

Dietary patterns and their association with glycated haemoglobin among adults with type 2 diabetes mellitus in urban DR Congo in 2025: a cross-sectional study

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Abstract

Background:

Type 2 diabetes mellitus (T2DM) is a growing public health concern in sub-Saharan Africa, where rapid urbanisation and dietary changes contribute to poor glycaemic control among diabetic patients. In the Democratic Republic of the Congo, little is known about how dietary practices affect glycaemic control among diabetic adults. This study assessed dietary patterns and their associations with glycated haemoglobin (HbA1c) among adults with T2DM in Kinshasa, with a focus on socioeconomic factors influencing diet.

Methods:

A cross-sectional survey was conducted in a random sample of 540 adults with T2DM attending 27 primary and 27 secondary health facilities in April 2025. Dietary practices were assessed using a qualitative 7-day food-frequency questionnaire covering 20 food groups. Principal component analysis identified dietary patterns, and survey-clustered generalised linear models were used to examine associations between dietary pattern quintiles and mean HbA1c, adjusting for sociodemographic, lifestyle, and food-insecurity variables.

Results:

Overall, 442/509 (86.8%) of participants had uncontrolled diabetes ($\text{HbA1c} \geq 7\%$), 40% reported severe HH food insecurity, and 60.9% were obese or overweight. Four dietary patterns explained 36.8% of the total variance: (1) vegetable, fish & plant-rich; (2) mixed protein & staple; (3) refined-grain & dairy-sweet; and (4) oil & dairy. Higher adherence to the refined-grain and dairy-sweet pattern was associated with higher HbA1c in Q2 (Adjusted $\text{Exp}(\beta) = 1.10$; 95% CI: 1.02–1.18), Q3 (Adjusted $\text{Exp}(\beta) = 1.09$; 95% CI: 1.03–1.15), and Q4 (Adjusted $\text{Exp}(\beta) = 1.08$; 95% CI: 1.01–1.16), compared with Q1. No clear associations were observed for other dietary patterns. Longer diabetes duration (> 5 years) was associated with higher HbA1c (Adjusted $\text{Exp}(\beta) = 1.05$; 95% CI: 1.01–1.10), while age was inversely associated (Adjusted $\text{Exp}(\beta) = 0.9965$; 95% CI: 0.994–0.999).

Conclusion:

Among clinic-attending adults with T2DM in Kinshasa, a diet high in refined grains and dairy-sweets was associated with poorer glycaemic control. Poor glycaemic control was widespread despite reported dietary adherence, suggesting ineffective nutrition guidance and systemic barriers like food insecurity. The findings argue for the urgent need to integrate culturally adapted nutrition counselling and affordable food-based interventions into diabetes management.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) has emerged as a major non-communicable disease globally, with rapidly increasing prevalence and associated complications, particularly in low- and middle-income countries (LMIC). Sub-Saharan Africa (SSA) is expected to experience the highest percentage increase in diabetes cases by 2050 and currently has the highest number of undiagnosed cases worldwide. The International Diabetes Federation (IDF) estimated that by 2024–2025, approximately one in twenty African adults would be diabetic, the majority of whom will be undiagnosed. Diabetes was responsible for over 200,000 deaths across the African continent in 2024, and without significant intervention, this number is expected to more than double by the middle of the century (1).

One of the key factors driving the rapid rise in T2DM is the nutrition transition, a shift in dietary and lifestyle patterns that tends to accompany economic growth, urbanisation, and increased income. As populations move away from traditional diets rich in whole foods, legumes, and vegetables toward diets dominated by energy-dense edible oils and highly processed foods, and adopt more sedentary lifestyles, the risk of non-communicable diseases such as T2DM has grown markedly (2, 3). In the Democratic Republic of the Congo (DRC), a combination of rapid urbanisation, shifting dietary patterns, poverty, and poor access to health care for chronic disease management contributes to an increased risk of premature death (4). The most recent DRC Demographic and Health Survey (DHS) confirmed a high burden of diabetes, both diagnosed and undiagnosed, in the urban setting of Kinshasa (5).

Nutrition therapy is a crucial component of diabetes management, particularly in settings with limited therapeutic resources, due to its scalability and cost-effectiveness. Current clinical practice standards underscore the importance of individualised medical nutrition therapy to enhance glycaemic control, improve weight, and reduce cardiometabolic risk (6). Glycated haemoglobin (HbA1c) is a blood assay used by clinicians to assess diabetic control over the previous 2–3 months. Optimal diabetic control aims for an HbA1c of $\leq 7\%$ for non-pregnant adults (6). Since 2020, several systematic reviews and meta-analyses have demonstrated that diets high in fibre and low in processed foods, such as Mediterranean-style, DASH-aligned, or carbohydrate-controlled diets, consistently lead to small but clinically significant reductions in HbA1c (7). In addition, increased intake of viscous and fermentable fibres mechanistically slows carbohydrate absorption, reduces postprandial glycemia, and increases insulin sensitivity, thereby improving medium-term glycaemic metrics (7–9). Improved dietary control of diabetes is often accompanied by lower weight and blood pressure and an improved lipid profile, thereby improving overall cardiovascular risk.

While the importance of dietary management of diabetes is well-established, patients with T2DM in sub-Saharan Africa face several challenges, including limited dietary knowledge, poverty, severe food insecurity, and poor access to structured nutrition services (10–12). Research conducted in Ethiopia and Nigeria has shown that poor dietary knowledge and high incidence of harmful dietary behaviours, such as the consumption of sugar-sweetened beverages and irregular meal patterns, are associated with poor glycaemic control (13, 14). A recent systematic review and meta-analysis from the Horn of Africa found

that fewer than half of patients with T2DM had good dietary practices, highlighting persistent gaps in adherence to dietary recommendations and the implementation of nutrition education in diabetes care (15). Further, a recent study conducted in Kinshasa has highlighted poor diabetic control among patients in the context of an inadequate health system and the importance of diet as a modifiable factor (16).

A gap exists regarding the relationship between dietary practices of adults with T2DM and glycaemic control in an urban setting in DRC. This study contributed to address this gap by examining the dietary landscape and its correlation with glycaemic control in T2DM. This study aimed to explore the impact of dietary patterns on HbA1c among adults with T2DM in Kinshasa, with a focus on socioeconomic factors influencing dietary adherence, to inform the design of culturally appropriate nutrition interventions.

METHOD

Study design

The study used a health facility-based cross-sectional design to assess the association between dietary practices and HbA1c measures among adults with T2DM in Kinshasa in 2025.

Study setting

This study was conducted in Kinshasa, the capital of the Democratic Republic of Congo (DRC), which has a mixed health system comprising public, private, and faith-based facilities. Healthcare in Kinshasa is organised into three levels: primary, secondary, and tertiary care. Primary and secondary level facilities are the main points of contact for most patients with T2DM, offering routine consultations, basic laboratory tests, and medication follow-up. At the primary level, care is predominantly delivered by nurses under the supervision of physicians. While physicians are permanently based at secondary-level facilities, their presence at primary-level facilities is limited, typically providing supervision and consultations only once or twice per month. Nutritionists are available in some secondary facilities, but their main role is to provide inpatient care.

Healthcare costs are primarily borne by patients themselves, either out-of-pocket or paid by health insurance (which is limited), as there is no universal health insurance system and limited government subsidy for chronic disease management. Services are typically fee-for-service, with prices varying between facilities and often lacking standardised tariffs. As a result, out-of-pocket payments represent a significant barrier to accessing regular care, especially for low-income patients. Additional barriers include limited availability of diabetes specialists, irregular supply of essential medications, and inadequate diagnostic infrastructure. There are no dietary guidelines available and little access to nutritionists. Many patients cannot afford fruits, vegetables or lean protein, and cheaper foods are often high in carbohydrates and low in nutritional value.

Study population

The study population comprised T2DM patients, aged 19–70 years, attending primary or secondary health care facilities who had been diagnosed with T2DM more than 6 months ago and were older than 18 years. Patients with coexisting renal disease, liver disease, or other serious diseases that could affect their dietary requirements or a previous history of diabetic ketoacidosis, haemoglobinopathies and haemolysis were excluded from the study.

Sampling

a. Sample size:

The following formula was used to estimate sample size: $n \geq Z^2 (pq/d^2) deff$. We assumed $p = 50\%$ as the proportion of uncontrolled diabetic patients was unknown, $d = 0.05$ for absolute precision, $deff = 1.4$ (default design effect), and cluster size = 10, with a 95% response rate. The minimum sample size was 528 diabetic patients.

b. Sampling techniques:

We proceeded with two-stage stratified sampling. In the first stage, we divided the health facilities (HF) into two strata, primary and secondary, in order to ensure that a diverse population of T2DM patients was included in the sample; we randomly selected 27 health facilities (30%) in each stratum, using a list of health facilities managing diabetes provided by the National Program for Diabetes Control (representing the Health Ministry) that contains the number of diabetic patients by health facility. In the second stage, a sample corresponding to 15% of the total number of T2DM patients followed in each health facility was targeted (approximately 8–12 patients per facility, average of 10). Participant selection was conducted through simple random sampling from the list of patients who attended the consultation on the day of the survey (corresponding to the diabetic clinic day), which served as the operational sampling frame. A random-number generator application was used to ensure unbiased selection.

Figure 1. sampling approach

Data collection

Standard operating procedures (SOPs) were developed to guide the data collection. We recruited eight fieldworkers among health professionals who have previous experience in data collection and trained them over 5 days in survey methodology and in understanding and administering the data collection tool, including one day for the pretest. The pretest took place in a health facility not selected for the study on the fifth day of training. Field workers visited two health facilities to collect data from 8–10 diabetic patients. The research team, data collection tool, and methodology were evaluated during the pretest. A

debriefing was held in the afternoon to review all observations, and the necessary adaptations were implemented.

After obtaining authorisation from the relevant administrative authorities, each pair of fieldworkers visited approximately 14 health facilities over 18 days in April 2025 and, in each facility, conducted the required number of interviews with T2DM patients after obtaining written informed consent. Fieldworkers used the registration list of patients who attended the consultation that day to randomly select patients for interview. We used a standardised, structured questionnaire on a tablet (with KoboToolbox) to collect data among diabetic patients. Anthropometric and blood pressure measures were conducted, and a capillary blood sample was collected to measure HbA1c.

Data collection was supervised by the Principal Investigator (PI) regularly to ensure completeness and consistency. The PI visited the team during data collection to ensure fieldwork was conducted in accordance with the SOP. Every day, data was sent to our server for quality analysis, and feedback was provided to the field team to ensure data quality.

Variables and data tool

Data were collected about socioeconomic and sociodemographic characteristics (age, sex, level of education, area of residence), medical history, coexisting morbidity and complications, dietary practices (e.g., Who buys food? Is the food homemade? Who prepares food? Food consumption), food security using the Household Food Insecurity Access Scale (HFIAS) (17), lifestyle (alcohol/smoking/physical activity), anthropometry, blood pressure, and HbA1c.

Dietary data were collected using an adapted qualitative food frequency questionnaire based on FAO guidelines, which assessed the frequency of consumption of locally relevant food items over the last week (the last 7 days before the interview day) (18). Participants were asked about the frequency of consumption of each specific food item listed in the adapted food list (after the pretest). Our food frequency question contained 185 food items (including local foods), which were finally grouped into 20 food groups: whole grains, refined grains, roots-tubers, legumes, nuts-seeds, non-starchy vegetables, whole fruits, fresh fruit juices, meats, processed meat, poultry, fish, eggs, insects, milk, milk products, tea-coffee, beverages-sweet, plant-oils, and saturated fats.

Alcohol intake was assessed following WHO STEPWISE (2006) guidelines and classified as follows: current consumption (any alcohol intake in the past 30 days), occasional consumption (any alcohol intake within the past year but more than 30 days), and abstinence (no alcohol intake in the past year) (19).

Smoking status was categorised as current daily smokers (regular daily tobacco use). Information on age at smoking initiation, duration of use (years), and average number of cigarettes smoked per day was also recorded.

Physical activity was assessed by using the Global Physical Activity Questionnaire (GPAQ) (19, 20). Physical activity was assessed across three domains: work-related, travel-related, and leisure-related, expressed as median minutes per week spent in each.

Assessment of weight (using the SECA weight scale), height, waist circumference, and blood pressure (using the OMRON tensiometer) was done and categorised as described in the STEPWISE document. The nutritional status was determined by body mass index [$BMI = \text{Weight}(\text{kg})/\text{Height}^2 (\text{m}^2)$].

HbA1c measurement: The HbA1c level was measured after completion of the questionnaire using the A1CNow machine according to the manufacturers' instructions (21–23). The fieldworker ensured that all test components were kept at room temperature. A sterile lancet was used to obtain a capillary blood sample, which was collected using the blood collector. The blood collector was then attached to the shaker, mixed vigorously, and allowed to stand for 2 minutes. Subsequently, the test cartridge was inserted into the monitor, and the prepared sample was applied, initiating the test automatically. After approximately 5 minutes, the HbA1c result displayed on the monitor was read and accurately recorded on the data collection tool.

Data transformation and data analysis

Data processing and analysis were performed using Stata version 18 software. HbA1c was categorised as optimal control (HbA1c < 7%), suboptimal control (HbA1c 7–8%), and poor control (HbA1c ≥ 8%) (ADA, 2025). BMI was categorised as underweight (< 18.5 kg/m²), normal weight (18.5–24.9 kg/m²), overweight (25.0–29.9 kg/m²), and obese (≥ 30.0 kg/m²) (19). Waist circumference was categorised as abdominal obesity (men ≥ 94 cm; women ≥ 80 cm) or not. Blood pressure was categorised as high blood pressure (systolic blood pressure ≥ 140 mm Hg and/or diastolic blood pressure ≥ 90 mm Hg) or normal. Continuous data (age and disease duration) were summarised as medians with interquartile ranges, as they were not normally distributed. The data were checked for distribution. Categorical data were summarised as frequencies and percentages. We used visual and statistical tests to check the distribution of HbA1c levels (comparing mean and median, plotting histogram to visualise skewness, and using formal tests for skewness and normality).

From the dietary data, we calculated the frequency of consumption for each food group item and summarised the data as mean frequencies, due to their normal distribution. The identified practices and their key characteristics were described (e.g., high in fruits and vegetables and low in processed foods). The food groups commonly consumed were identified.

We performed factor analysis to define data-driven dietary patterns among diabetic patients. First, all food group consumption frequencies were standardised by converting them into z-scores to ensure comparability across items. Using these standardised variables, factor analysis (principal component factoring) was applied to identify underlying dietary patterns based on food consumption correlations. The number of factors to retain was determined by eigenvalues greater than one, scree plot examination, and interpretability of factor loadings. The retained factors were rotated using the Varimax orthogonal

rotation method to improve interpretability. Individual factor scores were computed based on the regression scoring method and subsequently categorised into quintiles to examine their associations with glycaemic control.

Considering that HbA1c is a strictly positive continuous variable frequently exhibiting right skewness, we utilised a gamma regression model with a log link function as our principal analytical method. This model is very adept at analysing positive outcomes such as HbA1c, guaranteeing that predicted values are positive, a constraint of ordinary least squares (OLS) regression. Moreover, gamma distribution facilitates the interpretation of relative (multiplicative) effects, which hold clinical significance for biomarkers like HbA1c. The gamma regression model evaluated the correlation between HbA1c and several related variables, including age, body mass index (BMI) categories, dietary patterns (F1 to F4), food insecurity status, sex, and duration since diagnosis. The model was modified to account for clustering among 54 facilities, resulting in robust standard errors.

We utilised linear regression as a sensitivity analysis to investigate the determinants affecting HbA1c levels in a cohort of 509 people. The linear regression model evaluated the correlation between HbA1c and multiple predictor variables, including age, body mass index (BMI) categories, dietary patterns (F1 to F4), food insecurity status, sex, and duration since diagnosis. The model was modified to account for clustering among 54 facilities, resulting in robust standard errors.

Both models yielded comparable substantive conclusions, so enhancing confidence in the robustness of our findings. The linear regression model functions as a sensitivity analysis, but gamma regression is statistically favoured for its suitability for the distribution and characteristics of the result variable. This dual methodology offers an extensive comprehension of the factors influencing HbA1c levels in our study cohort.

RESULTS

We approached 540 patients with T2DM, and all consented to participate. However, some participants did not complete the HbA1c measurement (31/540, 5.7%) due to some technical error (high temperature, inadequate sample quantities) and the limited number of tests available. The missing values were not considered in the model. Those participants were similar to others regarding age, BMI, alcohol consumption, smoking status, food insecurity and disease's duration (time since diagnosis). A total of 540 patients with type 2 diabetes, with a median age of 59 (51.0-64.5) years and a median disease duration of 6 (2–11) years, were included in the study. A total of 329/540 (60.9%) participants were obese or overweight, and 393/540 (72.8%) had abdominal obesity. A total of 369/540 (68.3%) diabetic patients were food insecure, including 40% with severe food insecurity (Table 1).

Table 1
Sociodemographic and health characteristics of participants

characteristic	n = 540	%
Sex		
Male		208 38.5
Female		332 61.5
Level of education		
Never attended school	14	2.6
Primary school attended but did not complete	38	7.0
Primary school completed	26	4.8
Secondary attended but did not complete	159	29.4
Secondary completed	151	28.0
University	152	28.2
Marital status		
Single	39	7.2
Married/ living in couple	359	66.5
Divorced/ Separated	33	6.1
Widow (er)	109	20.2
Income-generating activity		
No activity	184	34.1
Trade and services	91	16.8
Employed / wage-earning	138	25.6
Agriculture (for own consumption and/or sale)	90	16.7
Other	37	6.9
Level of food security (HFIAS)		
No or mild food insecurity	171	31.7
Moderate food insecurity	153	28.3
Severe food insecurity	216	40.0
<i>*High blood pressure means systolic blood pressure $\geq$ 140 mm Hg and/or diastolic blood pressure $\geq$ 90 mm Hg</i>		

characteristic	n = 540	%
Nutritional status		
Underweight (< 18.5 kg/m ²)	23	4.3
Normal weight (18.5–24.9 kg/m ²)	188	34.8
Overweight (25.0-29.9 kg/m ²)	192	35.5
Obesity (≥ 30,0 kg/m ²)	137	25.4
Abdominal obesity		
No	147	27.2
Yes (Men ≥ 94 cm; Women ≥ 80 cm)	393	72.8
Hypertension		
Normal blood pressure measured today	217	40.2
High blood pressure measured today*	323	59.8
Self-reported complications		
Diabetic foot	183	33.9
Renal disorder	5	0.9
Retinopathy	105	19.44
Cataract	82	15.2
Erectile dysfunction	111	20.6
Neuropathy	40	7.4
Glycemic control#		
Optimal control (HbA1c < 7%)	67	13.2
Suboptimal control (HbA1c 7–8%)	61	12.0
Poor control (HbA1c ≥ 8%)	381	74.8
*High blood pressure means systolic blood pressure ≥ 140 mm Hg and/or diastolic blood pressure ≥ 90 mm Hg		

#n = 509

We found that 284/540 (52.6%) of diabetic patients had a low self-reported physical activity level, and 93/540 (17.2%) of participants reported that they currently drink alcohol (Table 2).

Table 2
Lifestyle of participants

Domains	N	%
Alcohol consumption		
No consumption for the past one year	375	69.5
Current alcohol consumption (within 30 days)	93	17.2
Occasional alcohol consumption	72	13.3
Smoking status		
No smoking	517	96.1
Smoking but not daily	21	3.9
Physical activity levels*		
Low	284	52.6
Moderate	209	38.7
High	47	8.7

** Levels of physical activity (low, moderate, high) were defined according to the WHO STEPwise/GPAQ (2006) classification, based on weekly MET-minutes, activity frequency, duration, and intensity.*

Table 3 shows dietary practices of participants. The majority (324/540, 60%) of type 2 diabetic patients had two meals per day, and 342/540 (63.3%) had snacks between meals. Most participants (92/540, 17%) declared not strictly complying with the diet recommended by the physician (Table 3).

Table 3
Food- and dietary-related practices among type 2 diabetes patients

Practices	N	%
Who cook the food		
Myself	175	32.4
My partner	146	27.0
My child/other family member	192	35.6
Housekeeper	27	5.0
How often do you eat street foods*?		
Never	307	56.8
Sometimes	176	32.6
Often	44	8.2
Always	13	2.4
How often do you eat fast food#		
Never	420	77.8
Sometimes	111	20.5
Often/always	9	1.7
Number of meals per day		
One	45	8.3
two	324	60.0
Three s	166	30.7
More than three	5	1.0
Having snack between meals		
Yes	342	63.3
No	198	36.7
Do you strictly follow the diet recommended by your doctor?		
Yes	448	83.0
No	92	17.0

** Fast foods = mass-produced, standardised meals served quickly (often chain restaurants); # Street food = local, freshly prepared dishes sold at stalls or carts.*

HbA1c levels among study participants ranged from 4% to 14%, with a mean of 9.70% (SD of 2.28). Fifty percent of them exhibited HbA1c levels over 9.6%. The analysis of HbA1c levels across different nutritional status categories based on BMI reveals significant differences ($p = 0.0335$). Notably, individuals classified as underweight exhibited a mean HbA1c level of 11.06%, which is considerably higher than the other groups. The Bonferroni post-hoc tests indicate that the difference in HbA1c levels between underweight and overweight groups shows a significant difference (mean difference = -1.44, $p = 0.031$), as well as between underweight and obesity (mean difference = -1.52, $p = 0.024$). The analysis for HbA1c levels across food insecurity categories also indicates significant differences ($p = 0.0136$). Individuals classified as experiencing severe food insecurity had a higher mean HbA1c level of 10.07% compared to those with no or mild food insecurity (9.52%) and those with moderate food insecurity (9.41%). Post-hoc comparisons reveal that the difference between severe food insecurity and no or mild food insecurity is statistically significant (mean difference = 0.55, $p = 0.025$) (Fig. 2).

A total of 442/509 (86.8%; IC95%: 83.6–89.5) participants had uncontrolled diabetes ($\text{HbA1c} \geq 7\%$, combining suboptimal and poor control), while 381/509 (74.8%) had poor control ($\text{HbA1c} \geq 8\%$) (Table 1).

Figure 2. Comparative analysis of HbA1c levels across demographic and clinical categories

Figure 3 shows a slight negative trend, indicated by a regression line, suggesting that as age increases, HbA1c levels tend to decrease slightly. The statistical values highlight a significant p-value (0.004), indicating that the relationship is statistically significant but weak. In contrast, a negligible positive trend, with a regression line indicating that HbA1c levels do not significantly change with time since diagnosis (see also figure S1 in the additional file 1).

Figure 3. Relationship between HbA1c and age versus time since diagnosis in adults with type 2 diabetes

Figure 4 illustrates the average weekly consumption frequencies of various food groups. Vegetables, whole grains, refined grains, plant oils, fish, and whole fruits were the most frequently consumed. Legumes, meats, sweetened beverages, processed meats, and dairy products were rarely consumed.

Figure 4. Average consumption of food groups per week

Four major dietary patterns were identified through principal component analysis, explaining 36.8% of total variance (Table 4). An average loading of at least 0.35 was considered for defining the patterns (Additional file 2, Table S1).

Table 4
Description of dietary patterns after factor analysis

Factor	Label	Description
F1	Vegetable, Fish & Plant-rich pattern	High vegetables, fish, nuts/seeds, insects and whole fruits (traditional/healthy composition) (like a pescatarian dietary pattern)
F2	Mixed protein & staple pattern	High roots/tubers, legumes, poultry, meat, and eggs (balanced, moderate animal and plant staples) (like an omnivore dietary pattern)
F3	Refined-grain & Dairy-sweet pattern	High refined grains, milk, sweet drinks, and plant oils (energy-dense, westernized)
F4	Oil & Dairy pattern	High plant oils, milk products and red meat (moderate fats, lower saturated sources)

Four distinct dietary patterns were examined in relation to HbA1c using clustered survey generalized linear models (gamma family, log link). After multivariable adjustment, the refined-grain & dairy-sweet pattern was positively associated with higher HbA1c (Table 5). Participants in the second quintile of the Refined-grain & Dairy-sweet (F3) dietary pattern exhibited a 10% increase in mean HbA1c levels compared to the reference category (Q1) (Adjusted $\text{Exp}(\beta) = 1.10$; 95% CI: 1.02–1.18; $p = 0.009$). Similarly, those in the third quintile of F3 showed an 8% increase in HbA1c levels compared to the reference category (Adjusted $\text{Exp}(\beta) = 1.09$; 95% CI: 1.03–1.15; $p = 0.004$). Participants in the fourth quintile of F3 also had a significant increase of 8% in HbA1c levels (Adjusted $\text{Exp}(\beta) = 1.08$; 95% CI: 1.01–1.16; $p = 0.030$) (Table 5).

Underweight individuals had a 12% increase in mean HbA1c levels compared to those with normal BMI (Adjusted $\text{Exp}(\beta) = 1.12$; 95% CI: 1.02–1.24; $p = 0.018$). Furthermore, participants who had been diagnosed for more than 5 years showed a 5% increase in mean HbA1c levels (Adjusted $\text{Exp}(\beta) = 1.05$; 95% CI: 1.01–1.10; $p = 0.013$), indicating a notable impact of time since diagnosis on metabolic health. Age was also negatively associated with HbA1c levels, where each additional year was linked to a 0.35% decrease in mean HbA1c (Adjusted $\text{Exp}(\beta) = 0.996$; 95% CI: 0.994–0.998; $p = 0.003$). Other covariates, including sex, food security, and F1, F2 and F4 dietary patterns, were not significantly related to HbA1c (Table 5).

Table 5
Associations between dietary patterns and HbA1c levels among adults with type 2 diabetes in Kinshasa
(n = 509)

HbA1c	Unadjusted		Adjusted			
	exp(β)	95% CI	P	exp(β)	95% CI	p
Vegetable, Fish & Plant-rich (F1)						
Q2 vs Q1 (ref)	0.99	0.93–1.06	0.821	1.02	0.95–1.09	0.641
Q3 vs Q1	1.04	0.97–1.12	0.264	1.05	0.98–1.12	0.200
Q4 vs Q1	1.01	0.94–1.09	0.699	1.02	0.95–1.09	0.633
Q5 vs Q1	1	0.94–1.08	0.886	1.00	0.94–1.07	0.952
Mixed protein & Staple (F2)						
Q2 vs Q1 (ref)	0.98	0.91–1.06	0.655	0.98	0.90–1.06	0.555
Q3 vs Q1	0.96	0.90–1.03	0.297	0.96	0.90–1.03	0.239
Q4 vs Q1	0.98	0.91–1.05	0.501	0.96	0.89–1.03	0.291
Q5 vs Q1	0.99	0.94–1.07	0.999	0.99	0.92–1.06	0.702
Refined-grain & Dairy-sweet (F3)						
Q2 vs Q1 (ref)	1.09	1.02–1.18	0.02	1.10	1.02–1.18	0.009
Q3 vs Q1	1.08	1.02–1.15	0.014	1.09	1.03–1.15	0.004
Q4 vs Q1	1.09	1.01–1.17	0.03	1.08	1.01–1.16	0.030
Q5 vs Q1	1.07	0.99–1.14	0.054	1.05	0.98–1.12	0.169
Oil & Dairy (F4)						
Q2 vs Q1 (ref)	0.93	0.87-1.00	0.057	0.93	0.87-1.00	0.053
Q3 vs Q1	0.98	0.92–1.05	0.593	0.99	0.92–1.06	0.701

HbA1c	Unadjusted			Adjusted		
	exp(β)	95% CI	P	exp(β)	95% CI	p
Q4 vs Q1	0.94	0.87–1.01	0.088	0.95	0.89–1.02	0.189
Q5 vs Q1	0.99	0.93–1.05	0.713	1.00	0.94–1.07	0.967
Sex	-					
Male vs female	0.98	0.94–1.03	0.419	0.98	0.94–1.02	0.282
Age	0.99	0.99–1.00	0.005	0.99	0.994–0.998	0.003
BMI_category	-					
underweight	1.14	1.04–1.24	0.003	1.12	1.02–1.24	0.018
Overweight	0.99	0.94–1.03	0.609	0.99	0.95–1.04	0.860
Obesity	0.98	0.93–1.04	0.474	0.98	0.92–1.04	0.510
Time_since diagnostic	-					
More than 5 years vs 0–5 years	1.04	1.00–1.08	0.032	1.05	1.01–1.10	0.013
Food insecurity levels (hfias_3cat)						
Moderate food insecurity vs no or middle food insecurity	0.99	0.94–1.04	0.628	0.98	0.93–1.02	0.308
Severe food insecurity vs no or middle food insecurity	1.06	1.02–1.10	0.007	1.03	0.99–1.08	0.191

Q1-Q5: quintiles 1 to 5; BMI: Body mass index.

In a sensitive analysis, four distinct dietary patterns were examined in relation to HbA1c using clustered survey linear regression models. After multivariable adjustment, we got similar results (additional file 3, table S2). The post estimation plot of the two models are presented as additional files 4 and 5 (Figures S2 and S3).

DISCUSSION

This study provides novel evidence on the relationship between dietary patterns and glycaemic control among adults with T2DM in an urban sub-Saharan African context. Four dietary patterns were identified

that reflect different stages of the nutrition transition in Kinshasa: the Vegetable-Fish & Plant-rich pattern, which resembles a traditional high-fibre diet; the Mixed protein and staple pattern, representing a balanced omnivorous diet; the Refined-grain and Dairy-sweet pattern, which reflects a more westernised urban diet; and the Oil and Dairy pattern, characterised by higher fat intake. A key finding is that higher adherence to the refined-grain and dairy-sweet pattern was associated with higher HbA1c, while other dietary patterns were not associated with HbA1c. Importantly, despite the majority of participants reporting adherence to medical dietary advice, almost nine out of ten had uncontrolled diabetes, indicating a major disconnect between perceived dietary compliance and effective glycaemic control.

A key contribution of this study lies in identifying which components of the urban diet are most strongly associated with poor glycaemic control, rather than focusing on overall dietary diversity alone. Higher adherence to a pattern characterised by refined grains, sweetened beverages, dairy products, and plant oils was consistently associated with higher HbA1c levels. This finding aligns with evidence from global studies showing that refined carbohydrates and sugar-sweetened beverages are major dietary drivers of hyperglycemia among people with diabetes (24). These foods promote rapid postprandial glucose excursions, low satiety, and hepatic insulin resistance, resulting in sustained elevations of HbA1c (7, 8). The prominence of this pattern also reflects the ongoing nutrition transition described in urban African settings, where traditional diets are increasingly replaced by processed and energy-dense foods due to their affordability, availability, and convenience (2, 3). This transition is also evident in the high prevalence of overweight and obesity, which affects more than 60% of participants in the present study. These findings suggest that urban diabetic patients in Kinshasa are increasingly exposed to obesogenic food environments similar to those described in other low- and middle-income countries (11). Strengthening diabetes nutrition education to address the metabolic impact of refined foods and improving access to affordable high-fibre staples could therefore yield substantial benefits for glycaemic control. The inverse association observed between BMI and HbA1c in our study may reflect underlying disease severity or reverse causation, whereby individuals with poorer glycaemic control lose weight. Similar patterns have been described in previous studies, particularly in clinical and low-resource settings, and should be interpreted with caution (25–27).

For the oil and dairy pattern, estimates suggested a possible inverse association at moderate levels of adherence, but confidence intervals included the null, and the association was not consistent across higher quintiles. This may reflect heterogeneity within the dietary pattern, which could encompass both healthier (e.g., low saturated fat, plant-based fats) and less healthy (e.g., sweetened dairy products or excess red meat intake) food choices. Evidence suggests that unsaturated fats and certain dairy products may improve insulin sensitivity and metabolic outcomes (28–30). Therefore, these findings should be interpreted with caution, and further research is needed. This emphasises the necessity of balanced, context-specific dietary guidance rather than uniform, simplistic restriction messages.

Dietary patterns characterised by vegetables, fish, legumes, and traditional staples were not independently associated with better glycaemic control. Rather than indicating a lack of benefit from these foods, this finding likely reflects structural and contextual constraints that limit their effectiveness.

In this study, more than two-thirds of participants experienced household food insecurity, and severe food insecurity seems to predict higher HbA1c, even if there is uncertainty. Food insecurity has been shown to disrupt meal regularity, encourage reliance on cheaper refined foods, and increase physiological stress responses, all of which can worsen glycaemic control (11, 31). In such settings, even diets that appear plant-rich may be consumed inconsistently, in insufficient quantities, or prepared using energy-dense cooking methods, reducing their metabolic benefits.

An important and policy-relevant finding is the disconnect between patient perceptions and objective glycaemic outcomes. Despite widespread self-reported adherence to dietary recommendations, glycaemic control remained poor for most participants. Similar discrepancies have been reported in other African settings, where limited access to nutritionists, inconsistent dietary messaging, and low health literacy undermine effective self-management (Abose et al., 2024; Lubaki et al., 2024). These findings suggest that current dietary counselling approaches may be insufficiently specific, practical, or culturally adapted to support meaningful behaviour change. This may also suggest that the structural problems in diabetes management are huge and nutrition is only one of the components.

From a clinical and public health perspective, these results underscore the urgent need to strengthen medical nutrition therapy within routine diabetes care in the DRC. Integrating structured, culturally adapted nutrition counselling into primary and secondary health services could help translate dietary advice into effective glycaemic control, particularly in resource-constrained settings (6, 7). Furthermore, the independent association between food insecurity and HbA1c highlights the importance of linking diabetes care with nutrition-sensitive social protection measures, such as food subsidies, vouchers, or community-based food programmes.

At the policy level, the findings reinforce concerns about the rapid nutrition transition occurring in urban African settings and its implications for chronic disease management. Addressing the affordability and marketing of refined grains and sugar-sweetened beverages, while supporting access to traditional high-fibre foods, legumes, and vegetables, could contribute to improved diabetes outcomes at the population level (2, 3). By identifying dietary patterns specific to Kinshasa, this study provides actionable evidence to inform the design of context-appropriate nutrition interventions and policies.

Strengths and limitations

This study has several strengths, including the use of a data-driven dietary pattern approach, the inclusion of household food insecurity as a key determinant, and the use of HbA1c as an objective marker of glycaemic control. Additionally, the application of survey-weighted generalised linear models (GLM, gamma family with log link) ensured appropriate handling of the skewed distribution of HbA1c and accounted for the complex sampling design, improving the validity. However, important limitations should be acknowledged. The cross-sectional design precludes causal inference, and dietary intake was assessed using a qualitative food frequency questionnaire without portion-size or cooking-method information, which may have introduced measurement error. Findings are based on a clinic-attending

population in Kinshasa and may not fully represent those outside the healthcare system or in rural areas, indicating a valuable direction for future inclusive research. Self-reported behaviours may be affected by recall or social desirability bias, and HbA1c was measured using a point-of-care device, which may have slightly higher variability than laboratory-based assays. Additionally, factors known to affect HbA1c measurements, such as haemoglobin variants (including anaemia), renal disease, and liver disease, were not directly measured (e.g., haemoglobin levels, renal or liver function tests). However, individuals known to have severe forms of these conditions were excluded from the study. Nonetheless, this device has been validated for field use and has been employed in national surveys in the DRC.

Despite these limitations, the study provides critical baseline evidence on how dietary patterns, food insecurity, and nutrition transition interact to influence glycaemic control among urban adults with T2DM in the DRC.

CONCLUSION

This study fills a major evidence gap on the dietary patterns and glycaemic control of adults with type 2 diabetes in the DRC, where limited data exist on how dietary practices influence metabolic outcomes. Using a data-driven approach, four distinct dietary patterns were identified, with the refined-grain and dairy-sweet pattern associated with higher HbA1c levels, suggesting a detrimental effect of energy-dense, low-fibre diets common in urban settings. The findings also reveal a major disconnect between reported adherence and actual control, highlighting a failure of current nutrition guidance. However, our clinic-based sample may not fully represent individuals with diabetes outside the healthcare system. These findings provide important insights into dietary practices among patients receiving care in urban Kinshasa. The findings underscore the urgent need to integrate culturally adapted nutrition counselling and affordable food-based interventions into diabetes care. Policies should prioritise strengthening dietary education within primary care, improving access to healthy foods, and promoting traditional, plant-based diets. Future longitudinal and intervention studies are warranted to confirm these associations and guide evidence-based nutritional policies for diabetes management in sub-Saharan Africa, especially in DRC.

Abbreviations

ADA
American Diabetes Association
CI
confidence interval
DRC
Democratic Republic of the Congo
HF
Health Facility
HFIAS

Household Food Insecurity Access Scale
T2DM
Type 2 Diabetes Mellitus.

Declarations

Supplementary Information

Supplementary information is available following the references and includes Additional files 1-5.

Ethics approval and consent to participate

The ethical approval for this research was granted by the Ethics Committee of “Ecole de Santé Publique de Kinshasa” [Kinshasa School of Public Health], at the University of Kinshasa (Reference: ESP/CE/190/2024) on December 2, 2024. All study procedures involving human participants were performed in accordance with relevant guidelines and regulations (such as the Declaration of Helsinki). All participants received comprehensive information detailing the objectives, methodologies, voluntary nature of the study, and confidentiality guarantees. A written informed consent was systematically obtained before any data collection. The rigorous anonymisation of the data and its secure storage on protected computer systems were ensured.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used in this study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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No funding was received for this study.

Authors' contributions

Steve Botomba carried out the study, participated in data collection, and drafted the manuscript. Pierre Akilimali, Branly Mbunga, and Steve Botomba performed the statistical analysis and contributed to study design, data interpretation, and manuscript drafting. Christiane Horwood participated in the conceptualisation of the study, data acquisition, analysis, and interpretation and drafted the manuscript. Marie-Claire Muyer, Lyn Haskins, Nickson Poka, and Mala Ali Mapatano contributed to data interpretation and manuscript drafting. All authors read and approved the final manuscript.

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Use of artificial intelligence

For this paper, ChatGPT 5 and Paperpal were used for translating and improving English, but the authors assume the responsibility of the content.

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Figures

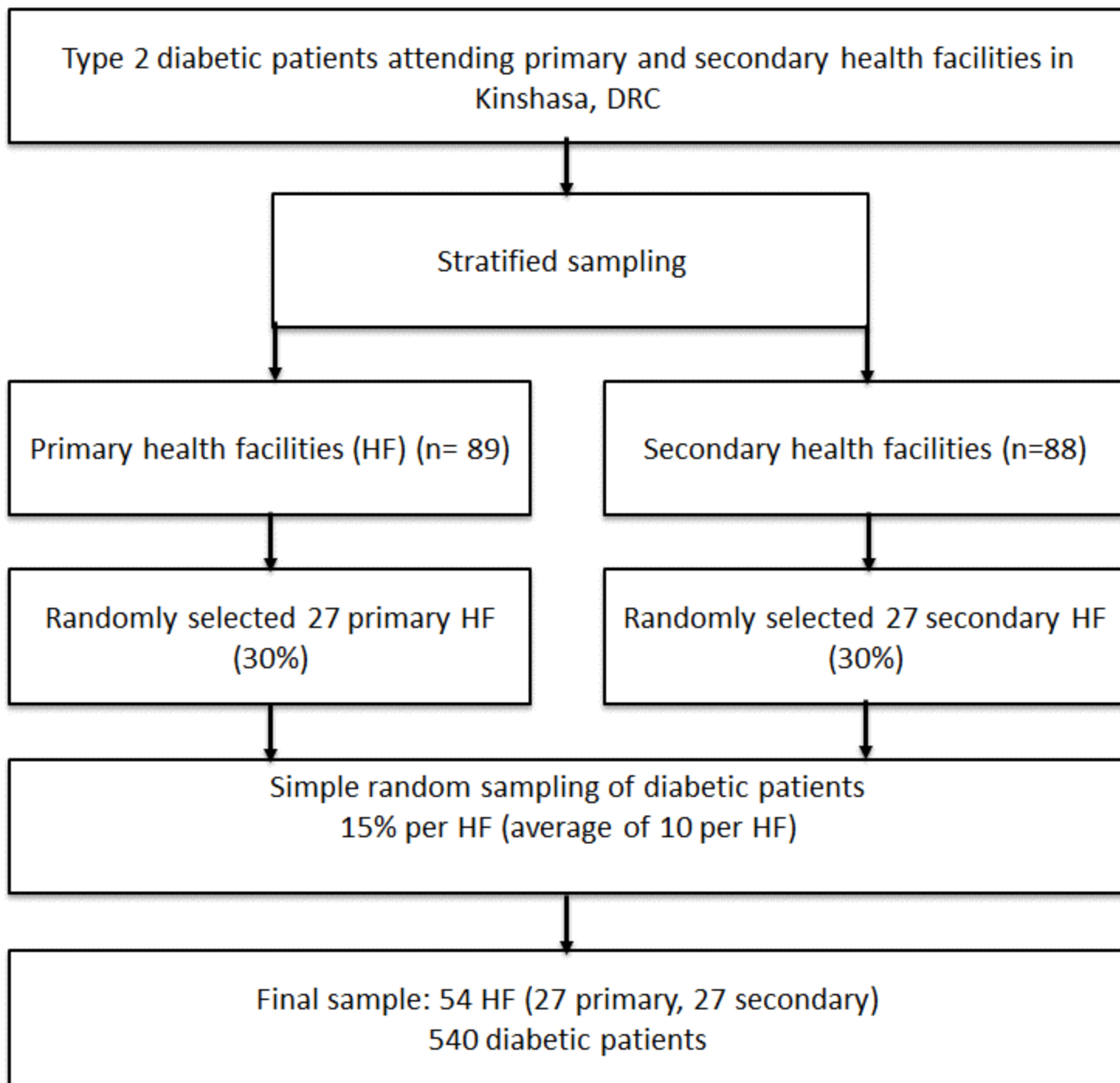


Figure 1

sampling approach

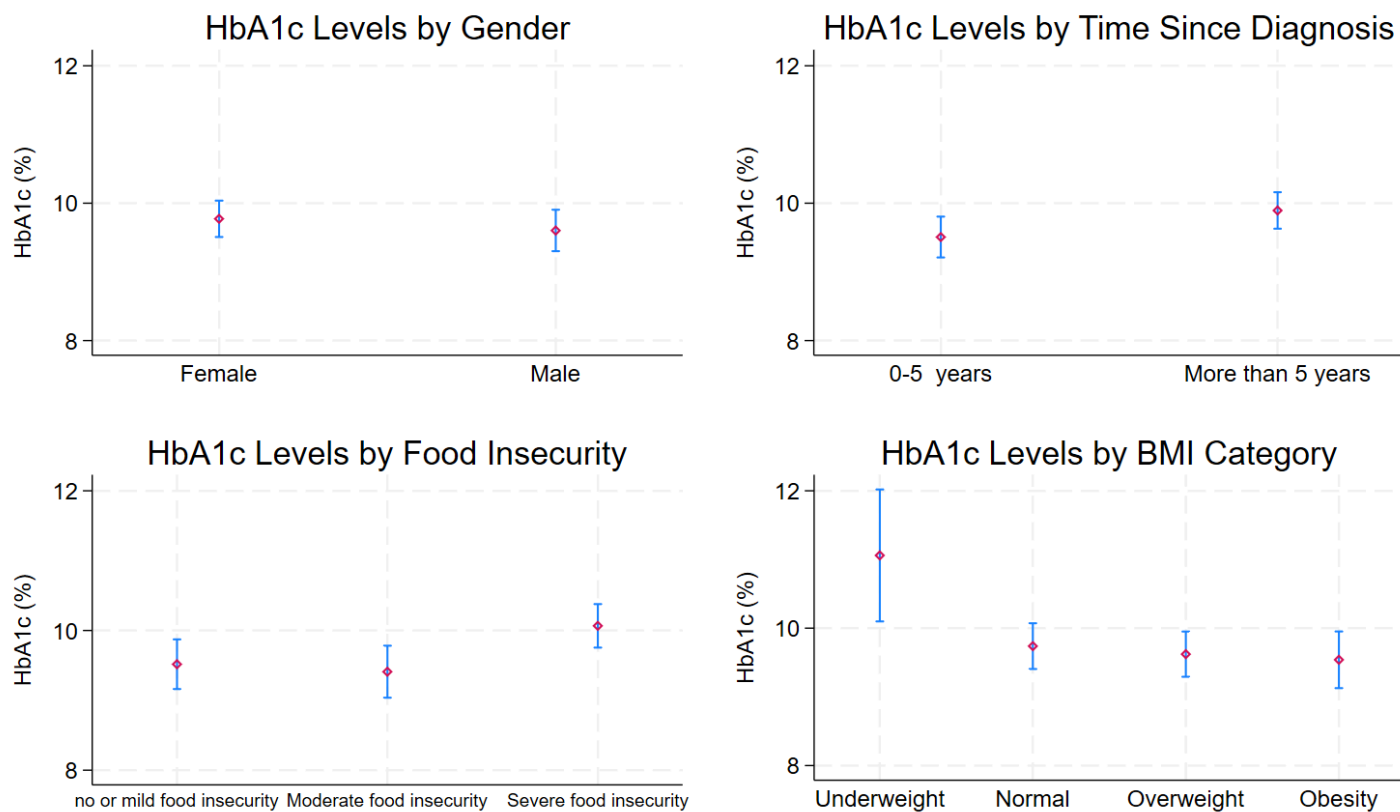


Figure 2

Comparative analysis of HbA1c levels across demographic and clinical categories

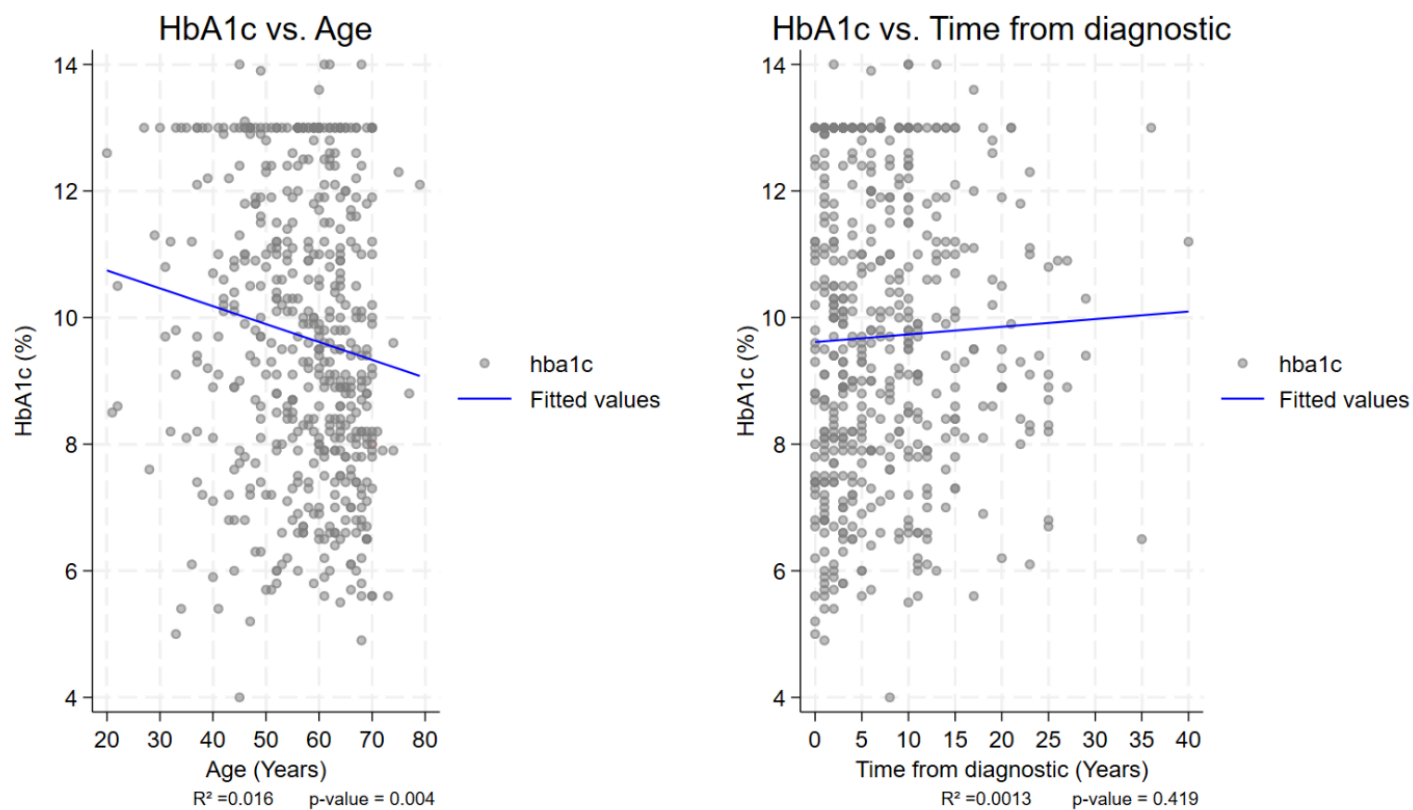


Figure 3

Relationship between HbA1c and age versus time since diagnosis in adults with type 2 diabetes

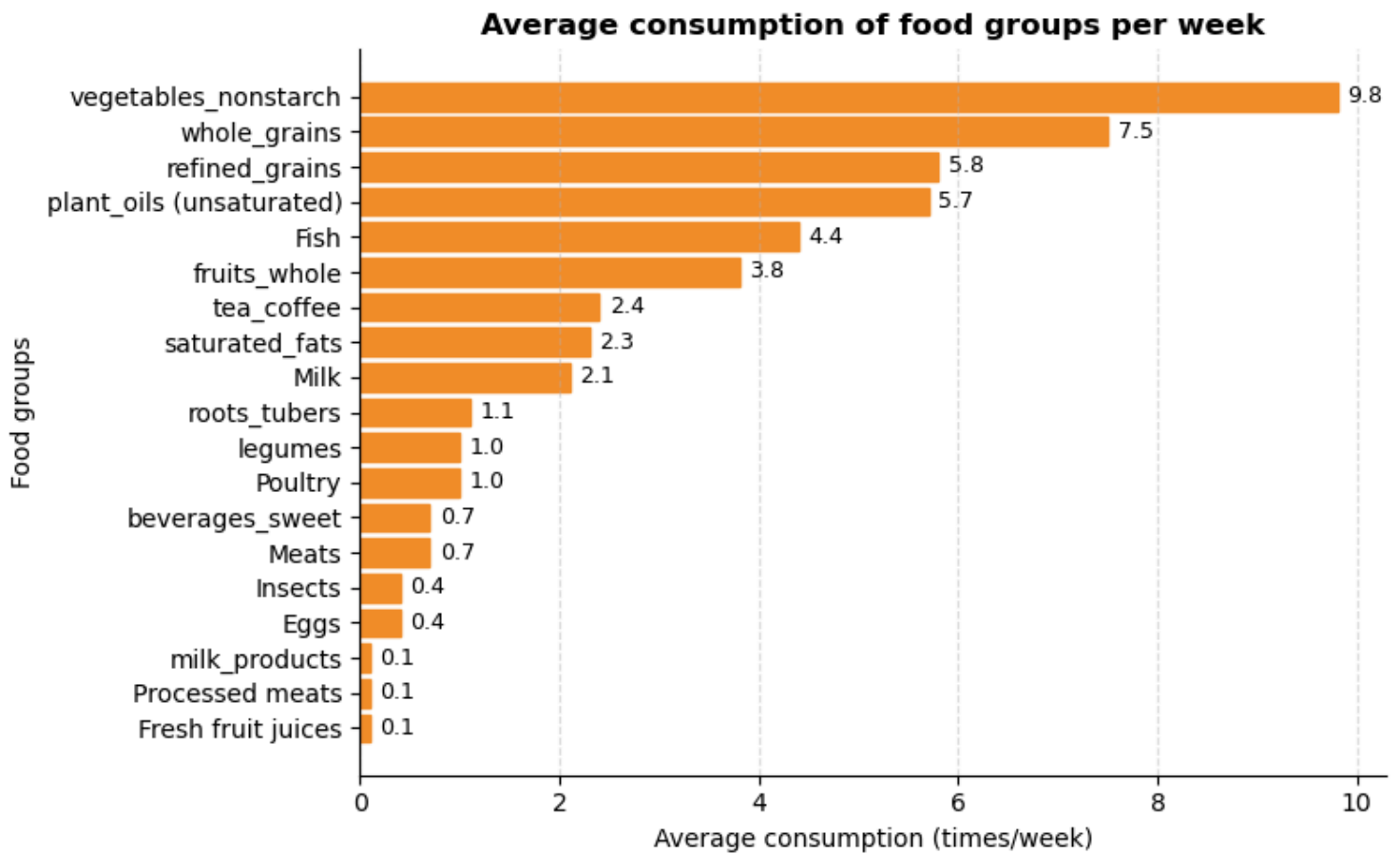


Figure 4

Average consumption of food groups per week

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