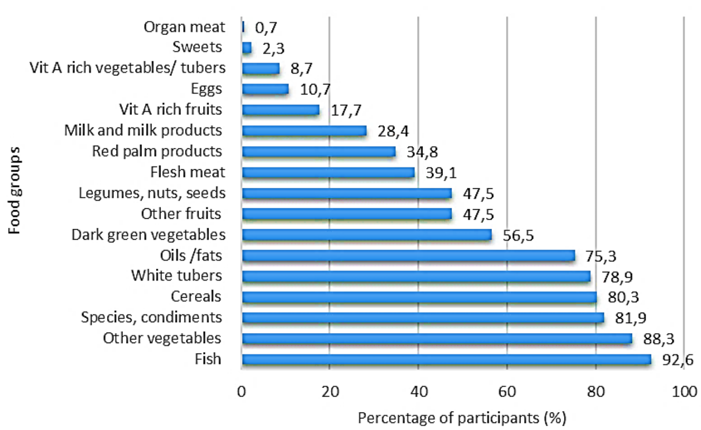

Figure 1. Food groups consumed by participants (n=299)

Table 3. Association of sociodemographic characteristics and glycemic control

Characteristics	FBG				
	Good (< 130mg/dL) n (%)	Poor (≥ 130mg/dL) n (%)	Total	Chi square	*p*-value
Hospital facility				0.002	0.963
Buea Regional hospital	42(14.0)	149(49.8)	191(63.9)		
Limbe Regional hospital	24(8.0)	84(28.1)	108(36.1)		
Town				0.012	0.912
Buea	42(14.0)	150(50.2)	192(64.2)		
Limbe	24(8.0)	83(27.8)	107(35.8)		
Sex				1.611	0.204
Females	35(11.7)	103(34.4)	138(46.2)		
Males	31(10.4)	130(43.5)	161(53.8)		
Marital status				0.129	0.720
Married	54(18.1)	186(62.2)	240(80.3)		
Single/Divorce/Widow(er)	12(4.0)	47(15.7)	59(19.7)		
Age (years)				1.074	0.300
45–59	29(9.7)	86(28.8)	115(38.5)		
≥ 60	37(12.4)	147(49.2)	147(49.2)		
Family size				**4.396**	**0.036**
> 4 persons	32(10.7)	80(26.8)	112(37.5)		
≤ 4 persons	34(11.4)	153(51.2)	187(62.5)		
Educational level of head of the household				4.745	0.191
No formal education	2(0.7)	13(4.3)	15(5.0)		
Primary education	5(1.7)	7(2.3)	12(4.0)		
Secondary education	8(2.7)	18(6.0)	26(8.7)		
Tertiary education	51(17.1)	195(65.2)	246(82.3)		
Household income level (FCFA)				0.243	0.886
≤ 100,000	7(2.3)	28(9.4)	35(11.7)		
110,000- 200,00	31(10.4)	102(34.1)	133(44.5)		
≥ 210,000	28(9.4)	103(34.4)	131(43.8)		

Table 4. Association of health-related factors, dietary diversity, food insecurity and the nutritional status with glycemic control

Characteristics	FBG			FBG	
	Good (<130mg/dL) n (%)	Good (≥ 130mg/dL) n (%)	Total n (%)	Chi square	*p*-value
Blood Pressure (BP)				1.927	0.382
HBP stage	35(11.7)	145(48.5)	180(60.2)		
Normal	9(3.0)	23(7.7)	32(10.7)		
Pre-hypertensive	22(7.4)	65(21.7)	87(29.1)		
Body Mass Index (BMI)				0.092	0.762
Normal	18(6.0)	68(22.7)	86(28.8)		
Overweight/obese	48(16.1)	165(55.2)	213(71.2)		
Diabetes duration				0.074	0.785
> 5 years	29(9.7)	98(32.8)	127(42.5)		
≤ 5 years	37(12.4)	132(45.2)	172(57.5)		
Food insecurity				2.165	0.539
Food secure	55(18.4)	206(68.9)	261(87.3)		
Mildly food insecure	5(1.7)	9(3.0)	14(4.7)		
Moderately food insecure	6(2.0)	17(5.7)	23(7.7)		
Severe food insecure	0(0.0)	1(0.3)	1(0.3)		
Dietary diversity score groups				0.317	0.854
1–3 food groups	2(0.7)	7(2.3)	9(3.0)		
4–5 food groups	11(3.7)	46(15.4)	57(19.1)		
≥ 6 food groups	53(17.7)	180(60.20	233(77.9)		

3.4 Factors associated with the glycemic control of T2DM

Multivariate logistic regression analysis was employed to assess the association between sociodemographic characteristics, health-related factors, dietary diversity, food insecurity, nutritional status, and glycemic control in individuals with T2DM.

The analysis revealed that only household size was the sole significant predictor of glycemic control. Participants residing in household with ≤ 4 family member demonstrated an approximately 2-fold increased likely of exhibiting poor FPG levels compared to those residing in households with > 4 family members (AOR: 1.83, 95% CI: 1.02; 3.28, p = 0.042) as detailed in Table 5.

Table 5. Factors associated the glycemic control of participants with T2DM

Characteristic	n	Poor FBG (%)	aOR (95% CI)	p value
Sex of participants				
Male	130	43.5	1.59 (0.89; 2.86)	0.120
Female	103	34.4	1	
Household family size				
≤ 4	153	51.2	1.83(1.02;3.28)	**0.042**
> 4	80	26.8	1	
Blood pressure of participants				
Normal	23	7.7	0.57 (0.23; 1.37)	0.207
Prehypertension	65	21.7	0.72 (0.39; 1.34)	0.207
HBP stage	145	48.5	1	
Food security				
Yes	27	9.0	0.75 (0.32; 1.74)	0.500
No	206	68.9	1	
Dietary diversity				
1–3 food groups	7	2.3	1.55 (0.29; 8.15)	0.608
4–5 food groups	46	15.4	1.38(0.64; 2.97)	0.414
≥ 6 food groups	180	60.2	1	
BMI				
Overweight/ obesity	165	55.2	0.77(0.40; 1.47)	0.419
Normal	68	22.7	1	

4 Discussion

This study sought to determine the influence food security, dietary diversity, and nutritional status on glycemic control among individuals with T2DM receiving treatment at two public health facilities in the Fako Division, Cameroon. The findings revealed that the majority of participants were male, food secure, consumed a diverse diet, and reported a sedentary lifestyle.

The prevalence of household food insecurity among the study participants was relatively low (12.7%), with mild and moderate food insecurity reported at 0.3%, 4.7%, and 7.7% respectively. On the other hand, a significant proportion (87.3%) of households were food secure. This lower prevalence of food insecurity may be attributed to the older age demographic of the participants, who often have reduced financial obligations, and the smaller household sizes, resulting in fewer individuals to feed. Furthermore, some participants reported financial support from their children, while others maintained income through salaries, pension, farming, or grading. In contrast, Tezera *et al.* (2022) reported a higher prevalence of food insecurity (50.7%) in Ethiopia. Food-insecure individuals with T2DM are at a significantly elevated risk of poor glycemic control, struggle to afford appropriate diabetic diets, and are less likely adhere to dietary counselling compared to their food-secured counterparts (Seligman, Laraia & Kushel, 2010). Additionally, food-secure individuals with T2DM are better able to meet their caloric needs and manage their weight, which may positively influence glycemic control (Shalowitz *et al.*, 2017; Berkowitz & Gao, 2014).

The dietary diversity assessment revealed that fish, other vegetables, species/condiment, cereals, and white tubers were the most frequently consumed food groups, while vitamin A-rich vegetables/tubers, eggs, sweets, and organ meat were the least frequently consumed. A considerable portion (77.9%) of participants consumed six or more healthy food groups, indicating a diverse diet, while 19.1% consumed 4–5 healthy food groups, and 3.0% consumed 1–3 healthy food groups. These findings contrast with those reported by Madlala *et al.* (2022) in South Africa, where 70.4% of T2DM individuals consumed fewer than five of the ten healthy food groups, suggesting low dietary diversity. This discrepancy may be due to the higher educational attainment, stable income, and nutritional knowledge of the participants in the present study, enabling them to afford and select healthier food options.

Additionally, 30.1% of the participants were classified as obese, 41.1% as overweight, and only 28.8% exhibited a normal BMI. Obesity is recognized as a significant risk factor for the development of T2DM compared to normal BMI. Several studies have reported higher HbA1c levels in individuals with a elevated BMI, and a positive correlation between mean BMI and HbA1c levels (Boye *et al.,* 2021). This may be attributed to excessive caloric intake and a predominantly sedentary lifestyle among the participants. The likelihood of diabetes or uncontrolled blood glucose levels was observed to be twofold or greater in overweight and obese individuals compared to those with normal weight. These results are consistent with studies conducted in Malaysia (Firouzi, Barakatun-Nisak and Azmi, 2015) and Saudi Arabia (Alzaheb & Altemani, 2018), which reported overweight and obesity prevalence rates of 86.5% and 72.3%, respectively, among T2DM patients. The likelihood of being diabetic or exhibiting an uncontrolled blood glucose level is two-fold or more among overweight and obese individuals as compared to normal weight individuals.

In the present study, 77.9% of participants exhibited poor FPG levels (≥ 130 mg/dL). This high prevalence of uncontrolled T2DM is concerning and aligns with previous research conducted in other African nations. For instance, Dimore, Edosa, & Mitiku (2023) reported poor glycemic control in 72.8% of T2DM patients in the Hadiya zone, Southern Ethiopia. Discrepancies in sample size may account for some of the observed differences. The previous studies present higher sample sizes compared to the current study.

No significant association were noticed between dietary diversity, household food insecurity, nutritional status, and glycemic control in the study population ($p > 0.05$). However, previous studies have demonstrated a significant association between BMI and glycemic control in T2DM individuals across multiple studies, with a general trend of declining glycemic control with increasing BMI (Al-Rasheedi, 2015; Boye *et al.,* 2021; Madlala *et al.,* 2022). In addition, similar studies have reported that both food insecurity and dietary diversity are a concern among adults diagnosed with T2DM (Mphwantheet *et al.,* 2018; Wang *et al.,* 2023).

Conversely, a significant association was observed between household family size and poor glycemic control (AOR: 1.83, 95% CI: 1.02-3.28, $p = 0.042$). Participants residing in households with fewer than four members were more likely to exhibit poor glycemic control. These findings reveal the significance of the household context in diabetes interventions, implying that household members not directly targeted by such interventions may still influence dietary adherence and glycemic control (Seligman *et al.,* 2015). Identical results have been reported in randomized controlled trials conducted in the United States (Hager *et al.,* 2023; Seligman *et al.,* 2015).

Limitations and strength of the study

The current study possesses several limitations that should be considered when interpreting the findings. The cross-sectional design prevents the establishment of causal relationships. Furthermore, a substantial portion of the data was based on self-reported information, which may be subject to recall bias and reporting inaccuracies, particularly regarding income and dietary intake. The dietary diversity score was based on the minimum dietary diversity for women score, which has not been validated for male participants or older women. Furthermore, indicators of nutritional status, such as overweight and obesity, reflect long-term cumulative processes, while dietary data were collected for a 24-hour prior.

However, the study also possesses several strengths. A relatively large, calculated sample size was utilized to enhance the statistical power of the analysis. Robust statistical methods were employed to analyze the data and potential confounders were accounted for in the multivariate analysis, thereby strengthening the validity of the findings.

5 Conclusions

The present study revealed that a substantial proportion of individuals with T2DM, attending urban healthcare facilities with established follow-up protocols, exhibited overweight or obese BMIs, reported food security, and demonstrated acceptable dietary diversity, despite suboptimal glycemic control. Overall, with the exception of household size, sociodemographic characteristics, dietary diversity, household food insecurity, and nutritional status did not demonstrate significant association with glycemic control in this population. Specifically, individuals residing in smaller households were observed to possess a higher likelihood of poor glycemic control. These findings underline the necessity for targeted educational and dietary interventions aimed at enhancing nutritional status and FPG management in individuals with T2DM.

Acknowledgment: The authors thanks everyone who contributed to the success of this research.

Source of funding: None, the study was self-funded by authors.

Previous submissions: The manuscript has not presented in any scientific forum or meeting.

Authors' Contribution: Betrand A. Tambe, **Solange A. N. Nneh** and **Fabrice T. Djikeng** participated in the concept, design, definition of intellectual content, literature search, data acquisition, data analysis. All authors participated in interpretation statistical analysis, manuscript preparation, manuscript editing, and manuscript review and the approved the final manuscript.

Conflicts of Interest: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Preprint deposit: Authors did not share this manuscript as a preprint deposit.

REFERENCES

Al-Rasheedi, A. A. (2015). Glycemic control among patients with type 2 diabetes mellitus in countries of Arabic Gulf. *International Journal of Health Sciences*, *9*(3), 345–350. https://doi.org/10.12816/0024701 [Crossref] [PubMed] [Google Scholar] [Publisher]

Alzaheb, R. A., & Altemani, A. H. (2018). The prevalence and determinants of poor glycemic control among adults with type 2 diabetes mellitus in Saudi Arabia. *Diabetes, Metabolic Syndrome and Obesity,* 11, , 15-21. https://doi.org/10.2147/DMSO.S156214 [Crossref] [PubMed] [Google Scholar] [Publisher]

American Diabetes Association (2011). Standards of medical care in diabetes--2011. *Diabetes care*, *34 Suppl 1*(Suppl 1), S11–S61. https://doi.org/10.2337/dc11-S011 [Crossref] [PubMed] [Google Scholar] [Publisher]

Bakr, E. S. H. (2015). Nutritional assessment of type II diabetic patients. *Pakistan Journal of Nutrition,* 14(6), 308-315. https://doi.org/10.3923/pjn.2015.308.315 [Crossref] [Google Scholar] [Publisher]

Berkowitz, S. A., Gao, X., & Tucker, K. L. (2014). Food-insecure dietary patterns are associated with poor longitudinal glycemic control in diabetes: results from the Boston Puerto Rican Health study. *Diabetes Care*, 37(9), 2587-2592. https://doi.org/10.2337/dc14-0753 [Crossref] [PubMed] [Google Scholar] [Publisher]

Bigna, J. J., Nansseu, J. R., Katte, J. C., & Noubiap, J. J. (2018). Prevalence of prediabetes and diabetes mellitus among adults residing in Cameroon: a systematic review and meta-analysis. *Diabetes Research and Clinical Practice*, 137, 109-118. https://doi.org/10.1016/j.diabres.2017.12.005. [Crossref] [PubMed] [Google Scholar] [Publisher]

Boye, K. S., Lage, M. J., Thieu, V., Shinde, S., Dhamija, S., & Bae, J. P. (2021). Obesity and glycemic control among people with type 2 diabetes in the United States: A retrospective cohort study using insurance claims data. *Journal of Diabetes and its Complications*, 35(9), 107975.https://doi.org/10.1016/j.jdiacomp.2021.107975 [Crossref] [PubMed] [Google Scholar] [Publisher]

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J. P., Chastin, S., Chou, R., Dempsey, P. C., DiPietro, L., Ekelund, U., Firth, J., Friedenreich, C. M., Garcia, L., Gichu, M., Jago, R., Katzmarzyk, P. T., Lambert, E., … Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine*, *54*(24), 1451–1462. https://doi.org/10.1136/bjsports-2020-102955 [Crossref] [PubMed] [Google Scholar] [Publisher]

Cioana, M., Deng, J., Nadarajah, A., Hou, M., Qiu, Y., Chen, S. S. J., Rivas, A., Toor, P. P., Banfield, L., Thabane, L., Chaudhary, V., & Samaan, M. C. (2023). Global Prevalence of Diabetic Retinopathy in Pediatric Type 2 Diabetes: A Systematic Review and Meta-analysis. *JAMA Network Open*, *6*(3), e231887. https://doi.org/10.1001/jamanetworkopen.2023.1887 [Crossref] [PubMed] [Google Scholar] [Publisher]

Coates J, Swindale A, Bilinsky P. (2007). Household Food Insecurity Access Scale (HFIAS) for measurement of food access: indicator guide. Washington, DC: Food and Nutrition Technical … . (August):Version 3. https://doi.org/10.1037/e576842013-001 [Crossref] [Google Scholar] [Publisher]

Dimore, A. L., Edosa, Z. K., & Mitiku, A. A. (2023). Glycemic control and diabetes complications among adult type 2 diabetic patients at public hospitals in Hadiya zone, Southern Ethiopia. *PloS One*, *18*(3), e0282962. https://doi.org/10.1371/journal.pone.0282962 [Crossref] [PubMed] [Google Scholar] [Publisher]

Duvenage, H., Gericke, G. J., & Muchiri, J. W. (2023). Diet quality of adults with poorly controlled type 2 diabetes mellitus at a tertiary hospital outpatient clinic in Tshwane District, South Africa. *South African Journal of Clinical Nutrition*, 36(3), 93-99. https://doi.org/10.1080/16070658.2022.2114406 [Crossref] [Google Scholar] [Publisher]

FANTA & FAO (2016) . *Minimum Dietary Diversity for Women: A Guide for Measurement* . Food and Agriculture Organization of the United Nations. Rome; 2016. 1–82 p. [Google Scholar]

FAO. (2010) *Guidelines for measuring household and individual dietary diversity*. FAO. 1–60 p. [Google Scholar] [Publisher]

Firouzi, S., Barakatun-Nisak, M. Y., & Azmi, K. N. (2015). Nutritional status, glycemic control and its associated risk factors among a sample of type 2 diabetic

individuals, a pilot study. *Journal of Research in Medical Sciences,* 20(1), 40-46.
[PubMed] [Google Scholar] [Publisher]

Frayne, B., Pendleton, W., Crush, J., Acquah, B., Battersby-Lennard, J., Bras, E., ... & Zanamwe, L. (2010). The State of Urban Food Insecurity in Southern Africa (rep., pp. 1-54). Kingston, ON and Cape Town: African Food Security Urban Network. Urban Food Security Series No. 2.
[Google Scholar] [Publisher]

Hager, K., Shi, P., Li, Z., Chui, K., Berkowitz, S. A., Mozaffarian, D., Chhabra, J., Wilken, J., Vergara, C., Becker, E., Small, S., Ling, B., Cash, S. B., Folta, S. C., & Zhang, F. F. (2023). Evaluation of a Produce Prescription Program for Patients with Diabetes: A Longitudinal Analysis of Glycemic Control. *Diabetes care*, *46*(6), 1169–1176. https://doi.org/10.2337/dc22-1645 [Crossref] [PubMed] [Google Scholar] [Publisher]

Hall, V., Thomsen, R. W., Henriksen, O., & Lohse, N. (2011). Diabetes in Sub Saharan Africa 1999-2011: epidemiology and public health implications. A systematic review. *BMC Public Health*, *11*, 564. https://doi.org/10.1186/1471-2458-11-564 [Crossref] [PubMed] [Google Scholar] [Publisher]

Kyrou, I., Tsigos, C., Mavrogianni, C., Cardon, G., Van Stappen, V., Latomme, J., Kivelä, J., Wikström, K., Tsochev, K., Nanasi, A., Semanova, C., Mateo-Gallego, R., Lamiquiz-Moneo, I., Dafoulas, G., Timpel, P., Schwarz, P. E. H., Iotova, V., Tankova, T., Makrilakis, K., … Feel4Diabetes-study Group. (2020). Sociodemographic and lifestyle-related risk factors for identifying vulnerable groups for type 2 diabetes: a narrative review with emphasis on data from Europe. *BMC Endocrine Disorders*, *20*(Suppl 1), 134. https://doi.org/10.1186/s12902-019-0463-3 [Crossref] [PubMed] [Google Scholar] [Publisher]

Madlala, S. S., Hill, J., Kunneke, E., Kengne, A. P., Peer, N., & Faber, M. (2022). Dietary diversity and its association with nutritional status, cardiometabolic risk factors and food choices of adults at risk for type 2 diabetes mellitus in Cape Town, South Africa. *Nutrients*, *14*(15), 3191. https://doi.org/10.3390/nu14153191
[Crossref] [PubMed] [Google Scholar] [Publisher]

Mphwanthe, G., Weatherspoon, D., Kalimbira, A., & Weatherspoon, L. (2018). Food security, dietary diversity and glycemic control among adults diagnosed with type 2 diabetes in Malawi. *Journal of Nutrition Education and Behavior*, *50*(7), S13. https://doi.org/10.1016/j.jneb.2018.04.041
[Crossref] [Google Scholar] [Publisher]

Saeedi, P., Petersohn, I., Salpea, P., Malanda, B., Karuranga, S., Unwin, N., Colagiuri, S., Guariguata, L., Motala, A. A., Ogurtsova, K., Shaw, J. E., Bright, D., Williams, R., & IDF Diabetes Atlas Committee. (2019). Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9th edition. *Diabetes Research and Clinical Practice*, *157*(107843), 107843. https://doi.org/10.1016/j.diabres.2019.107843
[Crossref] [PubMed] [Google Scholar] [Publisher]

Seligman, H. K., Lyles, C., Marshall, M. B., Prendergast, K., Smith, M. C., Headings, A., Bradshaw, G., Rosenmoss, S., & Waxman, E. (2015). A pilot food bank intervention featuring diabetes-appropriate food improved glycemic control among clients in Three States. *Health Affairs (Project Hope)*, *34*(11), 1956–1963. https://doi.org/10.1377/hlthaff.2015.0641
[Crossref] [PubMed] [Google Scholar] [Publisher]

Seligman, H. K., Laraia, B. A., & Kushel, M. B. (2010). Food insecurity is associated with chronic disease among low-income NHANES participants. *The Journal of Nutrition*, *140*(2), 304–310. https://doi.org/10.3945/jn.109.112573 [Crossref] [PubMed] [Google Scholar] [Publisher]

Shalowitz, M. U., Eng, J. S., McKinney, C. O., Krohn, J., Lapin, B., Wang, C.-H., & Nodine, E. (2017). Food security is related to adult type 2 diabetes control over time in a United States safety net primary care clinic population. *Nutrition & Diabetes*, *7*(5), e277. https://doi.org/10.1038/nutd.2017.18 [Crossref] [PubMed] [Google Scholar] [Publisher]

Sultana, S., Lina, N. N., Hasan, M. T., Ferdaus, M. J., Dash, B. K., Ahmad, T., & Roy, R. K. (2020). Dietary diversity and associated health status of newly diagnosed type 2 diabetic patients in jashore region of Bangladesh. *Current Research in Nutrition and Food Science Journal*, 438–453. https://doi.org/10.12944/crnfsj.8.2.09 [Crossref] [Google Scholar] [Publisher]

Tezera, R., Sahile, Z., Yilma, D., Misganaw, E., Amare, E., & Haidar, J. (2022). Food security status of patients with type 2 diabetes and their adherence to dietary counselling from selected hospitals in Addis Ababa, Ethiopia: A cross-sectional study. *PloS One*, *17*(4), e0265523.
https://doi.org/10.1371/journal.pone.0265523
[Crossref] [PubMed] [Google Scholar] [Publisher]

Webb, P., Coates, J., Frongillo, E. A., Rogers, B. L., Swindale, A., & Bilinsky, P. (2006). Measuring household food insecurity: why it's so important and yet so difficult to do. *The Journal of Nutrition*, *136*(5), 1404S-1408S. https://doi.org/10.1093/jn/136.5.1404S [Crossref] [PubMed] [Google Scholar] [Publisher]

Wang S., Wen, J., Miao, D., Sun, Z., Li, D., & Pan, E. (2023). Mediating effect of BMI on the relation of dietary patterns and glycemic control inT2DM patients: results from China community-based cross-sectional study. *BMC Public Health*, *23*(1), 468. https://doi.org/10.1186/s12889-022-14856-5 [Crossref] [PubMed] [Google Scholar] [Publisher]

Wong, T. Y., & Sabanayagam, C. (2020). Strategies to tackle the global burden of diabetic retinopathy: From epidemiology to artificial intelligence. *Ophthalmologica. Journal International d'ophtalmologie. International Journal of Ophthalmology. Zeitschrift Für Augenheilkunde*, *243*(1), 9–20. https://doi.org/10.1159/000502387 [Crossref] [PubMed] [Google Scholar] [Publisher]

World Health Organization. (2003). Screening for type 2 diabetes: report of a World Health Organization and International Diabetes Federation meeting (No. WHO/NMH/MNC/CRA/03.1). World Health Organization [Google Scholar] [Publisher]