



The association of the dietary approach to stop hypertension (DASH) diet with blood pressure, glucose and lipid profiles in Malaysian and Philippines populations

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Abstract *Background and aim:* Despite a growing body of evidence from Western populations on the health benefits of Dietary Approaches to Stop Hypertension (DASH) diets, their applicability in South East Asian settings is not clear. We examined cross-sectional associations between DASH diet and cardio-metabolic risk factors among 1837 Malaysian and 2898 Philippines participants in a multi-national cohort.

Methods and results: Blood pressures, fasting lipid profile and fasting glucose were measured, and DASH score was computed based on a 22-item food frequency questionnaire. Older individuals, women, those not consuming alcohol and those undertaking regular physical activity were more likely to have higher DASH scores. In the Malaysian cohort, while total DASH score was not significantly associated with cardio-metabolic risk factors after adjusting for confounders, significant associations were observed for intake of green vegetable [0.011, standard error (SE): 0.004], and red and processed meat (−0.009, SE: 0.004) with total cholesterol. In the Philippines cohort, a 5-unit increase in total DASH score was significantly and inversely associated with systolic blood pressure (−1.41, SE: 0.40), diastolic blood pressure (−1.09, SE: 0.28), total cholesterol (−0.015, SE: 0.005), low-density lipoprotein cholesterol (−0.025, SE: 0.008), and triglyceride (−0.034, SE: 0.012) after adjusting for socio-demographic and lifestyle groups. Intake of milk and dairy products, red and processed meat, and sugared drinks were found to significantly associated with most risk factors.

Conclusions: Differential associations of DASH diet and dietary components with cardio-metabolic risk factors by country suggest the need for country-specific tailoring of dietary interventions to improve cardio-metabolic risk profiles.

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Introduction

The Dietary Approaches to Stop Hypertension (DASH) diet, recommended by the American Heart Association and the National Institutes of Health in the U.S. for managing blood pressure and protecting heart health [1,2], and based on typical American diets, is high in fruits, vegetables and low-calorie dairy products (e.g., milk), and low in total and saturated fat, and cholesterol [3]. Evidence from randomized controlled trials and prospective cohort studies in Western populations has demonstrated the DASH diet's benefits on blood pressure, plasma glucose, lipid profiles as well as risk of and mortality from cardiovascular disease (CVD) [4–12].

However, the applicability of DASH diets in Asian settings is not clear. The DASH diet is rich in low-fat dairy products (e.g., milk), while lactose intolerance is especially prevalent among East Asians [13]. Given that Asia is culturally, ethnically and nutritionally heterogeneous, there is a need to study the effects of DASH diet in different Asian populations. Previous studies have shown reduced risk of stroke associated with DASH-style diet among Taiwanese, and lower prevalence of hypertension among South Koreans with sodium-reduced DASH diet [14,15]. While two Iranian randomized controlled trials reported that consumption of DASH diet was associated with improvements in blood pressure, glucose and lipid profiles [4,5], another Iranian study found non-significant changes in fasting plasma glucose between the DASH and control diet [16]. Currently, data on the DASH diet in the South East Asian region is limited. Since the DASH indexes used in previous Asian studies vary in the food/nutrient items (e.g., sodium, alcohol) chosen for inclusion, the generalizability of their findings to the South East Asian settings may be restricted. This study, therefore, examined the cross-sectional association between a DASH dietary pattern and blood pressure, fasting lipid profile and fasting glucose level in the Malaysia and Philippines cohorts from the LIFE course study in CARDiovascular disease Epidemiology (LIFECARE).

Methods

LIFECARE is a multi-national longitudinal study that aims to examine the relationship between psycho-social characteristics, lifestyle factors and cardiovascular risk factors in four southeast Asian countries (Malaysia, Indonesia, Philippines and Thailand). Individuals (aged 18–50 years) without history of pre-existing CVD or malignancy were eligible to participate. Pregnant or lactating women were excluded from participation. As detailed dietary

information was only available for the Malaysian and Philippines cohorts, the current analysis was restricted to baseline survey data from these two countries.

Study population

Ethics approval was obtained from the Medical Research & Ethical Committee of the Ministry of Health Malaysia for the Malaysian cohort, and the Institutional Review Boards of the National Institutes of Health at the University of the Philippines Manila and Cardinal Santos Medical Centre for the Philippines cohort. Written informed consent was obtained from all participants prior to study initiation. The Malaysian cohort was recruited from Kuching city and Sarawak between January 2010 and December 2011 through invitations to companies and schools to recruit their employees; outreach to local village heads to encourage participation; and by approaching attendees and visitors at the Clinical Research Centre at the Sarawak General Hospital. The Philippines cohort was recruited from urban and rural communities in Metro Manila and 4 nearby provinces between March 2009 and May 2011. Eight villages were randomly selected from each municipality in the study region, and households and individuals randomly selected from each village and household, respectively. A total of 2533 individuals from Malaysia and 3072 individuals from Philippines were recruited.

Data collection

The National Nutrition and Health Survey (NNHes) instrument was adapted to collect data on personal and socio-demographic characteristics, smoking and alcohol consumption [17]. All standardized questionnaires were in English, Bahasa Malaysia (Malaysia) or Tagalog (Philippines), and interviewer-administered. Information on race was only collected in Malaysia.

Anthropometric and blood pressure measurements

Weight and height were assessed by a SECA 755 stadiometer at the Malaysia study site, and by a Detecto weighing scale and a Tanita Height Measurement (MICRO-TOISE), respectively at the Philippines site. All measurements were made after removing shoes and any heavy objects.

Seated resting systolic (SBP) and diastolic (DBP) blood pressures were measured by Accoson sphygmomanometers at the Malaysia site, and OMRON IA2 blood pressure monitors at the Philippines site.

Biochemical measurements

Fasting venous blood samples were obtained from all participants, and sent to biochemistry laboratories at Sarawak General Hospital, Malaysia and Philippines General Hospital, Philippines, respectively, for storage and analysis. Levels of fasting plasma glucose (FG), serum total cholesterol (TC), triglyceride (TG), and high-density lipoprotein cholesterol (HDL-C) were assessed by COBAS Intergra analyzer; LDL-C was measured using COBAS Intergra analyzer in the Philippines, and was calculated using the Friedewald formula in Malaysia. The coefficients of variation for FG, HDL-C, TC and TG ranged between 1.95 and 2.25%, 3.91–4.84%, 2.06–2.09% and 2.29–2.44%, respectively.

Dietary assessment and DASH score

All participants completed an interviewer-assisted self-administered 22-item food frequency questionnaire, which is suitable for large-scale international epidemiological studies, and focused on specific food groups in the DASH diet rather than individual food items/preparations that may differ by countries (refer to [Appendix 1](#)). Participants were asked to first indicate the frequency of food intake, and record their exact number of consumption per month, week or day. The DASH score, based on the scoring system created by Fung et al. [9], was constructed. This scoring was chosen as it is the only scoring system that includes sodium, and computes a DASH score based on the directly reported food groups. Other reported scoring systems either do not include sodium intake [18,19], or rely on nutrient databases to derive estimates of nutrient intake, which may be difficult to compute as our questionnaire only captured broad food groups and not individual dishes consumed [20]. Eleven of the 22 food groups were summed and re-categorized into 8 major components: Red and Processed Meats (i.e., fresh meat, processed/pre-cook/tinned meat, and processed fish items), Sweetened Beverages (i.e., fruit juice/sweetened drinks), Sodium Intake (i.e., salty snacks, condiments and seasonings), Fruits, Vegetable, Nuts and Legumes, Dairy Products, and Whole Grain. Whole Grain component was not available in the Philippines site, and was subsequently excluded from DASH score calculation. For the remaining 7 components, we classified participants into quintiles according to their intake ranking within their country. Four healthy components were scored from 1 to 5, with higher score indicating higher consumption. The three less healthy components (Red and Processed Meats, Sweetened Beverages, and Sodium Intake) were reverse coded before summation, with higher scores indicating lower consumption. The modified DASH score ranged from 7 to 35.

Statistical analysis

Prior to data analysis, we excluded individuals who were younger than 18 years, on anti-hypertensive or lipid medication, had history of diabetes or CVD, or had

incomplete data on key health measures. The final analysis included 1837 participants (73%) from Malaysia and 2898 participants (94%) from the Philippines. FG, TC, HDL-C, LDL-C and TG were log-transformed to achieve a normal distribution. Body mass index (BMI) was calculated as the weight divided by the square of the body height. We performed chi-square tests to examine differences between DASH score categories, and socio-demographic and lifestyle factors in each country. We assessed the independent association of total DASH score and CVD risk factors using three multivariable linear regression models. Model 1 adjusted for age and gender, while Model 2 further adjusted for education, employment status, smoking, alcohol drinking, stress, financial stress, exercise, urban/rural area, and race (only available from Malaysia). Model 3 controlled for all model 2 covariates and additionally for BMI. In order to correct for multiple tests, crude p-values were adjusted using the Benjamini–Hochberg correction [21], with significance level at adjusted p-value < 0.05. Regression results were expressed as the mean difference in the CVD risk factors per 5-unit increase in DASH score. Further sensitivity analyses were performed to assess the impact of unmeasured confounding on our effect estimates that were found to be statistically significant in Model 2, using the R “obsSens” package [22,23]. All statistical tests were two-sided with the level of significance defined as p-value < 0.05. All analyses were performed in the statistical environment R Software, version 3.1.2 (R Development Core Team, Vienna).

Results

Participants in both countries were on average 35 years old, with nearly 60% of participants being female ([Table 1](#)). Most Malaysian participants (88%) were urban residents, whereas the Philippines participants were mainly rural residents (74%). Levels of FG and TG were higher for the Philippines cohort, but TC, LDL-C and DBP were higher for the Malaysian cohort. The Malaysian cohort consumed higher amount of fruits and vegetables, and the Philippines cohort consumed more milk and dairy products, sugared drinks, and sodium (e.g., condiments). In both countries, participants in the highest DASH score quintile, implying the “best” diet, tended to be relatively older (i.e., aged 40–50), female, or exercise more regularly and not drink alcohol, as compared to those in the lowest quintile ([Tables 2 and 3](#)). Higher percentages of Malaysian participants from the highest quintile were non-smokers and had lower financial stress compared to those in the lower quintiles. Race was examined only in the Malaysian cohort, with lower percentage of Chinese in the higher DASH quintile. More Philippines participants from the highest quintile were unemployed compared to those in the lowest quintile.

Associations between DASH score and cardio-metabolic risk factors for Malaysia and Philippines are summarized in [Fig. 1](#). In the Malaysian cohort, a 5-unit increase in DASH score was only statistically significantly

Table 1 Characteristics of participants in the LIFECARE cohort in Malaysia and Philippines.

Parameters	Malaysia (N = 1837)	Philippines (N = 2898)
Age, years (mean \pm SD)	35.17 \pm 8.06	35.58 \pm 8.55
Age group, years, N(%)		
18–29	556 (30.27)	851 (29.37)
30–39	717 (39.03)	1061 (36.61)
40–50	564 (30.70)	986 (34.02)
Sex, N(%)		
Male	746 (40.61)	1264 (43.62)
Female	1091 (59.39)	1634 (56.38)
Race, N(%)		
Malay	303 (16.49)	NA
Chinese	891 (48.50)	
^a Bumiputra Sarawak	591 (32.17)	
^b Others	52 (2.83)	
Area, N(%)		
Urban	1617 (88.02)	751 (25.91)
Rural	220 (11.98)	2147 (74.09)
CVD biomarkers (median, IQR)		
SBP (mmHg)	117.0 (109.0–125.0)	117.5 (108.5–128.9)
DBP (mmHg)	77.0 (70.0–82.5)	70.0 (63.5–78.5)
FG (mmol/L)	4.80 (4.50–5.10)	5.11 (4.71–5.59)
TC (mmol/L)	5.28 (4.67–5.98)	4.66 (4.00–5.38)
HDL-C (mmol/L)	1.41 (1.19–1.68)	1.12 (0.92–1.35)
LDL (mmol/L)	3.25 (2.67–3.91)	2.87 (2.27–3.48)
TG (mmol/L)	1.03 (0.75–1.54)	1.19 (0.86–1.71)
Dietary quality		
DASH score (mean \pm SD)	20.19 \pm 3.71	19.85 \pm 3.80
DASH score (median, IQR)	20.00 (18.00–23.00)	20.00 (17.00–22.00)
Components of DASH score (times/day) (median, IQR)		
Fruits	0.43 (0.29–1.00)	0.29 (0.14–0.57)
Green vegetables	2.00 (1.00–2.00)	0.29 (0.14–0.57)
Nuts & legumes	0.14 (0.07–0.43)	0.14 (0.03–0.14)
Milk and dairy products	0.29 (0.03–1.00)	0.42 (0.07–1.07)
Red and processed meat	0.43 (0.14–1.00)	0.50 (0.29–0.86)
Sugared drinks	0.29 (0.07–0.43)	0.43 (0.14–1.00)
Sodium intake		
Salty snacks	0.14 (0.03–0.43)	0.29 (0.07–0.43)
Condiments and seasonings	0.14 (0.03–0.43)	1.00 (0.43–2.00)

Abbreviations SD = standard deviation; IQR = interquartile range; CVD = cardiovascular diseases; SBP = systolic blood pressure; DBP = diastolic blood pressure; FG = fasting glucose; TC = total cholesterol; HDL-C = high-density lipoprotein cholesterol; LDL-C = low-density lipoprotein cholesterol; TG = triglyceride.

^a Bumiputra Sarawak includes Bidayuh, Iban and 25 other ethnic groups in Sarawak.

^b Includes Indian and those races not from Sarawak (Sabah Bumi, Dusun, Kedazan, Brunei).

associated with a 0.012 unit-reduction in TC in model 1 adjusting for age and gender, though the association became non-significant in model 2 and 3 where we additionally adjusted for socio-demographic and lifestyle groups and BMI ([Supplementary Table 1](#)). Of the individual components of DASH score examined, increased green vegetable intake was associated with lower TC and LDL-C level in model 1, and these associations remain significant upon adjusting for BMI (model 3). Green vegetable intake was also significantly and positively associated with BMI in model 1. Increased intake of red and processed meat was significantly associated with lower SBP, TC, LDL-C and BMI, and higher HDL-C, whereas increased sodium intake was associated with reduction in FG in model 1. These associations, however, were non-significant in model 2 and 3.

The evidence for an association between DASH score and CVD risk factors was stronger in the Philippines cohort

([Supplementary Table 2](#)). A 5-unit increase in DASH score was significantly and inversely associated with SBP and DBP, FG, TC, LDL-C, TG and BMI in models 1 and models 2 adjusting for socio-demographic and lifestyle groups. Further adjustment of BMI (model 3) rendered most of these associations non-significant, except for those with DBP and FG. Of the individual components, increased green vegetable intake was associated with lower HDL-C level in model 1 and 3. Increased milk and dairy intake was associated with lower SBP, TG and BMI, and higher HDL-C in both models 1 and 2, and with DBP in model 2. Yet, these associations became non-significant after adjusting for BMI (model 3). Higher red and processed meat intake was associated with DBP and BMI in model 2, and the association with DBP was significant upon adjusting for BMI (model 3). Finally, intake of sugared drinks was positively associated with TC, LDL-C, irrespective of model construct; and sugared drinks was also

Table 2 Associations of socio-demographic characteristics with DASH quintile, Malaysia cohort.

DASH quintile	Q1	Q2	Q3	Q4	Q5	p-value [€]
Mean (SD)	15.49 (1.55)	18.50 (0.50)	20.48 (0.50)	22.49 (0.50)	25.58 (1.67)	
Age group						
18–29	117 (39.1)	106 (30.3)	101 (27.9)	96 (29.6)	75 (21.6)	<0.0001
30–39	179 (39.5)	142 (40.6)	149 (41.2)	109 (33.6)	138 (39.8)	
40–50	97 (21.4)	102 (29.1)	112 (30.9)	119 (36.7)	134 (38.6)	
Sex						
Male	220 (48.6)	159 (45.4)	133 (36.7)	121 (37.4)	113 (32.6)	<0.0001
Female	233 (51.4)	191 (54.6)	229 (63.3)	203 (62.7)	234 (67.4)	
Education attainment						
None to primary	28 (6.2)	18 (5.1)	22 (6.1)	30 (9.3)	21 (6.1)	0.4669
Secondary	253 (55.9)	195 (55.7)	201 (55.5)	164 (50.6)	201 (57.9)	
Tertiary	172 (38.0)	137 (39.1)	139 (38.4)	130 (40.1)	125 (36.0)	
Employment status						
Employed/self-employed	426 (94.0)	317 (90.6)	330 (91.1)	292 (90.1)	312 (89.9)	0.5251
Unemployed	26 (5.7)	33 (9.4)	31 (8.6)	31 (9.6)	34 (9.8)	
^a Others	1 (0.0)	0 (0.0)	1 (0.0)	1 (0.0)	1 (0.0)	
Race						
Malay	67 (14.8)	45 (12.9)	57 (15.7)	69 (21.3)	65 (18.7)	0.0013
Chinese	247 (54.5)	184 (52.6)	178 (49.2)	134 (41.4)	147 (42.4)	
^b Bumiputra Sarawak	132 (29.1)	112 (32.0)	119 (32.9)	111 (34.3)	117 (33.7)	
^c Others	7 (1.5)	9 (2.6)	8 (2.2)	10 (3.1)	18 (5.2)	
Area						
Urban	416 (91.8)	311 (88.9)	315 (87.0)	269 (83.0)	305 (87.9)	0.0059
Rural	37 (8.2)	39 (11.1)	47 (13.0)	55 (17.0)	42 (12.1)	
Smoker						
No	337 (74.4)	277 (79.1)	298 (82.3)	273 (84.3)	301 (86.7)	<0.0001
Yes	116 (25.6)	73 (20.9)	64 (17.7)	51 (15.7)	46 (13.3)	
Alcohol						
No	221 (48.8)	182 (52.0)	210 (58.0)	208 (64.2)	233 (67.2)	<0.0001
Yes	232 (51.2)	168 (48.0)	152 (42.0)	116 (35.8)	114 (32.8)	
Exercise						
None	245 (54.1)	172 (49.1)	173 (47.8)	127 (39.2)	122 (35.2)	<0.0001
Little	156 (34.4)	135 (38.6)	130 (35.9)	146 (45.1)	161 (46.4)	
Moderate	42 (9.3)	37 (10.6)	48 (13.3)	34 (10.5)	51 (14.7)	
Daily	10 (2.2)	6 (1.7)	11 (3.0)	17 (5.2)	13 (3.7)	
Level of financial stress						
None/little	171 (37.7)	158 (45.1)	166 (45.9)	150 (46.3)	179 (51.6)	<0.0001
Moderate	236 (52.1)	175 (50.0)	173 (47.8)	160 (49.4)	159 (45.8)	
High/severe	46 (10.2)	17 (4.9)	23 (6.4)	14 (4.3)	9 (2.6)	
Stress at work or home						
Never experienced stress	76 (16.8)	67 (19.1)	61 (16.8)	69 (21.3)	75 (21.6)	0.7285
Some period of stress	280 (61.8)	219 (62.6)	223 (61.6)	197 (60.8)	204 (58.8)	
Several periods of stress	80 (17.7)	52 (14.9)	68 (18.8)	47 (14.5)	59 (17.0)	
Permanent stress	17 (3.7)	12 (3.4)	10 (2.8)	11 (3.4)	9 (2.6)	

€ P values for chi-square test. Bold text indicates a statistically significant difference with $p < 0.05$.

^a Others employment status includes retired, on disability/social security and student.

^b Bumiputra Sarawak includes Bidayuh, Iban and 25 other ethnic groups in Sarawak.

^c Includes Indian and those races not from Sarawak (Sabah Bumi, Dusun, Kedazan, Brunei).

linked to FG in model 1, and BMI in model 1 and 2. [Supplementary tables 3–9](#) show the result of sensitivity analysis accounting for unmeasured confounding. While the sensitivity analyses generally suggest that DASH score itself is beneficial, unmeasured confounding exists when it has moderate or greater correlation with the DASH score, and has a greater risk difference for increasing the cardio-metabolic parameters.

Discussion

This study found that the DASH dietary pattern and its association with cardio-metabolic profiles differed by

country, with significant within-country variations by socio-demographic characteristics. DASH score was significantly associated with TC in the Malaysian cohort, which may be driven by the significant association observed for intake of green vegetable, and red and processed meat with TC. In the Philippines cohort, DASH score was significantly linked to all but HDL-C. Upon adjusting for socio-demographic and lifestyle groups, intake of milk and dairy products, red and processed meat, and sugared drinks had significant associations with most cardio-metabolic risk factors.

Intakes of fruits was clearly low in both countries. However, Philippine participants reported substantially

Table 3 Associations of socio-demographic characteristics with DASH quintile, Philippines cohort.

DASH quintile	Q1	Q2	Q3	Q4	Q5	p-value [€]
Mean (SD)	15.24 (1.75)	18.54 (0.50)	20.48 (0.50)	22.47 (0.50)	25.69 (1.73)	
Age group						
18–29	280 (35.3)	176 (31.9)	179 (29.0)	112 (24.6)	103 (21.5)	<0.0001
30–39	279 (35.2)	212 (38.5)	228 (36.9)	169 (37.1)	173 (36.1)	
40–50	234 (29.5)	163 (29.6)	211 (34.1)	175 (34.1)	203 (42.4)	
Sex						
Male	389 (49.1)	229 (41.6)	274 (44.3)	175 (38.4)	197 (41.1)	0.0020
Female	404 (51.0)	322 (58.4)	344 (55.7)	281 (61.6)	282 (58.9)	
Education attainment						
None to primary	142 (17.9)	120 (21.8)	130 (21.0)	105 (23.0)	101 (21.1)	0.0871
Secondary	354 (44.6)	253 (45.9)	305 (49.4)	209 (45.8)	219 (45.7)	
Tertiary	297 (37.5)	178 (32.3)	183 (29.6)	142 (31.1)	159 (33.2)	
Employment status						
Employed/self-employed	569 (71.7)	350 (63.5)	410 (66.3)	300 (65.8)	321 (67.0)	0.0028
Unemployed	214 (27.0)	189 (34.3)	194 (31.4)	154 (33.8)	156 (32.6)	
^a Others	10 (1.3)	12 (2.2)	14 (2.3)	2 (0.04)	2 (0.04)	
Area						
Urban	211 (26.6)	150 (27.2)	156 (25.2)	116 (25.4)	118 (24.6)	0.8618
Rural	582 (73.4)	401 (72.8)	462 (74.8)	340 (74.6)	361 (75.4)	
Smoker						
No	560 (70.6)	390 (70.8)	449 (72.7)	323 (70.8)	360 (75.2)	0.4159
Yes	233 (29.4)	161 (29.2)	169 (27.4)	133 (29.2)	119 (24.8)	
Alcohol						
No	277 (34.9)	222 (40.3)	247 (40.0)	205 (45.0)	225 (47.0)	0.0002
Yes	516 (65.1)	329 (59.7)	371 (60.0)	251 (55.0)	254 (53.0)	
Exercise						
None	582 (73.4)	387 (70.2)	401 (64.9)	327 (71.7)	303 (63.3)	0.0057
Little	127 (16.0)	88 (16.0)	124 (20.1)	71 (15.6)	95 (19.8)	
Moderate	64 (8.1)	51 (9.3)	57 (9.2)	38 (8.3)	56 (11.7)	
Daily	20 (2.5)	25 (4.5)	36 (5.8)	20 (4.4)	25 (5.2)	
Level of financial stress						
None/little	278 (35.1)	188 (34.1)	197 (31.9)	150 (32.9)	165 (34.4)	0.7799
Moderate	432 (54.5)	301 (54.6)	361 (58.4)	254 (55.7)	272 (56.8)	
High/severe	83 (10.5)	62 (11.3)	60 (9.7)	52 (11.4)	42 (8.8)	
Stress at work or home						
Never experienced stress	127 (16.0)	89 (16.1)	97 (15.7)	80 (17.5)	101 (21.1)	0.1761
Some period of stress	539 (68.0)	364 (66.1)	441 (71.4)	312 (68.4)	310 (64.7)	
Several periods of stress	101 (12.7)	79 (14.3)	58 (9.4)	53 (11.6)	55 (11.5)	
Permanent stress	26 (3.3)	19 (3.4)	22 (3.6)	11 (2.4)	13 (2.7)	

[€] P values for chi-square test. Bold text indicates a statistically significant difference with $p < 0.05$.

^a Others employment status includes retired, on disability/social security and student.

higher intakes of sugared drinks and sources of sodium (salty snacks, condiments and seasonings) compared to Malaysian participants, consistent with previously reported taste preferences in this population [24]. We found higher DASH scores among older participants, women, non-drinkers and those who exercised, which may be explained by greater knowledge and positive attitudes towards healthier eating in these sub-groups [5,14]. Our findings are in line with previous work that suggests the co-existence of healthy behaviors, and that people adopt patterns of health-related behaviors, rather than individual behaviors [25].

In Malaysia, Chinese participants had the lowest DASH score, which may be attributable to varying socio-cultural and religious influences on dietary practices between ethnic groups, and is consistent with ethnic variations reported elsewhere [26]. Financial stress was inversely associated with DASH score in Malaysia. Similar associations between stress and poor diet quality and

higher energy intake have been reported previously in Latino and Hispanic adults [27]. Stress may lead to overconsumption of highly palatable calorie-dense foods in favor of healthier choices, due to emotion-rather than hunger-driven eating [28,29]. The different stresses associated with diet between countries may relate to the different social settings from which participants were drawn in each country.

Consistent with previous studies [1,4,5,8,30], significant associations were found between DASH scores and several cardio-metabolic risk factors. TC was consistently associated with DASH scores in both countries, while blood pressure, LDL-C and FG were also associated with DASH scores in the Philippines. There were also differences in terms of which dietary components were associated with specific risk factors between the countries. In Malaysia, TC and LDL-C was inversely associated with intake of green vegetables, whereas these factors were linked to intake of sugared drinks in the Philippines. Intake of sugared drinks

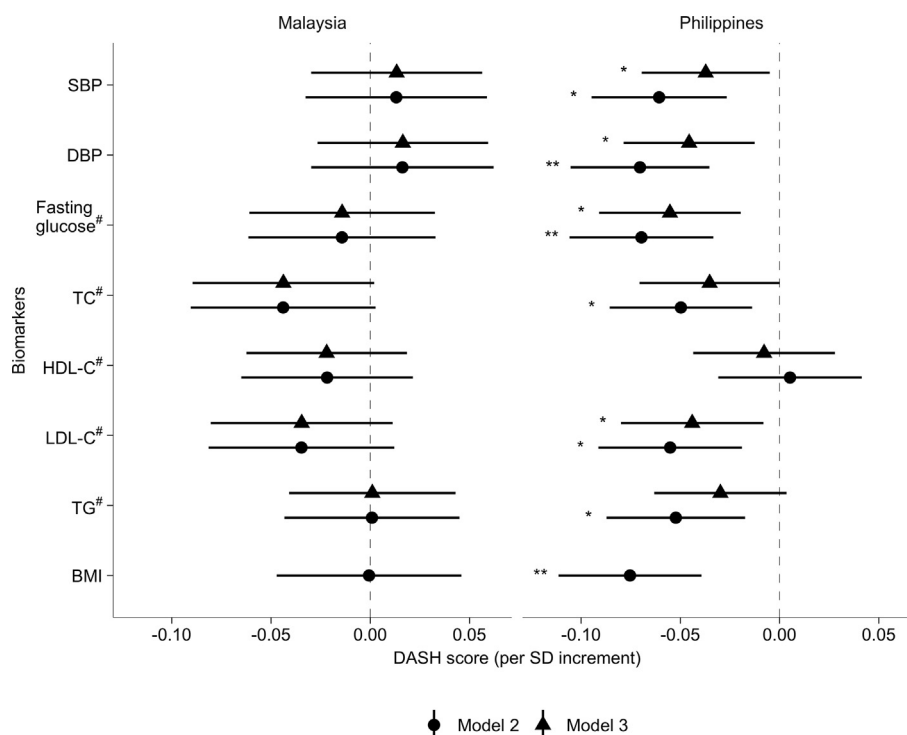


Figure 1 Standardized regression coefficient (95% CI) for the association between DASH score and CVD biomarkers by country. Model 2: Additional adjustment for education, employment status, smoking, alcohol drinking, stress, financial stress, exercise and urban/rural area; Model 3: Additional adjustment for BMI. Benjamin & Hochberg was applied to adjust the p-values for multiple comparisons. Significance level at * $p < 0.05$, ** $p < 0.001$.

was also associated with FG levels. This mirrored the level of intake of these specific food groups in the respective countries. Dairy intake was associated with lower TG levels in both countries, but meat intake was associated with higher blood pressure only in the Philippines. Our findings suggest that it may be important to tailor specific dietary advice and target specific food groups based on dietary patterns of the local population in order to effectively reduce population risk.

Limitations of our study include its cross-sectional nature, so that causal inferences cannot be drawn. Food frequency intake of participants were self-reported, which may subject to reporting errors [28,31]. Measurement errors cannot be eliminated; though interviewers were trained to elicit dietary history, and excluded participants with known chronic diseases were excluded in order to minimize such error. Another limitation is that the food frequency questionnaire used in our study was not validated and contained only 22 broad food groups. A more comprehensive version of the questionnaire containing wider selections of food items might have yielded more precise estimates of the relationship between dietary pattern and cardio-metabolic parameters. However, the questionnaire was tailored to local diets, and therefore may be a more accurate capture of the dietary patterns. While the questionnaire focused on frequency, rather than quantity, of food-group intake [32], frequency is generally more important than portion size information in nutritional epidemiology, particularly after adjusting for age and gender [33]. Also, comparison of levels of intake of diet components between our study and previous studies

are difficult given the differences in dietary assessment methods used. Last but not least, unmeasured confounders could influence our conclusions under certain conditions.

In conclusion, higher DASH score was associated with lower TC levels in Malaysia and the Philippines. LDL-C, FG and blood pressure levels were also inversely associated with DASH score in the Philippines. Older individuals, women, those not consuming alcohol or undertaking regular physical activity were more likely to report a DASH-like diet/healthier diet. The cardio-metabolic associations with DASH diet and dietary components varied by country, suggesting the need for country-specific tailoring of dietary interventions to improve cardio metabolic risk profiles. These associations should be investigated in future longitudinal studies to confirm our findings and establish temporal associations.

Conflict of interest

There are no conflicts of interest among the authors.

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Disclaimer

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Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.numecd.2018.04.014>.

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