BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2024-091025
Article Type:	Original research
Date Submitted by the Author:	10-Jul-2024
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Keywords:	Cardiovascular Disease, Cross-Sectional Studies, NUTRITION & DIETETICS, PUBLIC HEALTH

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Diet quality, nutrient intake pattern and the risk factors of dyslipidemia in patients with cardiovascular disease: a hospital based cross-sectional study, Bangladesh

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Abstract

Background Diet plays a crucial role in the management of dyslipidemia, as it directly impacts cardiovascular health. The aim of the study was to determine the association between the risk of dyslipidemia among cardiac patients and their dietary quality. **Methods** By means of a cross-sectional survey, 600 cardiovascular disease (CVD) patients were selected for the study. Data on risk factors for dyslipidemia were collected using a structured questionnaire. A Semi-quantitative Food Frequency Questionnaire was used to measure the foods intake. Diet quality was evaluated by Global Diet Quality Score (GDQS). Binary logistic regression model was performed to evaluate risk factors for dyslipidemia among CDV patients. **Results** About two-thirds of participants exhibited dyslipidemia. According to GDQS, 71.3% were at low and 28.7% were at moderate risk for developing noncommunicable disease. Dyslipidemia patients ate more total fat and cholesterol, and most of the nutrients significantly differ among the dyslipidemia and non- dyslipidemia groups. They consumed more unhealthy foods such as sweets, ice cream, red meat, and high-fat dairy. Males (AOR = 2.149); retired or housewife individuals (AOR = 7.00; and AOR = 2.897); those with higher body mass index (BMI) (AOR = 2.3); and moderate-risk GDQS scores (AOR = 3.209) were significantly at an elevated risk for dyslipidemia found in binary logistic regression analysis. **Conclusions** Dietary patterns, which are rich in fats and sugar and low in fiber, were notably associated with dyslipidemia in the study population. The study highlights the potential of targeted nutritional interventions with a multifaceted approach to managing dyslipidemia, emphasizing the need for personalized dietary guidelines that consider the individual's gender, occupation, and BMI.

Key Words: Cardiovascular disease, Dyslipidemia, Diet quality, Global Diet Quality Score, Nutrients, Bangladesh

WHAT IS ALREADY KNOWN ON THIS TOPIC

- The beneficial role of good dietary practice on cardiovascular disease and Dyslipidemia has been shown previously.

WHAT THIS STUDY ADDS

- Our data presented that there is a relation between diet quality (GDQS) and lower risk of dyslipidemia of the CVD patients, possibly more consumption of healthy food and low intake of unhealthy foods.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- The study has revealed some important differences regarding nutrients and food intake patterns among cardiac patients with and without dyslipidemia, which can provide valuable insights for developing targeted interventions and personalized dietary recommendations.

Introduction

Cardiovascular diseases (CVD) exert a notable impact on the morbidity and mortality in Bangladesh [1]. The prevalence of CVD in Bangladesh exhibits significant variation, with estimates ranging from 0.062% to 77.7% [1]. However, when considering many studies, the pooled prevalence of CVD is 5.0%, regardless of the types of CVD, gender and geographical location of the study participants [1]. Among all types of CVD, heart disease had the highest reported prevalence (21%), and stroke had the lowest reported prevalence (1%) [1]. Increased risk factors for CVD include high blood pressure, elevated levels of total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C) and triglycerides (TG), decreased levels of HDL-C, overweight and obesity, cigarette smoking, low physical activity, age, genetic factors, dietary patterns, changing lifestyles, working patterns, inadequate knowledge, inappropriate attitude and behavior toward lifestyle, etc [2]. Dyslipidemia is widely recognized as a significant risk factor for cardiovascular disease (CVD) and associated mortality in countries with developed as well as developing economies [2-3]. An increased prevalence of dyslipidemia has been exceedingly reported in Bangladesh [1, 3]. This indicates that dyslipidemia may have a substantial impact on the emergence of cardiovascular disease (CVD) in Bangladesh.

Dyslipidemia is characterized by a progressive elevation of lipids and lipoproteins in the bloodstream, either independently or in conjunction. There is a strong correlation between dietary habits and cardiovascular risk factors [4]. Due to its direct effect on cholesterol levels and cardiovascular health, diet quality is a critical component in the therapy of dyslipidemia. A diet's quality can be defined as the degree to which its individual components contribute to good health. While specific nutrients, foods, and bioactive compounds may have an impact on health, research suggests that dietary patterns as a whole have a more significant impact [5]. Poor dietary habits, such as eating too much sugar and saturated fat or not enough healthy fruits and vegetables or fiber, are inversely related to healthy blood lipid levels and a higher risk of

many diseases, including cardiovascular disease [6]. Assessing diet quality provides a comprehensive view of a person's overall eating habits and their impact on health outcomes. Despite the importance of diet in managing dyslipidemia and preventing cardiovascular diseases, there is a lack of research in Bangladesh on the potential link between dietary habits of CVD patients and the risk of dyslipidemia. To fill this informational vacuum and learn more about the dietary variables that cause dyslipidemia in Bangladesh, additional study is necessary.

A number of tools exist for assessing people's eating habits; one of these is the Global Diet Quality Score (GDQS), which is based on food and represents dietary quality in terms of nutrient sufficiency and the development of chronic diseases in different geographical areas. Incorporating a more extensive range of food groups than most current diet metrics, the GDQS metric divides foods into healthy and unhealthy categories and uses a straightforward score system based on the effects and benefits of consumed amounts [7]. This research aims to use the GDQS metric to find out whether there is a correlation between cardiac patients' dietary quality and the risk of dyslipidemia. The study also aims to find links between dyslipidemia risk and age, gender, BMI, and other comorbidities. Ultimately, this research aims to provide clinicians and policymakers with the necessary evidence to promote optimal cardiovascular health in Bangladesh and similar populations.

Materials and Methods

Study area and study design

The study was conducted across two key medical facilities in Bangladesh, targeting a diverse patient population. Data collection occurred at the outpatient tertiary care unit of the National

Institute of Cardiovascular Diseases (NICVD) hospital, located in Dhaka. Additionally, the study encompassed the coronary care unit of Sadar Hospital in Noakhali.

The study was a cross-sectional design. The timeframe of the study spanned from January 2022 to October 2022. During this period, a grand total of 600 participants (without any missing variable of the interest) were enrolled in the research. The participants consisted of individuals who had recently been diagnosed with a cardiovascular condition, such as myocardial infarction, chest pain, or heart failure, or were receiving ongoing treatment.

Socio-demographic and Biochemical characteristic variables

Participants filled out self-reported questionnaires that included questions about their age, sex, education, income, health, diet, cigarette and alcohol usage, and other socioeconomic and demographic factors. For further investigation, biochemical data such as blood pressure and lipid profile levels (TC, LDL cholesterol, HDL cholesterol, TG) were extracted from their biochemical report. There are three kind of lipid profiles: high, borderline high, and normal as classify according to Adult Treatment Panel III (ATP III) of the National Cholesterol Education Program (NCEP) guideline 2002) [8]. Dyslipidemia was defined as having at least one of the following: total cholesterol ≥ 200 mg/dL; total triglycerides ≥ 150 mg/dL; LDL-C ≥ 130 mg/dL and HDL-C < 40 mg/dL [8]. Body mass index (BMI) was calculated and classified using Asian BMI standards [9]. Data on clinical history of diabetes mellitus, hypertension and chronic kidney disease was also acquired.

Nutrient and diet quality measurement

A previously validated semi-quantitative food frequency questionnaire was administered to collect data from participants on their usual dietary pattern within the last 1 months [10]. A total number of 166 food items that are typical of both urban and rural Bangladeshis, as well

as unique foods from different regions, are included in the questionnaire [10]. People were shown pictures of various sized portions of the same meal and asked to choose one based on the size. The pictures were of basic household portions, such as an empty bowl, plate, spoon, or glass, and the participants were asked to indicate how full each one was.

Nutrient and energy estimates were derived from dietary data of 122 out of 166 food items extracted from the Food Composition Table (FCT) of Bangladesh [11]. In the event that a particular food item was not present in this FCT, information regarding its composition was obtained from the Indian food composition table [12], and rest of them were calculation according to standard recipe composition.

The Global Diet Quality Score (GDQS) assesses nutrient adequacy and study the association between chronic diseases in a global context [13]. The GDQS coding method categorizes foods into 25 groups: 16 healthy food groups (dark green/leafy/ cruciferous /deep orange/other vegetables, deep orange fruits and tubers, citrus and other fruits, legumes, nuts and seeds, poultry and game meat, fish, whole grains, liquid oils, low-fat dairy, and eggs), 2 unhealthy food groups when consumed in large quantities (high fat dairy and red meat), and 7 unhealthy food groups (white roots and tubers, processed meats, refined grains and baked goods, sugar-sweetened beverages, sweets, and ice cream). Healthy food categories received positive ratings, with higher scores corresponding to greater consumption. Consuming less of harmful food groups generally results in higher ratings, except for high fat dairy and red meat, which scored better with moderate consumption and worse with very low or very high intakes. GDQS are calculated according to guidelines [7,13]. The GDQS is the total of the scores for all 25 food

categories, which vary from 0 to 49 points. GDQS was classified as high risk (GDQS <15), moderate risk (GDQS:15-22.99) and low risk for poor diet quality (GDQS ≥ 23) [13].

Ethical consideration

This research was carried out with the authorization of the FAHS Research Ethics Committee at DIU (Ref. No.: FAHSREC/DIU/2023/1109). Each participant provided informed consent and received knowledge of their freedom to remove themselves from the study at any time without facing any consequences.

Statistical method

Data was analyzed statistically using SPSS 21.0. While continuous variables were shown as mean ± SD, categorical variables were given as frequency and percentage. When data were not normally distributed, Medium (25 percentiles -75 percentiles) were used, and Mann-Whitney test was employed to assess differences between groups. A chi-square test was done to assess the association for categorical variables. Binary logistic regression analysis was used to identify independent predictors of dyslipidemia, calculating adjusted odds ratio (AOR) and 95% confidence intervals. The model's multicollinearity was checked using the variance inflation factor (VIF) to remove the bias or confounder. The final logistic regression model included all variables with *p*-values less than 0.25 in the bivariate analysis. The criterion for statistical significance was established as a p-value less than 0.05.

Results

Socio-demographic, Anthropometric and clinical characteristics of the study participants

A total of 54.3% study participants were male. The majority of the CVD patients were from rural area and in older age group. More than half (56.3%) of the research population had

completed education only until primary school, and 52.8% of the subjects reported a monthly income below 20,000 TK (Table 1). Regarding occupation, only one-fourth of the population under study held steady employment, while the remainder were either retired or housewives. There were 52.8% of subjects were overweight, 21.3% were of normal weight, 23.2% were obese, and 2.7% were underweight. Furthermore, diabetes, hypertension, and chronic kidney disease were present concurrently in 38.8%, 74.1%, and 29.3%, respectively, of the participants (Table 1). The majority of the study population (61.7%) exhibited dyslipidemia (Table 1). HDL-C<40 mg/dl had the highest prevalence of lipid abnormalities among all cardiac patients in the study (41.5%), followed by triglycerides 200 mg/dl (20.5%), LDL-C 160 mg/dl (19.8%), and total cholesterol 240 mg/dl (12.5%) (Table 1).

Table 1: General Characteristics of the study subject

		Frequency (%)
AGE	20-45	119 (19.8%)
	46-60	257(42.8%)
	>60	224 (37.3%)
SEX	Male	326(54.3)
	Female	274 (45.7)
Marital status	Married	579 (96.5%)
	Others	21 (3.5%)
Education	Upto primary	338 (56.3%)
	Secondary or higher	262 (43.7%)
Income	<20000	317 (52.8%)
	≥20000 BDT	283 (47.3%)
Employment	Service or retired	212 (35.3%)
	Housewife	233 (38.8%)
	Worker and others	155 (25.8%)
Family size	<4 members	181 (30.2%)
	≥4 members	419 (69.5%)
Area	Urban	189
	Rural	411
BMI (Asian)	<18.5	16 (2.7%)

	18.5-22.9	128 (21.3%)
	23-27.49	317 (52.8%)
	≥27.5	139 (23.2%)
Present of NCD	Diabetes	233 (38.8%)
	Hypertension	444 (74.1%)
	Osteoarthritis	418 (69.7%)
	Asthma	266 (44.3%)
	Chronic Kidney Disease	176 (29.3%)
Plasma cholesterol (mg/dl)	Normal (<200 mg/dl)	295 (49.2%)
	Borderline high (200-239)	230 (30.3%)
	High risk (≥240)	75 (12.5%)
HDL (mg/dl)	Normal (≥60)	86 (14.3%)
	Borderline risk (40-59)	265 (44.2%)
	High risk (<40)	249 (41.5%)
LDL (mg/dl)	Normal (<100)	180 (30%)
	Borderline risk (100-159)	301 (50.2%)
	High risk (≥160)	119 (19.8%)
TG (mg/dl)	Normal (150)	279 (46.5%)
	Borderline risk (150-199)	196 (32.7%)
	High risk (≥200)	125 (20.5%)
Dyslipidemia (If any one of the parameters of cholesterol, HDL, LDL, and TG are in high risk)	Yes	370 (61.7%)
	No	230 (38.3)

The dyslipidemia pattern in connection with other variables

Table 2 describes the distribution of CVD patients according to dyslipidemia, and association with various sociodemographic variables. BMI, gender, income, education status, employment status and smoking were found statistically significant in different groups (dyslipidemia vs non-dyslipidemia) (Table 2). The proportion of the study population with dyslipidemia was significantly higher than those without dyslipidemia irrespective of the presence or absence of diabetes or hypertension (Table 2). All the lipid profiles were found significant between the groups (Table 2).

Table 2: Risk Factors of Dyslipidemia of the CVD patients

Factor	Non-Dyslipidemia	Dyslipidemia	λ^2, p value

BMI	<23.0	56 (38.9)	88 (61.1)	9.93, 0.007
	23.0 - 27.49	136 (42.9)	181 (57.1)	
	≥27.5	38 (27.3)	101 (72.7)	
AGE	20-45	39 (32.8)	80 (67.2)	1.94, 0.379
	46-60	102 (39.7)	155 (60.3)	
	>60	89 (39.7)	135 (60.3)	
SEX	Male	108 (33.1)	218 (66.9)	8.18, 0.005
	Female	122 (44.5)	152 (55.5)	
Total Cholesterol (mg/dl)	Normal	108 (36.6)	187 (63.4)	68.0, <0.001
	Borderline risk	122 (53.0)	108 (47.0)	
	High risk	0	75 (100)	
HDL(mg/dl)	Normal	63 (73.3)	23 (26.7)	267.4, <0.001
	Borderline risk	167 (63.0)	98 (37.0)	
	High risk	0	249 (100)	
LDL (mg/dl)	Normal	60 (33.3)	120 (66.7)	117.8, <0.001
	Borderline risk	170 (56.5)	131 (43.5)	
	High risk	0	119 (100)	
TG (mg/dl)	Normal	99 (35.5)	180 (64.5)	146.0, <0.001
	Borderline risk	131 (66.8)	65 (33.2)	
	High risk	0	125 (100)	
Education	Primary	161 (47.6)	177 (52.4)	28.32, <0.001
	Secondary	69 (26.3)	193 (73.7)	
Income	<20,000	153 (48.3)	164 (51.7)	28.04, <0.001
	≥20,000	77 (27.2)	206 (72.8)	
Employment	Service/retired	35 (16.5)	177 (83.5)	67.74, <0.001
	Housewife	111 (47.6)	122 (52.4)	
	Labors/others	84 (54.2)	71 (45.8)	
Diabetes	Yes	127 (54.5)	106 (45.5)	42.15, <0.001
	No	103 (28.1)	264 (71.9)	
Hypertension	Yes	181 (40.8)	263 (59.2)	4.67, 0.035
	No	48 (31.0)	107 (69.0)	
CKD	Yes	59 (33.5)	117 (66.5)	2.44, 0.140
	No	171 (40.3)	253 (59.7)	
Smoking	Yes	13 (22.8)	44 (77.2)	6.42, 0.014
	No	217 (40.0)	326 (60.0)	
Area	Urban	65 (34.4)	124 (65.6)	1.81, 0.206
	Rural	165 (40.1)	246 (59.9)	

Dietary patterns and nutrient intake of the participants

The participants' nutrient intake patterns are summarized in Table 3. The median intake of energy, protein and fat of the CVD patients were 1828.5 Kcal, 63.3 gram and 34.3 gram, respectively. The difference in carbohydrate, protein, fat, and dietary fiber (DF) intake between the two groups was statistically significant, with subjects with dyslipidemia consuming more total fat and protein while non-dyslipidemia subjects had greater carbohydrate and DF intake

(Table 3). In individuals with dyslipidemia, the intake of saturated, monounsaturated, and polyunsaturated fatty acids, along with total cholesterol, was significantly elevated in terms of fat quality (Table 3).

Table 3: Dietary Nutrient Intake pattern in different groups

Nutrient	All patients	Non-Dyslipidemia group	Dyslipidemia group	P* value
Kcal	1828.5 (1612-1983)	1835.5 (1618-1970)	1820 (1609-2017)	0.696
Protein	63.3 (56.6-75.3)	62.2 (56.7- 68.1)	65.8 (56.4 -79.0)	0.001
CHO	328.6 (289.5-357.3)	342.6 (295.3-366)	324.1 (285.8-352.8)	0.001
FAT	34.3 (31.6-46.4)	33.1 (31.2 -35.2)	36.7 (32.2 -48.2)	<0.001
DF	25.0 (21.8-28.3)	26.1 (21.9-29.1)	24.4 (21.6-27.5)	0.045
Vit C	136.9 (123-152)	138.2 (125-155)	136.2 (122-150)	0.069
Ca	597 (526-677)	550 (505-611)	629 (542-696)	<0.001
Fe	14.5 (13.2-15.6)	14.5 (13.1-15.4)	14.6 (13.3-15.8)	0.129
Zinc	9.1 (8.2-10.4)	8.9 (8.2-9.9)	9.3 (8.2-10.8)	0.005
Cu	1.9 (1.6-2.1)	1.9 (1.6-2.1)	1.9 (1.6-2.1)	0.474
Mg	373 (339-407)	380 (344-413)	372 (338-401)	0.170
Na	783 (617-893)	653 (594-843)	836 (644-916)	<0.001
K	1924 (1743-2139)	1881 (1716-2011)	1988 (1757-2193)	<0.001
Vitamin B2	0.95 (0.84-1.07)	0.87 (0.82-0.96)	1.0 (0.89-1.1)	<0.001
Folate	200 (181-222)	200 (182-222)	198 (180-222)	0.793
Vitamin B6	1.08 (0.95-1.17)	1.06 (0.93-1.13)	1.11 (0.96-1.20)	0.001
Vitamin A	539 (442-621)	555 (454-633)	534 (443-609)	0.011
Vitamin D	0.74 (0.55-0.91)	0.67 (0.52-0.78)	0.8 (0.60-0.97)	<0.001
Beta Carotene	3937(3037-5025)	4443 (3226-5565)	3427 (2695-4437)	<0.001
Vitamin E	5.2 (4.8-5.6)	5.1 (4.7-5.3)	5.3 (4.8-5.7)	<0.001
SAFA	9.25 (8.1-12.9)	8.5 (7.8 – 9.6)	10.2 (8.4 – 14.2)	<0.001
MUFA	8.82(8.2-12.2)	8.5 (8.1 – 9.1)	9.5 (8.3 – 12.9)	<0.001
PUFA	13.5 (13.1-16.3)	13.3 (13.0-13.8)	13.8 (13.1-16.8)	<0.001
Cholesterol	156.1 (134-199)	151.4 (128.5-183.9)	161.2 (135.1-206.0)	0.012
Retinol	152.3 (76.5-303.7)	138 (84.5-258.8)	262.8 (72.0-313.0)	0.005
Niacin	23.6 (19.8-45.3)	25.9 (19.8-35.6)	22.3 (19.7-47.0)	0.015
Phosphate	978 (881-1107)	947 (881-1042)	993 (878-1164)	0.001
Vitamin B1	0.95 (0.85-1.04)	0.94 (0.84-1.01)	0.96 (0.85-1.06)	0.030
Data are presented as Medium (25 percentiles -75 percentiles) *Independent Samples Mann-Whitney U test between Dyslipidemia and non-dyslipidemia groups				

Diet quality and Risk factor for dyslipidemia:

The consumption levels of twenty-five GDQS food groups, categorized into three distinct groupings, is shown in Table 4. Patients diagnosed with dyslipidemia exhibited notably

reduced intake of dark orange fruits, dark-colored leafy greens, deeply orange vegetables, as well as other vegetables that are considered healthful, in comparison to their non-dyslipidemic counterparts. On the other hand, dyslipidemia patients consumed significantly more quantities of whole grains, citrus fruits, pulses, nuts and seeds, fish, and poultry. Consumption of low fat milk products was similar in both groups. As for foods classified as unhealthy, dyslipidemia patients consumed significantly more sweets and ice cream, while the same was true for non-dyslipidemia patients regarding consumption of refined grains and white roots/tubers. For the two food groups classified as unhealthy if consumed excessively (red meat, high fat dairy), dyslipidemia patients consumed both of these in significantly greater quantities. The study population's GDQS show that 71.3% were low and 28.7% were moderate risk for poor diet quality. In bivariate analysis, there was a significant difference in diet quality among dyslipidemia and non- dyslipidemia groups (p=0.033) (Table 4).

Table 4: Consumption of different food groups of the study subject and diet quality

Nutrient	All patients	Non-Dyslipidemia group	Dyslipidemia group	P* value
Healthy Foods				
Citrus fruits	41.5 (26 – 51)	40.1 (31 – 45)	45.4 (25 – 54)	0.008
Deeply orange fruits	27.6 (22 – 35)	28.1 (24 – 37)	26.9 (21 – 33)	0.004
Other fruits	64.6 (54 – 77)	64.6 (57 – 74)	64.6 (53 – 79)	0.704
Dark green leafy vegetables	51.2 (36 – 68)	67.6 (45 – 76)	45.2 (34 – 67)	<0.001
Cruciferous vegetables	9.6 (7.6 – 13.8)	10.2 (7.6 – 12.5)	9.6 (7.6 – 13.8)	0.450
Deep orange vegetables	5.4 (3.2 – 7.2)	6.3 (3.2 – 8.9)	5.4 (3.1 – 6.3)	<0.001
Other vegetables	75.5 (63 – 116)	85.8 (68 – 120)	68.8 (61 – 85)	<0.001
Legumes	31.6 (13.3 – 45)	30.9 (13 – 40.6)	32.9 (13.1 – 54)	0.017
Deep orange tubers	0	0	0	
Seeds and nuts	3.2 (2.2 – 4.5)	2.7 (1.5 – 4.4)	3.2 (2.7 – 5.3)	<0.001
Whole grains	7.7 (6.7 – 10.9)	7.4 (6.2 – 9.8)	8.1 (6.8 – 11.0)	<0.001
Liquid oils	15.5 (15.4 – 17.2)	15.5 (15.3 – 15.7)	15.7 (15.4- 17.2)	<0.001
Fish and shellfish	51.8 (45.4 – 60)	50.8 (45 – 56)	55 (46 - 61)	0.001
Poultry and meat	12 (9.4 – 20)	11 (7.8 – 14.1)	14.9 (10 – 20.1)	<0.001
Low-fat dairy	21 (12 – 35.8)	20.3 (13.2 – 27.8)	21.7 (12 – 39.4)	0.170
Eggs	16.9 (14.3 – 26.4)	17 (14.2 – 24.9)	16.9 (14.3–26.7)	0.924
Unhealthy in excessive amounts				
High-fat dairy	17.8 (4.2 – 53.9)	17 (4.2 – 30.4)	17.8 (8.3 – 54)	<0.001
Red meat	20.9 (10.3 – 35.9)	12.5 (3.4 – 23.2)	24.3 (15.5 -39.8)	<0.001

Unhealthy food				
Processed meat	0	0	0	
Refined grains and backed goods	326 (286 – 373)	354 (300 – 390)	313 (279 – 346)	<0.001
Sweets and ice cream	58.5 (18.5 – 77.8)	24 (17 – 58)	67 (26 – 95)	<0.001
Sugar-sweetened beverage	0	0	0	
Juice	0	0	0	
White roots and tubers	16.4 (13 – 31)	23.9 (12.2 – 34.5)	15 (13 – 23.30	0.006
Purchased deep fried foods	6.6 (5.2 – 8)	7.0 (5.2 – 8.0)	6.6 (5.2 – 8.0)	0.484
GDQS				
Low risk (≥23)	428 (71.3)	176 (41.1)	252 (58.9)	χ^2=4.9, p=0.033
Moderate risk (15-22.9)	172 (28.7)	54 (31.4)	118 (68.8)	
Data are presented as Medium (25 percentiles -75 percentiles) *Independent Samples Mann-Whitney U test between Dyslipidemia and non-dyslipidemia groups				

The analytical outcomes of multivariable logistic regression are shown in Table 5. Numerous variables, including sex, level of employment, BMI and GDQS were identified as potential contributory factors for the lipid profile abnormalities (P-value <0.05) in multivariable logistic regression analysis (Table 5). Male participants were more than twice as likely as female participants to have dyslipidemia (AOR: 2.149, 95% CI: 1.060 – 4.356). In terms of employment, participants who were retired or in service (AOR: 7.00, 95% CI: 3.532 – 13.87), and those who were housewives (AOR: 2.897, 95% CI: 1.295 – 6.482), were at greater risk of developing dyslipidemia, compared to those who were laborers. Moreover, participants who had BMI ≥27.5 (obese) were shown to have twice the risk of dyslipidemia than non-obese individuals. Lastly, it was revealed that patients with GDQS 15-22.99, i.e. moderate risk of poor diet quality, had a threefold greater (AOR:3.209, 95% CI: 2.042 – 5.045) chance of developing dyslipidemia than those with low risk of poor diet quality (Table 5).

Table 5: Model of Binary logistic regression for the predation of dyslipidemia

	β	AOR	95% CI of AORs	Sig
Aged more than 60 year (r)				.734
age 20-45	.002	1.002	0.572 – 1.755	.995

aged 46-60	-.151	0.860	0.563 – 1.313	.485
SEX: Female (r)				
Male	.765	2.149	1.060 – 4.356	.034
Income: 20000 TK(BD) and more (r)				
Income <20000 TK (DB)	-.199	0.820	0.494 – 1.361	.443
Education Secondary to Higher (r)				
Education up to Primary	-.293	0.746	0.457 – 1.219	.242
Employment: Laborers & other (r)				<0.001
Retired & service job	1.946	7.000	3.532 – 13.87	<0.001
Housewife	1.064	2.897	1.295 – 6.482	0.010
Smoking: No (r)				
Smoking: yes	-.242	0.785	0.368 – 1.673	0.531
Diabetics: No (r)				
Diabetics: Yes	-.449	0.638	0.404 – 1.007	0.054
Hypertension: No (r)				
Hypertension: Yes	-.310	0.733	0.468 – 1.148	0.175
CKD: No (r)				
CKD: Yes	.082	1.086	0.700 – 1.686	0.713
BMI: <27.5 (not obese) (r)				
BMI: ≥27.5 (Obese)	.833	2.300	1.401 – 3.778	0.001
GDQS: Low risk of NCD (score ≥23.0) (r)				
GDQS: Moderate risk of NCD (score 15-22.99)	1.166	3.209	2.042 – 5.045	<0.001
Constant	-.698	0.498		0.213

Discussion

This study was conducted to determine the burden of dyslipidemia and its risk factors in cardiac patients. The results indicate that risk factors, such as BMI, gender, occupation and the risk of poor diet quality were significantly associated with dyslipidemia in cardiac patients. The study has revealed some important differences regarding nutrients and food intake patterns among cardiac patients with and without dyslipidemia, which can provide valuable insights for developing targeted interventions and personalized dietary recommendations.

High-BMI individuals had a greater prevalence of dyslipidemia, according to the study's findings. This shows that cardiac patients must maintain a healthy weight to avoid and manage dyslipidemia. Higher BMI has consistently been linked to dyslipidemia [14]. This is likely due to the fact that obesity is often associated with poor dietary choices and higher intake of

unhealthy fats and sugars, which can lead to imbalances in lipid levels [15]. Furthermore, excess body weight can also contribute to free fatty acids, insulin resistance and inflammation, all of which are known to play a role in dyslipidemia development [16]. Low-grade chronic inflammation with elevated levels of adipokines produced from adipose tissues is commonly observed in individuals with obesity that can further disrupt lipid metabolism, by affecting lipid synthesis and clearance leading to dyslipidemia [17].

The results of this study showed that gender played a significant role in the development of dyslipidemia, with males being two times more likely to have the condition. A number of earlier studies, in Bangladesh and elsewhere, support this finding [3, 18]. Some evidence has suggested that hormonal differences between males and females may contribute to the gender disparity in dyslipidemia [19]. Dyslipidemia is more prominent in older women, possibly due to reduction of estrogen levels occurring during menopause, which can negatively impact serum lipid levels in postmenopausal women [20].

The prevalence of dyslipidemia was substantially higher among individuals engaged in service or those who were retired, as well as among housewives, but not among laborers. This discrepancy in dyslipidemia prevalence among different occupational groups suggests that certain factors related to sedentary lifestyles and dietary habits may contribute to the heightened risk observed in service workers, retirees, and housewives. Service workers frequently encounter sedentary and/or highly stressful work conditions. Sitting for extended periods in the workplace has previously been discovered to elevate the likelihood of various cardio-metabolic repercussions [21]. Long-term job stress can cause dyslipidemia [22]. It can influence inflammation and cortisol levels, which affect fat intake and metabolism [23]. Retirees and housewives, on the other hand, may have more free time and access to unhealthy food options, leading to higher rates of dyslipidemia.

According to the study, those who are defined as having a moderate risk of poor diet quality are three times more likely to acquire dyslipidemia than people who are classed as having a low risk of diet quality among Bangladeshi cardiac patients. Notably, this is the first study to examine the Global Diet Quality Score in this context. Previously a study conducted in Mexico has found GDQS to be inversely associated with LDL cholesterol [24]. Patients with dyslipidemia predominantly consumed high-protein, high-fat and high-glycemic foods such as dairy, red meat, sweets, and ice cream, with minimal intake of fruits and vegetables. This diet, rich in cholesterol and saturated fatty acids, while low in fiber, has been identified as a contributor to increased LDL-cholesterol levels or raises the risk of dyslipidemia in general [25-26]. A research in Taiwan revealed a link between a diet rich in meat and sugar and increased TG levels and decreased HDLC levels [27]. Red and processed meat with high levels of heme iron and saturated fatty acids can reduce LDL receptor-mediated clearance and increase oxidative stress, putting individuals at risk for dyslipidemia when combined with a diet high in protein and sugar [28]. Past studies have shown that consuming more refined grains, sugar, and sweets while eating fewer fruits and vegetables is linked to higher levels of LDL-C and TG [29-30]. Conversely, Non-dyslipidemia individuals in the present study, ate a high-carbohydrate diet with all vegetables, thus ingesting more fiber and bioactive chemicals, which decrease CVD risk [31]. According to prior research, it has been shown that the consumption of viscous (soluble) dietary fiber derived from whole grains, vegetables, and some fruits has the potential to lower LDL-C levels [8]. Research findings have indicated that the consumption of both green vegetables and overall vegetable intake has been found to have a notable impact on reducing blood triglyceride (TG) levels [32]. Individuals without dyslipidemia had much greater consumption of vitamin A, C and folate, as well as carotenoids possessing antioxidant properties, which are well recognized as crucial indicators for prevention of dyslipidemia [33]. These findings emphasize the need of providing a balanced

and nutrient-rich diet in cardiac patients to reduce dyslipidemia risk and promote cardiovascular health.

In contrast, the Dyslipidemia patients displayed a remarkably high intake of a variety of items that the GDQS categorised as healthy, including whole grains, fish and shellfish, nuts and seeds, and all types of fruits. This implies that controlling dyslipidemia may require limiting the consumption of low-nutrient foods, such as refined carbs and sweets, rather than just increasing the intake of nutrient-dense foods in a diet high in sugar and protein. Similarly, Fung et al (2021) demonstrated that less consumption of unhealthy meals had bigger impact on lowering diabetes risk than eating nutritious foods among women in the United States, based on the GDQS [34]. However, Damigou et al. (2023) discovered that eating nutritious food is more crucial than avoiding unhealthy choices in preventing chronic illnesses [35]. Therefore, it could be beneficial to implement a mindful eating regimen that emphasizes including nutrient-dense food groups while reducing consumption of deleterious ones. International standards recommend limiting saturated fats, added sugars, and sodium [36-37]. These recommendations emphasize eating more vegetables, whole grains, fruits, lean meat, and low-fat milk. By adhering to these guidelines, individuals can decrease their risk of developing dyslipidemia and enhance their overall lipid profile. Our observations about dietary habits leading to dyslipidemia in Bangladesh mirror global dietary shifts. The transition towards "western diet" characterized by high calorie, higher-fat and lower-fiber diets is a worldwide phenomenon, previously seen in developed countries and now increasingly prevalent in developing nations [38-39]. This uniformity highlights the need for a global response to dietary education and health promotion. Determining the association between diet quality and dyslipidemia empowers patients by highlighting the impact of their dietary choices on their health outcomes. This knowledge can motivate patients to make positive changes, leading to better adherence to dietary recommendations and long-term benefits.

The current research possesses both merits and drawbacks. To the best of our understanding, this is the first investigation in Bangladesh that explores the correlation between dietary patterns and dyslipidemia components. It provides evidence regarding how overall diet quality may play an important role in dyslipidemia development. It's a cross-sectional study, so we cannot confirm causation but can make inferences about causal association. We used a food frequency questionnaire (FFQ) to collect information on people's eating habits. This FFQ was semi-quantitative, there was a possibility that there was some measurement error or recall bias. Moreover, despite the fact that the investigators of the study checked the medical records of the participants and the result ascertainment, it is possible that some cases that were not diagnosed or that were incidental were overlooked. The study did not extensively control for the impact of lipid-lowering medications or other treatments for cardiovascular diseases, which could affect lipid profiles independently of diet. In order to improve the generalizability of the findings, additional research should consider larger sample sizes and more diverse study populations to further validate these findings. Finally, the study highlights the need for dietary interventions but does not explore the impact of nutritional education and counseling on improving diet quality and managing dyslipidemia. Addressing these limitations in future study can lead to a more detailed and thorough understanding of the connection between diet quality and dyslipidemia in cardiovascular disease patients in Bangladesh.

Conclusion

Present study underscores the critical role of diet quality in managing dyslipidemia among CVD patients in Bangladesh and also emphasizes the importance of considering gender, BMI, and occupational status in the development of comprehensive health interventions. By advocating for an integrated approach that addresses the multifaceted nature of dyslipidemia through tailored dietary, lifestyle, and policy interventions, it opens the door for more study and prospective treatments in the area of cardiovascular health in Bangladesh, ultimately

contributing to the global efforts in cardiovascular health promotion and disease prevention. It is important for healthcare professionals to consider these risk factors when assessing patients for dyslipidemia and developing appropriate interventions.

Data availability statement

All data is presented in the article. Additional raw data will be available on request.

Author contribution statement

Tasmia Tasnim: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Chaity Bhatta: Analyzed and interpreted the data; Wrote the paper.

Kazi Muhammad Rezaul Karim: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Conflict of Interest

The authors declare that there is no conflict of interest.

Funding

The authors received no financial support for the research, authorship, and publication of this manuscript.

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BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2024-091025.R1
Article Type:	Original research
Date Submitted by the Author:	31-Oct-2024
Complete List of Authors:	Tasnim, Tasmia; Daffodil International University, Nutrition and Food Engineering Karim, Kazi Muhammad Rezaul; University of Dhaka, Institute of Nutrition and Food Science Bhatta, Chaity; Daffodil International University, Nutrition and Food Engineering
Primary Subject Heading:	Public health
Secondary Subject Heading:	Nursing, Public health, Cardiovascular medicine, Global health
Keywords:	Cardiovascular Disease, Cross-Sectional Studies, NUTRITION & DIETETICS, PUBLIC HEALTH

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Association of diet quality and nutrient intake with odds of dyslipidemia in patients with cardiovascular diseases: a hospital based cross-sectional study in Bangladesh

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Abstract

Objective: The aim of this study is to evaluate diet quality and others associated factors with dyslipidemia in cardiovascular disease (CVD) patients in Bangladesh.

Design: The study employed a cross-sectional design.

Setting: Data from medical records, dietary intake, and socioeconomic factors were collected from January to October 2022 at the National Institute of Cardiovascular Disease, Dhaka, and Noakhali Sadar Hospital.

Participants A total of 570 CVD patients, aged 25-80 years, who had received a confirmed diagnosis within the last three months were included in the study.

Main outcome measures The primary outcome were the Global Diet Quality Score (GDQS) and dyslipidemia. Multivariate logistic regression models were used to explore the associations between dyslipidemia and various sociodemographic, nutritional, and dietary factors among CVD patients.

Results Dyslipidemia was observed in more than two-thirds (70.4%) of participants. The mean GDQS score was 24.38, with 69.8% of the population maintaining a healthy diet. GDQS was significantly higher in the non-dyslipidemic group (25.21 ± 2.53) compared to the dyslipidemic group (24.03 ± 2.33). Nutrient intake was generally higher in non-dyslipidemic patients. The odds of hypercholesterolemia, hypertriglyceridemia, and elevated LDL were notably higher in the lowest GDQS tertile compared to the highest. Multivariable logistic regression identified sex, employment status, BMI, and GDQS as significant predictors of dyslipidemia. Males (AOR = 4.18, 95% CI: 2.32-7.54), housewives (AOR = 2.86), and obese individuals (AOR = 1.0) were at higher odds of dyslipidemia. Compared to the highest GDQS tertile, the odds of dyslipidemia were nearly double in the middle tertile (AOR: 1.87, 95% CI: 1.13–3.11) and almost four times higher in the lowest tertile (AOR: 3.67, 95% CI: 2.025–6.641).

Conclusions The study suggests that a high-quality diet can significantly reduce the odds of dyslipidemia, hypercholesterolemia, hypertriglyceridemia, and elevated LDL cholesterol. The study highlights the potential of targeted nutritional interventions with a multifaceted approach to managing dyslipidemia, emphasizing the need for personalized dietary guidelines that consider the individual's gender, occupation, and BMI.

Key Words: Cardiovascular disease, Dyslipidemia, Diet quality, Global Diet Quality Score, Nutrients, Bangladesh

STRENGTHS AND LIMITATIONS OF THIS STUDY

- The GDQS, which combines 25 healthy and unhealthy food groups, is a sensitive metric for assessing diet quality.
- The sample size was sufficient to allow for multivariate logistic regression models on nine independent variables, and the model demonstrated a good fit.
- Since the biochemical tests were performed at a different hospital or diagnostic facility, dyslipidemia may not have been correctly identified.
- Minor errors may be present as the analysis did not adjust for lipid-lowering medications.

Introduction

Heart disease is increasing worldwide, with South Asian nations experiencing the greatest prevalence and mortality rates among all low and middle-income countries (LMICs).[1] South Asian races possess a 3 to 5 times greater likelihood of acquiring heart disease, presenting symptoms 5 to 10 years earlier than in Western nations.[1] Nonetheless, Bangladesh, in particular, bears a disproportionate burden, with one of the highest incidences of CVD in the region, often affecting individuals earlier in life.[2] This escalating epidemic poses a significant challenge to public health, as CVD remains a leading cause of morbidity and mortality in Bangladesh.[3] The prevalence of CVD in the country varies widely, with estimates ranging from 0.062% to 77.7%, and pooled data suggest a 5% prevalence rate across the population, regardless of gender or geographical location.[3]

Several risk factors contribute to the increasing rates of CVD in Bangladesh, including hypertension, elevated total cholesterol (TC), low-density lipoprotein (LDL) cholesterol, triglycerides (TG), reduced levels of high-density lipoprotein (HDL) cholesterol, obesity, and poor dietary habits.[4] Dyslipidemia is widely recognized as a significant risk factor for cardiovascular disease (CVD) and associated mortality in countries with developed as well as developing economies.[4-5] An increased prevalence of dyslipidemia has been exceedingly reported in Bangladesh.[3, 5] This indicates that dyslipidemia may have a substantial impact on the emergence of cardiovascular disease (CVD) in Bangladesh.

Dyslipidemia is defined by a gradual increase in lipids and lipoproteins in the blood, occurring either independently or in combination. Dyslipidemia in adult cardiac patients can worsen pre-existing heart conditions and lead to further health complications. Atherosclerosis, driven by the buildup of fatty deposits in the arteries, significantly elevates the risk of angina, myocardial infarction, and stroke in patients with dyslipidemia.[6] Elevated LDL cholesterol and triglyceride levels are particularly concerning, as they increase the risk of plaque rupture, leading to

thrombosis and the potential for life-threatening coronary artery blockages.[7] Cardiac patients with dyslipidemia are more vulnerable to recurrent heart attacks due to the heightened risk of plaque instability and thrombosis, which may further damage the heart muscle and impair cardiac function.[8]

Diet quality is closely linked to lipid metabolism. Due to its direct effect on cholesterol levels and cardiovascular health, diet quality is a critical component in the therapy of dyslipidemia in the prevention and management of CVD.[9] A diet's quality can be defined as the degree to which its individual components contribute to good health. While individual nutrients, foods, and bioactive compounds can have targeted effects, it is the overall dietary pattern that exerts the most significant influence on health outcomes.[10] Low quality diets, high in sugar and saturated fat or not enough healthy fruits and vegetables or fiber, are inversely related to healthy blood lipid levels and a higher risk of many diseases, including cardiovascular disease.[11]

In Bangladesh, where both cardiovascular disease (CVD) and dyslipidemia rates are high [5], examining diet quality offers an opportunity to lower the risk of future cardiac events and improve overall prognosis in cardiac patients. While medications are commonly prescribed to manage dyslipidemia, improving diet quality offers a complementary, sustainable and accessible approach to treatment, for many patients, especially in resource-limited settings. By focusing on dietary interventions, healthcare providers can help patients make meaningful lifestyle changes that complement pharmacological treatments.

Assessing diet quality provides a comprehensive view of a person's overall eating habits and their impact on health outcomes. One of the most comprehensive tools for evaluating diet quality is the Global Diet Quality Score (GDQS), which assesses dietary intake based on food groups and their contribution to nutrient sufficiency and chronic disease risk across different regions. The GDQS offers a more nuanced view than traditional diet metrics, as it considers a wider range of food groups and categorizes foods into healthy and unhealthy categories based

on their effects on health outcomes.[12] The GDQS has been used previously in examining diet quality in relation to dyslipidemia, providing actionable insights for dietary modifications that contribute to better lipid profiles.[13-14]

Despite the importance of diet in managing dyslipidemia and preventing cardiovascular diseases, there is a lack of research in Bangladesh on the potential link between dietary habits and lipid profiles of individuals already suffering from CVD. Addressing this gap is essential for understanding the dietary factors that contribute to dyslipidemia in this population. Therefore, this study aims to evaluate diet quality and other factors associated with dyslipidemia in cardiac patients in Bangladesh. The central hypothesis is that higher GDQS scores, indicating better diet quality, will be inversely associated with the odds of dyslipidemia. By understanding the full range of factors, particularly dietary influences on lipid levels in CVD patients, healthcare providers can develop more effective, personalized treatment approaches to manage dyslipidemia and improve patient outcomes.

Materials and Methods

Study area and study design

The study was conducted across two key medical facilities in Bangladesh, targeting a diverse patient population. Data collection occurred at the outpatient tertiary care unit of the National Institute of Cardiovascular Diseases (NICVD) hospital, located in Dhaka. Additionally, the study encompassed the coronary care unit of Sadar Hospital in Noakhali.

The study was a cross-sectional design. The timeframe of the study spanned from January 2022 to October 2022. The inclusion criteria for this study were CVD patients aged 25 years and over who had a confirmed diagnosis of CVD within the last three months by a medical doctor and attended the selected hospitals for follow-up. The common types of CVD include coronary heart disease, cardiomyopathy, congenital heart disease, arrhythmia, rheumatic heart disease,

heart failure, and valvular heart disease.[3] The exclusion criteria were pregnant and breastfeeding women, individuals under 25 years of age, hospitalized patients with cardiovascular disease, chronic renal disease patients having dialysis or kidney transplants, those in advanced stages (eGFR <15%), subjects who did not complete the questionnaire, and those lacking recent biochemical data.

The sample size was calculated by formula n = 100 + 50*i* where *i* refers to number of independent variables in the final logistic regression model.[15] We assumed that the nine independent variables in the regression model, and the minimum sample size was 550. After adding 5.0% to account for any errors in the study process, 570 participants were required for the study.

Socio-demographic and Biochemical characteristic variables

Participants filled out self-reported questionnaires that included questions about their age, sex, education, income, employment status, health, diet, cigarette and alcohol usage, and other socioeconomic and demographic factors. For further investigation, blood lipid profile levels [total cholesterol (TC), low-density lipoprotein (LDL), high-density lipoprotein (HDL) and triglycerides (TG)] were extracted from their recent biochemical report. All the lipid profiles were analyzed using enzymatic colorimetric methods, checked according to their report. Lipid profiles were classified according to Adult Treatment Panel III (ATP III) of the National Cholesterol Education Program (NCEP) guideline 2002.[16] Dyslipidemia was defined as having at least one of the following: total cholesterol ≥ 200 mg/dL; total triglycerides ≥ 150 mg/dL; LDL ≥ 130 mg/dL and HDL < 40 mg/dL.[16] Further the lipid profiles were classified as elevated TG: TG ≥ 150 mg/dL; elevated TC: TC ≥ 200 mg/dL; elevated LDL: LDL ≥ 130 mg/dL and low HDL: HDL < 40 mg/dL.[16] Hypertension was defined as SBP ≥ 140 mm Hg and/or DBP ≥ 90 mm Hg and/or the use of antihypertensive drugs. Diabetes was defined as fasting blood

plasma glucose level ≥ 7.0 mmol/L. Chronic kidney disease (CKD) was defined as a reduced glomerular filtration rate (GFR) as <60%.

According to the standard procedures, the anthropometric information such as height and weight were measured. Body mass Index (BMI: kg/m2) was calculated by dividing participants' weight (in kilograms) by the square of their height (in meters). BMI was categorized into four groups which are underweight (<18.5 kg/m^2), normal weight (18.5 - 24.99 kg/m2), overweight (25.0 - 29.99 kg/m^2) and obese (≥30.0 kg/m^2) according to WHO. Smoking status was classified as nonsmoker and current smoker.

Nutrient and diet quality measurement

A previously validated semi-quantitative food frequency questionnaire was administered to collect data from participants on their usual dietary intake within the last one month.[17] A total number of 166 food items that are typical of both urban and rural Bangladeshis, as well as unique foods from different regions, are included in the questionnaire.[17] People were shown pictures of various sized portions of the same meal and asked to choose one based on the size. The pictures were of basic household portions, such as an empty bowl, plate, spoon, or glass, and the participants were asked to indicate how full each one was.

Nutrient and energy estimates were derived from dietary data of 122 out of 166 food items extracted from the Food Composition Table (FCT) of Bangladesh.[18] In the event that a particular food item was not present in this FCT, information regarding its composition was obtained from the Indian food composition table,[19] and rest of them were calculation according to standard recipe composition.

The Global Diet Quality Score (GDQS) assesses nutrient adequacy and studies the association between chronic diseases in a global context.[20] The GDQS coding method categorizes foods into 25 groups: 16 healthy food groups (dark green/leafy/ cruciferous /deep orange/other

vegetables, deep orange fruits and tubers, citrus and other fruits, legumes, nuts and seeds, poultry and game meat, fish, whole grains, liquid oils, low-fat dairy, and eggs), two unhealthy food groups when consumed in large quantities (high fat dairy and red meat), and seven unhealthy food groups (white roots and tubers, processed meats, refined grains and baked goods, sugar-sweetened beverages, sweets, and ice cream). Healthy food categories received positive ratings, with higher scores corresponding to greater consumption. Consuming less harmful food groups generally results in higher ratings, except for high fat dairy and red meat, which scored better with moderate consumption and worse with very low or very high intakes. GDQS are calculated according to guidelines.[12, 20] The GDQS is the total of the scores for all 25 food categories, which vary from 0 to 49 points (Annexure 1). GDQS was classified as high risk (GDQS <15), moderate risk (GDQS:15-22.99) and low risk for poor diet quality (GDQS ≥ 23).[20]

Ethical consideration

This research was carried out with the authorization of the FAHS Research Ethics Committee at DIU (Ref. No.: FAHSREC/DIU/2023/1109). Each participant provided informed consent and received knowledge of their freedom to remove themselves from study at any time without facing any consequences.

Statistical method

Data was analyzed statistically using SPSS 21.0. While continuous variables were shown as mean ± SD, categorical variables were given as frequency and percentage. When data were not normally distributed, Medium (25 percentiles -75 percentiles) were used, and Mann-Whitney test was employed to assess differences between groups. A chi-square test was done to assess the association for categorical variables. GDQS were categorized into tertiles, where T1

indicated the lowest, and T3 showed the highest score. Linear trend across tertile of GDQS were estimated among elevated TC, elevated TG, elevated LDL, low HDL and dyslipidemia and checked by the Cochran–Armitage test in STATA 13. Multivariate logistic regression analysis was used to identify independent predictors of dyslipidemia, calculating adjusted odds ratio (AOR) and 95% confidence intervals. Variance inflation factors (VIF) were used to assess multicollinearity prior to performing multivariate logistic regression. VIF values below 2.2 indicated the lack of collinearity issues.[21] The final logistic regression model included all variables with *p*-values less than 0.25 in the bivariate analysis. The criterion for statistical significance was established as a p-value less than 0.05.

Patient and public involvement

Patients and the public were not involved in the design, conduct, reporting, or dissemination plans of this research.

Results

Socio-demographic, Anthropometric and clinical characteristics of the study participants

A total of 54.9% study participants were male. The majority of the CVD patients were from rural areas and in middle age groups. More than half (56.8%) of the research population had completed education only until primary school, and 54.4% of the subjects reported a monthly income below 20,000 TK (Table 1). Regarding occupation, only one-fourth of the population under study held steady employment, while the remainder were either retired or housewives. 45.0% of subjects were overweight, 44.6% were normal and underweight, and 10.4 % were obese. Furthermore, diabetes, hypertension, and chronic kidney disease were present concurrently in 40.0 %, 74.0 %, and 30.0 %, respectively, of the participants (Table 1). The majority of the study population (70.4 %) exhibited dyslipidemia (Table 1).

Hypercholesterolemia (TC ≥ 200mg/dl) exhibited the highest frequency of lipid abnormalities among all cardiac patients in the research (55.5 %), followed by hypertriglyceridemia (TG ≥ 150 mg/dL, 52.2%), low HDL <40 mg/dL (40.9 %) and high LDL ≥ 130 mg/dL (40.4%) (Table 1).

Table 1: General Characteristics of the study subject

		Frequency (%)
Age in Year	20-45	117 (20.5)
	46-60	243 (42.6)
	>60	210 (36.8)
Gender	Male	313 (54.9)
	Female	257 (45.1)
Marital status	Married	551 (96.7)
	Others	19 (3.3)
Education	Up to primary	324 (56.8)
	Secondary or higher	246 (43.2)
Income	<20000	310 (54.4)
	≥20000 BDT	260 (45.6)
Employment	Service or retired	199 (34.9)
	Housewife	218 (38.2)
	Worker and others	153 (25.8)
Family size	<4 members	177 (31.1)
	≥4 members	393 (68.9)
Area	Urban	179 (31.4)
	Rural	391 (68.6)
BMI (WHO)	<25.0	254 (44.6)
	25-29.99	256 (45.0)
	≥30.0	59 (10.4)
Present of NCD	Diabetes	228 (40.0)
	Hypertension	421 (74.0)
	Osteoarthritis	401 (70.4)
	Asthma	255 (44.7)
	Chronic Kidney Disease	171 (30.0)
Total cholesterol (TC) (mg/dL)	Normal (<200 mg/dL)	282 (49.5)
	Elevated (≥ 200/mg dL)	288 (55.5)
HDL (mg/dL)	Normal/ Borderline risk (≥40)	337 (59.1)
	High risk (<40)	233 (40.9)
LDL (mg/dL)	Normal/ Borderline low (<130)	340 (59.6
	Elevated LDL (≥130)	230 (40.4)
TG (mg/dL)	Normal (<150)	272 (47.8)
	Elevated TG (≥ 150)	298 (52.2)

Dyslipidemia (at least one of the following: TC ≥ 200 mg/dL or TG ≥ 150 mg/dL or LDL ≥ 130 mg/dL or HDL < 40 mg/dL)	Yes	401 (70.4)
	No	169 (29.6)

BMI: Body mass index, NCD: Non communicable diseases, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, TG: Triglycerides, mg: milligram, dL: deciliter

The dyslipidemia pattern in connection with other variables

Table 2 describes the distribution of CVD patients according to dyslipidemia, and association with various sociodemographic variables. BMI, gender, income, education status, locality of the participants and hypertension were found statistically significant in different groups (dyslipidemia vs non-dyslipidemia) (Table 2).

Table 2: Associated factors for Dyslipidemia of the cardiovascular disease patients

Factor		Non-Dyslipidemia	Dyslipidemia	p value
BMI	<25.0	63 (24.8)	191 (75.2)	0.001
	25.0 – 29.99	95 (37.1)	161 (62.9)	
	≥30.0	11 (18.6)	48 (81.4)	
Age (Years)	20-45	41 (35.0)	76 (65.0)	0.338
	46-60	67 (27.6)	176 (72.4)	
	>60	61 (29.0)	149 (71.0)	
Gender	Male	78 (24.9)	235 (75.1)	0.007
	Female	91 (35.4)	166 (64.6)	
Education	Primary	84 (25.9)	240 (74.1)	0.027
	Secondary	85 (34.6)	161 (65.4)	
Income	<20,000	76 (24.5)	234 (75.5)	0.004
	≥20,000	93 (35.8)	167 (64.2)	
Employment	Service/retired	70 (35.2)	129 (64.8)	0.086
	Housewife	61 (28.0)	157 (72.0)	
	Labors/others	38 (24.8)	115 (75.2)	
Diabetes	Yes	59 (25.9)	169 (74.1)	0.112
	No	110 (32.2)	232 (67.8)	
Hypertension	Yes	137 (32.5)	284 (67.5)	0.012
	No	32 (21.6)	116 (78.4)	
CKD	Yes	48 (28.1)	123 (71.9)	0.618
	No	121 (30.3)	278 (69.7)	
Smoking	Yes	19 (36.5)	33 (63.5)	0.267
	No	150 (29.0)	368 (71.0)	
Area	Urban	64 (35.8)	115 (64.2)	0.038
	Rural	105 (26.9)	286 (73.1)	

BMI: Body mass index, CKD: Chronic kidney diseases,

Diet and nutrient intake of the participants

The participants' nutrient intake patterns are summarized in Table 3. The median intake of energy, protein and fat of the CVD patients was recorded at 1818 Kcal, 62.8 gram and 34.2 gram, respectively. The non-dyslipidemia group exhibits a significantly higher caloric intake, along with elevated consumption of most nutrients, encompassing both macronutrients and micronutrients, in comparison to the dyslipidemia group. (Table 3).

Table 3: Dietary Nutrient Intake pattern in different groups

Nutrients	All patients	Non-Dyslipidemia group	Dyslipidemia group	P* value
Energy (Kcal)	1818 (1609-1977)	1863 (1617-2055)	1793 (1591-1962)	0.013
Protein (g)	62.8 (56.3-74.3)	66.1 (57.8-79.8)	61.9 (55.5-72.4)	<0.001
Carbohydrates (g)	327 (287-356)	335 (289-364)	324 (287-353)	0.078
Fat & oil (g)	34.2 (31.5-45.8)	34.9 (31.8-47.3)	33.8 (31.5-45.3)	0.008
Dietary Fiber (g)	24.6 (21.4-28.2)	25.7 (22.7-28.5)	24.2 (21.0-27.9)	0.007
Vitamin C (mg)	136 (122-152)	137 (124-153)	136 (121-151)	0.164
Calcium (mg)	590 (523-673)	611 (536-688)	585 (510-660)	0.021
Iron (mg)	14.4 (13.1-15.5)	14.7 (13.4-15.9)	14.2 (12.9-15.5)	0.005
Zinc (mg)	9.1 (8.2-10.3)	9.5 (8.5-10.9)	8.9 (8.1-10.2)	<0.001
Copper (mg)	1.9 (1.6-2.1)	1.97 (1.7-2.1)	1.9 (1.6-2.1)	0.003
Magnesium (mg)	372 (338-404)	379 (345-414)	370 (332-400)	0.009
Sodium (mg)	777 (616-884)	770 (609-885)	786 (620-884)	0.970
Potassium (mg)	1912 (1742-2124)	1947 (1784-2226)	1889 (1713-2098)	0.002
Vitamin B2 (mg)	0.9 (0.8-1.1)	0.94 (0.86-1.01)	0.94 (0.83-1.05)	0.137
Folate (µg)	199 (179-222)	201 (187-222)	197 (175-221)	0.106
Vitamin B6 (mg)	1.1 (0.9-1.2)	1.1 (0.99-1.2)	1.06 (0.9-1.2)	0.004
Vitamin A (µg)	539 (442-620)	546 (470-622)	536 (435-612)	0.143
Vitamin D (µg)	0.73 (0.55-0.91)	0.76 (0.57-0.93)	0.7 (0.53-0.91)	0.138
Beta Carotene (µg)	3943 (3054-5026)	3896 (2984-5177)	3960 (3054-5011)	0.612
Vitamin E (mg)	5.1 (4.8-5.6)	5.3 (4.9-5.6)	5.07 (4.7-5.4)	<0.001
SAFA (g)	9.1 (8.1-12.1)	9.96 (8.1-13.8)	8.85 (8.1-12.4)	0.010
MUFA (g)	8.8 (8.1-12.1)	9.07 (8.3-12.4)	8.7 (8.1-11.5)	0.007
PUFA (g)	13.4 (13.0-16.4)	13.7 (13.1-16.6)	13.4 (13.0-15.8)	0.002
Cholesterol (mg)	154 (133-198)	163 (136-209)	152 (133-191)	0.019
Retinol (µg)	146 (75-302)	181 (83-305)	137 (71-294)	0.020
Niacin (mg)	22.3 (19.7-44.6)	29.7 (20.1-46.7)	21.4 (19.2-42.4)	0.001
Phosphate (mg)	966 (876-1102)	1007 (892-1171)	959 (855-1086)	0.002
Vitamin B1 (mg)	0.94 (0.84-1.03)	0.96 (0.87-1.04)	0.93 (0.84-1.03)	0.020
Data are presented as Median (25 percentiles -75 percentiles) *Independent Samples Mann-Whitney U test between Dyslipidemia and non-dyslipidemia groups.				

SAFA: Saturated fatty acids, MUFA: Monounsaturated fatty acids, PUFA: Poly unsaturated fatty acids, g: gram, mg: milligram, µg: microgram.

Diet quality and associated factor for dyslipidemia

The consumption levels of twenty-five GDQS food groups, categorized into three distinct groups, is shown in Table 4. It presents a detailed overview of the median consumption across various food categories, alongside the intake levels—low, medium, and high—of the respective food groups among individuals diagnosed with cardiovascular disease.

Over 70% of patients with cardiovascular disease reported a limited consumption of deep orange tubers, seeds and nuts, deep orange vegetables, low-fat dairy, and cruciferous vegetables, which are all part of the healthy food groups. Conversely, over 65% of the population exhibited increased consumption of liquid oil and dark green leafy vegetables (Table 4). More than 70% of people consumed less portions of several unhealthy foods, including processed meat, purchased deep fried, sugar-sweetened beverages, juice, and white roots and tubers. The GDQS is enhanced when a significant percentage of CVD patients consume fewer of various unhealthy food groups. The non-dyslipidemia group demonstrates a significantly higher consumption of legumes, poultry and meat, as well as whole grains, in comparison to the dyslipidemia group (Supplementary Table 1).

The mean GDQS for CVD patients was 24.38 (out of a 0 to 49 range score), and 69.8% of the population had a low-risk diet, while 30.2% and 0% had moderate and high-risk diet, respectively, according to GDQS cutoff points (Table 4). The GDQS was significantly higher in the non- dyslipidemia group (25.21 ± 2.53) as compared to dyslipidemia group (24.03 ± 2.33) (Table 4). In the non-dyslipidemia group, GDQS+ (0 to 32 score) and GDQS- (0 to 17 score) were also higher compared to dyslipidemia group, although only GDQS+ was statistically significant.

GDQS were categorized into tertiles, where T1 indicated the lowest (30.2 %), and T3 showed the highest score (34.9% observation) (Table 5). There were observed a trend among elevated TC, elevated TG, elevated LDL and dyslipidemia with GDQS (p-trend < 0.001) (Table 5). Hypercholesterolemia, hypertriglyceridemia, high LDL and dyslipidemia were significantly associated with diet quality. That means the odds of hypercholesterolemia, hypertriglyceridemia, high LDL and dyslipidemia were significantly higher in lowest tertile of GDQS as compared to highest tertile of GDQS (Table 5).

Table 4: Consumption of different food groups of the study subject and diet quality

Food Groups	All patients	Consumption level (%)		
Healthy Foods	Median intake (gm)	Low	Middle	High
Citrus fruits	41 (26-51)	19.6	73.9	1.1
Deeply orange fruits	27 (22-36)	36.7	63.3	0
Other fruits	64 (54-77)	2.6	97.0	0.4
Dark green leafy vegetables	51 (35.5-67.7)	0	33.2	66.8
Cruciferous vegetables	9.9 (7.6-13.8)	73.0	25.6	1.4
Deep orange vegetables	5.4 (3.1-7.6)	84.2	15.8	0
Other vegetables	77 (64-116)	0.4	73.5	26.1
Legumes	28.3 (13.3-41.9)	10.2	65.1	24.7
Deep orange tubers	0	100	0	0
Seeds and nuts	3.2 (2.2-4.9)	95.6	4.4	0
Whole grains	7.6 (6.7-10.8)	56.3	43.7	0
Liquid oils	15.5 (15.4-17.1)	0	0	100
Fish and shellfish	51.3 (45.0-59.7)	0	95.8	4.2
Poultry and meat	11.8 (9.4-20.1)	62.4	32.3	5.4
Low-fat dairy	21.0 (12.0-30.3)	75.3	24.7	0
Eggs	16.6 (14.2-25.7)	4.9	91.9	3.2
Unhealthy in excessive amounts				
High-fat dairy	17.8 (4.2-53.5)	65.8	34.2	0
Red meat	20.1 (10.3-32.7)	22.6	71.4	6.0
Unhealthy food				
Processed meat	0	100	0	0
Refined grains and backed goods	326 (285-373)	0	0	100
Sweets and ice cream	54.8 (18.7-77.8)	7.2	30.2	62.8
Sugar-sweetened beverage	0	89.5	10.5	0
Juice	0	79.1	20.9	0
White roots and tubers	16.4 (13.0-31.2)	69.5	30.5	0
Purchased deep fried foods	6.6 (5.2-8.0)	79.0	20.4	0

GDQS Score	All patients	Non-Dyslipidemia group	Dyslipidemia group	P* value
Total GDQS	24.38 ± 2.45	25.21 ± 2.53	24.03 ± 2.33	<0.001
GDQS+	13.70 ± 2.11	14.41 ± 2.11	13.40 ± 2.05	<0.001
GDQS-	10.67 ± 097	10.79 ± 1.03	10.63 ± 0.95	0.067
GDQS				
Low risk (≥23)	398 (69.8)			
Moderate risk (15-22.9)	172 (30.2)			
High risk diet (<15.0)	0			
Data are presented as Median (25 percentiles -75 percentiles) *Independent Samples Mann-Whitney U test between Dyslipidemia and non-dyslipidemia groups GDQS: Global diet quality score				

Table 5: Univariate analysis for measuring association with GDQS and dyslipidemia

Variables	DGQS Tertiles			
	T3(highest, reference)	T2 (middle)	T1 (lowest)	p-trend
Elevated TC, OR (95%CI)	1.0	1.95 (1.29-2.93)	2.01 (1.32- 3.08)	0.001
Elevated TG, OR (95%CI)	1.0	1.99 (1.326-2.973	3.33 (2.17-5.11)	<0.001
Elevated LDL, OR (95%CI)	1.0	2.07 (1.36 -3.13)	2.44 (1.59 -3.75)	<0.001
Low HDL, OR (95% CI)	1.0	0.61 (0.40- 0.93)	0.81 (0.52 – 1.24)	0.280
Dyslipidemia, OR (95% CI)	1.0	1.67(1.10- 2.53)	3.25 (2.01-5.28)	<0.001

HDL: High-density lipoprotein, LDL: Low-density lipoprotein, TG: Triglycerides, TC: Total cholesterol, GDQS: Global diet quality score, T: Tertiles of GDQS score, CI: confidence interval, OR: Odds ratio.

The analytical outcomes of multivariable logistic regression are shown in Table 6. Numerous variables, including sex, level of employment, BMI, hypertension and GDQS were identified as potential contributory factors for the lipid profile abnormalities (P-value <0.05) in multivariable logistic regression analysis (Table 6). Male participants were more than four time as likely as female participants to have dyslipidemia (AOR: 4.18, 95% CI: 2.32-7.54). In terms of employment, participants who were retired or in service (AOR: 1.5, 95% CI: 0.749 – 2.987, p-value 0.253), and those who were housewives (AOR: 2.86, 95% CI: 1.37 – 5.94, p-<0.005), were at greater odds of developing dyslipidemia, compared to those who were laborers. Moreover, participants who had BMI ≥30.0 (obese) were shown to have more odds of dyslipidemia than overweight individuals (AOR: 0.43, 95% CI: 0.21 – 0.91, p-value 0.026). Finally, compared to the highest tertile of the GDQS of the CVD patients, the odds of dyslipidemia were almost twice that of the middle tertile (AOR: 1.87, 95% CI:1.13 – 3.11, p-

value 0.015) and almost four times that of the lowest tertile (AOR: 3.67, 95% CI: 2.025 – 6.641, p-value <0.001) (Table 6).

Table 6: Model of Multivariate logistic regression for the predation of dyslipidemia

	β	AOR	95% CI of AORs	Sig
Gender: Female (r)		1.0		
Male	1.43	4.18	2.318-7.542	<0.001
Income: 20000 TK(BD) and more (r)		1.0		
Income <20000 TK (DB)	0.089	1.093	0.632 – 1.890	0.750
Education Secondary to Higher (r)		1.0		
Education up to Primary	0.099	1.104	0.678 – 1.799	0.690
Employment: Laborers & other (r)		1.0		0.015
Retired & service job	0.403	1.496	0.749 – 2.987	0.253
Housewife	1.05	2.857	1.373 – 5.944	0.005
Area: Rural (r)		1.0		
Urban	-0.181	0.835	0.545 – 1.278	0.405
Diabetics: Absent (r)		1.0		
Diabetics: Present	0.131	1.140	0.678 – 1.916	0.621
Hypertension: absent (r)		1.0		
Hypertension: Present	-0.532	0.587	0.361 – 0.956	0.032
BMI: ≥ 30.0 (Obese) (r)		1.0		0.006
BMI: <25.0 (normal and underweight)	-0.276	0.758	0.355 – 1.619	0.475
BMI: 25.0 – 29.99 (overweight)	-0.843	0.431	0.205 – 0.905	0.026
GDQS in tertiles				
T3 (highest tertile, GDQS: >24.75) (r)		1.0		<0.001
T2 (middle tertile, GDQS: 22.76 – 24.75)	0.628	1.874	1.131 – 3.106	0.015
T1 (lowest tertile, GDQS: ≤ 22.75)	1.299	3.667	2.025 – 6.641	<0.001

AOR: Adjusted odds ratio, CI: GDQS: Global diet quality score, T: Tertiles of GDQS score, CI: confidence interval, r: Reference, BMI: Body mass index, TK: Take, BD: Bangladesh

Discussion

This study aimed to assess the factors influencing dyslipidemia in individuals with cardiac conditions, focusing on diet quality, consumption of healthy and unhealthy foods, as measured by the Global Diet Quality Score (GDQS), and their relationship to dyslipidemia among cardiovascular disease (CVD) patients in Bangladesh. The results highlight the significant associations between dyslipidemia and various risk factors, including body mass index (BMI), gender, occupation, and diet quality. The study provides crucial insights into the characteristics and dietary intake patterns of cardiac patients with and without dyslipidemia, offering valuable

information for the development of targeted interventions and personalized dietary recommendations.

One of the key findings of this study is the strong association between higher BMI and the prevalence of dyslipidemia. The data suggest that maintaining a healthy weight is essential for cardiac patients to manage and prevent dyslipidemia. Previous research consistently links obesity with dyslipidemia due to poor dietary choices and increased consumption of unhealthy fats and sugars, which contribute to lipid imbalances.[22-23] Additionally, excess body weight can also contribute to free fatty acids, insulin resistance and inflammation, all of which are known to play a role in dyslipidemia development.[24]

The findings reveal a noticeable difference in dyslipidemia prevalence between sexes, with males being four times more likely to have the condition. A number of earlier studies, in Bangladesh and elsewhere, support this finding.[5, 25] In contrast, the lower prevalence of dyslipidemia among females may be attributed to the protective effects of estrogen, which positively influences lipid metabolism.[26]

Interestingly, occupation also emerged as a significant factor, with housewives being three times more likely to experience dyslipidemia compared to other occupational groups. A survey in Karachi revealed that a significant percentage of housewives were obese, largely due to unhealthy dietary practices, including frequent consumption of red meat, sweets, and junk foods, alongside a lack of physical activity.[27] Thus it suggests that housewives may have greater access to unhealthy food options which could contribute to poorer dietary habits and a higher incidence of dyslipidemia. Furthermore, the social and cultural dynamics in Bangladesh may influence dietary patterns and lifestyle choices among housewives, due to prioritizing the needs of their families over their own health, potentially increasing their vulnerability to dyslipidemia and other non-communicable diseases.[28-29]

The results from this study highlight significant differences in dietary patterns between CVD patients with and without dyslipidemia, as measured by the Global Diet Quality Score (GDQS). Participants without dyslipidemia had a healthier dietary pattern, as shown by their significantly higher GDQS and GDQS+ scores, indicating that a healthier overall dietary pattern is associated with better lipid profiles. Individuals at the lowest GDQS tertile had the highest likelihood of having elevated levels of LDL, triglycerides, and total cholesterol. The inverse association of high GDQS score with metabolic abnormalities including dyslipidemia has been proven elsewhere.[13,30] A previous study in Mexico discovered that GDQS was linked to lower total and LDL cholesterol levels.[31] Studies in Iran[32] and Sweden[33] have demonstrated that following healthy eating guidelines, as indicated by various diet quality index scores, is associated with lower levels of LDL, total cholesterol, or triglycerides. The overall mean GDQS of 24.38 across all patients suggests a moderately healthy diet among the population, with the majority (69.8%) classified as having a low-risk diet. Notably, there were no patients categorized in the high-risk group based on the GDQS cutoff points, indicating a generally positive trend in diet quality among CVD patients. In our analysis, consuming fewer unhealthy foods in the GDQS subcategory (GDQS−) did not affect the likelihood of dyslipidemia because patients in both groups had similar low intakes of unhealthy items. This is also why the average GDQS was higher for the entire study population. This suggests that the presence of dyslipidemia may be more strongly associated with the absence of positive dietary components, rather than the presence of unhealthy dietary factors. In other words, it is the inclusion of nutrient-dense, heart-healthy foods like whole grains, legumes, and poultry among participants without dyslipidemia that may play a more critical role in protecting against dyslipidemia, rather than merely avoiding unhealthy foods. Damigou et al [14] also discovered that consuming fewer unhealthy foods (as shown by higher GDQS values) was not linked to cardiovascular disease (CVD) or overall metabolic health, indicating that prioritizing the consumption of

nutritious food is more important than avoiding unhealthy options in preventing chronic diseases.

The non-dyslipidemia group reported significantly higher consumption of legumes, poultry and meat, and whole grains. The dietary patterns observed in non-dyslipidemia patients indicated a significant intake of nutrients that may contribute to improved lipid metabolism and lower the odds of dyslipidemia such as fiber, B-vitamins, MUFA and essential trace minerals such as copper, magnesium and zinc among them. Previous studies have shown that the consumption of viscous (soluble) dietary fiber from whole grains and legumes, along with the PUFAs and B vitamins, helps lower LDL cholesterol and triglycerides, which are key contributors to dyslipidemia.[16] Legumes, rich in phytosterols, have been proven to significantly reduce total cholesterol, LDL cholesterol, atherogenic apolipoprotein levels, and free fatty acids.[34] Essential trace minerals like zinc, copper, and magnesium, present in lean poultry and legumes, play a vital role in keeping cholesterol levels healthy.[35-36] These foods also provide vitamin B6 that help regulate homocysteine levels, reducing the risk of increased biosynthesis and secretion of cholesterol and TG.[37] MUFA found in poultry and some legumes help keep TG concentrations low.[38] Previous findings indicate that when lean meats (chicken/poultry, red meat, or fish) are the primary protein food source consumed as part of a healthy dietary pattern, it can result in favorable changes in blood lipids, most notably total and LDL cholesterol.[39-40] All these results underscore the importance of providing a balanced and nutrient-rich diet in cardiac patients to reduce dyslipidemia prevalence and promote cardiovascular health. International standards recommendations emphasize eating more vegetables, fruits, whole grains, and lean meat.[41-42] Determining the association between diet quality and dyslipidemia empowers patients by highlighting the impact of their dietary choices on their health outcomes. This knowledge can motivate patients to make positive changes, leading to better adherence to dietary recommendations and long-term benefits.

The current research possesses both merits and drawbacks. To the best of our understanding, this is the first investigation in Bangladesh that explores the correlation between dietary patterns and dyslipidemia components. It provides evidence regarding how overall diet quality may play an important role in dyslipidemia development. It's a cross-sectional study, so we cannot confirm causation but can make inferences about causal association. We used a food frequency questionnaire (FFQ) to collect information on people's eating habits. This FFQ was semi-quantitative, there was a possibility that there was some measurement error or recall bias. Moreover, despite the fact that the investigators of the study checked the medical records of the participants and the result ascertainment, it is possible that some cases that were not diagnosed or that were incidental were overlooked. The study did not extensively control for the impact of lipid-lowering medications or other treatments for cardiovascular diseases, which could affect lipid profiles independently of diet. In order to improve the generalizability of the findings, additional research should consider larger sample sizes and more diverse study populations to further validate these findings. Finally, the study highlights the need for dietary interventions but does not explore the impact of nutritional education and counseling on improving diet quality and managing dyslipidemia. Addressing these limitations in future study can lead to a more detailed and thorough understanding of the connection between diet quality and dyslipidemia in cardiovascular disease patients in Bangladesh.

Conclusion

Present study highlights the critical role of diet quality in managing dyslipidemia among CVD patients in Bangladesh and also emphasizes the importance of considering gender, BMI, and occupational status in the development of comprehensive health interventions. By advocating for an integrated approach that addresses the multifaceted nature of dyslipidemia through tailored dietary, lifestyle, and policy interventions, it opens the door for more study and

prospective treatments in the area of cardiovascular health in Bangladesh, ultimately contributing to the global efforts in cardiovascular health promotion and disease prevention. It is important for healthcare professionals to consider these risk factors when assessing patients for dyslipidemia and developing appropriate interventions.

Data availability statement

All data is presented in the article. Additional raw data will be available on request.

Author contribution statement

Tasmia Tasnim: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper; final approval of the version.

Chaity Bhatta: Analyzed and interpreted the data; Wrote the paper; final approval of the version.

Kazi Muhammad Rezaul Karim: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper; final approval of the version.

Kazi Muhammad Rezaul Karim (corresponding author) are responsible for the overall content as guarantor

Conflict of Interest

The authors declare that there is no conflict of interest.

Funding

The authors received no financial support for the research, authorship, and publication of this manuscript.

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Annexure 1: GDQS and GDQS Sub-Metric Food Groups and Scoring

Inclusion in Metrics	Scoring Classification	Food Group	Categories of Consumed Amounts (g/day)				Points Assigned			
			Low	Middle	High	Very High	Low	Middle	High	Very High
GDQS and GDQS+	Healthy	Citrus fruits	<24	24–69	>69		0	1	2	
		Deep orange fruits	<25	25–123	>123		0	1	2	
		Other fruits	<27	27–107	>107		0	1	2	
		Dark green leafy vegetables	<13	13–37	>37		0	2	4	
		Cruciferous vegetables	<13	13–36	>36		0	0.25	0.5	
		Deep orange vegetables	<9	9–45	>45		0	0.25	0.5	
		Other vegetables	<23	23–114	>114		0	0.25	0.5	
		Legumes	<9	9–42	>42		0	2	4	
		Deep orange tubers	<12	12–63	>63		0	0.25	0.5	
		Nuts and seeds	<7	7–13	>13		0	2	4	
		Whole grains	<8	8–13	>13		0	1	2	
		Liquid oils	<2	2–7.5	>7.5		0	1	2	
		Fish and shellfish	<14	14–71	>71		0	1	2	
		Poultry and game meat	<16	16–44	>44		0	1	2	
		Low-fat dairy	<33	33–132	>132		0	1	2	
		Eggs	<6	6–32	>32		0	1	2	
GDQS and GDQS–	Unhealthy in excessive amounts	High-fat dairy* (in milk equivalents)	<35	35–142	>142–734	>734	0	1	2	0
		Red meat	<9	9–46	>46		2	1	0	
	Unhealthy	Processed meat	<9	9–30	>30		2	1	0	
		Refined grains and baked goods	<7	7–33	>33		2	1	0	
		Sweets and ice cream	<13	13–37	>37		2	1	0	
		Sugar-sweetened beverages	<57	57–180	>180		2	1	0	
		Juice	<36	36–144	>144		2	1	0	
		White roots and tubers	<27	27–107	>107		2	1	0	
		Purchased deep fried foods	<9	9–45	>45		2	1	0	

Reference: Intake – Center for Dietary Assessment. The Global Diet Quality Score: Data Collection Options and Tabulation Guidelines. Washington, DC: Intake – Center for Dietary Assessment/FHI Solutions;2021.

Supplementary Table 1: Consumption of different food groups of the study subject in dyslipidemia and non-dyslipidemia groups.

Food Groups	Non-Dyslipidemia group	Dyslipidemia group	P* value
Healthy Foods			
Citrus fruits	42 (30.8-50.5)	41.4 (25.5-50.9)	0.461
Deeply orange fruits	27.6 (22.8-35.4)	27.5 (21.7-36.0)	0.885
Other fruits	65.8 (55.5-77.8)	64.2 (53.7-76.7)	0.221
Dark green leafy vegetables	49.5 (36.2-67.7)	53.6 (34.7-69.5)	0.869
Cruciferous vegetables	9.1 (6.7-12.2)	10.2 (7.6-13.8)	0.024
Deep orange vegetables	5.4 (3.1-7.6)	5.4 (3.2-7.4)	0.642
Other vegetables	72 (61-115)	77 (65-116)	0.127
Legumes	38.5 (15.4-48.2)	19.7 (12.7-41.5)	0.003
Deep orange tubers	0	0	
Seeds and nuts	3.1 (2.2-4.5)	3.1 (2.2-5.1)	0.501
Whole grains	8.9 (6.9-11.0)	7.6 (6.5-10.4)	0.016
Liquid oils	15.6 (15.4-17.1)	15.5 (15.4-17.0)	0.067
Fish and shellfish	52.9 (47.1-59.9)	51.4 (44.8-59.4)	0.142
Poultry and meat	14.1 (10.1-20.0)	11.6 (9.4-20.0)	0.004
Low-fat dairy	21.7 (12.2-39.4)	21.0 (12.0-29.9)	0.140
Eggs	16.9 (14.2-26.07)	16.6 (14.2-25.7)	0.436
Unhealthy in excessive amounts			
High-fat dairy	17.8 (12.5-54.0)	17.8 (4.2-53.5)	0.108
Red meat	23.1 (10.3-38.1)	19.9 (10.4-27.6)	0.105
Unhealthy food			
Processed meat	0	0	
Refined grains and backed goods	325 (283-378)	326 (288-370)	0.662
Sweets and ice cream	58.5 (18.3-94.0)	54.8 (18.6-75.1)	0.146
Sugar-sweetened beverage	0	0	
Juice	0	0	
White roots and tubers	17.1 (13.1-30.2)	16.4 (12.2-32.4)	0.680
Purchased deep fried foods	6.6 (5.08-8.0)	6.8 (5.2-8.0)	0.403

Data are presented as Median (25 percentiles -75 percentiles)
*Independent Samples Mann-Whitney U test between Dyslipidemia and non-dyslipidemia groups

BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2024-091025.R2
Article Type:	Original research
Date Submitted by the Author:	22-Nov-2024
Complete List of Authors:	Tasnim, Tasmia; Daffodil International University, Nutrition and Food Engineering Karim, Kazi Muhammad Rezaul; University of Dhaka, Institute of Nutrition and Food Science Bhatta, Chaity; Daffodil International University, Nutrition and Food Engineering
Primary Subject Heading:	Public health
Secondary Subject Heading:	Nursing, Public health, Cardiovascular medicine, Global health
Keywords:	Cardiovascular Disease, Cross-Sectional Studies, NUTRITION & DIETETICS, PUBLIC HEALTH

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Association of diet quality and nutrient intake with odds of dyslipidemia in patients with cardiovascular diseases: a hospital based cross-sectional study in Bangladesh

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Abstract

Objective: The aim of this study is to evaluate diet quality and others associated factors with dyslipidemia in cardiovascular disease (CVD) patients in Bangladesh.

Design: The study employed a cross-sectional design.

Setting: Data from medical records, dietary intake, and socioeconomic factors were collected from January to October 2022 at the National Institute of Cardiovascular Disease, Dhaka, and Noakhali Sadar Hospital.

Participants A total of 570 CVD patients, aged 25-80 years, with a confirmed diagnosis within the past three months, were included in the study.

Main outcome measures The primary outcomes were the Global Diet Quality Score (GDQS) and dyslipidemia. Multivariate logistic regression models were used to explore the associations between dyslipidemia and various sociodemographic, nutritional, and dietary factors in CVD patients.

Results Dyslipidemia was identified in more than two-thirds (70.4%) of participants. The mean GDQS score was 24.38, with 69.8% of the population maintaining a healthy diet. GDQS was significantly higher in the non-dyslipidemic group (25.21 ± 2.53) compared to the dyslipidemic group (24.03 ± 2.33). Nutrient intake was generally higher in non-dyslipidemic patients. The odds of hypercholesterolemia, hypertriglyceridemia, and elevated LDL were notably higher for participants in the lowest GDQS tertile compared to the highest. Multivariable logistic regression identified sex, employment status, BMI, and GDQS as significant predictors of dyslipidemia. Males (AOR = 4.18, 95% CI: 2.32-7.54), homemakers (AOR = 2.86), and obese individuals (AOR = 1.0) were at increased odds of dyslipidemia. Compared to the highest GDQS tertile, the odds of dyslipidemia were nearly double in the middle tertile (AOR: 1.87, 95% CI: 1.13–3.11) and almost four times higher in the lowest tertile (AOR: 3.67, 95% CI: 2.02–6.64).

Conclusions A high-quality diet was associated with significantly lower odds of dyslipidemia, hypercholesterolemia, hypertriglyceridemia, and elevated LDL cholesterol. The study findings highlight the potential of targeted nutritional interventions with a multifaceted approach to managing dyslipidemia, emphasizing the need for personalized dietary guidelines that consider the individual's gender, occupation, and BMI.

Key Words: Cardiovascular disease, Dyslipidemia, Diet quality, Global Diet Quality Score, Nutrients, Bangladesh

STRENGTHS AND LIMITATIONS OF THIS STUDY

- The GDQS, which combines 25 healthy and unhealthy food groups, is a sensitive metric for assessing diet quality.
- The sample size was sufficient to allow for multivariate logistic regression models on nine independent variables, and the model demonstrated a good fit.
- The cross-sectional design of this study prevents the establishment of causation between diet quality and dyslipidemia, restricting the findings to associations only.
- While adjustments were made for potential confounders, the possibility of residual confounding, such as the effects of lipid-lowering medications, cannot be entirely ruled out.

Introduction

Heart disease is increasing worldwide, with South Asian nations experiencing the greatest prevalence and mortality rates among all low and middle-income countries (LMICs).[1] South Asians are 3 to 5 times greater likelihood of acquiring heart disease, presenting symptoms 5 to 10 years earlier than in Western countries.[1] Among these nations, Bangladesh, bears a disproportionate burden, with one of the highest incidences of CVD in the region, often affecting individuals at a younger age.[2] This escalating epidemic poses a significant challenge to public health, as CVD remains a leading cause of morbidity and mortality in Bangladesh.[3] The prevalence of CVD in the country varies widely, with estimates ranging from 0.062% to 77.7%, and pooled data suggest a 5% prevalence rate across the population, regardless of gender or geographical location.[3]

Several risk factors contribute to the increasing rates of CVD in Bangladesh, including hypertension, elevated total cholesterol (TC), low-density lipoprotein (LDL) cholesterol, triglycerides (TG), reduced levels of high-density lipoprotein (HDL) cholesterol, obesity, and poor dietary habits.[4] Dyslipidemia is widely recognized as a significant risk factor for cardiovascular disease (CVD) and associated mortality in countries with developed as well as developing economies.[4-5] An increased prevalence of dyslipidemia has been exceedingly reported in Bangladesh.[3, 5] This indicates that dyslipidemia may have a substantial impact on the emergence of cardiovascular disease (CVD) in Bangladesh.

Dyslipidemia is characterized by abnormal lipids and lipoprotein levels in the blood, occurring either independently or in combination. In adult cardiac patients, dyslipidemia can exacerbate pre-existing heart conditions and lead to further health complications. Atherosclerosis, caused by the accumulation of fatty deposits in the arteries, significantly elevates the risk of angina, myocardial infarction, and stroke in individuals with dyslipidemia.[6] Elevated LDL cholesterol and triglyceride levels are particularly concerning, as they increase the risk of plaque rupture,

thrombosis and life-threatening coronary artery blockages.[7] Cardiac patients with dyslipidemia are more vulnerable to recurrent heart attacks due to the heightened risk of plaque instability and thrombosis, which may further damage the heart muscle and impair cardiac function.[8]

Diet quality is closely linked to lipid metabolism. Due to its direct effect on cholesterol levels and cardiovascular health, diet quality is a critical component in the therapy of dyslipidemia in the prevention and management of CVD.[9] A diet's quality can be defined as the degree to which its individual components contribute to good health. While individual nutrients, foods, and bioactive compounds may have targeted effects, it is the overall dietary pattern that exerts the most significant influence on health outcomes.[10] Diets low quality diets characterized by high sugar and saturated fat or content and insufficient intake of fruits and vegetables or fiber are inversely associated with healthy blood lipid levels and a higher risk of diseases, including CVD.[11]

In Bangladesh, where both CVD and dyslipidemia rates are high [5], examining diet quality offers an opportunity to lower the risk of future cardiac events and improve overall prognosis in cardiac patients. While medications are commonly prescribed to manage dyslipidemia, improving diet quality offers a complementary, sustainable, and accessible approach to treatment, for many patients, especially in resource-limited settings. Dietary interventions can empower healthcare providers to help patients make meaningful lifestyle changes that complement pharmacological treatments.

Assessing diet quality provides a comprehensive view of eating habits and their impact on health outcomes. One of the most comprehensive tools for evaluating diet quality is the Global Diet Quality Score (GDQS), which assesses dietary intake based on food groups and their contribution to nutrient sufficiency and chronic disease risk across different regions. The GDQS offers a more nuanced view than traditional diet metrics, as it considers a wider range of food groups and categorizes foods into healthy and unhealthy categories based on their

effects on health outcomes.[12] The GDQS has been used previously in examining diet quality in relation to dyslipidemia, providing actionable insights for dietary modifications that contribute to better lipid profiles.[13-14]

Despite the importance of diet in managing dyslipidemia and preventing cardiovascular diseases, there is a lack of research in Bangladesh on the potential link between dietary habits and lipid profiles of individuals with existing CVD. Addressing this gap is essential for understanding the dietary factors that contribute to dyslipidemia in this population. Therefore, this study aims to evaluate diet quality and other factors associated with dyslipidemia in cardiac patients in Bangladesh. The central hypothesis is that higher GDQS scores, reflecting better diet quality, will be inversely associated with the odds of dyslipidemia. By exploring the full range of factors, particularly dietary influences on lipid levels in CVD patients, this research seeks to inform more effective, personalized treatment approaches to manage dyslipidemia and improve patient outcomes.

Materials and Methods

Study area and study design

The study was conducted across two key medical facilities in Bangladesh, targeting a diverse patient population. Data were collected from the outpatient tertiary care unit of the National Institute of Cardiovascular Diseases (NICVD) hospital, located in Dhaka and the coronary care unit of Sadar Hospital in Noakhali.

This cross-sectional study was carried out over a 10-month period, from January 2022 to October 2022. The inclusion criteria for this study were CVD patients aged 25 years and older, who had a confirmed diagnosis of CVD within the last three months by a medical doctor and were attending the selected hospitals for follow-up. Common types of CVD included coronary heart disease, cardiomyopathy, congenital heart disease, arrhythmia, rheumatic heart disease,

heart failure, and valvular heart disease.[3] Exclusion criteria included pregnant and breastfeeding women, individuals under 25 years of age, hospitalized patients with cardiovascular disease, chronic renal disease patients having dialysis or kidney transplants, those in advanced stages (eGFR <15%), participants who failed to complete the questionnaire, and individuals lacking recent biochemical data.

The sample size was determined using the formula n = 100 + 50*i* where *i* refers to number of independent variables in the final logistic regression model.[15] Based on an assumption of nine independent variables in the regression model, the minimum required sample size was 550. To account for potential errors during the study process, an additional 5.0% was added, resulting in a total sample size of 570 participants.

Socio-demographic and Biochemical characteristic variables

Participants completed self-reported questionnaires that included questions about their age, sex, education, income, employment status, health, dietary habits, smoking, alcohol consumption, and other socioeconomic and demographic factors. Additionally, blood lipid profile data [total cholesterol (TC), low-density lipoprotein (LDL), high-density lipoprotein (HDL) and triglycerides (TG)] were extracted from participants' recent biochemical report for further analysis. All the lipid profiles were analyzed using enzymatic colorimetric methods, checked according to their report. Lipid profiles were classified according to Adult Treatment Panel III (ATP III) guidelines of the National Cholesterol Education Program (NCEP,2002).[16] Dyslipidemia was defined as having at least one of the following: total cholesterol ≥ 200 mg/dL; total triglycerides ≥ 150 mg/dL; LDL ≥ 130 mg/dL and HDL < 40 mg/dL.[16] Additionally, the lipid profiles were categorized as follows: elevated TG (TG ≥ 150 mg/Dl); elevated TC (TC ≥ 200 mg/dL); elevated LDL (LDL ≥ 130 mg/dL) and low HDL (HDL < 40 mg/dL).[16] Hypertension was defined as systolic blood pressure (SBP) ≥ 140 mm Hg, diastolic blood pressure (DBP) ≥ 90 mm Hg and/or the use of antihypertensive drugs. Diabetes was

defined as fasting blood plasma glucose level ≥ 7.0 mmol/L. Chronic kidney disease (CKD) was defined as a reduced glomerular filtration rate (GFR) of <60%.

Anthropometric measurements, including height and weight, were taken following standard procedures. Body mass Index (BMI: kg/m2) was calculated by dividing participants' weight (in kilograms) by the square of their height (in meters). BMI was categorized into four groups based on World Health Organization (WHO) guidelines: underweight (<18.5 kg/m^2), normal weight (18.5 - 24.99 kg/m2), overweight (25.0 - 29.99 kg/m^2) and obese (≥30.0 kg/m^2). Smoking status was classified as either nonsmoker or current smoker.

Nutrient and diet quality measurement

A previously validated semi-quantitative food frequency questionnaire was administered to collect data from participants on their usual dietary intake over the past month. The questionnaire included 166 food items that are typical of both urban and rural Bangladeshis, as well as unique regional foods.[17] To aid accurate portion estimation, participants were shown images of various portions sizes for the same food item. These images featured basic household portions, such as an empty bowl, plate, spoon, or glass, and the participants were asked to indicate their usual portion size by selecting the appropriate level of fullness.

Nutrient and energy estimates were derived from dietary data of 122 out of 166 food items based on the Food Composition Table (FCT) of Bangladesh.[18] For food items not listed in the Bangladeshi FCT, composition data were supplemented from the Indian food composition table,[19] and additional calculations were performed according to standard recipe composition.

The Global Diet Quality Score (GDQS) was used to evaluate nutrient adequacy and examine the association between chronic diseases in a global context.[20] The GDQS coding method categorizes foods into 25 groups: 16 healthy food groups (dark green/leafy/ cruciferous /deep orange/other vegetables, deep orange fruits and tubers, citrus and other fruits, legumes, nuts

and seeds, poultry and game meat, fish, whole grains, liquid oils, low-fat dairy, and eggs), two unhealthy food groups when consumed in large quantities (high fat dairy and red meat), and seven unhealthy food groups (white roots and tubers, processed meats, refined grains and baked goods, sugar-sweetened beverages, sweets, and ice cream). Healthy food categories received positive ratings, with higher scores reflecting greater consumption. Consuming less harmful food groups generally results in higher ratings, except for high fat dairy and red meat, which scored better with moderate consumption and worse with very low or very high intakes. GDQS are calculated according to standardized guidelines.[12, 20] The GDQS is the total of the scores for all 25 food categories, which vary from 0 to 49 points (Annexure 1). Diet quality was classified as follows: high risk for poor diet quality (GDQS <15), moderate risk (GDQS:15-22.99) and low risk (GDQS ≥ 23).[20]

Ethical consideration

This research was carried out with the authorization of the FAHS Research Ethics Committee at DIU (Ref. No.: FAHSREC/DIU/2023/1109). Each participant provided informed consent and received knowledge of their freedom to remove themselves from study at any time without facing any consequences.

Statistical method

Data was analyzed statistically using SPSS 21.0. While continuous variables were shown as mean ± SD, categorical variables were given as frequency and percentage. When data were not normally distributed, Medium (25 percentiles -75 percentiles) were used, and Mann-Whitney test was employed to assess differences between groups. A chi-square test was done to assess the association for categorical variables. GDQS were categorized into tertiles, where T1 indicated the lowest, and T3 showed the highest score. Linear trend across tertile of GDQS

were estimated among elevated TC, elevated TG, elevated LDL, low HDL and dyslipidemia and checked by the Cochran–Armitage test in STATA 13. Multivariate logistic regression analysis was used to identify independent predictors of dyslipidemia, calculating adjusted odds ratio (AOR) and 95% confidence intervals. Variance inflation factors (VIF) were used to assess multicollinearity prior to performing multivariate logistic regression. VIF values below 2.2 indicated the lack of collinearity issues.[21] The final logistic regression model included all variables with *p*-values less than 0.25 in the bivariate analysis. The criterion for statistical significance was established as a p-value less than 0.05.

Patient and public involvement

Patients and the public were not involved in the design, conduct, reporting, or dissemination plans of this research.

Results

Socio-demographic, Anthropometric and clinical characteristics of the study participants

A total of 54.9% study participants were male. Most of the cardiovascular disease (CVD) patients were from rural areas and in middle age groups. Over half of the study population (56.8%) had completed education only up to the primary school level, and 54.4% of the subjects reported a monthly income below 20,000 TK (Table 1). Regarding occupation, only one-fourth of the participants were engaged in steady employment, while the remainder were either retired or home-makers. In terms of body mass index (BMI) distribution, 45.0% of subjects were classified as overweight, 44.6% fell into normal or underweight, and 10.4 % were obese. Additionally, comorbid conditions such as, diabetes, hypertension, and chronic kidney disease were observed in 40.0 %, 74.0 %, and 30.0 %, of the participants, respectively (Table 1). The majority of the study population (70.4 %) exhibited dyslipidemia (Table 1). Among lipid

abnormalities, hypercholesterolemia (TC ≥ 200mg/dl) was the most prevalent, affecting 55.5% of participants, followed by hypertriglyceridemia (TG ≥ 150 mg/dL, 52.2%), low HDL <40 mg/dL (40.9 %) and high LDL ≥ 130 mg/dL (40.4%) (Table 1).

Table 1: General Characteristics of the study subject

		Frequency (%)
Age in Year	20-45	117 (20.50)
	46-60	243 (42.60)
	>60	210 (36.80)
Gender	Male	313 (54.90)
	Female	257 (45.10)
Marital status	Married	551 (96.70)
	Others	19 (3.30)
Education	Up to primary	324 (56.80)
	Secondary or higher	246 (43.20)
Income	<20000	310 (54.40)
	≥20000 BDT	260 (45.60)
Employment	Service or retired	199 (34.90)
	Homemakers	218 (38.20)
	Worker and others	153 (25.80)
Family size	<4 members	177 (31.10)
	≥4 members	393 (68.90)
Area	Urban	179 (31.40)
	Rural	391 (68.60)
BMI (WHO)	<25.0	254 (44.60)
	25-29.99	256 (45.00)
	≥30.0	59 (10.40)
Present of NCD	Diabetes	228 (40.00)
	Hypertension	421 (74.00)
	Osteoarthritis	401 (70.40)
	Asthma	255 (44.70)
	Chronic Kidney Disease	171 (30.00)
Total cholesterol (TC) (mg/dL)	Normal (<200 mg/dL)	282 (49.50)
	Elevated (≥ 200/mg dL)	288 (55.50)
HDL (mg/dL)	Normal/ Borderline risk (≥40)	337 (59.10)
	High risk (<40)	233 (40.90)
LDL (mg/dL)	Normal/ Borderline low (<130)	340 (59.60)
	Elevated LDL (≥130)	230 (40.40)
TG (mg/dL)	Normal (<150)	272 (47.80)
	Elevated TG (≥ 150)	298 (52.20)
Dyslipidemia (at least one of the following: TC ≥ 200 mg/dL or TG ≥	Yes	401 (70.40)
	No	169 (29.60)

150 mg/dL or LDL ≥ 130 mg/dL or HDL < 40 mg/dL)		

BMI: Body mass index, NCD: Non communicable diseases, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, TG: Triglycerides, mg: milligram, dL: deciliter

The dyslipidemia pattern in connection with other variables

Table 2 presents the distribution of CVD patients according to dyslipidemia, and its association with various sociodemographic and clinical variables. BMI, gender, income, education status, locality of the participants and hypertension were found statistically significant in different groups (dyslipidemia vs non-dyslipidemia) (Table 2).

Table 2: Associated factors for Dyslipidemia of the cardiovascular disease patients

Factor		Non-Dyslipidemia	Dyslipidemia	p value
BMI	<25.0	63 (24.80)	191 (75.20)	0.001
	25.0 – 29.99	95 (37.10)	161 (62.90)	
	≥30.0	11 (18.60)	48 (81.40)	
Age (Years)	20-45	41 (35.00)	76 (65.00)	0.338
	46-60	67 (27.60)	176 (72.40)	
	>60	61 (29.00)	149 (71.00)	
Gender	Male	78 (24.90)	235 (75.10)	0.007
	Female	91 (35.40)	166 (64.60)	
Education	Primary	84 (25.90)	240 (74.10)	0.027
	Secondary	85 (34.60)	161 (65.40)	
Income	<20,000	76 (24.50)	234 (75.50)	0.004
	≥20,000	93 (35.80)	167 (64.20)	
Employment	Service/retired	70 (35.20)	129 (64.80)	0.086
	Homemakers	61 (28.00)	157 (72.00)	
	Labors/others	38 (24.80)	115 (75.20)	
Diabetes	Yes	59 (25.90)	169 (74.10)	0.112
	No	110 (32.20)	232 (67.80)	
Hypertension	Yes	137 (32.50)	284 (67.50)	0.012
	No	32 (21.60)	116 (78.40)	
CKD	Yes	48 (28.10)	123 (71.90)	0.618
	No	121 (30.30)	278 (69.70)	
Smoking	Yes	19 (36.50)	33 (63.50)	0.267
	No	150 (29.00)	368 (71.00)	
Area	Urban	64 (35.80)	115 (64.20)	0.038
	Rural	105 (26.90)	286 (73.10)	

BMI: Body mass index, CKD: Chronic kidney diseases,

Diet and nutrient intake of the participants

The nutrient intake patterns of the participants are summarized in Table 3. The median intake of energy, protein and fat of the CVD patients was recorded at 1818 Kcal, 62.8 gram and 34.2 gram, respectively. The non-dyslipidemia group demonstrated significantly higher caloric intake and greater consumption of most nutrients, including both macronutrients and micronutrients, in comparison to the dyslipidemia group. (Table 3).

Table 3: Dietary Nutrient Intake pattern in different groups

Nutrients	All patients	Non-Dyslipidemia group	Dyslipidemia group	P* value
Energy (Kcal)	1818 (1609-1977)	1863 (1617-2055)	1793 (1591-1962)	0.013
Protein (g)	62.8 (56.3-74.3)	66.10 (57.80-79.80)	61.90 (55.50-72.40)	<0.001
Carbohydrates (g)	327 (287-356)	335 (289-364)	324 (287-353)	0.078
Fat & oil (g)	34.20 (31.50-45.80)	34.90 (31.80-47.30)	33.80 (31.50-45.30)	0.008
Dietary Fiber (g)	24.60 (21.40-28.20)	25.70 (22.70-28.50)	24.20 (21.00-27.90)	0.007
Vitamin C (mg)	136 (122-152)	137 (124-153)	136 (121-151)	0.164
Calcium (mg)	590 (523-673)	611 (536-688)	585 (510-660)	0.021
Iron (mg)	14.40 (13.10-15.50)	14.70 (13.40-15.90)	14.20 (12.90-15.50)	0.005
Zinc (mg)	9.10 (8.20-10.30)	9.50 (8.50-10.90)	8.90 (8.10-10.20)	<0.001
Copper (mg)	1.90 (1.60-2.10)	1.97 (1.70-2.10)	1.90 (1.60-2.10)	0.003
Magnesium (mg)	372 (338-404)	379 (345-414)	370 (332-400)	0.009
Sodium (mg)	777 (616-884)	770 (609-885)	786 (620-884)	0.970
Potassium (mg)	1912 (1742-2124)	1947 (1784-2226)	1889 (1713-2098)	0.002
Vitamin B2 (mg)	0.90 (0.80-1.10)	0.94 (0.86-1.01)	0.94 (0.83-1.05)	0.137
Folate (µg)	199 (179-222)	201 (187-222)	197 (175-221)	0.106
Vitamin B6 (mg)	1.10 (0.90-1.20)	1.10 (0.99-1.20)	1.06 (0.90-1.20)	0.004
Vitamin A (µg)	539 (442-620)	546 (470-622)	536 (435-612)	0.143
Vitamin D (µg)	0.73 (0.55-0.91)	0.76 (0.57-0.93)	0.70 (0.53-0.91)	0.138
Beta Carotene (µg)	3943 (3054-5026)	3896 (2984-5177)	3960 (3054-5011)	0.612
Vitamin E (mg)	5.10 (4.80-5.60)	5.30 (4.90-5.60)	5.07 (4.70-5.40)	<0.001
SAFA (g)	9.10 (8.10-12.10)	9.96 (8.10-13.80)	8.85 (8.10-12.40)	0.010
MUFA (g)	8.80 (8.10-12.10)	9.07 (8.30-12.40)	8.70 (8.10-11.50)	0.007
PUFA (g)	13.40 (13.00-16.40)	13.70 (13.10-16.60)	13.40 (13.00-15.80)	0.002
Cholesterol (mg)	154 (133-198)	163 (136-209)	152 (133-191)	0.019
Retinol (µg)	146 (75-302)	181 (83-305)	137 (71-294)	0.020
Niacin (mg)	22.30 (19.70-44.60)	29.70 (20.10-46.70)	21.40 (19.20-42.40)	0.001
Phosphate (mg)	966 (876-1102)	1007 (892-1171)	959 (855-1086)	0.002
Vitamin B1 (mg)	0.94 (0.84-1.03)	0.96 (0.87-1.04)	0.93 (0.84-1.03)	0.020
Data are presented as Median (25 percentiles -75 percentiles) *Independent Samples Mann-Whitney U test between Dyslipidemia and non-dyslipidemia groups.				

SAFA: Saturated fatty acids, MUFA: Monounsaturated fatty acids, PUFA: Poly unsaturated fatty acids, g: gram, mg: milligram, µg: microgram.

Diet quality and associated factor for dyslipidemia

The consumption levels of twenty-five GDQS food groups, categorized into three distinct groups, are presented in Table 4. This table provides a detailed overview of the median consumption across various food categories, alongside intake levels—low, medium, and high for these food groups among individuals diagnosed with cardiovascular disease.

Over 70% of patients with cardiovascular disease reported a limited consumption of foods from the healthy food groups, including deep orange tubers, seeds and nuts, deep orange vegetables, low-fat dairy, and cruciferous vegetables. Conversely, over 65% of the population exhibited high consumption of liquid oil and dark green leafy vegetables (Table 4). Additionally, more than 70% of people reported consuming less portions of several unhealthy foods, including processed meat, purchased deep fried, sugar-sweetened beverages, juice, and white roots and tubers. The GDQS score improves significantly when a high percentage of CVD patients consume fewer of various unhealthy food groups. The non-dyslipidemia group demonstrates a significantly higher consumption of legumes, poultry and meat, as well as whole grains, in comparison to the dyslipidemia group (Supplementary Table 1).

The mean GDQS for CVD patients was 24.38 (on a scale of 0 to 49), 69.8% of the population had a low-risk diet, while 30.20% and 0% had moderate and high-risk diet, respectively, according to GDQS cutoff points (Table 4). The GDQS was significantly higher in the non-dyslipidemia group (25.21 ± 2.53) compared to the dyslipidemia group (24.03 ± 2.33) (Table 4). Within the non-dyslipidemia group, GDQS+ (scores ranging from 0 to 32) and GDQS- (scores ranging from 0 to 17 score) were also higher compared to dyslipidemia group, although only GDQS+ was statistically significant.

GDQS was categorized into tertiles, with T1 representing the lowest scores (30.20 %), and T3 the highest (34.9%) (Table 5). A significant trend was observed among elevated TC, elevated TG, elevated LDL and dyslipidemia with GDQS (p-trend < 0.001) (Table 5). Hypercholesterolemia, hypertriglyceridemia, high LDL and dyslipidemia were significantly associated with diet quality. Specifically, the odds of these conditions were significantly higher within lowest tertile of GDQS compared to those on the highest tertile (Table 5).

Table 4: Consumption of different food groups of the study subject and diet quality

Food Groups	All patients	Consumption level (%)		
Healthy Foods	Median intake (gm)	Low	Middle	High
Citrus fruits	41 (26-51)	19.60	73.90	1.10
Deeply orange fruits	27 (22-36)	36.70	63.30	0
Other fruits	64 (54-77)	2.60	97.00	0.40
Dark green leafy vegetables	51 (35.50 - 67.70)	0	33.20	66.80
Cruciferous vegetables	9.90 (7.60 - 13.80)	73.00	25.60	1.40
Deep orange vegetables	5.40 (3.10 - 7.60)	84.20	15.80	0
Other vegetables	77 (64-116)	0.40	73.50	26.10
Legumes	28.30 (13.30 - 41.90)	10.20	65.10	24.70
Deep orange tubers	0	100	0	0
Seeds and nuts	3.20 (2.20 - 4.90)	95.60	4.40	0
Whole grains	7.60 (6.70 - 10.80)	56.30	43.70	0
Liquid oils	15.50 (15.40 - 17.10)	0	0	100
Fish and shellfish	51.30 (45.00 - 59.70)	0	95.80	4.20
Poultry and meat	11.80 (9.40 - 20.10)	62.40	32.30	5.40
Low-fat dairy	21.00 (12.00 - 30.30)	75.30	24.70	0
Eggs	16.60 (14.20 - 25.70)	4.90	91.90	3.20
Unhealthy in excessive amounts				
High-fat dairy	17.80 (4.20 - 53.50)	65.80	34.20	0
Red meat	20.10 (10.30 - 32.70)	22.60	71.40	6.00
Unhealthy food				
Processed meat	0	100	0	0
Refined grains and backed goods	326 (285-373)	0	0	100
Sweets and ice cream	54.80 (18.70 - 77.80)	7.20	30.20	62.80
Sugar-sweetened beverage	0	89.50	10.50	0
Juice	0	79.10	20.90	0
White roots and tubers	16.40 (13.00 - 31.20)	69.50	30.50	0
Purchased deep fried foods	6.60 (5.20 - 8.00)	79.00	20.40	0
GDQS Score	**All patients**	**Non-Dyslipidemia group**	**Dyslipidemia group**	**P* value**

Total GDQS	24.38 ± 2.45	25.21 ± 2.53	24.03 ± 2.33	<0.001
GDQS+	13.70 ± 2.11	14.41 ± 2.11	13.40 ± 2.05	<0.001
GDQS-	10.67 ± 0.97	10.79 ± 1.03	10.63 ± 0.95	0.067
GDQS				
Low risk (≥23)	398 (69.80)			
Moderate risk (15-22.9)	172 (30.20)			
High risk diet (<15.0)	0			
Data are presented as Median (25 percentiles -75 percentiles) *Independent Samples Mann-Whitney U test between Dyslipidemia and non-dyslipidemia groups GDQS: Global diet quality score				

Table 5: Univariate analysis for measuring association with GDQS and dyslipidemia

Variables	DGQS Tertiles			
	T3(highest, reference)	T2 (middle)	T1 (lowest)	p-trend
Elevated TC, OR (95%CI)	1.0	1.95 (1.29-2.93)	2.01 (1.32- 3.08)	0.001
Elevated TG, OR (95%CI)	1.0	1.99 (1.33- 2.97)	3.33 (2.17-5.11)	<0.001
Elevated LDL, OR (95%CI)	1.0	2.07 (1.36 -3.13)	2.44 (1.59 -3.75)	<0.001
Low HDL, OR (95% CI)	1.0	0.61 (0.40- 0.93)	0.81 (0.52 – 1.24)	0.280
Dyslipidemia, OR (95% CI)	1.0	1.67(1.10- 2.53)	3.25 (2.01-5.28)	<0.001

HDL: High-density lipoprotein, LDL: Low-density lipoprotein, TG: Triglycerides, TC: Total cholesterol, GDQS: Global diet quality score, T: Tertiles of GDQS score, CI: confidence interval, OR: Odds ratio.

The analytical results of the multivariable logistic regression are shown in Table 6 Several factors, including sex, level of employment, BMI, hypertension and GDQS were identified as potential contributory factors for the lipid profile abnormalities (P-value <0.05) in multivariable logistic regression analysis (Table 6). Male participants were more than four time as likely as female participants to have dyslipidemia (AOR: 4.18, 95% CI: 2.32-7.54). Regarding employment, participants who were retired or employed in services (AOR: 1.5, 95% CI: 0.75 – 2.99, p-value 0.253), and homemakers (AOR: 2.86, 95% CI: 1.37 – 5.94, p-<0.005), had higher odds of developing dyslipidemia, compared to laborers. Participants with a BMI ≥30.0 (obese) were found to have higher odds of dyslipidemia than overweight individuals (AOR: 0.43, 95% CI: 0.21 – 0.91, p-value 0.026). Finally, compared to the highest tertile of the GDQS in CVD patients, the odds of dyslipidemia were nearly twice as high in the middle tertile (AOR: 1.87, 95% CI:1.13 – 3.11, p-value 0.015) and almost four times higher in the lowest tertile (AOR: 3.67, 95% CI: 2.02 – 6.64, p-value <0.001) (Table 6).

Table 6: Model of Multivariate logistic regression for the predation of dyslipidemia

	β	AOR	95% CI of AORs	Sig
Gender: Female (r)		1.00		
Male	1.43	4.18	2.32-7.54	<0.001
Income: 20000 TK(BD) and more (r)		1.00		
Income <20000 TK (DB)	0.09	1.09	0.63 – 1.89	0.750
Education Secondary to Higher (r)		1.00		
Education up to Primary	0.09	1.10	0.68 – 1.80	0.690
Employment: Laborers & other (r)		1.00		0.015
Retired & service job	0.40	1.49	0.75 – 2.99	0.253
Housewife	1.05	2.85	1.37 – 5.94	0.005
Area: Rural (r)		1.00		
Urban	-0.18	0.83	0.54 – 1.28	0.405
Diabetics: Absent (r)		1.00		
Diabetics: Present	0.13	1.14	0.68 – 1.92	0.621
Hypertension: absent (r)		1.00		
Hypertension: Present	-0.53	0.59	0.36 – 0.95	0.032
BMI: ≥ 30.0 (Obese) (r)		1.00		0.006
BMI: <25.0 (normal and underweight)	-0.28	0.76	0.35 – 1.62	0.475
BMI: 25.0 – 29.99 (overweight)	-0.84	0.43	0.20 – 0.90	0.026
GDQS in tertiles				
T3 (highest tertile, GDQS: >24.75) (r)		1.00		<0.001
T2 (middle tertile, GDQS: 22.76 – 24.75)	0.63	1.87	1.13 – 3.11	0.015
T1 (lowest tertile, GDQS: ≤ 22.75)	1.30	3.67	2.02 – 6.64	<0.001

AOR: Adjusted odds ratio, CI: GDQS: Global diet quality score, T: Tertiles of GDQS score, CI: confidence interval, r: Reference, BMI: Body mass index, TK: Take, BD: Bangladesh

Discussion

This study aimed to assess the factors influencing dyslipidemia in individuals with cardiac conditions, focusing on diet quality, consumption of healthy and unhealthy foods, as measured by the Global Diet Quality Score (GDQS), and their relationship to dyslipidemia among cardiovascular disease (CVD) patients in Bangladesh. The findings highlight significant associations between dyslipidemia and various risk factors, including body mass index (BMI), gender, occupation, and diet quality. These results provide crucial insights into the characteristics and dietary intake patterns of cardiac patients with and without dyslipidemia, offering valuable information for the development of targeted interventions and personalized dietary recommendations.

One key finding of this study is the strong association between higher BMI and the prevalence of dyslipidemia. The data suggest that maintaining a healthy weight is essential for cardiac patients to manage and prevent dyslipidemia. Previous research consistently links obesity with dyslipidemia due to poor dietary choices and increased consumption of unhealthy fats and sugars, which contribute to lipid imbalances.[22-23] Additionally, excess body weight can also contribute to free fatty acids, insulin resistance and inflammation, all of which are known to play a role in dyslipidemia development.[24]

Gender differences in dyslipidemia prevalence were also significant, with males being four times more likely to have dyslipidemia than females. This finding aligns with earlier studies conducted in Bangladesh and globally.[5, 25] The lower prevalence of dyslipidemia among females may be attributed to the protective effects of estrogen on lipid metabolism, as estrogen positively influences lipid profiles.[26]

Interestingly, occupation emerged as a significant factor, with homemakers being three times more likely to experience dyslipidemia than other occupational groups. A survey in Karachi revealed that a significant percentage of homemakers were obese, largely due to unhealthy dietary practices, including frequent consumption of red meat, sweets, and junk foods, coupled with a lack of physical activity.[27] Thus it suggests that homemakers may have greater access to unhealthy food options which could contribute to poorer dietary habits and a higher incidence of dyslipidemia. Social and cultural dynamics in Bangladesh may exacerbate this issue, as homemakers often prioritize the needs of their families over their own health, potentially increasing their vulnerability to dyslipidemia and other non-communicable diseases.[28-29]

The results from this study highlight significant differences in dietary patterns between CVD patients with and without dyslipidemia, as measured by the GDQS. Participants without dyslipidemia had a healthier dietary pattern, as shown by their significantly higher GDQS and

GDQS+ scores. This indicates that a diet rich in nutrient-dense, heart-healthy foods is associated with better lipid profiles. Conversely, individuals in the lowest GDQS tertile had the highest likelihood of having elevated levels of LDL, triglycerides, and total cholesterol. These findings align with previous studies, which have demonstrated an inverse association between diet quality scores and metabolic abnormalities including dyslipidemia.[13,30] For example, a previous study in Mexico discovered that higher GDQS scores were associated with lower total and LDL cholesterol levels.[31] Similarly, research in Iran[32] and Sweden[33] has shown that adherence to healthy eating guidelines, as indicated by various diet quality indices, correlates with improved lipid profiles. The mean GDQS of 24.38 observed in this study suggests a moderately healthy diet among the population, with the majority (69.8%) classified as having a low-risk diet. Notably, no participants fell into the high-risk group based on the GDQS cutoff points, indicating a positive trend in diet quality among CVD patients. In our analysis, consuming fewer unhealthy foods in the GDQS subcategory (GDQS−) did not affect the likelihood of dyslipidemia because patients in both groups had similar low intakes of unhealthy items. This is also why the average GDQS was higher for the entire study population. This suggests that the presence of dyslipidemia may be more strongly associated with the absence of positive dietary components, rather than the presence of unhealthy dietary factors. In other words, it is the inclusion of nutrient-dense, heart-healthy foods like whole grains, legumes, and poultry among participants without dyslipidemia that may play a more critical role in protecting against dyslipidemia, rather than merely avoiding unhealthy foods. This finding aligns with previous research indicating that diets emphasizing nutrient-dense foods are more effective at promoting cardiovascular health than those solely focused on reducing unhealthy food intake.[14] Participants without dyslipidemia reported significantly higher consumption of legumes, poultry and meat, and whole grains. These foods are rich in nutrients that contribute to improved lipid metabolism, such as fiber, B-vitamins, MUFA and essential trace minerals such

as copper, magnesium and zinc. Previous studies have shown that the consumption of viscous (soluble) dietary fiber from whole grains and legumes, along with the PUFAs and B vitamins, helps lower LDL cholesterol and triglycerides, which are key contributors to dyslipidemia.[16] Legumes, in particular, are rich in phytosterols, which have been proven to reduce total cholesterol, LDL cholesterol and atherogenic apolipoprotein levels.[34] Essential trace minerals like zinc, copper, and magnesium, present in lean poultry and legumes, in maintaining healthy cholesterol levels.[35-36] These foods also provide vitamin B6 that help regulate homocysteine levels, reducing the risk of increased biosynthesis and secretion of cholesterol and TG.[37] MUFA found in poultry and some legumes help keep TG concentrations low.[38] Lean meats (chicken/poultry, red meat, or fish when consumed as part of a balanced diet, it can result in favorable changes in blood lipids, particularly reductions in total and LDL cholesterol.[39-40] All these findings underscore the importance of a balanced and nutrient-rich diet in cardiac patients for reducing dyslipidemia prevalence and promoting cardiovascular health. International dietary guidelines recommend increasing the consumption of vegetables, fruits, whole grains, and lean meat.[41-42] Raising awareness about the impact of dietary choices on lipid profiles can empower patients to adopt healthier eating habits, ultimately improving adherence to dietary recommendations and yielding long-term benefits.

The current research possesses both merits and drawbacks. To the best of our understanding, this is the first investigation in Bangladesh that explores the relationship between dietary patterns and dyslipidemia components, offering valuable evidence on the role of diet quality in dyslipidemia development. However, as a cross-sectional study, it cannot establish causation but only infer association. Dietary data were collected using a semi-quantitative food frequency questionnaire (FFQ) which may be prone to measurement error and recall bias. Additionally, despite verifying participants' medical records, some undiagnosed or incidental cases of dyslipidemia may have been overlooked. The study also did not extensively control for the

impact of lipid-lowering medications or other treatments for cardiovascular diseases, which could affect lipid profiles independently of diet.

Future research should include larger, more diverse populations to enhance the generalizability of these findings. Investigating the impact of nutritional education and counseling on improving diet quality and managing dyslipidemia could also provide more actionable insights. Addressing these limitations in future studies can lead to a more detailed and thorough understanding of the connection between diet quality and dyslipidemia in cardiovascular disease patients in Bangladesh.

Conclusion

This study highlights the critical role of diet quality in managing dyslipidemia among CVD patients in Bangladesh, while also emphasizing the importance of considering gender, BMI, and occupational status in the development of comprehensive health interventions. By advocating for an integrated approach that addresses the multifaceted nature of dyslipidemia through tailored dietary, lifestyle, and policy interventions, it opens the door for more study and prospective treatments in the field of cardiovascular health in Bangladesh, ultimately contributing to the global efforts in cardiovascular disease prevention and health promotion. It is important for healthcare professionals to consider these risk factors when assessing patients for dyslipidemia and developing appropriate interventions.

Data availability statement

All data is presented in the article. Additional raw data will be available on request.

Author contribution statement

Tasmia Tasnim: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper; final approval of the version.

Chaity Bhatta: Analyzed and interpreted the data; Wrote the paper; final approval of the version.

Kazi Muhammad Rezaul Karim: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper; final approval of the version.

Kazi Muhammad Rezaul Karim (corresponding author) are responsible for the overall content as guarantor

Conflict of Interest

The authors declare that there is no conflict of interest.

Funding

The authors received no financial support for the research, authorship, and publication of this manuscript.

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Supplementary Table 1: Consumption of different food groups of the study subject in dyslipidemia and non-dyslipidemia groups.

Food Groups	Non-Dyslipidemia group	Dyslipidemia group	P* value
Healthy Foods			
Citrus fruits	42 (30.8-50.5)	41.4 (25.5-50.9)	0.461
Deeply orange fruits	27.6 (22.8-35.4)	27.5 (21.7-36.0)	0.885
Other fruits	65.8 (55.5-77.8)	64.2 (53.7-76.7)	0.221
Dark green leafy vegetables	49.5 (36.2-67.7)	53.6 (34.7-69.5)	0.869
Cruciferous vegetables	9.1 (6.7-12.2)	10.2 (7.6-13.8)	0.024
Deep orange vegetables	5.4 (3.1-7.6)	5.4 (3.2-7.4)	0.642
Other vegetables	72 (61-115)	77 (65-116)	0.127
Legumes	38.5 (15.4-48.2)	19.7 (12.7-41.5)	0.003
Deep orange tubers	0	0	
Seeds and nuts	3.1 (2.2-4.5)	3.1 (2.2-5.1)	0.501
Whole grains	8.9 (6.9-11.0)	7.6 (6.5-10.4)	0.016
Liquid oils	15.6 (15.4-17.1)	15.5 (15.4-17.0)	0.067
Fish and shellfish	52.9 (47.1-59.9)	51.4 (44.8-59.4)	0.142
Poultry and meat	14.1 (10.1-20.0)	11.6 (9.4-20.0)	0.004
Low-fat dairy	21.7 (12.2-39.4)	21.0 (12.0-29.9)	0.140
Eggs	16.9 (14.2-26.07)	16.6 (14.2-25.7)	0.436
Unhealthy in excessive amounts			
High-fat dairy	17.8 (12.5-54.0)	17.8 (4.2-53.5)	0.108
Red meat	23.1 (10.3-38.1)	19.9 (10.4-27.6)	0.105
Unhealthy food			
Processed meat	0	0	
Refined grains and backed goods	325 (283-378)	326 (288-370)	0.662
Sweets and ice cream	58.5 (18.3-94.0)	54.8 (18.6-75.1)	0.146
Sugar-sweetened beverage	0	0	
Juice	0	0	
White roots and tubers	17.1 (13.1-30.2)	16.4 (12.2-32.4)	0.680
Purchased deep fried foods	6.6 (5.08-8.0)	6.8 (5.2-8.0)	0.403

Data are presented as Median (25 percentiles -75 percentiles)

*Independent Samples Mann-Whitney U test between Dyslipidemia and non-dyslipidemia groups

Annexure 1: GDQS and GDQS Sub-Metric Food Groups and Scoring

Inclusion in Metrics	Scoring Classification	Food Group	Categories of Consumed Amounts (g/day)				Points Assigned			
			Low	Middle	High	Very High	Low	Middle	High	Very High
GDQS and GDQS+	Healthy	Citrus fruits	<24	24–69	>69		0	1	2	
		Deep orange fruits	<25	25–123	>123		0	1	2	
		Other fruits	<27	27–107	>107		0	1	2	
		Dark green leafy vegetables	<13	13–37	>37		0	2	4	
		Cruciferous vegetables	<13	13–36	>36		0	0.25	0.5	
		Deep orange vegetables	<9	9–45	>45		0	0.25	0.5	
		Other vegetables	<23	23–114	>114		0	0.25	0.5	
		Legumes	<9	9–42	>42		0	2	4	
		Deep orange tubers	<12	12–63	>63		0	0.25	0.5	
		Nuts and seeds	<7	7–13	>13		0	2	4	
		Whole grains	<8	8–13	>13		0	1	2	
		Liquid oils	<2	2–7.5	>7.5		0	1	2	
		Fish and shellfish	<14	14–71	>71		0	1	2	
		Poultry and game meat	<16	16–44	>44		0	1	2	
		Low-fat dairy	<33	33–132	>132		0	1	2	
		Eggs	<6	6–32	>32		0	1	2	
GDQS and GDQS–	Unhealthy in excessive amounts	High-fat dairy* (in milk equivalents)	<35	35–142	>142–734	>734	0	1	2	0
		Red meat	<9	9–46	>46		2	1	0	
	Unhealthy	Processed meat	<9	9–30	>30		2	1	0	
		Refined grains and baked goods	<7	7–33	>33		2	1	0	
		Sweets and ice cream	<13	13–37	>37		2	1	0	
		Sugar-sweetened beverages	<57	57–180	>180		2	1	0	
		Juice	<36	36–144	>144		2	1	0	
		White roots and tubers	<27	27–107	>107		2	1	0	
		Purchased deep fried foods	<9	9–45	>45		2	1	0	

Reference: Intake – Center for Dietary Assessment. The Global Diet Quality Score: Data Collection Options and Tabulation Guidelines. Washington, DC: Intake – Center for Dietary Assessment/FHI Solutions;2021.