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Is the diet of a middle income country sustainable ? An exploratory study from Malaysia

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Abstract:

A sustainable diet which is healthy and environmental friendly is a climate change mitigation option in addition to being a health promoting diet. However, there is a scarcity of information if the Asian diets are sustainable. Therefore, this study aimed to investigate if the diet of the Malaysian population is healthy and sustainable. This is a cross sectional study using dietary data generated from food frequency questionnaires (FFQ). The carbon footprint data were linked with the food items/ food groups in the FFQ. The nutrients of the participants' diet were computed and the proportions of those who met the recommended nutrients intake were established. Contribution of carbon footprint for different food groups and total carbon footprint for each participant's diet were computed and expressed as $kgCO_2eq$. Comparison of carbon footprint from participants' diets between age, sex and ethnicity were carried out. A total of 4825 participants were included in the analysis. Majority were Malays (66.4 %), females (84.0%), married (80.0%) and in the age groups of 30s to 40s (68.8%). The mean total energy intake was 2485 ± 1000 kcal/day. Only 40 to 60% of all participants achieved the Malaysia Recommended Nutrient Intake (RNI) for calcium and less than half of the female participants who were aged 50 years and below fulfilled the RNI for iron. The most commonly consumed food groups were vegetables (270g/day), wheat, rice, fruits, sugar, seafood, poultry, legumes, snacks, milk and beef (46g/day). Total carbon footprint from the participants' diets were 2.96 $kgCO_2eq$/day, with the highest contributions of carbon footprint from rice, vegetables, beef, sugar, other cereals, poultry, seafood, wheat, milk, fruits, legume and snacks. Subgroups such as males, Malays and younger participants were more likely to consume diets with higher carbon footprint, compared to their counterparts. The participants' diet was low in carbon footprint and environmentally friendly, however the quality of diet may need to be improved. Education measures should be targeted for all population and specifically for the sub-groups that consumed diets with higher carbon footprint.

(330 words)

Keywords – sustainable diet, carbon footprint, recommended nutrient intake, Malaysia

Introduction:

Climate change is a great threat to human globally. Malaysia, an upper middle income country, has also experienced climate change with extreme temperature and severe floods that damaged public infrastructure, caused mortality and morbidity among the population. Significant reductions in greenhouse gas emissions (GHGE) need to be achieved to limit global warming of 2 °C to avoid dangerous climate change (IPCC, 2014). Globally, it is estimated that the food system accounted for a quarter of all GHGE (IPCC, 2014). While reducing GHGE in the food system may mitigate climate change, it is recognised that dietary intakes of population need to be changed in order to achieve these targets (Macdiarmid, 2013).

Food system contributes to 19%–29% of the anthropogenic GHGE globally (Vermeulen, Campbell, & Ingram, 2012). Shift on dietary pattern was recommended to reduce environmental impact from food system (Hallström, Carlsson-Kanyama, & Börjesson, 2015). Shifting the typical Western diet to a more sustainable dietary pattern may reduce 70% to 80% of GHGE and land use with 50% reduction in water use (Aleksandrowicz, Green, Joy, Smith, & Haines, 2016). Western diet is commonly labelled as diets with high calorie, high consumption in red meat (such as beef and mutton), saturated fat, sodium or salt, sugar or sweetened beverages, highly processed foods; and low consumption in complex carbohydrates (such as wholemeal products, nuts, legumes, fruits and vegetables). According to the latest commissioned report by EAT and Lancet (W. Willett et al., 2019), diets with an appropriate caloric intake and consist of a diversity of plant-based foods, low amounts of animal source foods, unsaturated rather than saturated fats, and small amounts of refined grains, highly processed foods, and added sugars; are the solutions for the human health and environmental sustainability goals.

The current global focus is to improve diet quality while reducing the environmental impact simultaneously (Conrad et al., 2018). Diets with higher quality have been connected with lower environmental impact in terms of greenhouse gas, water use and land use (Conrad et al., 2018; He, Baiocchi, Hubacek, Feng, & Yu, 2018; Prates, 2017). Assessment of GHGE is necessary in measuring the environmental impact of diet. Most studies that measured GHGE from diets were from the Western countries. Meanwhile, only a few similar studies are found in the Asia region, namely from China and India.

Stylianou et al reported that most studies assessed the environmental impact of diets without their nutritional effects (Stylianou et al., 2016). Measurement of GHGE from dietary patterns in India showed that diet with rice and meat emitted the highest environmental impact compared to others (Green et al., 2018). Another study by Song, Li, Semakula, and Zhang (2015) reported pork, rice and vegetables as the food with highest environmental footprint for diet in China. However, both studies focused solely on environmental impact of diets and missed the health or nutritional aspect from the diet, which is a crucial component to assess in sustainable diet. On the other hand, putting up nutritional goals without consideration for the environment may worsen the environment by increasing GHGE (Florent Vieux, Perignon, Gazan, & Darmon, 2018). Therefore, assessment of sustainable diets should comprise both nutritional and environmental impacts.

In the midst of global GHGE problem, food insecurity and malnutrition emerged from global dietary transition of more fat and oil, refined sugar and meat, resulted in higher rates of non-communicable diseases (Tilman & Clark, 2014). It is a challenge for food system to comprehend the global demand of providing healthy food for nine to ten billion people by 2050 without harming the environment (Godfray et al., 2010). In addition to the existing issue of global food supply, climate change is threatening food security by affecting crop production in certain parts of the world (Sabaté, Harwatt, & Soret, 2016). Hence, a sustainable diet that incorporates both health benefits and less environmental impact which is applicable to the present and future generation, was introduced.

In addition, a sustainable diet which is healthy and environmental friendly (with low greenhouse gas emission) is a climate change mitigation option that requires relatively little investment in technology or infrastructure. Similar diets have also been proposed in the latest EAT-Lancet commission report (W. Willett et al., 2019). A sustainable diet can result in concurrent reductions in environmental and health impacts globally and in most regions, particularly in high-income and middle-income countries (Springmann et al., 2018). A sustainable diet can achieve per capita GHGE reduction of 25-50% in the United Kingdom (Macdiarmid et al., 2012).

GHGE or carbon footprint is widely used as an environmental indicator to assess the climate impact from diet (Ridoutt, Hendrie, & Noakes, 2017). Carbon footprint determines the Global Warming Potential of a certain food product based on the amount of the emitted greenhouse gas. The carbon footprint includes the emission of carbon dioxide, methane and nitrous oxide throughout the life cycle (Virtanen et al., 2011). The food products from animal such as beef, mutton, dairy products, poultry and fish emitted more carbon dioxide, higher carbon footprint than the crops (Macdiarmid et al., 2012). Some alternatives to reduce greenhouse gas from diet are by selecting local food products, reduce meat consumption, meat substitution with other protein-rich foods like nuts and pulses (Althaus et al., 2007).

The use of Life Cycle Analysis (LCA) method in quantifying greenhouse gas emission from food source is commonly used. LCA method utilizes cradle- to- grave concept in quantifying the greenhouse gas emitted by goods from various life stages and commonly expressed in carbon dioxide equivalent (CO_2eq) (Hellweg & Milà i Canals, 2014). One of the commonly discussed boundaries on LCA is the extent of the phases involved in the assessment. Most studies stop at the gate or production phase and excluded the consumption and waste management phase (Schau & Fet, 2008), which may underestimate the total carbon footprint of food products. Nevertheless, this method has been widely used in measuring environmental impact in food system as the estimation of carbon footprint at the consumption and waste management phase is complicated. Combination of nutritional quality with LCA is suggested for comparative assessments of dietary patterns from both health and environment aspects (Heller, Keoleian, & Willett, 2013).

Malaysia has gone through rapid industrialization and economic growth in the past decades. The Malaysian diet has changed to be higher in total calorie, fat and sodium as well as lower fibre intake; and coupled with a sedentary lifestyle; the prevalence of obesity and non-communicable diseases (NCDs) has increased markedly. In 2015, the prevalence of overweight and obesity was 30% and 17.7% respectively, with the prevalence of diabetes being 17.5% and hypertension 30.3% (Institute for Public Health, 2015).

There is a lack of awareness in sustainable diet as a driver for health promotion and climate change mitigation in the Malaysian setting. There is also a scarcity of research in the assessment if the Malaysian diet is healthy and sustainable. Information on the contribution of GHGE from the Malaysian diet is lacking. Therefore, this study was initiated to investigate if the current diet of the Malaysian population is healthy and sustainable by studying both environmental and nutritional aspects.

Objectives

A sustainable diet in the context of this study includes only health (dietary recommendations) and reduced GHGE in terms of carbon footprint. The general objective was to determine the factors associated with carbon footprint and compliance to the Malaysian Recommended Nutrient Intake. The specific objectives were to :

a) Describe the energy, macro- and micro-nutrients (of Public Health importance) intake of the participants
b) Compute the carbon footprint of the participants' diet
c) Describe the commonly consumed food groups and food groups that contributed to carbon footprint
d) Determine the factors associated with carbon footprint of participants' diet
e) Determine the participants' compliance to the Malaysian Recommended Nutrient intake

Methods:

Study Design & Sampling Method

This was a cross sectional study using secondary data from an existing cohort of teachers from the Clustering of Lifestyle Risk Factors and Understanding its Association with Stress on Health and Well-Being among School Teachers (CLUSTer) study in Malaysia (Moy et al., 2014). This study is a prospective cohort study designed to investigate the clustering of lifestyle risk factors and stress, and subsequently, to follow-up the population for important health outcomes. Participants were selected through multistage sampling, where six out of 12 states in Malaysia were randomly selected, and teachers from 70% of public schools in all districts of the selected states were invited. Eligible participants were teachers with permanent employment in the selected public schools. The data used in this study was collected in 2014-2016 from three states in Peninsular Malaysia (ie: Wilayah Persekutuan Kuala Lumpur, Selangor and Johor) using a validated food frequency questionnaire (FFQ).

Food frequency questionnaire (FFQ)

The FFQ consisted of 136 food items with a combination of raw, cooked and mixed dishes. Information on beef, poultry, and fish was categorized by typically used cooking methods such as deep-fried, cooked with coconut milk, cooked without coconut milk, grilled/roasted, or steamed. The serving sizes were based on the usual household measurements according to the food atlas from Shahar *et al* (Shahar, Safii, Manaf, & Haron, 2009). Colour photographs of serving size for selected food items were attached with the FFQ to improve the estimation of serving size. The participants were required to write for each food item the number of times per day, week, month or year as well as the number of serving size in a specified unit that they typically consumed over the past year. The frequency intake specified as weekly, monthly and yearly was converted to daily. The daily intake of the nutrients for each food item was calculated using the product-sum method (WC. Willett, 2012). The Nutritionist Pro software (Axxya Systems, 2006) with nutrients' values based on the Malaysia Food Composition Database (Tee, Ismail, Nasir, & Katijah, 1997) were used for nutrient computation. The participants' most commonly consumed food items were reported. Their intakes on total energy / calorie, macro-nutrients (ie: carbohydrate, protein and fat) and public health important micro-nutrients (ie: iron, calcium and Vitamin C) were computed and compared with the Malaysian Recommended Nutrient Intake (RNI). Proportions of participants meeting the RNI were established. Comparisons of participants meeting the RNI were also carried out between age, sex, ethnicity and rural/urban setting.

Carbon footprint data

Data on carbon footprint from foods were obtained from the Ecoinvent database (Althaus et al., 2007) as there is no available local carbon footprint data. Additional carbon footprint data on fruits and vegetables were obtained from Thailand LCA database (MTEC, 2015) due to its availability of carbon footprint data for local fruits like *durian*, *rambutan* and mangosteen. The estimation of carbon footprint covered the boundaries of cradle to gate or production. Details on carbon footprint on food items are shown at Appendix A.

The carbon footprint data were linked with the food items in the FFQ. Similar to study conducted by Berners-Lee, Hoolohan, Cammack, and Hewitt (2012), the weight of the food items from the FFQ were multiplied with the available data on carbon footprint (CO_2 eq) per 100g food before being summed up for the total diet. Contribution of carbon footprint for different food groups and total carbon footprint for each participant's diet were computed and expressed as kgCO_2eq (GHG weighted by global warming potential over a 100-year time frame). Global warming potential over 100 year time (GWP_{100}) was recommended by the Intergovernmental Panel on Climate Change (IPCC) as a meaningful environment metric for climate impact assessment and it is widely used (Ridoutt et al., 2017).

The highest contributors for carbon footprint were presented. Median carbon footprint values were used as the cut-off values to categorise the diets into categories of high or low carbon footprint since there is no established standards in Malaysia as well as the Asian countries. Comparison of carbon footprint from participants' diets between age, sex, ethnicity and rural/urban setting were carried out.

Data analysis

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Data was analysed using SPSS version 21. Data was described using means ± standard deviation, proportions and frequencies. Comparison of means were carried out using independent t-test (two groups) and ANOVA (three groups). Multivariate Logistic Regression was carried out to adjust for potential confounders. Odds ratio (OR) with 95% confidence interval were reported. Significant level was pre-set at 0.05.

Ethics clearance

Ethics clearance was obtained from the Medical Ethics Committee of the University Malaya Medical Centre (reference no. 950.1). Approval was also granted by the Malaysia Ministry of Education, education departments in all the selected states, and principals of all participating schools. All participants provided written informed consent.

Results

Characteristics of participants

A total of 4825 participants were included in the analysis (Table 1). The participants were majority Malays (66.4 %), females (84.0%), married (80.0%), had a degree (72.1%) and in the age groups of 30s to 40s (68.8%).

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Table 1: Socio-demographic characteristics of participants

Variables		n (%)
State	WPKL	2033 (42.1)
	Selangor	1922 (39.8)
	Johor	870 (18.0)
Sex	Male	772 (16.0)
	Female	4053 (84.0)
Age groups	<30 years	734 (15.2)
	30-39 years	1630 (33.8)
	40 – 49 years	1690 (35.0)
	≥ 50 years	771 (16.0)
Race	Malays	3202 (66.4)
	Chinese	1237 (25.6)
	Indians	358 (7.4)
	Others	28 (0.6)
Marital status	Single	645 (13.4)
	Married	3858 (80.0)
	Divorce/Widowed	124 (2.6)
Education level	Diploma	1042 (21.6)
	Degree	3480 (72.1)
	Master /PhD	303 (6.3)
Area	Urban	3220 (66.7)
	Rural	1605 (33.3)

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Energy, macro- and micro-nutrients

From the obtained secondary data, diets with total calorie less than 500 and more than 5,000 kcal (extreme values) were excluded. The total energy intake was 2485.6±1000.3 kcal/day with males taking higher calories than the females (Table 2). The contribution of macronutrients for total calorie were about 48% for carbohydrates, 18% protein and 33% fat. The mean nutrients intakes in total energy, protein, vitamin C, calcium and iron are presented in Table 2. There were significant differences in energy, % macronutrients and micronutrients between gender. When the participants' nutrients (vitamin C, calcium and iron) intake were compared with the Malaysian Recommended Nutrients Intake (RNI) (Nutrition, 2017), only 40 to 60% of all participants achieved the RNI for calcium (Figure 1) and less than half the female participants who were aged 50 years and below fulfilled the RNI for iron (Figure 2). On the other hand, all participants fulfilled the RNI for vitamin C (Figure 3).

Table 2: Total energy and percentage macronutrients intakes of participants

	Total	Male (817)	Female (4229)	p value
Energy (kcal/d)	2485.61±1000.28	2598.27±988.24	2464.15±1001.24	0.001
% Carbohydrates	48.63±7.52	50.2±7.43	48.3±7.50	<0.001
% Protein	18.09±3.58	17.50±3.55	18.20±3.58	<0.001
% Fat	33.27±5.66	32.29±5.35	33.45±5.70	<0.001
Vitamin C (mg/d)	161.10±152.53	140.72±116.51	164.99±158.18	<0.001
Calcium (mg/d)	1643.64±1738.61	1365.46±1222.61	1696.63±1815.68	<0.001
Iron (mg/d)	31.13±16.16	32.23±15.92	30.92±16.20	0.038

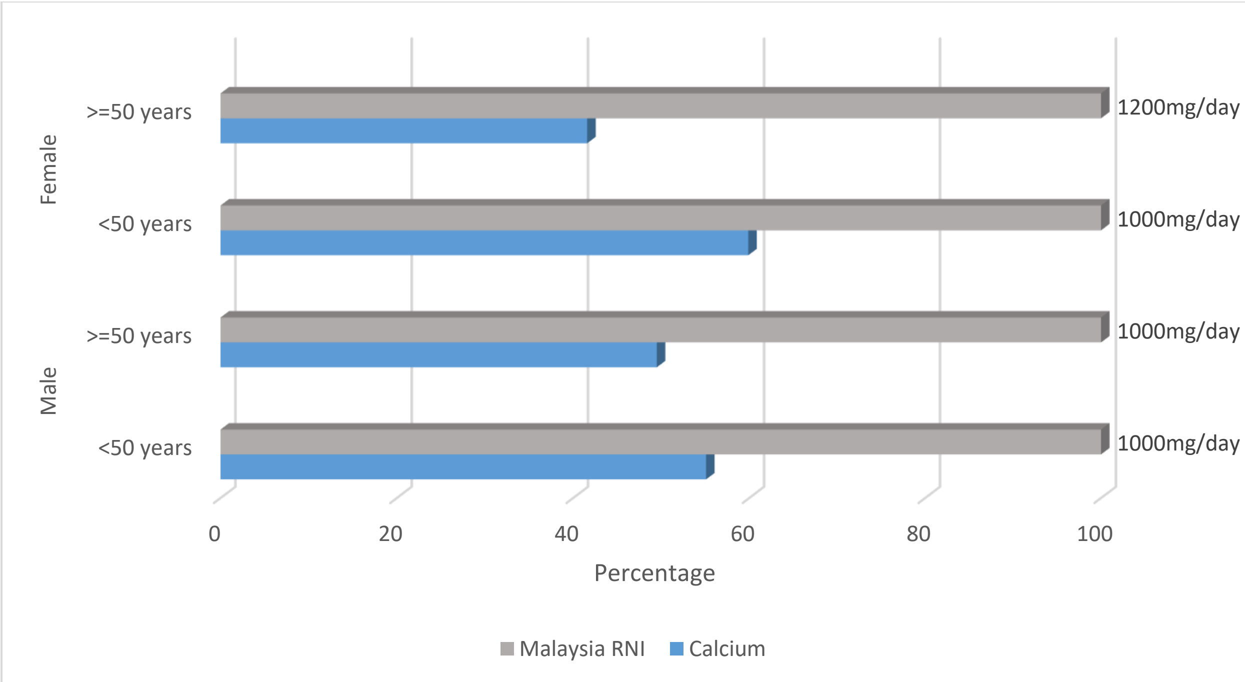

Figure 1: Proportions of participants who achieved the Malaysian Recommended Nutrients Intake (Calcium)

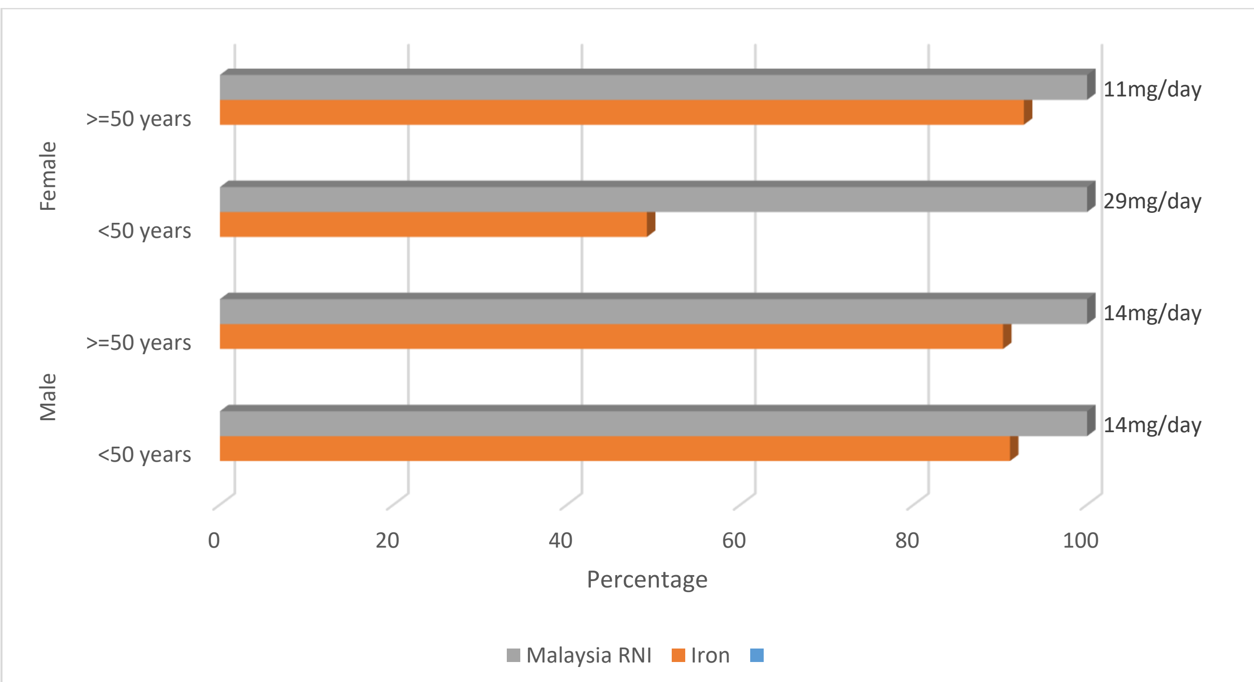

Figure 2: Proportions of participants who achieved the Malaysian Recommended Nutrients Intake (Iron)

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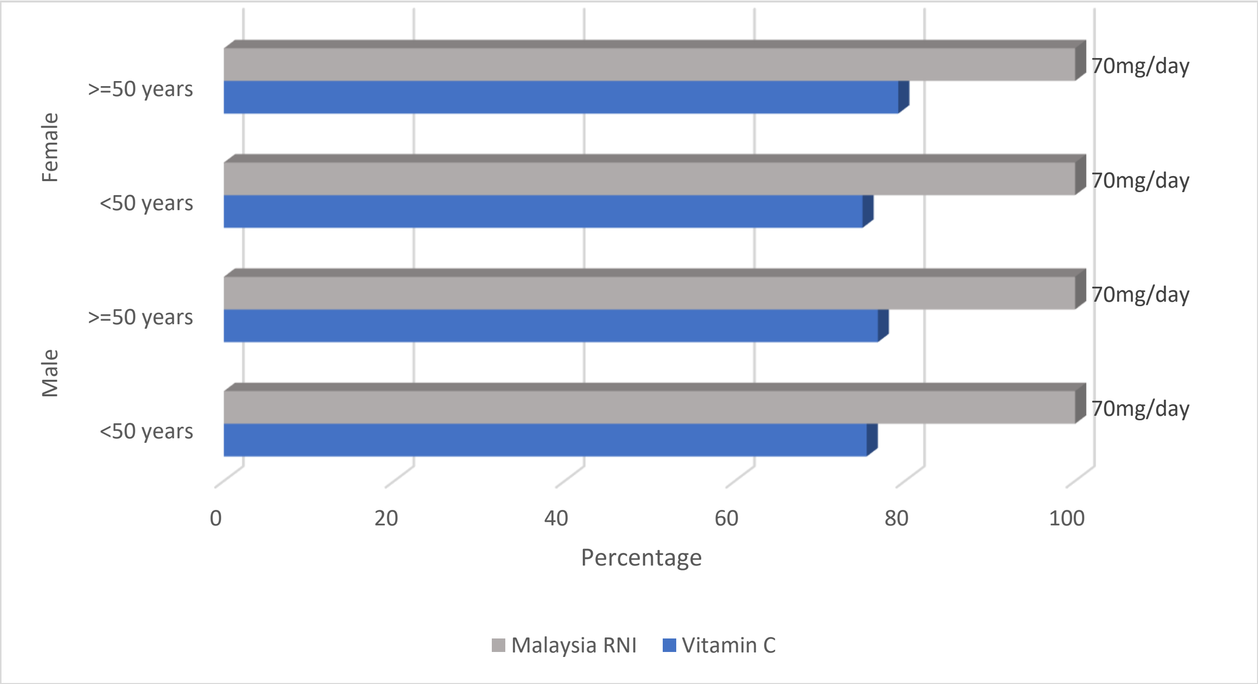

243 Figure 3: Proportions of participants who achieved the Malaysian Recommended Nutrients Intake
244 (Vitamin C)

245

Commonly consumed food groups

The most commonly consumed food groups were vegetables (270g/day), wheat, rice, fruits, sugar, seafood, poultry, legumes, snacks, milk and beef (46g/day) (Figure 4). Total vegetables were contributed by leafy vegetables (74%) and root vegetables (26%). For wheat, 70% were from noodles and 30% from bread. Fish contributed 75% of total seafood consumption, with the rest from shellfish. Snacks were mainly local dessert /"kuih" (56%), curry puffs (16%), doughnuts (13%), biscuits (12%) and cakes (4%). Sugar was mostly contributed by sweetened beverages (92.5%) with only 7.5% from simple sugar added to meals/drinks.

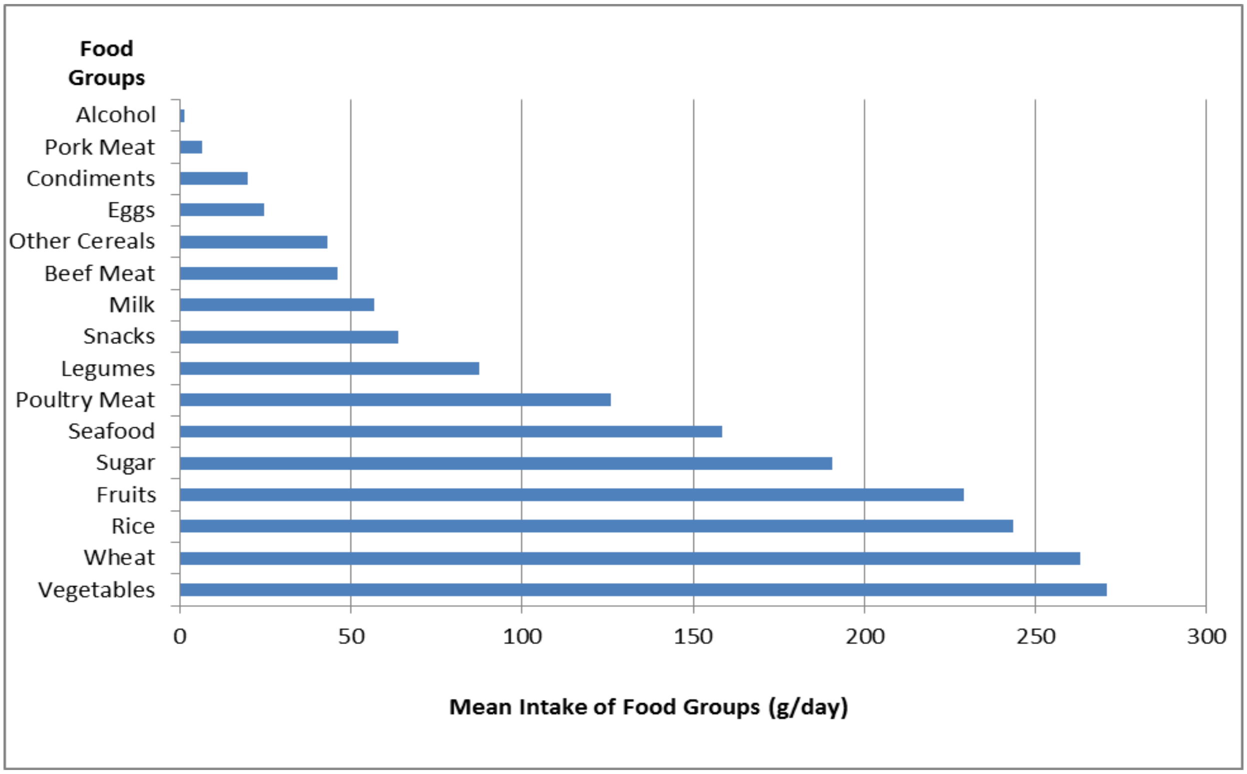

Figure 4: Mean intake of food groups (g /per day)

Carbon footprint contributors

The mean total carbon footprint from the participants' diets was 2.96 kgCO_2eq/day. The highest contributions of carbon footprint were from rice, vegetables, beef, sugar, other cereals, poultry, seafood, wheat, milk, fruits, legume and snacks (Figure 5).

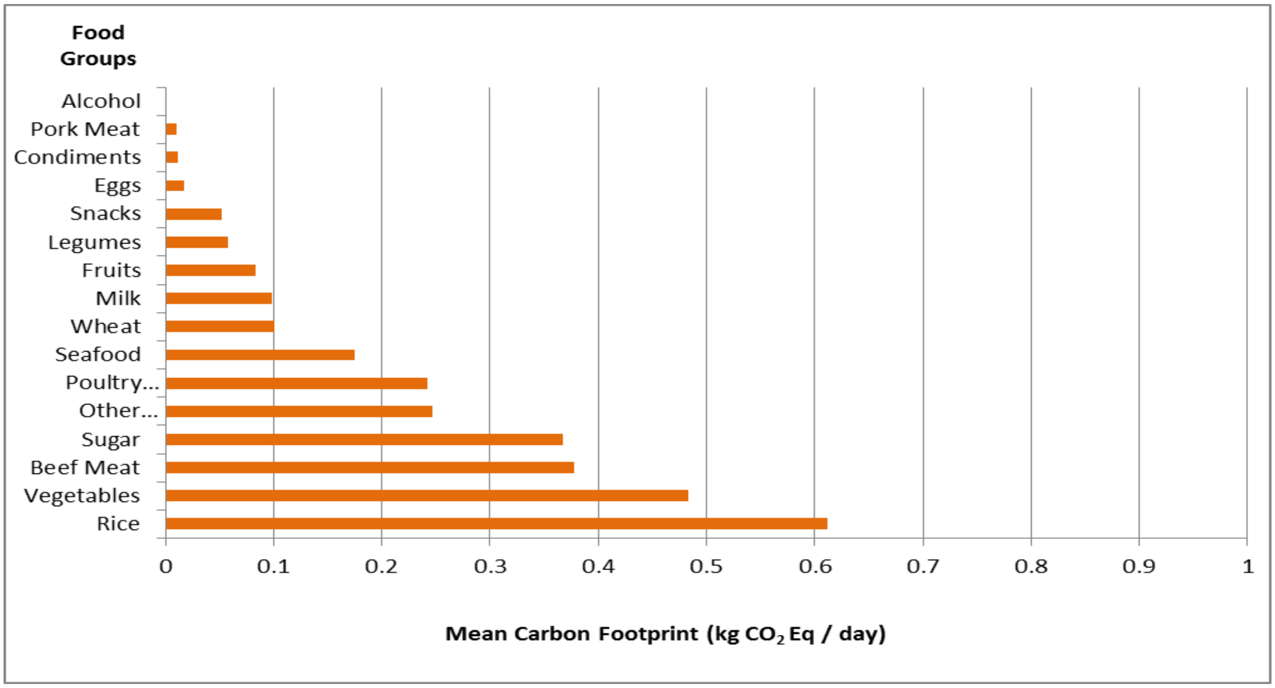

Figure 5: Contribution of carbon footprint from food groups (kgCO_2eq/day)

Carbon footprint by sub-groups

Participants in their fifties, Chinese and Indians, females and those residing at the urban area had lower mean dietary carbon footprint compared to their counterparts (Table 3). After adjusted for age, sex, ethnicity and urban rural setting (Table 4); older (age $\geq$50 years) participants, females and Chinese / Indian ethnic participants were found to be more likely to consume diets with lower carbon footprint.

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Table 3: Mean carbon footprint (kgCO_2 Eq /day) of participants

	n	Mean	p value
Urban	3220	2.89±1.58	0.001
Rural	1605	3.05±1.60	
*Age group (n=5046)			
<30	734	3.07±1.57[a]	<0.001
30-39	1630	3.07±1.66[ab]	
40-49	1690	2.92±1.56[b]	
≥50	771	2.62±1.48[c]	
*Ethnic group			
Malays	3202	3.18±1.63[a]	<0.001
Chinese	1237	2.46±1.41[b]	
Indians	358	2.54±1.36[b]	
Others	28	2.33±0.93	
Males	772	3.27±1.71	<0.001
Females	4053	2.88±1.56	

*Different alphabets (a,b,c,d) denote significant difference between groups

Table 4: Association of socio-demographic characteristics with categories of carbon footprint

(n=4825)	n	Crude OR (95% CI)	*Adjusted OR (95% CI)
Urban	3220	0.76 (0.67,0.86)	0.99 (0.88, 1.14)
Rural	1605	1.0	1.0
Age group (years)			
<30	734	1.0	1.0
30-39	1630	0.93 (0.78, 1.11)	0.94 (0.79, 1.12)
40-49	1690	0.83 (0.70, 0.98)	0.83 (0.69, 0.99)
≥50	771	0.55 (0.45, 0.68)	0.61 (0.50, 0.75)
Ethnic group*			
Malays	3202	1.0	1.0
Chinese	1237	0.39 (0.34, 0.45)	0.42 (0.36, 0.48)
Indians	358	0.47 (0.38, 0.59)	0.49(0.39, 0.61)
Others	28	0.41 (0.19, 0.90)	0.44 (0.20, 0.97)
Sex			
Males	772	1.54 (1.31, 1.80)	1.41 (1.19,1.66)
Females	4053	1.0	1.0

*adjusted for age group, ethnic group, sex and urban/rural setting

Discussion

Most of the participants' intakes in vitamin C and iron fulfilled the Malaysian RNI (Nutrition, 2017) except females less than 50 years old who did not achieve the RNI for iron. The participants' intake in calcium only achieved about half of the Malaysian RNI. The participants' diet had lower carbon footprint compared to the West. The reasons could be due to the participants' diets had very low intakes in beef, milk and dairy products. Although the dietary carbon footprint was low, subgroups such as males, Malays and younger participants were more likely to consume diets with higher carbon footprint, compared to their counterpart. These findings may be the first in the country as well as the South East Asia region, and may serve as a platform for future research.

The participants were in the age groups of 30s to 50s, majority females, with tertiary education. These were the characteristics of teachers in Malaysia. Their diets were higher in fats (more than 30%) while protein and carbohydrates were within recommendations. Most participants achieved the Malaysian RNI (Nutrition, 2017) for vitamin C and iron, except females aged less than 50 years old. Similar findings were reported from the Malaysian Nutrition Survey which found lower intake of iron and calcium than the Malaysian RNI, particularly among women (Mirnalini et al., 2008). Females in their reproductive age group had higher RNI for iron, recommended to cater for their needs during pregnancy and lactation. These women should be educated on the types of iron rich foods and ways to increase these foods.

Half of the participants did not achieve the RNI for calcium. As these participants did not consumed much milk and dairy products due to their cultural dietary pattern, intervention measures should be taken to encourage them to consume calcium rich vegetables such as mustard leaves, spinach and cabbage. In addition, milk consumption of at least one to two servings per day should also be promoted to increase the calcium content in their diets. The moderate recommended milk consumption is based on the compromise of its health / nutrition and environmental impact. Large increase of milk consumption will inevitably increase the carbon footprint of a diet. Therefore, a combination of plant and animal sources of calcium will improve the quality as well as reduce the environmental impact of the diet.

Meanwhile, white rice, sugar, fish and vegetables remained as the top food items consumed by Malaysian adults over 11 years (2003 to 2014) (Kasim, Ahmad, Bin, & Aris, 2018). As per the norms of an Asian diet, rice is the most consumed food item as it is the staple food of the country (Kasim et al., 2018) . Noodles (from wheat) and sugar were other highly consumed food items. These two food items were refined carbohydrates and have poorer diet quality compared to complex carbohydrates. High intakes of refined carbohydrates are associated with overweight/ obesity as well as higher rates of non-communicable diseases (Tokunaga et al., 2012) such as diabetes, hypertension, ischemic heart diseases and certain types of cancers. Brown rice rich with vitamins and minerals should be promoted. The participants should be educated on the adverse effects of high consumption of sweetened beverages and desserts rich with sugar. They should be encouraged to reduce sugar in their beverages and select desserts with less sugar.

Seafood (fish) was the main animal source of protein, followed by poultry, similarly as reported by other local studies (Ooraikul, Sirichote, & Siripongvutikorn, 2008). Consumption of beef and pork was low due to religious reasons, as most Chinese and Indians may not take beef while pork was forbidden among the Muslims. Dairy intakes were low as Malaysians were found to take less milk (Hin & Khor, 2011). Therefore, the contribution of greenhouse gas emissions in terms of carbon footprint of the participants' diet was low compared to Australia (14 kg CO_2 eq/day) (Hendrie, Ridoutt, Wiedmann, & Noakes, 2014), United Kingdom (5.7 kg CO_2 eq/day) (Murakami & Livingstone, 2018), France (4.17 kg CO_2 eq/day) (F. Vieux, Darmon, Touazi, & Soler, 2012) and Netherlands (3.9 kg CO_2 eq/day) (Temme et al., 2015). The western diets are usually high in beef, milk and dairy products which are the main contributors of greenhouse gas. Our findings in dietary carbon foot print were comparable with a study from China (Song et al., 2015) as well as vegan's diet (2.89 kg CO_2 eq/day) from the United Kingdom (Scarborough et al., 2014). These observed difference may be due to different dietary practices, cultural or religions, as well as source of LCA database used in the carbon footprint computation (Veeramani, Dias, & Kirkpatrick, 2017). Although carbon foot print data from other countries were used, our findings were comparable with other Asian countries such as China (Song et al., 2015).

The main contributors of greenhouse gas in this study were rice, vegetables and beef. Although rice contributed to low amount of greenhouse gas (Xu & Lan, 2016), the high quantity of rice consumption contributed to the high level of carbon footprint in the diet. The same was applied to vegetables. On the other hand, although beef consumption was low, the high carbon footprint of beef per se contributed large amount of carbon footprint in the diet. Similar pattern was also found in a study on greenhouse gas emission from food consumption in India (Vetter et al., 2017).

As Malaysia is located by the coast, fish is the main source of protein in our diet. Although the carbon footprint from fish may be lower than beef and poultry, there is some concern in the high consumption of fish. The Sustainable Development Goals on "Responsible Consumption & Production" (Leal Filho et al., 2018) may be compromised if no actions are taken on controlling the amount of fish consumed by the population. There may be no sustainability of fish stock supply for the future generations. Measures in educating the public regarding sustainable fish source and types should be taken, as recommended by WWF (WWF Malaysia, 2013). However, this issue cannot be addressed in the current study as we did not collect data in this aspect. In addition, there are no measures taken by the authorities to enforce on the determination of the source or origin of fish consumed.

Although the carbon footprint from the participants' diet was low, there is a need to further explore the sub-groups that consumed diets with higher carbon footprint. The Malay participants had the highest carbon footprint in their diet compared to the Chinese and Indian participants who avoided beef for religious reasons. Generally, Malays consumed more meat as compared to Chinese and Indians, for both rural and urban settings in Malaysia (Tey, Mad Nasir, Alias, Zainalabidin, & Amin, 2008). However, among the Chinese and Indian participants who did not consume beef, the Indian participants' diet had higher carbon footprint compared to the Chinese, probably due to the higher energy consumption among the Indians which contributed to higher carbon footprint. Females and older age group ($\geq$ 50 years) had lower carbon footprint may be due to their lower intake in total calories, or they were more health conscious and opted for less meat or animal source protein in their diets. Similar findings on gender and age differences were reported among Irish adults (Hyland, Henchion, McCarthy, & McCarthy, 2016).

Limitations and strengths

These findings should be interpreted cautiously as there are a few limitations which need to be addressed. First, the study population may not represent the general population as they are teachers with higher education status. Second, the carbon footprint data are not local data, there may be discrepancies in the values. Using non local carbon footprint data in the computation of carbon footprint in the Malaysian diet may cause under- or over-estimation. However, this was inevitable as currently there is no local carbon footprint data available. The findings may serve as an estimation of the environmental impact of the Malaysian diet. Further research should be embarked on working out the carbon food print of local food items in the country.

In addition, carbon footprint as a proxy for GHGE does not represent the full range of environmental impacts associated with a diet. Water deprivation, land degradation, and biodiversity loss which are environmental areas of concerns were not included. However, all the above mentioned data are unavailable and that was not part of our research questions.

On the other hand, this study may be the first of its kind in Malaysia or South East Asia. To the best of the authors' knowledge, we have yet to find a similar published paper form Malaysia or South East Asia. These findings may provide the platform for future research to build on. More work should also be started on the issues of sources of fish and its consumption.

Conclusions:

The participants' diet was low in carbon footprint and environmentally friendly, however the quality of diet may need to be improved. Although most participants achieved the RNI for the public health important nutrients (iron, calcium and vitamin C), the intakes of refined carbohydrates such as white rice, noodles and sugar were high. High intake of fish may be good for health but poses threat in sustainability issues for the future generation. Certain sub-groups (Malays, younger age group and males) tended to consume diets with higher carbon footprint, compared to their counterparts. Education measures should be targeted for all population and specifically for the above-mentioned sub-groups.

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