ORIGINAL ARTICLE

Ultra-processed Food Consumption in Relation to BMI and Body Fat Percentage of Adults in Terengganu

Asma' Ali, Nurul Atiqah Khasbullah, Fauziah Tufail Ahmad, Hayati Mohd Yusof

School of Food Science & Technology, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Malaysia

ABSTRACT

Introduction: There is an emergent increase of ultra-processed food consumption in developing countries including Malaysia which carries a likelihood towards the increase of obesity. However, few studies have been done in relating between ultra-processed consumption and obesity, especially in Malaysia. Therefore, this study aims to determine the consumption of ultra-processed foods and its relationship with BMI and body fat percentage among university committee in Kuala Nerus, Terengganu. **Methods:** A cross-sectional study was performed among 167 individuals aged 18 to 59 years old in Kuala Nerus. Data were collected using a researcher-administered questionnaire which consisted of three different sections: socio-demographic profile, two days 24-hour dietary recall, and nutritional status assessment on BMI and body fat percentage. Consumption of ultra-processed foods were determined by classifying two days 24-hour dietary recall based on ultra-processed food classification. Data were analyzed using SPSS version 21.0 with $p<0.05$ to indicate significant. **Results:** The results showed Group 4 (ultra-processed foods) contributes 23% of overall daily energy consumption while Group 1+2 (unprocessed or minimally processed food + culinary ingredients) and Group 3 (processed foods) had contributed 75% and 2% respectively. Results showed that there was no relationship found between the ultra-processed food consumption and nutritional status through spearmen correlation at $p<0.05$. **Conclusion:** It is evidently clear from the findings that the consumption of ultra-processed foods is providentially still low among the respondents.

Keywords: Ultra-processed food, BMI, Body fat percentage, Terengganu, Malaysia

Corresponding Author:
Asma' Ali, PhD
Email: asma.ali@umt.edu.my
Tel: +609-6684969

INTRODUCTION

NOVA (a name, not an acronym) food classification is an emerging approach to determine contribution of each food groups especially ultra-processed foods groups and its relation to nutritional status or diet-related diseases (1). NOVA classification is one of the superlative techniques recognized by the Food and Agriculture Organization of the United Nations and the Pan American Health Organization as a valid tool to observe ultra-processed food (UPP) consumption (2) that can be associated to the nutritional status of an individual. In Brazil, studies using NOVA have shown an association between consumption of UPP with obesity (3,4). While in Canada, NOVA classification has been carried out to determine trends of their population dietary patterns, and the effect of ultra-processed foods on markers of nutrient profile of diets (5). In Chile, it has been performed to measure the impact of ultra-processed foods consumption on the diet quality (6). NOVA characterized all foods consumed into its four distinguish groups which are categorized according to their degree of processing (7,8).

Ultra-processed foods are convenient to consume anywhere, as they are usually portable and time-saving (3). As stated by Monteiro et al. (8), the focal goal of industrial ultra-processing is to produce goods that are ready to eat, ready to drink or to heat, accountable to substitute Group 1 and Group 2 which are minimally processed. Despite the rising number of these ultra-processed foods, they do have an obesogenic nutrient profile according to national studies on diets undertaken in the USA, Canada, Brazil and Chile and influence the weight gained of an individual (8). Excess weight is evidently linked with an amount number of diet-related diseases, including cardiovascular disease, type II diabetes mellitus, and high blood pressure. Many studies have shown that obesity and overweight also increase the risk of mortality. The prevalence of obesity among adults in Malaysia from 1996 (4.5%) to 2006 (14%) has increased more than threefold (9). Malaysians have betrothed extensive intensive actions to alleviate the upsurge in obesity prevalence. Yet, the obstacles to reduce obesity prevalence is intimidating as the prevalence of obesity increased by 2.6% in 2015 from 2011. Meanwhile, the prevalence of obesity of adults in Terengganu had increase about 4.8% from 2011 (14.0%) to 2015 (18.6%). However, the association between the

consumption of ultra-processed food and the obesity epidemic is still unclear (5) as scarce studies has been carried out in investigating the percentage of ultra-processed consumption and its relationship towards BMI and body fat in Malaysia. To our knowledge, only one study has been done in Malaysia on ultra-processed consumption, however, that study was restricted by the limited items of the food frequency questionnaire used, that may be unable to gauge all the ultra-processed food consumption (10).

Therefore, this study is crucially vital to be carried out in order to determine ultra-processed food consumption in relation to BMI and body fat percentage among university committee in Kuala Nerus. The relationship must be analyzed to determine whether large quantities of ultra-processed food are inherently obesogenic, especially in Malaysia, as there has been a lack of studies on ultra-processed food consumption. The Malaysian Ministry of Health has highlighted the importance of carrying out studies on the consumption of ultra-processed food to reduce non-communicable disease (NCD) in Malaysia Nutrition Research Priorities, 2016-2020 (11, 12). Thus, this study aims to relate between ultra-processed food consumption, BMI, and body fat among adults in Kuala Nerus.

MATERIALS AND METHODS

Research design

The cross-sectional study had been carried out among university committee in Kuala Nerus, a district in the state of Terengganu, for a duration of two months (July to September 2018). Kuala Nerus was selected through purposive sampling and convenience sampling was used for subject sampling. The eligible criteria for this sample selection was that the respondents must be an adult of a university committee ranging between 18 to 59 years old living in Kuala Nerus. Ethical approval for this research was received from the Human Ethic Board of Committees of Universiti Malaysia Terengganu with reference number: UMT/JKEPM/2017/3. The respondents provided written informed consent document prior to data collection. The minimum sample size for this study was 165 adult respondents based on the Cochran formula (13), given the expected proportion obese people in Terengganu is 28.9% (9).

Research Instruments

The research instrument used in this study was the distribution of questionnaires to the respondents. In the questionnaire, socio-demographic profile data, the consumption of ultra-processed foods using two days 24-hours dietary recall data and nutritional assessment; and height, weight, BMI and body fat percentage were recorded to achieve the objectives stated.

The questionnaire contains three sections: sociodemographic profile, consumption of ultra-processed food and nutritional status assessment. In section A, information such as age, gender, race, religion, marital status, level of education, monthly household, job and frequency of daily cooking routine was obtained. Next, the foods and drinks consumed by the respondents during the past 24-hours were listed on section B for two non-consecutive days, consisting of one weekday and one weekend. This section comprised columns of food items, drinks, detailed on ingredients of foods, preparation of food and serving amount of food taken which they were asked to recall and reported detailed information. Section C consisted of the anthropometry measurements of the respondents, which included the measurement of body weight and body height (using stadiometer Seca 703, Germany), body mass index (BMI) and body fat percentage (using Tanita Bioelectrical Impedence Analysis BC-541, Japan). The BMI calculated was compared with WHO Asian BMI Classification (14), while the body fat was compared to the NIH/WHO guidelines (15).

NOVA classification

The food intakes of respondents were recorded in Microsoft Excel for NOVA classification purposes. There are four groups in the NOVA food classification which is Group 1, Group 2, Group 3 and Group 4. Although the standard NOVA classification has four major classifications, this study combined both Group 1 and Group 2, while Group 3 and Group 4 remain the same. The main justification for combining both Group 1 and 2 is to ease the food classification and reduce errors as meticulously disaggregation of ingredients were required. The foremost aim was to highpoint the contribution of Group 4 prominently. Crino et al. (16) also ease his food classification by categorizing into only two categories, which were unprocessed (consist of unprocessed, minimally processed and processed culinary ingredients) and processed (ultra-processed food products). In this study, the first group is unprocessed or minimally processed food that comprises natural/raw foods or slightly solely treated raw food without any other ingredients like sugar, oil or salt. The second group encompasses processed cooking elements. These are ingredients derived from Group 1 or from nature. The third group is processed food produced by adding sugar, oil or sugar and applying processes manners for instance curing, fermentation, or smoking. The fourth group is ultra-processed food products prepared mainly or completely from manufacturing ingredients and comprising slight or no total foods. Once categorized into their respective NOVA food groups in Microsoft Excel, the average energy intake contributions (%) in each group, Group 1+2, Group 3 and Group 4, were calculated.

Identifying misreporting

Goldberg method was used to identify under-reporters and over-reporters of total energy of respondents. Under-reporters were subjects with estimated values of the ratio

reported energy intake to estimated basal metabolic rate (EIrep:BMRest) below 0.996. Over-reporters were subjects with estimated values of the ratio reported energy intake to estimated basal metabolic rate (EIrep:BMRest) above 2.570. A regression equation of basal metabolic rate for the entire data, including weight and age, was established (17). Individual ratio reported energy intake to estimated basal metabolic rate was calculated using Goldberg formula which ratio reported energy intake to estimated basal metabolic rate (EIrep:BMRest) was equal to average energy intake divided by basal metabolic rate. Thirty-three out of 200 respondents were eliminated in the study as they were below the cut-off limit. Thus, the remaining 167 respondents were evaluated in the study to find the relationship between ultra-processed foods consumptions and its nutritional status (BMI and body fat percentage).

Data Collection

The respondents were approached and asked about their willingness to participate. Once agreed, they were given a set of questionnaires and informed consent forms, and were asked to fill in the Section A by themselves. They were then interviewed for their dietary intake for the past 24 hours from midnight to the previous midnight. The respondents were asked to recall and reported detailed information. For example, if a respondent had a sandwich for breakfast, he/she would be asked about the preparation method, ingredients, type of bread and number of pieces consumed. Visual aids for serving size measurements such as household serving size references (using the Malaysian Food Album) were provided to help respondents in reporting to the utmost precise serving size. Standard household tools such as ladle, teaspoon, tablespoon, china bowl, glass and cup were brought to the respondents during interview sessions to improve the accuracy of food and beverage serving sizes they consumed. The time required to complete a 24-hour dietary recall usually is between 20 and 50 minutes. The recorded food data of 24-hour dietary recall were double checked, and inconsistencies were verified by the time the complete questionnaire was collected, resulting in no missing values. Next, their telephone number was taken for further information about the date and time of nutritional assessment. On the nutritional assessment day, their body mass index and body fat percentage were measured.

Data Analysis

Analysis was performed using IBM SPSS Statistics 20.0. Descriptive test was run to determine the percentage of socio-demographic data, nutritional status and contribution of total energy intake of each groups. Spearman correlation was used to determine the relationship between ultra-processed food consumption and nutritional status (BMI body fat percentage) at $p < 0.05$.

RESULTS

Table I shows that most of the respondents were female (74.9%), married (58.7%) and were predominantly Malay (91.6%); thus, 92.2% were Muslim. About half of the respondents had a degree (44.9%), and a household monthly income of less than RM3000 (48.5%). A majority of the respondents were students (30.5%) and university staff (24.6%). The result also showed that most respondents did not cook everyday (62.3%), while only 37.7% respondents cooked every day. The findings is attributed by the nature of the studied group where majority were students who don't cook or not allowed to cook. Previous studies had inferred that greater home food preparation skills or frequency was associated with lower consumption of ultra-processed food (18).

Table II shows the average energy intake for weekdays, weekends and average of both based on gender- and age-specific factors for descriptive purposes. The average energy intake was from 1635 kcal/day to 2146 kcal/day. What stands out in the table is that the average energy intake for male and female is mostly lower than recommended during both weekdays and weekends. Previous study showed that young adult women living in urban consumed almost 93% of energy RNI (19). This is contradict to a study done among university students where the findings depict that those students had low energy intakes which is below 80% of total energy recommendation by the RNI (17). Despite MANS findings showing reduced of total energy intake, it is somewhat surprising that the trend of overweight and obesity in Malaysia is still escalating (20).

Classification of Energy Intake based on NOVA Classification and its relation to nutritional status of respondents

It is apparent from Table III that ultra-processed food in Group 4 contributes 23% of overall daily consumption in total calories, while Group 1+2 and Group 3 had 75% and 2% contribution respectively. Group 1 and Group 2 were combined because it is the unprocessed food while Group 3 and Group 4 were not combined, even though both are processed food groups, as we need to distinguish between these processed and highly processed foods (UPP) (16).

Table IV shows that 41.3% of respondents have normal BMI, 33.5% are overweight, 15.6% are obese and 9.6% were underweight. The mean BMI was 24.9 ± 5.19 which was in the overweight range of BMI regardless of a slightly higher percentage of respondents having normal BMI. Closer inspection of the table shows that total of overweight and obese respondents was 49.1%, which is greater than the percentage of respondents with normal BMI. Body fat percentage assessment is gender- and age-specific as well BMI. Findings shows that 46.1%

Table I: Socio-demographic profiles of the respondents (n=167)

Socio-demographic Profiles	Distribution (n=167) Frequency (%)
Gender	
Male	42 (25.1)
Female	125 (74.9)
Age	
18-25	52 (31.1)
26-30	30 (18.0)
31-35	43 (25.7)
36-40	24 (14.4)
41-45	7 (4.2)
46-50	5 (3.0)
51-55	5 (3.0)
56-60	1 (0.6)
Race	
Malay	153 (91.6)
Chinese	12 (7.2)
Indian	1 (0.6)
Others	1 (0.6)
Religion	
Muslim	154 (92.2)
Buddhist	11 (6.6)
Hindu	1 (0.6)
Marital status	
Single	66 (39.5)
Married	98 (58.7)
Divorce	2 (1.2)
Widow	1 (0.6)
Educational level	
Secondary school	34 (20.4)
Diploma	37 (22.2)
Degree	75 (44.9)
Master	14 (8.4)
PhD	4 (2.4)
Others	3 (1.8)
Monthly household	
Less than RM3000	81 (48.5)
RM3000-RM3999	36 (21.6)
RM4000-RM4999	20 (12.0)
RM5000-RM5999	16 (9.6)
RM6000 and above	14 (8.4)
Occupation	
Clerk	27 (16.2)
Student	51 (30.5)
Businessman	6 (3.6)
Science officer	8 (4.8)
Security guard	7 (4.2)
Lecturer	2 (1.2)
University staff	41 (24.6)
Technician	4 (2.4)
Others	21 (12.6)
Cooking everyday	
Yes	63 (37.7)
No	104 (62.3)

Table II: Distribution of total energy intake (kcal) (n=167)

Days	Gender	Age group based on RNI	Mean ± SD [a]/ Median (IQR)[b]
Weekdays	Male	19-29	2146 ± 619.77 [a]
		30-59	1948 ± 515.84 [a]
	Female	19-29	1635 ± 485.55 [a]
		30-59	1870 ± 506.31 [a]
Weekends	Male	19-29	2025 ± 504.67 [a]
		30-59	1863 (687.26) [b]
	Female	19-29	1635 (693.00) [b]
		30-59	1908 ± 434.12 [a]
Average weekdays	Male	19-29	2086 ±323.86) [a]
and weekends		30-59	1837 (510.33) [b]
	Female	19-29	1714 ± 312.74 [a]
		30-59	1889 ± 344.26 [a]

a = Mean is used since it is normally distributed
b = Median is used since it is not normally distributed

Table III: Energy Consumption from each group towards total daily energy intake (%) in two days 24-hours dietary recall

Total Energy Intake by NOVA food classification (kcal)	Percentage of contribution from each group towards total daily energy intake (%)	Mean ± SD / Median (IQR)
Total energy intake (kcal)		1821.11 (472.84)
Total energy intake for :		
Group 1 + Group 2 (kcal)	75%	1401.54 ± 415.63
Group 3 (kcal)	2%	8.05 (38.21)
Group 4 (kcal)	23%	370.15 (39.26)

Table IV: Nutritional status (BMI and Body Fat Percentage) of respondents (n=167)

Nutritional status	Distribution (n = 167) Frequency (%)	Mean ± SD
BMI		
Underweight (<18.5)	16 (9.6)	24.9 ± 5.19
Normal (18.5-22.9)	69 (41.3)	
Overweight (23.0-24.9)	56 (33.5)	
Obese (≥ 25)	26 (15.6)	
Body fat percentage		
Under Fat	25 (15.0)	27.1 ± 8.95
Normal	77 (46.1)	
Over Fat	36 (21.6)	
Obese	29 (17.4)	

BMI cut-off points is based on the WHO Asian BMI Classification (14).
Body fat percentage range reference for adults is based on NIH/WHO BMI guidelines as reported by Gallagher et al (15).

were normal, 21.6% were over fat, 17.4% were obese and 15% were under fat. The mean body fat percentage obtained was 27.1 ± 8.95. It reported that most of the respondents had risk to obesity due to the fat percentage level. This result is somewhat counterintuitive as ultra-

processed food consumption among adults in Kuala Nerus contributes only 23% of their total energy intake but most of the respondents had achieved greater BMI than the recommended.

With respect to the aim of this study, it was found that there was no significant relationship between ultra-processed food consumption (UPP) and nutritional status (BMI and body fat percentage) through Spearman correlation at $p < 0.05$ as shown in Table V.

Table V: Relationship between UPP and Nutritional Status (n=167)

Ultra-processed food (Group 4)			
Nutritional status	**Mean ± SD**	**Correlation relation (r)**	**p-value**
BMI	24.9 ± 5.19	-0.004	0.954
Body fat percentage	27.1 ± 8.95	-0.450	0.568

*Spearman correlation is significant at p<0.05

DISCUSSION

Very little was found in previous studies on the consumption of ultra-processed foods in Malaysia namely Terengganu. With respect to the gap, this study was designed to determine the ultra-processed food consumption and its likelihood towards BMI and body fat percentage. As mentioned earlier, diets relatively high in minimally processed foods tend to have the most healthful nutritional profile while diets high in ultra-processed foods is the least healthful profile (7). Ultra-processed foods are hyper-palatable and were designed usually in form of snacks, drinks or ready-to-consume dishes to be consumed anywhere and often. This may gradually cause destruction to the processes that regulate satiety and appetite if prolonged (21). Ultra-processed foods tend to have higher energy density and higher glycemic index which will result in high blood glucose level and subsequently increase in the energy intake (22). This study found that the consumption of ultra-processed foods was about 23%. The percentage of ultra-processed food consumption among adults in Kuala Nerus which was 23% was lower than the percentage of ultra-processed food consumption among Brazilian adolescents and adults which was about 30% (3). This is because unprocessed foods persevere the foremost source of the individual energy intake in Kuala Nerus. A previous study of food consumption in Jakarta indicated that processed or ultra-processed foods have not yet subjugated, and that unprocessed foods are the main source of food consumption in that country (23). In contrast to most high income countries, ultra-processed products have yet to displace the staple foods (24). Thus, in Kuala Nerus, people still consumed mainly food that is mainly unprocessed or minimally processed foods. Even though the percentage of cooking frequency is low, they tend to eat food outside but prefer traditional food rather than fast food.

This finding contradicts previous studies which have suggested that positive associations exist between consumption of UPP and risk of overweight, obesity and markers of metabolic syndrome (3, 4). A 15-year prospective study in the US had found that there was a significant positive correlation between consumption of potato chips, sugar sweetened drinks, and processed meat and long-term weight gain. This 15-year prospective study reveals that fast food intake among young adults had significant changes to their body weight and insulin resistance (3). Contrary to expectations that ultra-processed food consumption has been positively related with obesity prevalence, it does not mean that the obesity is decreasing, as the average BMI of the respondents is higher than the normal BMI recommendation. This discrepancy could be attributed to the short time of dietary recall for two days which may not be relatively sufficient to gauge the actual energy intake of an individual. Moreover, this result may be explained by the fact that the respondents' dietary intake had higher meal portion size and also low physical activity. This explanation may support the hypothesis that less physical activity (25), sedentary lifestyle (26) and occupational changes (27) affects body sizes resulting in an increase in percentage of overweight and obesity not solely depending on consumption of ultra-processed foods. These findings cannot be extrapolated to the entire Malaysian population, as this is the first study done on classifying dietary intake via NOVA approach where few limitations may be presence during the classifying procedures. Therefore, these results therefore need to be interpreted with caution. For instance, the self-reported dietary recall were solemnly reliant on the respondents' ability to remember and their honesty in responding towards the recall. Thus, the outcomes may not disclose the definite dietary consumption of the respondents. Another source of uncertainty is the accuracy of the nutrient intake estimation since the main reference was the Malaysian food composition database which has not been updated for years. The study is somewhat limited by the lack of information on the cooked food items which were not available in the database and has been substituted with raw food sources and ingredients. This may allow possible bias in the nutrient composition assessment. It is recommended that further research be undertaken in the following areas; use different type of dietary methods such as 24-hour dietary record questionnaires and household food purchase that have a clear cut distinction between intakes of Group 1+Group 2, Group 3 and Group 4. The dietary record may be more accurate compared to dietary recall, as the respondents need to complete the forms by themselves. What is now needed is a cross-national study on a larger scale involving other nutritional status to acquire better understanding on the impact of ultra-processed foods consumption.

This study was unable to find any significant relationship between BMI, body fat and consumption of ultra-processed foods. Other studies reveal that

there was a clear association between BMI and intake of ultra-processed foods (28,29). In previous study, high convenience foods consumption among boys at baseline significantly predicted change in increasing body fat percentage as reported β= 0.104 with p-value less than 0.05 (30). Laska et al. (31) showed that there was an affirmative connotation between diet soft drinks consumption and body fat percentage (β-3.64; p<0.001). In a longitudinal analysis also showed that there was a significant relationship between sweetened beverages consumption and body fat percentage (β= 0.73; p=0.001). It is additionally attention-grabbing to note that most of the overweight/obese respondents may be so due to large portions (32) and frequent consumption of high sweetened foods and drinks (33).

An implication of this is the possibility that NOVA approach classification based on the nature of processing has offered different perspectives towards food groupings. Conventionally, the food pyramid has been used as guideline in food classification, but classifying foods based on industrial processing has given a new overview of food consumption through the food processing instead of using the typical types of macronutrients such as carbohydrate, protein and fat in classification. This study has shed contemporary light on the contentious issue of ultra-processed food consumption in Malaysia as highlighted in Nutrition Research Priorities in Malaysia for 11th Malaysia Plan (2016-2020). Therefore, a greater focus on ultra-processed consumption in Malaysia could produce interesting findings that account more for its implications towards the nutritional status of the Malaysian population.

CONCLUSION

It is clear that the adults in Kuala Nerus consumed less ultra-processed foods than unprocessed, minimally processed food and culinary ingredients that had contributed to the majority of their total energy intake. In general, the nutritional status of the respondents was fairly moderate, because their average BMI and body fat percentage were overweight. The results showed that the respondents are prone to the risk of diet-related diseases, despite their low consumption of ultra-processed food compared to the minimally and culinary processed food. There was no significant relationship between ultra-processed food consumption, BMI and body fat percentage. It can be assumed that the nutritional status may not be primarily influenced by the consumption of ultra-processed food, but perhaps from minimally and culinary processed food consumption among the respondents.

ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to all the subjects for their participation, full cooperation and patience during the study. This study was funded under the Universiti Malaysia Terengganu (UMT)'s *Tabung Penyelidik Muda* scheme (No. Vot: 68007/2016/83).

REFERENCES

1. Monteiro CA, Levy RB, Claro RM, Castro IRRD, Cannon G. A new classification of foods based on the extent and purpose of their processing. Cadernos de Saude Publica. 2010;26(11):2039-2049.
2. Monteiro CA, Cannon G, Levy R, Moubarac JC, Jaime P, Martins AP, Canella D, Louzada M, Parra D. NOVA. The star shines bright. World Nutrition. 2016;7(1-3):28-38.
3. Louzada ML, Baraldi LG, Steele EM, Martins AP, Canella DS, Moubarac JC, Levy RB, Cannon G, Afshin A, Immura F, Mozaffarian D, Monteiro CA. Consumption of ultra-processed foods and obesity in Brazilian adolescents and adults. Preventive Medicine. 2015;81:9-15.
4. Carnella DS, Levy RB, Martins APB, Claro RM. Ultra-Processed Food Products and Obesity in Brazilian Households (2008–2009). PloS one 9. 2014;9(3): e92752.
5. Moubarac JC, Martins APB, Claro RM, Levy RB, Cannon G, Monteiro CA. Consumption of Ultra-Processed Foods and Likely Impact on Human Health. Evidence from Canada. Public Health Nutrition. 2012;16(12):2240-2248.
6. Crovetto F, Figueras F, Triunfo S, Crispi F. First trimester screening for early and late preeclampsia based on maternal characteristics, biophysical parameters, and angiogenic factors. Prenat Diagn. 2014;35(2):183-91.
7. Adams SA, Choi SK, Eberth JM, Brandth HM, Friedman DB, Hebert JR. Characterisation of UK diets according to degree of food processing and associations with socio-demographics and obesity: cross-sectional analysis of UK National Diet and Nutrition Survey (2008–12). International Journal of Behavioral Nutrition and Physical Activity. 2015;12(1):160.
8. Monteiro CA, Cannon G, Moubarac JC, Levy RB, Louzada ML, Jaime P. The UN Decade of Nutrition, the NOVA food classification and the trouble with ultra-processing. Public Health Nutrition. 2017;21(1):5-17.
9. National Health & Morbidity Survey. NCD Risk factors. Ministry of Health. 2015.
10. Asma'A, Wan Syakirah Alia WMS, Aziz Y, Hayati MY. Energy contribution of NOVA food groups and socio-demographic determinants of ultra-processed groups among adults in Terengganu, Malaysia. Food Research. 2019;3(6):640-648.
11. National Plan of Action for Nutrition of Malaysia III 2016-2025. Ministry of Health. National Coordinating Committee on Food and Nutrition (NCCFN). 2016.

12. Nutrition Research Priorities in Malaysia. For 11th Malaysia Plan (2016-2020). Ministry of Health Malaysia. 2016.
13. Cochran WG. Sampling Techniques. 2nd Ed. John Wiley and Sons Inc, New York. 1963.
14. WHO Expert Consultation. Appropriate body mass index for Asian populations and its implication for policy and intervention strategies. Lancet. 2004:363:157-163
15. Gallagher D, Heymsfield SB, Heo M, Jebb SA, Murgatroyd PR, Sakamoto Y. Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. The Am. J. of Clinical Nutr. 2000:1;72(3):694-701.
16. Crino M, Barakat T, Trevena H. Systematic review and comparison of classification frameworks describing the degree of food processing. Nutr Food Technol. 2017;3(1):138.
17. Ismail MN, Ng KK, Chee SS, Roslee R, Zawiah H. Predictive Equations for the Estimation of Basal Metabolic Rate in Malaysian Adults. Mal J Nutr. 1998;14:81-90.
18. Lam T, Lenton S, Ogeil R, Burns L, Aiken A, Chickritzhs T, Gilmore W. Most Recent Risky Drinking Session with Austalian Teenagers. Australian and New Zealand Journal of Public Health. 2017;41(1):105-110.
19. Karupaiah T, Swee WCS, Liew SY, Ng BK, Chinna K. Dietary Health Behaviors of Women Living In High Rise Dwellings: A Case Study of an Urban Community in Malaysia. J Community Health. 2013;38(1):163-171.
20. Shahar HT, Mohd Taib MN, Chin YS. Insullin Resistance, Inflammation and Metabolic Syndrome in Normal Weight and Overweight/ Obese Primary School Children. Mal J Nutr. 2018;24(2):153-161.
21. Lee CL, Norimah AK, Mohd Noor I. Association of energy intake and macronutrient composition with overweight and obesity in Malay women from Klang Valley. Malaysian Journal of Nutrition. 2010;16(2):251-60.
22. Monteiro CA, Moubarac JC, Canella D, Louzada ML,Cannon G. Household Availability of Ultra-Processed Foods and Obesity in Nineteen European countries. Public Health Nutrition. 2011;21(1):1-9.
23. Setyowati D, Andarwulan N, Giriwono PE. Processed and Ultra-processed Food Consumption Pattern in the Jakarta Individual Food Consumption Survey 2014. Asia Pac J Clin Nutr. 2014;27(4):840-847.
24. Monteiro CA, Moubarac JC, Cannon G, Ng SW, Popkin B. Ultra-processed Products are Becoming in the Global Food System. Obes Rev. 2013;14:21-28.
25. Wareham NJ, van Sluijs EM, Ekelund U. Physical activity and obesity prevention: a review of the current evidence. Proceedings of the Nutrition Society. 2005;64(2):229-47.
26. Cureau FV, Sparrenberger K, Bloch KV, Ekelund U, Schaan BD. Associations of multiple unhealthy lifestyle behaviors with overweight/obesity and abdominal obesity among Brazilian adolescents: A country-wide survey. Nutrition, Metabolism and Cardiovascular Diseases. 2018;28(7):765-74.
27. Pigeyre M, Dauchet L, Simon C, Bongard V, Bingham A, Arveiler D, Ruidavets JB, Wagner A, Ferrиres J, Amouyel P, Dallongeville J. Effects of occupational and educational changes on obesity trends in France: the results of the MONICA-France survey 1986–2006. Preventive medicine. 2011;1;52(5):305-9.
28. Swinburn BA, Sacks G, Hall KD, McPherson K, Finegood DT, Moodie ML, Gortmaker SL. The global obesity pandemic: shaped by global drivers and local environments. The Lancet. 2011;27;378(9793):804-14.
29. Cunha DB, Costa THM, Veiga GV, Pereira RA, Sichieri R. Ultra-Processed Food Consumption and Adiposity Trajectories in a Brazilian Cohort of Adolescents: ELANA Study. Nutr & Diabetes. 2018;8:28.
30. Alexy U, Libuda L, Mersmann S, Kersting M. Convenience Foods in Children's Diet and Association with Dietary Quality and Body Weight Status. European Journal of Clinical Nutrition. 2011;65:160-166.
31. Laska MN, Murray DM, Lytle LA, Harnack LJ. Longitudinal associations between key dietary behaviors and weight gain over time: transitions through the adolescent years. Obesity (Silver Spring). 2012;20:118–125.
32. Abidin NZ, Zulkepli JH, Zaibidi NZ. The effect of food portion sizes on the obesity prevention using system dynamics modelling. In AIP Conference Proceedings 2014;Sep 12:Vol.1613(1):436-443.
33. Ahmad MH. Food Consumption Patterns: Findings from the Malaysian Adults Nutrition Survey (MANS) 2014. Med. J. Malays. 2014;70(Supplement1).