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Changes in diet quality and risk of hypertension in adults: Evidence from the NCDs cohort study, Bogor, Indonesia

Perubahan kualitas diet dan risiko hipertensi pada dewasa: Analisis dari studi kohor FRPTM di Bogor, Indonesia

Salsabil Naqiyyah[1], Ikeu Tanziha[2*], Dodik Briawan[3], Woro Riyadina[4]

[1] Department of Community Nutrition, Faculty of Human Ecology (FEMA), IPB University. Bogor, Jawa Barat, Indonesia
E-mail: salsabilnaqiyyah@gmail.com
[2] Department of Community Nutrition, Faculty of Human Ecology (FEMA), IPB University. Bogor, Jawa Barat, Indonesia
E-mail: ikeu_jamilah@apps.ipb.ac.id
[3] Department of Community Nutrition, Faculty of Human Ecology (FEMA), IPB University. Bogor, Jawa Barat, Indonesia
E-mail: dbriawan@gmail.com
[4] enter for Public Health and Nutrition Research, Health Research Organization, National Research and Innovation Agency (BRIN), Cibinong, Jawa Barat, Indonesia.
E-mail: w_riyadina01@gmail.com

***Correspondence Author:**
Department of Community Nutrition, Faculty of Human Ecology (FEMA), IPB University, Jalan Lingkar Akademik, Dramaga, Kabupaten Bogor, Provinsi Jawa Barat, Indonesia, 16680
E-mail: ikeu_jamilah@apps.ipb.ac.id

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Abstract

The prevalence of hypertension is increasing globally, including in Indonesia. Therefore, dietary patterns such as the Dietary Approaches to Stop Hypertension (DASH) diet are recommended to help control blood pressure. However, research on adherence to the DASH diet and its relationship with blood pressure in Indonesia is still limited, especially in long-term cohort studies. This study aimed to analyze the relationship between changes in dietary quality and blood pressure. This study design is a retrospective cohort study used secondary data from the Non-Communicable Disease Risk Factor Cohort Study (FRPTM) conducted in five urban villages in Bogor City from 2011 to 2018, involving 1,724 adult respondents. The analysis was performed using the chi-square test and multiple logistic regression analyses. The results showed no significant relationship between diet quality at baseline, follow-up, or changes in diet quality and the blood pressure. However, individuals with worsening diet quality had a 1.2-fold higher risk of developing hypertension (OR=1.237; 95%CI=0.886–1.727), while those with stable poor diet quality had a 1.3-fold higher risk (OR=1.285; 95%CI=0.905–1.824) than individuals with improved diet quality. In conclusion, these findings suggest that a decline in dietary quality may increase the risk of hypertension.

Keywords: Change in Diet Quality, Cohort, DASH diet, Hypertension, Indonesia

Abstrak

Prevalensi hipertensi terus meningkat secara global, termasuk di Indonesia, sehingga pola makan seperti Dietary Approaches to Stop Hypertension (DASH) diet direkomendasikan untuk membantu mengontrol tekanan darah. Namun, penelitian terkait kepatuhan terhadap DASH diet dan hubungannya dengan tekanan darah di Indonesia masih terbatas, terutama dalam studi jangka panjang seperti kohor. Penelitian ini bertujuan untuk menganalisis hubungan antara perubahan kualitas diet dengan status tekanan darah. Desain penelitian ini adalah studi kohor retrospektif menggunakan data sekunder dari Studi Kohor Faktor Risiko Penyakit Tidak Menular (FRPTM) yang dilaksanakan di lima kelurahan Kota Bogor pada tahun 2011–2018, melibatkan 1.724 responden dewasa. Analisis dilakukan menggunakan uji chi-square dan regresi logistik berganda. Hasil penelitian menunjukkan tidak terdapat hubungan yang signifikan antara kualitas diet pada baseline, follow-up, maupun perubahan kualitas diet dengan status tekanan darah. Namun, individu dengan kualitas diet yang memburuk memiliki potensi risiko 1,2 kali lebih tinggi mengalami hipertensi (OR=1,237; 95%CI=0,886–1,727), sedangkan mereka dengan kualitas diet yang stabil buruk memiliki potensi risiko 1,3 kali lebih tinggi (OR=1,285; 95%CI=0,905–1,824) dibandingkan individu dengan perubahan kualitas diet yang membaik. Kesimpulan, temuan ini

menunjukkan kecenderungan bahwa penurunan kualitas diet berpotensi meningkatkan risiko hipertensi.

Kata Kunci: DASH diet, Hipertensi, Indonesia, Kohor, Perubahan kualitas diet

Introduction

Hypertension was defined as a blood pressure of ≥140/90mmHg and/or the use of antihypertensive medication (NHLBI, 2004; WHO, 2021). This condition may lead to complications such as kidney failure, stroke, blindness, vascular rupture, and cognitive impairment (WHO, 2013). Globally, an estimated 1,28 billion adults aged 30-79 years have hypertension, most of whom remain undiagnosed or uncontrolled (WHO, 2021). In Indonesia, findings the Basic Health Research Survey (Riskesdas) findings indicate an increase in the prevalence of hypertension from 25.8% in 2013 to 34.1% in 2018 (Ministry of Health of the Republic of Indonesia, 2018).

Hypertension is influenced by various non-modifiable risk factors, including age, sex, and genetics (Rahman et al., 2021), as well as modifiable risk factors, such as nutritional status, stress, smoking behavior, physical activity, and dietary patterns (Gamage & Seneviratne, 2021; Hossain et al., 2019; Indrapal et al., 2022; Li et al., 2017; Wang et al., 2020). Dietary patterns play a critical role in the prevention and management of hypertension (Schwingshackl et al. 2019). Adopting a healthier and higher-quality diet, when combined with medical treatment, can optimize blood pressure control in individuals with hypertension (Motamedi et al. 2021).

The DASH diet is a dietary pattern specifically designed to prevent and control hypertension. Developed by the National Heart, Lung, and Blood Institute (NHLBI) in the United States, the DASH diet is intended to prevent and control hypertension and has been researched for over two decades (NHLBI, 2006; Singh et al., 2023). The DASH diet focuses on increasing the intake of nutrients that play a role in lowering blood pressure, especially minerals (potassium, calcium, and magnesium), protein, and fiber, while limiting the intake of sodium, saturated fat, and cholesterol (National Heart Lung and Blood Institute 2006). Various studies have demonstrated the effect of the DASH diet on blood pressure in individuals with hypertension (Filippou et al., 2020; Schwingshackl et al., 2019; Theodoridis et al., 2023). The DASH Accordance Score was used to determine whether a person's diet aligned with DASH diet principles. This score allows for a quantitative assessment of the quality of an individual's diet based on its proximity to the DASH dietary principles, both at a single point in time and with changes over time (Heidari et al., 2020).

However, previous studies in Indonesia have only assessed dietary patterns at a single point in time and have not used a longitudinal approach (Islami et al., 2019; Rahadiyanti et al., 2015; Al Rahmad et al., 2021). The use of cohort data measured at multiple time points allows for the observation of these changes. Therefore, the dynamics of changes in dietary quality and their relationship with blood pressure status have not been well described. However, dietary patterns are dynamic and can change over time due to socio-demographic influences, psychosocial changes, interventions, or changes in individual habits (Quan et al., 2024). The use of cohort data measured at multiple time points allows for the observation of these changes. Therefore, the dynamics of changes in dietary quality and their relationship with blood pressure status have not been well described. However, dietary patterns are dynamic and can change over time due to socio-demographic influences, psychosocial changes, interventions, or changes in individual habits (Quan et al., 2024). Furthermore, the use of measurement tools, such as the DASH Accordance Score, to assess changes in dietary quality in Indonesia remains limited. In Indonesia, there has only been one cohort study related to non-communicable diseases: the Cohort Study of Risk Factors for Non-Communicable Diseases (FRPTM) in Bogor City, West Java Province, conducted by the Health Research and Development Agency of the Indonesian Ministry of Health.

This study aimed to analyze the relationship between changes in diet quality, as measured by the DASH score, and blood pressure status in Indonesian adults using secondary data from a cohort study in Bogor City. This is the first study in Indonesia to examine changes in dietary quality and its

impact on blood pressure status using cohort data. The results are expected to provide an overview of dietary quality, its changes over time, and its impact on the incidence of hypertension, a topic that has not been widely studied in Indonesia to date. Given the increasing burden of hypertension, particularly in Indonesia, this study can serve as a basis for policymaking and designing more targeted nutritional interventions to improve dietary quality and reduce the.

Methods

The present study employed a retrospective cohort design to investigate dietary quality and modifications in accordance with DASH diet recommendations, as well as the impact of additional determinants on blood pressure status. These outcomes are currently observable, and the influencing exposures will be retrospectively. The data analyzed in this study were sourced from the FRPTM cohort study conducted in Bogor. This extensive study was conducted from 2011 to 2021 across five urban villages in Bogor City: Kebon Kelapa, Babakan Pasar, Babakan, Ciwaringin, and Panarangan. This research primarily focused on three major non-communicable diseases: coronary heart disease, type 2 diabetes mellitus, and stroke.

The data utilized in this study were derived from phase 1 (baseline 2011) and phase 2 (baseline 2012) data collection, covering the period from 2011 to 2018 with a biannual data collection interval. Data were collected from various points to ensure alignment with the study objectives. Data were collected at three intervals: baseline (2011-2012), fourth-year follow-up (2015-2016), and sixth-year follow-up (2017-2018). Although data are available up to 2021, this study exclusively employed FRPTM cohort data up to 2018, as data from to 2019-2021 were incomplete due to measurement limitations imposed by the COVID-19 pandemic.

The research was conducted in five sub-districts within the Bogor Tengah District, Bogor City, West Java Province: Kebon Kelapa, Babakan Pasar, Babakan, Ciwaringin, and Panarangan. Authorization for data use was obtained at the study's inception in 2011, and ethical approval was granted by the Health Research Ethics Committee of the National Research and Development Agency (Approval Number: LB.02.01/2/KE.076/2018) in 2018. Data processing and analysis for this study will be conducted between August 2024 and 2025.

The analysis focused on respondents who exhibited normal blood pressure at baseline or were not afflicted with hypertension at baseline. These individuals were subsequently classified into two cohorts at the 6-year follow-up: normotensive and hypertensive (in 2017 for respondents in phase 1 and in 2018 for respondents in phase 2). Subject selection adhered to specific inclusion and exclusion criteria as follows. The inclusion criteria were as follows: (1) absence of hypertension at baseline, (2) absence of comorbidities at baseline, and (3) absence of congenital physical disability. The exclusion criteria were as follows: (1) pregnancy or breastfeeding at baseline and (2) incomplete data due to loss to follow-up or withdrawal during cohort data collection. Based on these criteria, 1, 724 participants were included in this study, comprising 1,200 normotensive and 524 hypertensive individuals.

Data on food and nutrient intake in the FRP Cohort Study were collected through 24-hour food recall interviews. Although 24-hour food recall data have limitations in capturing long-term dietary patterns, this method was employed because of data availability within the FRP Cohort Study. This study utilized baseline and 4-year follow-up data to assess dietary quality at baseline and two years prior to the outcome (6-year follow-up). Dietary intake data were analyzed using the 2020 Indonesian Food Composition Table (TKPI) Nutrient Database. In cases of incomplete nutrient data in the TKPI, the Nutrisurvey application was employed for analysis. Incomplete nutrient data were supplemented by referencing the ASEAN and Singapore databases through a borrowing system. A total of 779 food items, including raw, processed, and packaged foods, were retrieved from the participants recalls at both baseline and follow-up.

The DASH Accordance Score scheme utilized in this study to evaluate diet quality is grounded in previous research (Bullock et al., 2022; Heidari et al., 2020; Kim & Andrade, 2016) adapted from the DASH eating plan from the National Heart Lung and Blood Institute (2006) and has been modified to better fit the policy framework, thereby increasing its relevance to the cultural context of Indonesia, specifically in Bogor City, where the FRPTM Cohort Study was

conducted. The analysis concentrated on nine key nutrients that constitute the DASH Accordance Score: sodium, cholesterol, saturated fat, total fat, protein, calcium, magnesium, and fiber. The DASH Accordance Score was derived by summing the scores of these nine components, with a total range of 0–9 (Table 1). A score of 1, 0.5, and 0 was awarded if the subject's intake met the target, medium target, and 0 if neither target is achieved for each nutrient. Diet quality was classified as good (total diet quality score ≥4.5) or poor (total diet quality score <4.5) (Mellen et al., 2008). Changes in diet quality were assessed by comparing diet quality at two different data collection points to evaluate the dietary patterns of the subjects over time and their effect on blood pressure levels. This assessment aimed to determine the degree to which diet impacts blood pressure, particularly in individuals with hypertension.

The dependent variable was blood pressure status, which was classified as either normotension or hypertension. Normotension refers to subjects who have not been diagnosed with hypertension, are not taking antihypertensive medication, have a systolic blood pressure <140 mmHg, and a diastolic blood pressure <90 mmHg. Hypertension was defined as a diagnosis of hypertension, use of antihypertensive medication, or systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg. Blood pressure measurements taken in this study were derived from baseline data and the 6-year follow-up.

In this study, additional variables examined included age, sex, educational attainment, occupational status, body mass index (BMI), waist circumference, physical activity, smoking status, mental and emotional disorders, and number of comorbidities. Age was stratified into four categories: 25–34, 35–44, 45–55, and ≥55 years. Sex was classified as male or female. Educational attainment was divided into two categories: low and middle-to-high. Occupational status was categorized as either employed or unemployed. Data regarding age, sex, educational attainment, and occupational status were collected through interviews using a cohort study questionnaire at baseline. BMI was classified into three categories: non-obese (<25.0), overweight (25.0–27.0), and obese (>27.0). Waist circumference was categorized as normal or at risk. BMI was determined by calculating weight and height, with weight, height, and waist circumference measured at the 4-year follow-up visit.

Physical activity was quantified by considering both the intensity and duration of the activity, and was subsequently expressed in Metabolic Equivalent (MET) units. Physical activity was categorized into two groups: sufficient (≥600 MET) and insufficient (<600 MET). Smoking status was assessed using the Brinkman Index and classified as smokers or non-smokers. Mental emotional disorders were evaluated using the Self-Reporting Questionnaire (SRQ), which comprises 20 dichotomous questions regarding mental health symptoms. These disorders were categorized as non-stressful (score <6) or stressful (score ≥6). The comorbidities examined in this study included non-communicable diseases such as Diabetes Mellitus (DM), Coronary Heart Disease (CHD), and stroke. The presence of comorbidities was classified into two categories: no comorbidities and comorbidities. Data pertaining to physical activity, smoking status, mental emotional disorders, and the number of comorbidities were derived from a 4-year follow-up.

Tabel 1. Modified DASH accordance score scoring criteria

Nutrients	Skor 1 (DASH score target)	Skor 0,5 (Medium)	Skor 0 (Poor)
Sodium (mg/day)	<1740	1740 – 2000	>2000
Cholesterol (mg/day)	<198	198 – 300	>300
Saturated fat (% total calories/day)	<5.5	5.5 – 10	>10
Total fat (% total calories/day)	<20	20 – 25	>25
Protein (% total calories/day)	>15	15 – 10	<10
Calcium (mg/day)	>1000	650 – 1000	<650
Magnesium (mg/day)	>350	228 – 350	<228
Potassium (mg/day)	>4700	3055 – 4700	<3055
Fiber (g/day)	>30.0	19.5 - 30	<19.5

Description: DASH accordance score target based on a 2.100 kcal/day diet

Statistical analyses were conducted using Microsoft Excel 2016 and SPSS version 25. Univariate analysis was employed to examine the distribution of each variable concerning blood pressure status. The normality of the DASH–Accordance score components was assessed using the Kolmogorov-Smirnov test. To evaluate the differences between each DASH Accordance Score component at baseline and follow-up within the subject group, the Wilcoxon test was applied. The chi-square test was used to investigate the relationship between each independent variable and blood pressure status. A multivariate analysis was conducted using multiple logistic regression to determine the magnitude of influence of each variable that was significant at $p < 0.25$ in the bivariate test of blood pressure status.

Result and Discussion

Among the 1,724 subjects, 69.6% (n=1,200) were normotensive, while 30.4% (n=524) were hypertensive. The median DASH Accordance Score declined from baseline to the 4-year follow-up (Table 2). Regarding the nine components of the DASH Accordance Score, the median sodium values were elevated at baseline. Conversely, the median values for cholesterol, saturated fat, total fat, protein, potassium, and fiber were higher at the 4-year follow-up. In normotensive individuals, the median magnesium and calcium values were elevated at the 4-year follow-up, whereas these values were higher in hypertensive individuals at baseline.

The majority of participants demonstrated poor dietary quality at both baseline and the 4-year follow-up, with a greater proportion of dietary quality decline observed in the hypertensive group (Table 3). Individuals with hypertension were more likely to be obese and have central adiposity, whereas those with normotension generally demonstrated lower levels of obesity and maintained a normal abdominal circumference. Furthermore, the prevalence of hypertension increased with age. Individuals with hypertension were more likely to exhibit obesity and central abdominal obesity, whereas those with normotension generally presented with lower levels of obesity and normal abdominal circumference.

Tabel 2. Subjects DASH accordance score based on blood pressure status

DASH Accordance Score component	Normotension n=1200			Hypertension n=524		
	Baseline (median (min;max))	4-year follow-up (median (min;max))	p-value	Baseline (median (min;max))	4-year follow-up (median (min;max))	p-value
DASH Accordance score	3.0 (0.0 ; 6.0)	2.5 (0.0 ; 7.5)	<0.001*	3.0 (0.0 ; 6.5)	2.5 (0.0 ; 7.0)	<0.001*
Sodium (mg/day)	1500.50 (21.50 ; 17427.30)	1436.86 (0.45 ; 30072.15)	0.066	1614.74 (60.84 ; 12479.30)	1390.92 (84.82 ; 40829.87)	0.002*
Cholesterol (mg/day)	131.18 (0.00 ; 1782.42)	207.70 (0.0 ; 1505.30)	<0.001*	135.62 (0.0 ; 1485.28)	206.45 (0.0 ; 1020.20)	0.002*
Saturated fat (% total calories/day)	9.01 (0.00 ; 84.88)	11.50 (0.02 ; 54.23)	<0.001*	8.46 (0.0 ; 91.08)	11.10 (0.38 ; 62.14)	<0.001*
Total fat (% total calories/day)	21.23 (0.00 ; 186.74)	28.04 (0.06 ; 114.22)	<0.001*	20.69 (0.0 ; 127.93)	26.65 (0.93 ; 115.12)	<0.001*
Protein (% total calories/day)	8.22 (0.00 ; 36.94)	9.04 (0.26 ; 58.90)	<0.001*	8.21 (0.0 ; 27.48)	9.45 (1.30 ; 40.95)	<0.001*
Calcium (mg/day)	426.02 (1.47 ; 4931.92)	473.83 (11.25 ; 3738.62)	<0.001*	457.62 (1.55 ; 2030.32)	442.80 (44.70 ; 2809.23)	0.747
Magnesium (mg/day)	181.34 (0.07 ; 1034.61)	196.56 (5.85 ; 1723.62)	<0.008*	188.51 (0.02 ; 929.34)	187.42 (25.45 ; 1460.01)	0.613

Potassium (mg/day)	1243.77 (0.26 ; 13055.94)	1393.76 (17.10 ; 64074.24)	<0.001*	1283.79 (1.19 ; 6728.45)	1383.75 (220.41 ; 36220.37)	0.003*
Fiber (g/day)	4.64 (0.00 ; 45.33)	5.86 (0.09 ; 97.26)	<0.001*	5.33 (0.0 ; 48.55)	5.51 (0.12 ; 56.91)	0.64

*Wilcoxon signed-rank test. *Significant at p<0,05.*

Tabel 3. Characteristics of subjects

Characteristics	Blood Pressure Status		p-value
	Normotension n=1200 (%)	Hypertension n=524 (%)	
Changes in diet quality			
Stable poor	179 (14.9)	63 (12)	0.178*
Worsening	582 (48.5)	275 (52.5)	
Improvement	439 (36.6)	186 (35.5)	
Baseline diet quality			
Good	64 (5.3)	30 (5.7)	0.742
Poor	1136 (94.7)	494 (94.3)	
Diet quality at 4 years follow-up			
Good	90 (7.5)	28 (5.3)	0.103*
Poor	1110 (92.5)	496 (94.7)	
BMI			
Not overweight (<25.0)	706 (58.8)	190 (36.3)	<0.001**
Overweight (25.0 – 27.0)	195 (16.3)	79 (15.1)	
Obese (>27.0)	299 (24.9)	255 (48.7)	
Abdominal circumference			
Normal	604 (50.3)	157 (30)	<0.001**
Centeal Obesity	596 (49.7)	367 (70)	
Age			
25-34 years	345 (28.7)	114 (21.8)	
35-44 years	458 (38.2)	188 (35.9)	<0.001**
45-54 years	303 (25.3)	146 (27.9)	
≥ 55 years	94 (7.8)	76 (14.5)	
Gender			
Male	363 (30.3)	142 (27.1)	0.186*
Female	837 (69.8)	382 (72.9)	
Education level			
Low	653 (54.4)	300 (57.3)	0.276
Middle and above	547 (45.6)	224 (42.7)	
Occupation			
Working	797 (66.4)	375 (71.6)	0.035**
Not working	403 (33.6)	149 (28.4)	
Physical activity			
Sufficient	564 (47)	250 (47.7)	0.786
Insufficient	636 (53)	274 (52.3)	
Smoking status			
Non-smoker	528 (44)	264 (50.4)	0.014**
Smoker	672 (56)	260 (49.6)	
Mental emotional disorder (MED)			
Not stressed	1135 (94.6)	489 (93.3)	0.302
Stressed	65 (5.4)	35 (6.7)	
Comorbidities			
No comorbidities	1127 (93.9)	481 (91.8)	0.106

Has commorbidities	73 (6.1)	43 (8.2)

*Pearson Chi-square Test. **Significant at p<0.05. *Significant at p<0.25*

The incidence of hypertension increases with age. In both groups, the majority were female, had low educational attainment, were employed, and participated in minimal physical activity. Hypertensive individuals were more frequently nonsmokers than normotensive individuals, who were more likely to smoke. Most individuals in both the normotensive and hypertensive categories did not experience stress and were free of comorbidities.

No association was observed between baseline diet quality and diet quality at the 4-year follow-up with respect to blood pressure status. Additionally, changes in diet quality were unrelated to blood pressure status. The chi-square test results indicated that the variables associated with blood pressure status included age, occupation, BMI, waist circumference, and smoking status. Multiple logistic regression analyses were conducted on the primary variable, changes in diet quality, as well as other variables with a significance value of <0.25, specifically age, sex, occupation, BMI, waist circumference, smoking status, and diet quality at the 4-year follow-up.

The final multiple logistic regression model is presented in Table 4. Interaction testing was performed based on the theoretical premise that nutritional status reflects the eating patterns. The results of the multiple logistic regression analysis indicated no significant association between changes in dietary quality and blood pressure status (p>0.05). However, the interaction between diet quality and BMI was significant (p<0.05). Compared with improvements in diet quality, deteriorations in diet quality were associated with a 1.2-fold increased risk of hypertension (OR=1.237; 95%CI=0.886–1.727), while consistently poor diet quality was associated with a 1.3-fold increased risk of hypertension (OR=1.285; 95%CI=0.905–1.824), after controlling for the interaction factors of BMI with diet quality, waist circumference, age, and occupation. The interaction between poor diet quality and BMI was associated with a 1.5-fold increased risk of hypertension (OR=1.473; 95%CI=1.287–1.687) compared with the interaction between good diet quality and BMI.

The age group of 35-44 years did not exhibit a statistically significant association with blood pressure status (p>0.05); however, it demonstrated a 1.2-fold increased risk (OR=1.181; 95%CI=0.892–1.565) of hypertension compared to the younger cohort aged 25-34 years. Conversely, the 45-54 age group showed a statistically significant association with blood pressure status (p<0.05) and presented a 1.5-fold heightened risk of hypertension (OR=1.529; 95%CI=1.132–2.064) relative to the 25-34 age group. The risk of hypertension was most pronounced in the 55-year-old age group, with a 2.6-fold increase (OR=2.625; 95%CI=1.789–3.853) compared to the younger cohort, and this finding was statistically significant (P <0.05).

Occupation was significantly associated with blood pressure status (p<0.05) after adjusting for variables such as changes in diet quality, the interaction between BMI and diet quality, waist circumference, and age. Unemployed individuals had a 0.6 times lower risk (OR=0.666; 95%CI=0.525–0.844) of developing hypertension than employed individuals, indicating that employed individuals had a higher risk of developing hypertension than their unemployed counterparts.

The findings of this study revealed no correlation between baseline diet quality and diet quality at the 4-year follow-up with respect to blood pressure status. Additionally, changes in diet quality were not related to blood pressure status. These results are consistent with those of a previous study by Kim & Andrade (2016) who identified no significant association between diet quality scores and hypertension diagnosis. This may be attributed to several methodological and biological factors, including the following.

First, the data utilized to assess diet quality in this study comprised solely 24-hour recalls, which are limited in accurately representing the daily consumption of the subjects. These data were used to accommodate the availability of consumption data in the FRPTM Cohort Study, which only included 24-hour recalls. However, not all nutrients are consumed in ideal amounts daily, complicating the measurement of diet quality and resulting in many subjects exhibiting poor diet quality (Kim & Andrade, 2016). Consequently, misclassification of diet quality categories occurred, leading to an underrepresentation of

its impact on blood pressure status in the present study.

Tabel 4. Multiple logistic regression result from selected characteristics with change in diet quality and Blood Pressure Status

Independent variables	p-value	OR (95% CI)
Changes in diet quality (Ref.= Improvement)		
Worsening	0.213	1.237 (0.886 – 1.727)
Stable poor	0.160	1.285 (0.905 – 1.824)
Interaction of BMI with diet quality (Ref.= Interaction of BMI with good diet quality)		
Interaction of BMI with poor diet quality	<0.001*	1.473 (1.287 – 1.687)
Abdominal circumference (Ref.= Normal)		
Central obesity	<0.001*	1.675 (1.269 – 2.211)
Age (Ref.= 25-34 years)		
35-44 years	0.245	1.181 (0.892 – 1.565)
45-54 years	0.006*	1.529 (1.132 – 2.064)
≥ 55 years	<0.001*	2.625 (1.789 – 3.853)
Occupation (Ref.= Working)		
Not working	0.001*	0.666 (0.525 – 0.844)

*Multivariable logistic regression analysis. *Significant at p<0.05. Ref.= Variable reference category.*

Second, diet quality is calculated from the subject's daily consumption and analyzed using databases and software containing nutrient data for specific food items. The availability of a comprehensive nutrient database is crucial for determining dietary quality calculations. In this study, the researchers encountered difficulties in locating a database that included complete data on calcium, magnesium, potassium, and fibers. Consequently, some subject consumption data showed zero values because the reference nutrient database could not be found. This significantly affected the final results regarding the nutritional quality of DASH diet components. Incomplete nutritional data pose a major challenge in reflecting and achieving a good and healthy diet supported by scientifically based data (de Quadros et al., 2022). This issue is prevalent in various countries, particularly in developing and lower-middle-income countries (Windus et al., 2025). Consequently, community nutritional intake is not well reflected in various studies or in the establishment of nutrition policies.

Third, the consumption of processed foods lacking comprehensive nutritional information on their packaging affects the accuracy of dietary quality assessment. According to Indonesian Food and Drug Monitoring Agency (BPOM) Regulation No. 26 of 2021, the nutritional information required for packaged foods includes total energy, fat, saturated fat, protein, carbohydrate, sugar, and salt (sodium) content. However, nutrients such as calcium, magnesium, potassium, and fiber are not mandated, resulting in the absence of these nutrient data in some processed foods and beverages consumed by the participants, which are essential for calculating DASH-compliant scores. Consequently, when these data were input and analyzed, the subject's consumption was recorded as 0, thereby influencing the classification of their diet quality. Although not statistically significant, this study identified a potential effect of dietary quality changes on the risk of hypertension. This finding is consistent with previous studies conducted in Indonesia, which reported no significant impact of food intake based on the DASH diet on hypertension (Islami et al., 2019; Rahadiyanti et al., 2015).

In this study, several significant non-modifiable risk factors for hypertension, including family history and hypertension duration, were not examined. These factors may affect the association between dietary quality and hypertension. Family history was not analyzed because of the absence of specific inquiries regarding family history of hypertension in the FRPTM cohort study questionnaire. Additionally, the duration of hypertension could not be determined because of the data collection interval. Consequently, family history and duration of hypertension may serve as residual confounders in the relationship

between changes in diet quality and blood pressure.

Furthermore, the lack of statistical significance in the relationship between changes in diet quality and hypertension status observed in this study may suggest the presence of long-term physiological adaptations in hypertensive individuals. As previously noted, the duration of hypertension was not examined in this study. It is plausible that participants who are aware of their health conditions may alter their diet and behaviors to improve their health, thereby complicating the observation of the effects of changes in diet quality on blood pressure status (reverse causality). Although not statistically significant, the direction of the relationship identified in this study indicates that changes in dietary quality may mitigate the risk of hypertension.

The present study identified an interaction between Body Mass Index (BMI) and diet quality, which affected the association between alterations in diet quality and blood pressure status. Additionally, this study revealed that individuals with central obesity have a heightened risk of developing hypertension. These findings align with those of a study conducted in China, which demonstrated that individuals with obesity and central obesity are more prone to developing hypertension (Wu et al., 2024).

Nutritional status is indicative of an individual's dietary habits and dietary quality. Obesity and increased waist circumference are linked to the accumulation of adipose tissue, particularly visceral fat, which is associated with elevated blood pressure. This relationship is mediated by several interconnected pathophysiological mechanisms, including sympathetic nervous system hyperactivity, activation of the Renin-Angiotensin-Aldosterone System (RAAS), alterations in renal structure and function, leptin resistance and hyperleptinemia, insulin resistance, and changes in the natriuretic peptide system (Chrysant, 2019; Shariq & Mckenzie, 2020). These findings suggest that the impact of dietary quality on blood pressure may be population-specific. Individuals with overweight and obesity are more prone to insulin resistance, RAAS activation, and oxidative stress, all of which affect the relationship between diet quality and its influence on blood pressure. This implies that diet quality may play a more favorable role in individuals with a normal nutritional status than in those who are overweight or obese.

This study identified a correlation between advancing age and the prevalence of hypertension, corroborating previous findings from Bangladesh (Rahman et al., 2021). The aging process is associated with reduced elasticity of blood vessels, which contributes to arterial stiffness. This stiffness diminishes the capacity for blood flow and consequently elevates the blood pressure. Additionally, aging is linked to endothelial dysfunction, resulting in decreased bioavailability of hormones that play crucial roles in the regulation of blood pressure. These physiological changes collectively contribute to the increase in blood pressure in older individuals (Glazier, 2022; Sun, 2015).

This study identified a heightened risk of hypertension among employed individuals. This observation is consistent with research conducted in Indonesia using data from the Indonesian Family Life Society (ISL). Specifically, the Indonesian Family Life Survey (IFLS) established a correlation between extended working hours and an increased propensity to develop hypertension (Andini & Siregar, 2024). Moreover, work-related stress, when combined with prolonged work durations, has been linked to an elevated risk of hypertension among working individuals, as demonstrated in various studies (Li et al. 2017; Landsbergis et al. 2025)

Notwithstanding its contributions, this study has several limitations. First, the nutrient analysis was descriptive in nature and did not accurately represent the actual dietary quality. This limitation is attributed to the fact that the intake data used to calculate the subjects total diet quality score was derived solely from a 24-hour recall, which is insufficiently representative due to its reliance on a single day's measurements. Second, the nutrient database available in Indonesia does not comprehensively encompass all the nutrients necessary for determining the total diet quality score. To address this issue, nutrient data were imported from ASEAN and Singapore databases. Thirdly, the processed foods consumed by the subjects did not include all the nutrient components of the Dietary Approaches to Stop Hypertension (DASH) diet, thereby affecting the subjects diet quality scores. A nutrient imputation approach was used to address this issue.

Conclusion

After adjusting for the interaction between diet quality and body mass index (BMI), waist circumference, age, and occupation, no significant association was observed between changes in diet quality and blood pressure. Nonetheless, a trend indicating an increased risk of hypertension was identified among individuals who experienced a decline in dietary quality. The interaction between diet quality and factors such as poor BMI, central obesity, advanced age, and occupation was associated with an increased risk of developing hypertension.

Education and interventions related to healthy eating habits in the community, especially for those with hypertension, are an important focus going forward, considering the various health impacts that can arise. The comprehensiveness of Indonesia's nutrient database needs to be improved to support various research, specifically in the field of nutrition and health. Furthermore, regulations are needed to include micronutrient information on packaged foods to encourage the public to make wiser food choices and consume more measured amounts.

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