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Food consumption and dyslipidemia in middle-aged adults in Indonesia: A cross-sectional national study

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Abstract

Background: Most people with abnormal lipid profiles are found in middle-aged adults in Indonesia. Unhealthy food consumption was positively associated with dyslipidemia. In contrast, healthy food consumption, including fruits and vegetables, was inversely associated with dyslipidemia. **Aim:** The aim of the study was to explore the association between food consumption with dyslipidemia among middle-aged adults in Indonesia. **Methods:** This is a cross-sectional study using secondary data from the national representative survey of Indonesian Basic Health Research (IBHR) conducted by the National Institute of Health Research Development (NIHRD), Ministry of Health, Indonesia, in 2018. The study recruited 10,608 participants aged from 45 to 59 years old. An unadjusted or adjusted odds ratio (OR) and 95% confidence intervals (CIs), and a multivariate logistic regression model were performed to evaluate the associations of food consumption with dyslipidemia. **Results:** Frequent consumption of barbecue and soft drink was significantly correlated with dyslipidemia (OR = 1.149, CI: 1.055–1.251 and OR = 1.202, CI: 1.041–1.388). Frequent consumption of soft drink, and inadequate intakes of fruits and vegetables were significantly correlated with dyslipidemia (OR = 1.254, CI: 1.012–1.553, OR = 1.178, CI: 1.013–1.388, OR = 1.219, CI: 1.011–1.471, respectively) in men. While, frequent consumption of barbecue was significantly correlated with dyslipidemia (OR = 1.203, CI: 1.068–1.355) in women. **Conclusion:** Frequent consumption of barbecue and soft drink increased the risk of developing dyslipidemia among middle-aged adults in Indonesia.

Keywords

Food consumption, dyslipidemia, middle-aged adult, cross-sectional study, Indonesia

Introduction

Cardiovascular diseases, including ischemic heart disease and stroke, contribute to the highest deaths from non-communicable diseases globally and in Southeast Asia (Dans et al., 2011; Roth et al., 2020). In Indonesia, cardiovascular diseases are estimated for 35% of deaths. The risk of premature death due to cardiovascular diseases tends to increase year by year until 2025 (NIHRD, 2018). Therefore, it is necessary to reduce the prevalence of cardiovascular diseases. Dyslipidemia represents a major risk factor for cardiovascular diseases related to the coronary artery and stroke. Epidemiology studies consistently showed that better management of dyslipidemia might reduce the incidence of coronary artery disease, morbidity, and mortality from cardiovascular diseases (Kopin and Lowenstein, 2017).

The prevalence of dyslipidemia among adults aged ≥25 years was around 40% globally and 30% in Southeast Asia (WHO, 2016). Based on the national report in Indonesia, the proportion of high total cholesterol, high LDL, high triglyceride, and low HDL in Indonesia for population ≥15 years were 7.6%, 9%, 13.8%, and 24.3%, respectively (NIHRD, 2018). The trend prevalence of abnormal lipid profiles in Indonesia tends to increase. Moreover, age and gender are physiologic factors that strongly influence plasma lipid levels. Most people with abnormal lipid profiles are found in middle-aged adults in Indonesia (NIHRD, 2018).

The mechanisms responsible for age-related dyslipidemia are physiological changes due to aging, undesirable changes in body composition, and increasing exposure to

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metabolic complications. Then, it can lead to the development of dyslipidemia (Liu and Li, 2015). Middle-aged adults should be the prioritized target for better control of dyslipidemia and early prevention of cardiovascular disease (Gu et al., 2018). Therefore, modifiable risk factors, including diet, physical activity, alcohol use, and smoking status, are essential determinants for lipid secretion and metabolism related to abnormal lipid levels (Hannon et al., 2018; Rhee et al., 2019; Wang and Xu, 2017). Moreover, there is a tendency for food patterns changes among Indonesian from healthy food consumption to unhealthy food consumption. Unhealthy food consumption is implicated in adverse cardiometabolic health and dyslipidemia (Cespedes and Hu, 2015). Nevertheless, the evidence among Indonesian people is less abundant.

A previous study found that a healthy food consumption characterized by water-soluble fiber and phytosterol has a beneficial effect on lipid profile (Antoniazzi et al., 2021; Badimon and Chiva-Blanch, 2019). Meanwhile, unhealthy food consumption characterized by saturated fat, trans fat, simple carbohydrate, sodium, caffeine, or food additives was positively associated with dyslipidemia (Asadi et al., 2019; Na et al., 2019). However, to the best of our knowledge, the study examined the association between food consumption with dyslipidemia mainly represents a national level in Indonesia was still rare. Hence, the objective of this study was to explore the association between unhealthy food consumption and healthy food consumption with dyslipidemia among middle-aged adults in Indonesia.

Methods

Study design and population

This is a cross-sectional study using secondary data from national representative survey of Indonesian Basic Health Research (IBHR) conducted by the National Institute of Health Research Development (NIHRD), Ministry of Health, Indonesia, in 2018. The study design and protocols are described previously (Dany et al., 2020; NIHRD, 2018). The survey covered households across the country using a stratification sampling method. In addition, these selected populations were sorted out to obtain the sub-sample for biomedical specimen tests, including total cholesterol, triglycerides, HDL, and LDL, which were nationally representative in 26 Indonesian provinces (NIHRD, 2018).

Furthermore, the selection of subjects was carried out by consecutive sampling if they met the inclusion and exclusion criteria. The inclusion criteria in this study were: (1) Adults aged 45–59 years old and (2) had lipid profile (total cholesterol, triglyceride, HDL, and LDL) data, socio-demographic data (age, gender, education, and residency), unhealthy food consumption, healthy food consumption, smoking status data, physical activity data, and alcohol use data. The exclusion criteria were missing and extreme data. Finally, 10,608 middle-aged adults were included in this study. We also estimated the minimum sample size for the study. The sample size was calculated using the formula for a cross-sectional study. The level of confidence ($Z\alpha^2$) was set at 95% with an effect size (d) of 5%, and the expected prevalence of dyslipidemia (P) based on the previous study in Indonesia was 36% (Lin et al., 2018); the minimum sample size needed in this study was 356 subjects.

This study was approved by the health research ethics committees of 'Aisyiyah Yogyakarta University (No.1771/KEP-UNISA/IV/2021) and NIHRD, Ministry of Health Republic of Indonesia No. LB.02.01/2/KE.267/2017. Written informed consent was obtained from all subjects.

Definition and data collection

In this study, dyslipidemia was defined based on the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) as meeting one of the following:

(1) Total cholesterol ≥240 mg/dL, (2) Triglyceride ≥ 200 mg/dL, (3) HDL <40 mg/dL, (4) LDL ≥1 60 mg/dL (Lin et al., 2018). All data in the current study were collected by IBHR using well-trained enumerators and standardized protocol (NIHRD, 2018). Blood samples were collected by trained nurses after overnight fasting for 12–14 h in the chosen health centers near the residential area of the subjects. Plasma total cholesterol, triglycerides, HDL, and LDL levels were analyzed enzymatically using a chemical autoanalyzer in the health centers (NIHRD, 2018).

Socio-demographic data (age, gender, education, and residency) were collected using household questionnaires. Unhealthy food consumption was defined as foods or drinks related to non-communicable diseases such as heart disease, hypertension, stroke, and chronic kidney disease (NIHRD, 2018). A validated food frequency questionnaire (FFQ) and food cards were used to assess daily food consumption. The FFQ was validated by the IBHS prior to the study (NIHRD, 2018). The FFQ contained seven unhealthy food items and two healthy food items. The unhealthy food items included fat food, barbecue, processed meat, seasoning sauce, soft drink, energy drink, and instant noodles, while the healthy food items included fruits and vegetables. The FFQ also contained six possible answers: ">1 time/day", "1 time/day", "3–6 times/week", "1–2 times/week", "≤3 times/month", and "never" in the last month. The following is a definition of unhealthy food items included in this study: (1) Fat food includes foods high in total fat, saturated fat, or/and cholesterol from animal-based or plant-based, such as fatty meats, fried food, foods containing coconut milk and/or margarine/butter, organ meats, eggs, and shrimps; (2) barbecue included food that are processed by burning on fire directly such as satay, grilled chicken, rolled goat, grilled fish, and the other grilled animal-based foods; (3) Processed meat/fish/chicken included animal-based food through processing and preservation such as corned beef, sausages, meat

burger, and smoked meat; (4) Seasoning sauce included flavor, stock powder, and the other food sauces that contain monosodium glutamate; (5) Soft drink included carbonated drink (coke zero was excluded); (6) Energy drink included caffeinated drinks as source of energy except coffee; and (7) Instant noodle (NIHRD, 2018).

The definition of fruits and vegetables are all types of vegetables and fruits in Indonesia that consumed as raw fruit/vegetable, cooked vegetable, and fruit juice, both imported and local. A questionnaire derived from STEP wise WHO and food cards were used to ask the average portion of consumption of vegetable and fruit for seven days in a week (NIHRD, 2018).

Physical activity data included frequency of physical activities in the last one week using modified Global Physical Activity Questionnaire. Vigorous-intensity physical activities refer to physical activities (e.g. jogging, aerobic gymnastics, weightlifting, etc.) done for a minimum three days in a week with a total activity time of ≥1500 MET minute. While, moderate-intensity physical activities refer to physical activities (e.g. dancing with moderate rhythm, cycling 10–15 km/h, low-intensity aqua aerobic, holding a child with body weight 20 kg or less, etc.) done for minimum five days or more with total activity time 150 min in a week (or ≥30 min per day) (Nurwanti et al., 2018).

All the variables were categorized in a binary form: (1) Unhealthy food consumption was categorized into frequent (≥1 time/week) and rare (≤3 times/month (included never consumed in last month)), (2) Vegetable intake was categorized into adequate (≥3 portion/day) and inadequate (<3 portion/day), (3) Fruit intake was categorized into adequate (≥ 2 portion/day) and inadequate (<2 portion/day), (4) Physical activity was categorized into high (vigorous and moderate physical activity) and low (except vigorous and moderate physical activity) (Nurwanti et al., 2019).

Statistical analysis

Statistical analyses were conducted using SPSS 25.0. Descriptive analysis presented as mean ± standard deviation (SD) for continuous variable and number (percentage) for categorical variables. A chi-square test was used for categorical variables to compare the differences between the characteristics (gender, physical activity, education, residency, alcohol and smoking status) of the subjects. An independent *t*-test was used for continuous variables to compare the differences in the mean of age and dyslipidemia components from the subjects with dyslipidemia and without dyslipidemia. An unadjusted or adjusted odds ratio (OR) and 95% confidence intervals (CIs), and a multivariable logistic regression model were used to evaluate the associations of food consumption with dyslipidemia. We used two analysis models. Model 1 was unadjusted and model 2 was adjusted for confounding variables including physical activity, smoking status, alcohol use, and socio-demographic characteristics (age, gender, education, and residency). p-value <0.05 was deemed statistically significant.

Results

Characteristics of the subjects

The characteristics of subjects stratified by dyslipidemia are reported in Table 1. The prevalence of dyslipidemia among middle-aged adults in Indonesia was 43.8%. The majority of the subjects with dyslipidemia were men (47.6%), living in urban areas (53.9%), older (51.74 ± 42.9), higher education (26%), low active (24.7%), smoking (40.3%), and drinking alcohol (1.4%) compared with those without dyslipidemia (all $p < 0.05$).

Our results also showed that the subjects with dyslipidemia had higher total cholesterol, LDL-C, and triglycerides, as well as lower HDL-C compared with those without dyslipidemia ($p < 0.05$). In terms of food consumption among middle-aged in Indonesia (Table 1), the proportion of frequent consumption of barbecue (31.3%), soft drink (8.8%), and inadequate vegetable intake (88.4%) were higher in the subjects with dyslipidemia compared with those without dyslipidemia ($p < 0.05$).

Food consumption and dyslipidemia

In a logistic regression model (Table 2), frequent consumption of barbecue (OR = 1.178, CI: 1.083–1.281) and soft drink (OR = 1.261, CI: 1.094–1.453) was a risk factor for dyslipidemia compared with rare. The inadequate intake of vegetables was also a risk factor (OR = 1.143, CI: 1.017–1.286) for dyslipidemia compared with adequate. After controlling for all confounding variables, consumption of barbecue and soft drink was still significantly correlated with dyslipidemia (OR = 1.149, CI: 1.055–1.251 and OR = 1.202, CI: 1.041–1.388), but not in vegetable intake (OR = 1.082, CI: 0.961–1.219). The ability of the independent variables in explaining the incidence of dyslipidemia was shown by the R^2 value of 2% in model 1 and 6% in model 2.

Table 3 shows the logistic regression model across gender. Frequent consumption of soft drink (OR = 1.247, CI: 1.008–1.543) was a risk factor for dyslipidemia in men. The inadequate intakes of fruits (OR = 1.283, CI: 1.129–1.478) and vegetables (OR = 1.278, CI: 1.061–1.539) were also risk factors for dyslipidemia compared with adequate in men. After controlling for all confounding variables, frequent consumption of soft drink, and inadequate intakes of fruits and vegetables were still significantly correlated with dyslipidemia (OR = 1.254, CI: 1.012–1.553, OR = 1.178, CI: 1.013–1.388, OR = 1.219, CI: 1.011–1.471, respectively) in men. Frequent consumption of barbecue (OR = 1.205, CI: 1.070–1.356) was a risk factor for dyslipidemia compared with rare in women. After controlling for all confounding variables, frequent consumption of barbecue was still significantly correlated

Table 1. Characteristics of the study participants ($n = 10.608$)*.

Variable	Total	Dyslipidemia		p**
		With dyslipidemia ($n = 4651$)	Without dyslipidemia ($n = 5957$)	
Socio-demographic characteristics				
Gender				**<0.001**
Men	4510 (42.5)	2215 (47.6)	2295 (38.5)	
Women	6098 (57.5)	2436 (52.4)	3662 (61.5)	
Residence				**<0.001**
Urban	5338 (50.8)	2505 (53.9)	2883 (48.4)	
Rural	5220 (49.2)	2146 (46.1)	3074 (51.6)	
	51.59 ± 4.29	51.74 ± 42.9	51.48 ± 4.23	**0.002**
Education				**<0.001**
Low (<senior high school)	8128 (76.6)	3441 (74)	4687 (78,7)	
High (≥senior high school)	2480 (23.4)	1210 (26)	1270 (21,3)	
Lifestyle				
Physical activity				**<0.001**
Low	2413 (22.7)	1148 (24.7)	1265 (21.2)	
High	8195 (77.3)	3503 (75.3)	4692 (78.8)	
Smoking status				**<0.001**
Yes	3813 (35.9)	1873 (40.3)	1940 (32.6)	
No	6795 (64.1)	2778 (59.7)	4017 (67.4)	
Alcohol use				**0.002**
Yes	116 (1.1)	67 (1.4)	49 (0.8)	
No	10,492 (98.9)	4584 (98.6)	5908 (99.2)	
Components of dyslipidemia				
Total cholesterol	194.01 ± 40.47	210.49 ± 48.42	181.14 ± 26.61	**<0.001**
LDL-C	131.14 ± 34.78	145.87 ± 40.93	119.63 ± 23.33	**<0.001**
HDL-C	48.56 ± 11.67	42.87 ± 11.46	53 ± 9.75	**<0.001**
Triglycerides	142.63 ± 98.41	193.3 ± 125.57	103.07 ± 36.97	**<0.001**
Unhealthy food consumption				
Fat food				**0.111**
Frequent (≥1 time/week)	9267 (87.4)	4036 (86.8)	5231 (87.8)	
Rare (≤3 times/month)	1341 (12.6)	615 (13.2)	726 (12.2)	
Barbecue				**<0.001**
Frequent (≥1 time/week)	3118 (29.4)	1456 (31.3)	1662 (27.9)	
Rare (≤3 times/month)	7490 (70.6)	3195 (68.7)	4295(72.1)	
Processed meat				0.388
Frequent (≥1 time/week)	2208 (20.8)	986 (21.2)	1222 (20.5)	
Rare (≤3 times/month)	8400 (79.2)	3665 (78.8)	4735 (79.5)	
Seasoning sauce				0.458
Frequent (≥1 time/week)	9463 (90.9)	4217 (90,7)	5426 (91,1)	
Rare (≤3 times/month)	965 (9.1)	434 (9.3)	531 (8.9)	
Soft drink				**0.001**
Frequent (≥1 time/week)	828 (7.8)	407 (8.8)	421 (7.1)	
Rare (≤3 times/month)	9780 (92.2)	4244 (91.2)	5536 (92.9)	
Energy drink				0.120
Frequent (≥1 time/week)	630 (5.9)	295 (6.3)	335 (5.6)	
Rare (≤3 times/month)	9978 (94.1)	4356 (93.7)	5622 (94.4)	
Instant noodle				0.565
Frequent (≥1 time/week)	5797 (54.6)	2527 (54.3)	3270 (54.9)	
Rare (≤3 times/month)	4811 (45.4)	2124 (45.7)	2687 (45.1)	
Healthy food consumption				
Fruits				0.452
Inadequate (<2 portion/day)	9774 (92.1)	4275 (91.9)	5499 (92.3)	
Adequate (≥2 portion/day)	834 (7.9)	376 (8.1)	458 (7.7)	
Vegetables				**0.025**
Inadequate (<3 portion/day)	9295 (87.6)	4113 (88.4)	5182 (87)	
Adequate (≥3 portion/day)	1313 (12.4)	538 (11.6)	775 (13)	

*Data are presented as t(%) for categorical variables and mean ± SD for continuous variables. **p-values were derived from chi-square test for categorical variables and independent t-test for continuous variables. Significant $p < 0.05$ is shown in bold font.

Table 2. Odd ratios (95% confidence intervals) for dyslipidemia across unhealthy food consumption and healthy food consumption.

	Dyslipidemia*	
Variable	Model 1**	Model 2***
Fat food		
Rare (≤3 times/month)	1(Ref)	1(Ref)
Frequent (≥1 time/week)	0.911 (0.812–1.022)	0.934 (0.831–1.049)
p	0.111	0.248
Barbecue		
Rare (≤3 times/month)	1(Ref)	1(Ref)
Frequent (≥1 time/week)	1.178 (1.083–1.281)	1.149 (1.055–1.251)
p	**<0.001**	**0.001**
Processed meat		
Rare (≤3 times/month)	1(Ref)	1(Ref)
Frequent (≥1 time/week)	1.042 (0.949–1.146)	1.031 (0.937–1.134)
p	0.388	0.531
Seasoning sauce		
Rare (≤3 times/month)	1(Ref)	1(Ref)
Frequent (≥1 time/week)	0.951 (0.832–1.086)	0.987 (0.862–1.129)
p	0.458	0.845
Soft drink		
Rare (≤3 times/month)	1(Ref)	1(Ref)
Frequent (≥1 time/week)	1.261(1.094–1.453)	1.202 (1.041–1.388)
p	**0.001**	**0.012**
Energy drink		
Rare (≤3 times/month)	1(Ref)	1(Ref)
Frequent (≥1 time/week)	1.137 (0.967–1.336)	1.046 (0.887–1.234)
p	0.120	0.590
Instant noodle		
Rare (≤3 times/month)	1(Ref)	1(Ref)
Frequent (≥1 time/week)	0.978 (0.905–1.056)	0.970 (0.897–1.049)
p	0.565	0.446
Fruits		
Adequate (≥2 portion/day)	1(Ref)	1(Ref)
Inadequate (<2 portion/day)	0.947 (0.821–1.092)	0.982 (0.849–1.135)
p	0.452	0.804
Vegetables		
Adequate (≥3 portion/day)	1(Ref)	1(Ref)
Inadequate (<3 portion/day)	1.143 (1.017–1.286)	1.082 (0.961–1.219)
p	**0.025**	0.195
R^2	**0.02**	**0.06**

*Analysis used logistic regression. The odds ratios were compared to the reference group (rare for unhealthy food and adequate for vegetable intake and fruit intake). ***Unadjusted* ****Adjusted* for residence, age, gender, physical activity, smoking, alcohol use, and education. Significant $p < 0.05$ is shown in bold font.

with dyslipidemia (OR = 1.203, CI: 1.068–1.355) in women. The ability of the independent variables in explaining the incidence of dyslipidemia was shown by the R^2 value of 2% in model 1 and 4% in model 2 in men and 2% in model 1 and 9% in model 2 in women.

Discussion

This cross-sectional study identified an association between food consumption and dyslipidemia among middle-aged adults in Indonesia. Our study revealed that frequent consumption of barbecue and soft drink was significantly associated with dyslipidemia. We also found that frequent consumption of soft drink, and inadequate intakes of vegetables and fruits were risk factors for dyslipidemia in men. While, frequent consumption of barbecue was a risk factor for dyslipidemia in women.

Frequent consumption of soft drinks increases the risk of dyslipidemia development. Consistent with our results, a study by Haslam *et al*. stated that the high consumption of soft drinks caused a negative effect on HDL and triglyceride, and an increased risk of dyslipidemia (Haslam et al., 2020). Soft drinks are classified as sugar-sweetened beverages, high in sucrose and fructose (Malik and Hu, 2015). Soft drinks can increase the risk of dyslipidemia, mainly in the triglyceride component. It may cause a hepatic fructose metabolism as the predispose to secondary lipogenesis (Malik and Hu, 2015). Compared to other

Table 3. Odd ratios (95% confidence intervals) for dyslipidemia across unhealthy food consumption and healthy food consumption in men and women.

	Men		Women	
	Dyslipidemia*		Dyslipidemia*	
Variable	Model 1**	Model 2***	Model 1**	Model 2***
Fat food				
Rare (≤3 times/month)	1(Ref)	1(Ref)	1(Ref)	1(Ref)
Frequent (≥1 time/week)	0.922 (0.772–1.101)	0.908 (0.759–1.085)	0.963 (0.820–1.132)	0.968 (0.824–1.138)
p	0.371	0.287	0.647	0.770
Barbecue				
Rare (≤3 times/month)	1(Ref)	1(Ref)	1(Ref)	1(Ref)
Frequent (≥1 time/week)	1.141 (0.999–1.303)	1.100 (0.962–1.258)	1.205 (1.070–1.356)	1.203 (1.068–1.355)
p	0.051	0.163	**0.002**	**0.002**
Processed meat				
Rare (≤3 times/month)	1(Ref)	1(Ref)	1(Ref)	1(Ref)
Frequent (≥1 time/week)	1.079 (0.930–1.253)	1.068 (0.919–1.240)	0.973 (0.852–1.112)	0.981 (0.858–1.122)
p	0.314	0.392	0.690	0.779
Seasoning sauce				
Rare (≤3 times/month)	1(Ref)	1(Ref)	1(Ref)	1(Ref)
Frequent (≥1 time/week)	1.005 (0.818–1.234)	1.024 (0.832–1.259)	0.997 (0.831–1.197)	1.027 (0.854–1.235)
p	0.963	0.825	0.976	0.775
Soft drink				
Rare (≤3 times/month)	1(Ref)	1(Ref)	1(Ref)	1(Ref)
Frequent (≥1 time/week)	1.247(1.008–1.543)	1.254 (1.012–1.553)	1.184 (0.930–1.507)	1.202 (0.944–1.530)
p	**0.042**	**0.038**	0.170	0.136
Energy drink				
Rare (≤3 times/month)	1(Ref)	1(Ref)	1(Ref)	1(Ref)
Frequent (≥1 time/week)	0.913 (0.732–1.137)	0.926 (0.742–1.156)	0.917 (0.664–1.266)	0.900 (0.651–1.243)
p	0.416	0.499	0.598	0.522
Instant noodle				
Rare (≤3 times/month)	1(Ref)	1(Ref)	1(Ref)	1(Ref)
Frequent (≥1 time/week)	1.031 (0.911–1.167)	1.024 (0.904–1.161)	0.922 (0.829–1.026)	0.954 (0.856–1.062)
p	0.625	0.446	0.135	0.388
Fruits				
Adequate (≥2 portion/day)	1(Ref)	1(Ref)	1(Ref)	1(Ref)
Inadequate (<2 portion/day)	1.283 (1.129–1.478)	1.178 (1.013–1.388)	1.081 (0.897–1.304)	1.109 (0.917–1.342)
p	**0.010**	**0.040**	0.413	0.285
Vegetables				
Adequate (≥3 portion/day)	1(Ref)	1(Ref)	1(Ref)	1(Ref)
Inadequate (<3 portion/day)	1.278 (1.061–1.539)	1.219 (1.011–1.471)	1.063 (0.909–1.242)	1.050 (0.898–1.227)
p	**0.010**	**0.039**	0.445	0.544
R^2	0.02	0.04	0.02	0.09

*Analysis used logistic regression. The odds ratios were compared to the reference group (rare for unhealthy food and adequate for vegetable intake and fruit intake). **Unadjusted ***Adjusted for residence, age, physical activity, smoking, alcohol use, and education. Significant $p < 0.05$ is shown in bold font.

simple sugars, fructose metabolism potentially leads to lipogenesis. It also increases subsequent visceral and intramuscular fat deposition (Badimon and Chiva-Blanch, 2019; Narain et al., 2017). In addition, increased de novo lipogenesis from the high intake of fructose may lead to the increase of VLDL production related to the small-dense LDL formation, also known as atherogenic dyslipidemia complex (Gugliucci, 2017).

This study also found a positive association between barbecue and dyslipidemia. Another previous cross-sectional study in Yogyakarta, Indonesia, also supports this finding (Huriyati et al., 2019). Barbecue in Indonesia is often marinated with lots of oil (mainly palm oil) and added with an oily sauce which is high in saturated fat and may increase the risk of dyslipidemia (Jusuf et al., 2020). Barbecue with a temperature above 120 °C is primarily producing acrylamide due to the Maillard reaction between amino acids and reducing sugars. This compound significantly increased total cholesterol, triglyceride, LDL, VLDL, and decreased HDL (Abdel-Moneim et al., 2019; Ramadhan and Khudair, 2018). Heterocyclic amines are formed during the meat cooking process, mainly with grilled. Heterocyclic amines can generate oxidative stress, which is also a risk factor for dyslipidemia

(Carvalho et al., 2015). Furthermore, future studies should deeply investigate how grilled food consumption can cause dyslipidemia.

According to this study, vegetable consumption was significantly correlated with dyslipidemia. The inadequate intake of vegetables increased the risk of developing dyslipidemia. However, after controlling for all confounding variables, the correlation was not significant. Adequate intake of vegetables, three portions per day, had a protective effect against dyslipidemia. As part of a healthy diet, vegetable helps reduce dyslipidemia (Liu et al., 2020). The water-soluble fiber content in the vegetable had a beneficial mechanism effect to improve the lipid profile, leading to the upregulation of hepatic LDL receptors. Then, it might cause faster catabolism and clearance. Moreover, the hypocholesterolemic effect of vegetable fiber consumption can decrease number of secreted VLDL particles and cholesterol ester transfer protein activity. It can reduce cholesteryl ester in VLDL particles that are transferred to LDL (Soliman, 2019). Vegetables contain plenty of carotenoid, isoflavone, phytoestrogen, and phytosterol. It acts as a chemoprotective agent by interacting with the underlying mechanisms of dyslipidemia. The various phytochemicals in vegetables exert their beneficial effects by reducing the circulating levels of cholesterol, inhibiting lipid oxidation, exhibiting antioxidative and anti-inflammatory activities (Upadhyay and Dixit, 2015). Recent management of dyslipidemia recommends 5–15 g/day of water-soluble fiber intake or 25–40 g/day of total fiber intake (Rhee et al., 2019).

Unlike vegetables, fruit consumption in this study was not significantly correlated with dyslipidemia. In our study, subjects not only consume raw/whole fruit but also processed fruit into fruit juices. Although fruit contains fiber and bioactive compounds that are beneficial to cardiometabolic health, fruit juices are often added with sugar, condensed milk, or creamer that might increase the calorie intake (Guasch-Ferré and Hu, 2019). Through this study, people should be wise and cautious when consuming fruit in the form of fruit juices. Further research is needed to separate the whole or fresh fruit from the fruit juices for dietary intake data collection.

This study showed that seasoning sauce as a flavor enhancer was not correlated with dyslipidemia. Nakamura et al. also found that seasoning sauce containing monosodium glutamate intake did not induce dyslipidemia (Nakamura et al., 2013). In contrast, other studies from Alwaleedi et al. and Zanfirescu et al. showed that MSG intake increased total cholesterol, triglyceride, LDL, and VLDL (Alwaleedi, 2016; Zanfirescu et al., 2019). Studies about the association between MSG and dyslipidemia are still controversial and limited, as most were preclinical studies. Flaws of those studies were the usage of different administration routes, rodent-based studies, and extremely high dosage compared to a common dietary human intake (Zanfirescu et al., 2019). According to the Total Diet Survey in Indonesia, the average intake of MSG from seasoning sauce per person per day was 0.5 g (NIHRD, 2018). These values were lower than the dosage of the studies that showed the adverse lipid profile effects. Additionally, MSG intake resulted in no observed-adverse-effects level or was acceptable for the human body at a normal dietary level (Zanfirescu et al., 2019).

Most middle-aged adults with dyslipidemia in Indonesia rarely consume energy drinks. Alsunni reported that the consumption of energy drinks had increased in the last two decades, only among adolescents and young adults (Alsunni, 2015). However, there was no association between energy drinks consumption and dyslipidemia in our study; even it was controlled by the confounders. Our result was in line with a cross-sectional study involving adults in Jeddah, Saudi Arabia (Enani et al., 2020). However, another study showed that energy drinks contain caffeine and large amounts of sugar. With this content, overconsumption of energy drinks had an undesirable effect on lipid profile, mainly increased triglyceride and decreased HDL levels (Famurewa et al., 2015; Malik and Hu, 2015).

Among middle-aged Indonesian adults, the proportion of frequently consumed Fat food was lower in subjects with dyslipidemia. Our study showed no statistical correlation between fat food consumption and dyslipidemia. In contrast, a consistent finding from another study found that often consumed fat food has been proposed for the excess intake of saturated fat (Sudargo et al., 2017). Although our study showed no association between fat food and dyslipidemia, cooking methods such as boiling and steaming are better in fat composition compared to frying especially for some animal proteins that are originally high in saturated and trans-fat (Scherr and Ribeiro, 2013).

Our study revealed that processed meat and instant noodle as part of the popular convenience food in Indonesia were not associated with dyslipidemia. On the contrary, Korea National Health and Nutrition Examination Survey stated that processed meat was positively related to dyslipidemia, mainly in total cholesterol and LDL (Cha and Park, 2019). Processed meat contains higher saturated fat, nitrate, and sodium than unprocessed meat for a better texture, taste, and extending its shelf life (Micha et al., 2012). Instant noodles that contain high-calorie and high concentrations of refined carbohydrates with a high glycemic index, fats, and sodium also contribute to an increased risk for metabolic disease, especially dyslipidemia (Huh et al., 2017). A recent study among adults in Korea showed that sodium intake was correlated with total cholesterol and LDL (Bu et al., 2012). Due to genetic factors, the different metabolic responses while consuming sodium food sources (e.g. processed meat and instant noodle) may interfere with the association in our study. Zhou et al. reported an interaction between sodium intake, genetic variants, and dyslipidemia among middle-aged in Asia

(Zhou et al., 2019). People with high genetic risk scores of particular genetic variants were mainly associated with dyslipidemia and may need to be careful about sodium intake to reduce their risk of dyslipidemia (Zhou et al., 2019).

The strength of our study is a large number of data and represents the Indonesian population. To our knowledge, this is the first study to investigate the association of food consumption with dyslipidemia among middle-aged in Indonesia, which also provides a variety of data information on lifestyle and socio-demographics. However, we had limitations in this study. First, dietary data were collected only using a frequency of intake. Therefore, there was no information regarding energy, macronutrient, and micronutrient intakes. Second, fruit juices and whole fruits were not separated in dietary data collection, which can be differently affected by the association with dyslipidemia. Third, we did not analyze the anthropometric data that might interfere with the results. Moreover, the R^2 in logistic regression analyses for dyslipidemia using food consumption as variables was relatively low; suggesting other factors outside the model still explain the incidence of dyslipidemia in middle-aged adults. Finally, the association of exposure and outcome in cross-sectional design may be difficult to interpret. Additional retrospective cohort design studies are needed to investigate the strong association and mechanism between food consumption and dyslipidemia. Finally, this study did not include the other confounding variables, such as drug consumption, comorbidities, and nutritional status.

Conclusions

Our findings suggest that diet as part of lifestyle plays an important role in dyslipidemia among the middle-aged in Indonesia. Frequent consumption of soft drinks, barbecues, and inadequate intake of vegetables were positively associated with an increased risk of developing dyslipidemia among middle-aged adults in Indonesia. Our results also suggest that frequent consumption of soft drinks, and inadequate intakes of fruits and vegetables were positively associated with an increased risk of developing dyslipidemia in men. In contrast, frequent consumption of barbecue was positively associated with an increased risk of developing dyslipidemia in women.

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Availability of data and materials

The data are available from the Data Management Laboratory of NIHRD, Ministry of Health, Republic of Indonesia (https://www.litbang.kemkes.go.id/layananpermintaan-data-riset) on reasonable request with prior officially written permission.

Authors' contributions

ZAP and AS contributed to the concept or study design, performed data analysis and interpretation. ZAP drafted the manuscript. AS revised the manuscript critically for important intellectual content. All authors approved the final manuscript.

Consent for publication

The authors have all gave their consent for publication of this manuscript.

Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

This study was approved by the health research ethics committees of 'Aisyiyah Yogyakarta University (No.1771/KEP-UNISA/IV/2021) and NIHRD, Ministry of Health, Republic of Indonesia (No. LB.02.01/2/KE.267/2017). Written informed consent was obtained from all subjects.

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