UNIVERSITY OF SOUTHAMPTON

FACULTY OF MEDICINE

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An Exploration of Dietary Patterns and the Relationship with Obesity in the Malaysian Population

by

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ABSTRACT

FACULTY OF MEDICINE

Public Health Nutrition

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AN EXPLORATION OF DIETARY PATTERNS AND THE RELATIONSHIP WITH OBESITY IN THE MALAYSIAN POPULATION

Asma Ali

Dietary patterns in Malaysia are changing rapidly as a result of the nutrition transition and these changes are potentially leading to an increase of obesity. However, Malaysia lacks studies investigating the association between dietary patterns and obesity using various dietary approaches. This cross-sectional secondary data analysis explored several approaches to characterising the dietary pattern of the Malaysian population and to assess which approach was a better predictor of obesity. Dietary data were collected from a representative sample of 3,063 adults aged between from 18 to 59 years using a validated semi-quantitative Food Frequency Questionnaire (FFQ). Data were analysed using SPSS version 21. Dietary patterns were characterised using three different approaches: The Ultra-Processed Products/Foods (UPP) measure; Principal Component Analysis (PCA); and revised Diet Quality Index (DQI-R). The UPP method groups food consumed into three groups: Group 1 (unprocessed or minimally processed foods) contributed 45.5% of total energy, Group 2 (processed culinary ingredients) providing 19.7% of total energy, Group 1&2 (traditional prepared foods) contributed 5.8%; and Group 3 (ultra-processed products/foods) contributed 29.8% of total energy intake. From the PCA, six dietary patterns were identified: "Traditional", "Prudent", "Modern", "Western", "Chinese" and "Combination". The DQI-R, mean score was 64.6 (SD = 8.2) out of a possible 100 points; the lower the score, the less healthy the diet. There was only weak or no association between each approach to assessing dietary pattern and level of BMI and prevalence of obesity. There were consistent associations found between the unhealthiest dietary patterns and consumption of fat, salt and sugar, and low fibre intake. This suggests that those eating more processed foods have a less healthy diet, even though, at present, this is not linked to excess energy intake and obesity. It will be important to monitor closely the changing patterns of diet in the Malaysian population. It is likely that, unless measures are taken, patterns will shift toward the consumption of more processed foods with consequent adverse impact on nutrient and energy intake and, consequently, on BMI.

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DECLARATION OF AUTHORSHIP

I, Asma Ali, declare that this thesis and the work presented in it are my own and have been generated by me as the result of my own original research.

An Exploration of Dietary Patterns and the Relationship with Obesity in the Malaysian Population

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. None of this work has been published before submission

Signed:

Date: 26.11.2014

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Definitions and Abbreviations

AHEI	Alternate Healthy Eating Index
aMED	alternate Mediterranean Diet Index
BMI	body mass index
BMR	basic metabolic rate
CA	Cluster analysis
DDS	Diet dietary score
DG	Director general
DQI-R	diet quality index revised
DVS	diet variety score
EAR	estimate of the average requirement
EB	Enumeration block
EI	Energy intake
FAO	Food and Agriculture Organization
FBS	food balance sheet
FFQ	Food frequency questionnaire
HACCP	hazard analysis critical control points
HEI	healthy eating index
IPH	Malaysian Institute of Public Health
kcal	kilocalories
LMICs	Lower- and middle-income countries
LQ	Living quarter
MANS	Malaysian Adult Nutrition Survey
MDG	Malaysian dietary guidelines
MDQI	Mediterranean Diet Quality Index
MOH	Malaysian Ministry of Health
MYR	Malaysian ringgit
NHMS	Malaysian National Health and Morbidity Survey
NSFHD	Malaysian Nutrition Section of the Family Health Development Division
Ob	Obesity
ODI	Overall Dietary Index
ODI-R	Overall Diet Quality Index Revised
RFS	Recommended Food Score
RNI	Malaysian recommended nutrient intake
RRR	Reduced rank regression
SD	Standard deviation
SE	Standard error
SES	socio economic status
SPSS	statistical package for the social sciences
TNC	transnational corporations

UK	United Kingdom
UL	tolerable upper intake level
UPP	ultra-processed foods/products
US	United States
USDA	United States Department of Agriculture
USM	University of Science Malaysia
WC	Waist circumference
WHO	world health organization
WHR	Waist hip ratio

Chapter 1: Introduction

1.1 General Introduction

"…All truths are easy to understand once they are discovered; the point is to discover them".

Galileo Galilei, Italian astronomer & physicist (1564 - 1642)

In September 2011, the United Nations General Assembly (UNGA) passed the resolution on the Prevention and Control of Non-communicable diseases (NCDs), which clearly highlighted the importance of poor nutrition and early under nutrition as major causes of NCDs in lower and middle-income countries (LMICs). This resolution has underlined the need for action to improve diet and physical activity patterns around the world to prevent the rise in obesity and other diet-related chronic diseases.

Overnutrition has seen a major change in Malaysia, but, although undernutrition has been reduced, it still exists in isolated groups and the particular challenge for Malaysia and newly emerging economic powers is how to ensure that both over and undernutrition are appropriately addressed, and to ensure that policies aimed at reducing undernutrition do not lead to problems of overnutrition. The UNGA declaration highlighted key actions that member states (i.e. countries such as Malaysia) needed to take to prevent and control NCDs. These included changes in dietary patterns to increase consumption of fruits and vegetables, while reducing intakes of fats, salt and sugars. The challenge for Malaysia is how best to achieve these changes. The first step is to identify the population's pattern of food consumption. To date, few national dietary survey data are available for an LMIC[1] country in nutrition transition, such as Malaysia.

Based on the few existing published national dietary survey data, Malaysia is going through a nutrition transition. Dietary patterns in Malaysia, and in most other LMICs around the world, have been changing rapidly. This transition has often been characterised as the 'westernisation' of traditional diets. Traditional diets based on locally grown and prepared foods are being replaced by foods often prepared away from the home, pre-processed foods and diets that are higher in fat, salt, and sugar (Popkin 2001; Popkin *et al.* 2012). The Malaysian dietary patterns tend to be more energy dense, with

[1] LMICs – lower- and middle-income countries

high sugar and fat intake when compared to the time trend from the serial surveys (Ismail *et al.* 2002; Tee *et al.* 2002). Most LMIC countries are experiencing transition in dietary patterns mainly because of rapid changes in globalisation and urbanisation (Lipoeto *et al.* 2012). Recent literature has identified several mechanisms as contributing factors to the nutrition transition, which include: global food trade; foreign direct investment; global food advertising and promotions; supermarket development; emergence of global agribusiness and transnational food companies; development of global rules that govern the production; trade and distribution of food; urbanisation and cultural change (Hawkes 2006). These contributing factors towards nutrition transition have triggered the economic growth in LMICs. Malaysia, as one of the LMICs, has acknowledged that these factors were part of the main influence of its economic growth. One of the examples from the food sectors/industries showing economic growth in Malaysia is the dramatic increase in the fast food industry, increasing from an estimated total sales of RM 1 billion (US$ 263 million) in 1997 to RM 1.3 billion (US$ 340 million) in 2000 (Ismail 2002). Malaysia offers a number of fast food brands, which include McDonalds's, Kentucky Fried Chicken (KFC), Pizza Hut, A&W, Nando's, Kenny Rogers and many more.

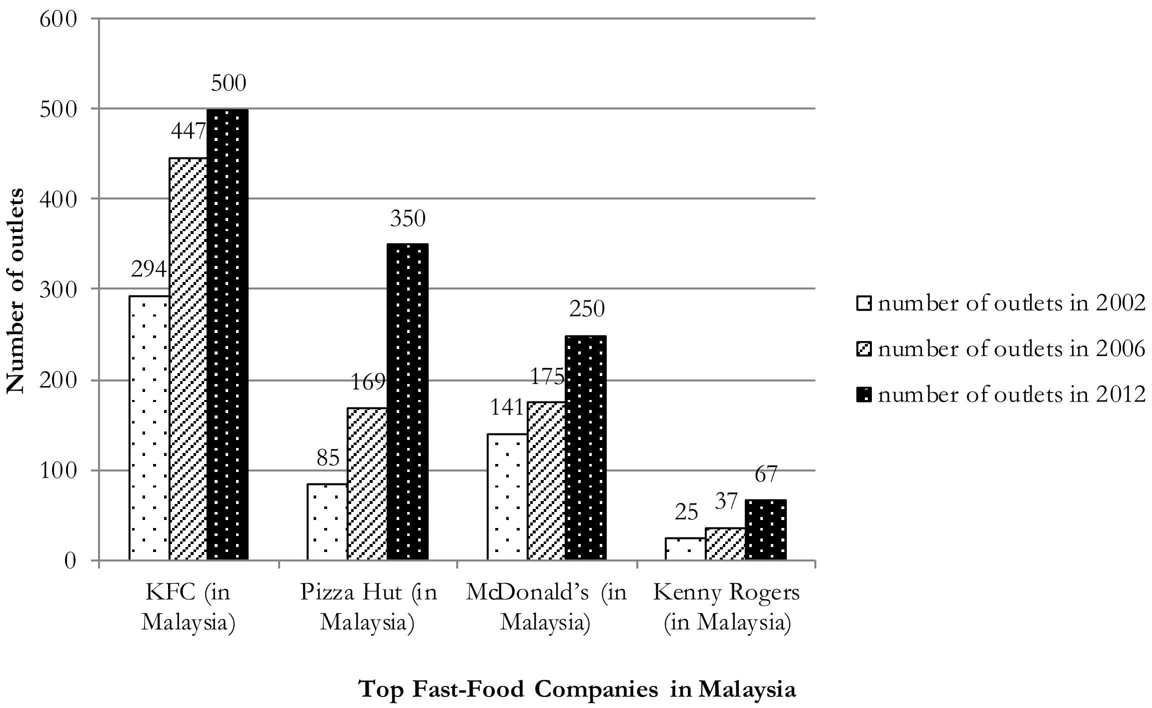


Figure 1.1: Number of outlets for the top fast-food companies in Malaysia in year 2002, 2006 and 2012

(Source: Ismail 2002, (KFC 2012; Kenny Rogers Malaysia 2015; McDonalds' Malaysia 2015; Pizza Hut 2015)

Figure 1.1 shows the number of outlets for top fast food companies in Malaysia in 2002, 2006 and 2012. We can see the growth of fast food through the increasing number of outlets. KFC, originating from the USA, had an increase of 1.5 times within just four years from 2002 to 2006. Meanwhile, Table 1.1 shows the percentage of net sales growth of the top five major consumer goods merchants in Malaysia from 2003 to 2004. Nestle, Fraser & Neave and KFC were among the top five major consumer goods merchants, with a net sales growth of 9.2%, 7.3% and 22.9%, respectively. These companies were involved with food and beverages retail in Malaysia. We can see how these food industries play a major role in Malaysia's economy.

Table 1.1: Top-5 major consumer goods merchants in Malaysia (2003 – 2004)

Ranking	Company name	Core business	Net sales 2003 (USD m)	Net sales 2004 (USD m)	2003-2004 growth (%)
1	OYL Industries Bhd	Manufacture and sale of household electrical products	1,185	1,306	10.2
2	British American Tobacco (Malaysia) Bhd	Manufacture, import and sale of tobacco and luxury consumer products	842	859	2.0
3	Nestle (Malaysia) Bhd	Production, distribution and export of local Food & Beverage (F&B) products and distribution of imported F&B products	699	763	9.2
4	Fraser & Neave Holdings Bhd	Manufacture and retail soft drinks, dairy products and glass container	424	455	7.3
5	KFC Holdings (Malaysia) Bhd	Operates fast food restaurant chain, integrated poultry processing and retail operations	284	349	22.9

Source: PricewaterhouseCoopers (2005)

The increasing availability of highly processed foods over time has altered the traditional way of cooking into more of a 'ready-to-eat' or' just-a-minute' way of cooking (Pollan 2008). The emergence of fast food industries and food services has paved the way for Malaysians to consume more food away from home (FAFH). In 1999, almost 11% of Malaysians bought food away from home, an increase from 5% in 1973. On the other hand, food at home (FAH) decreased by 12% from 34% in 1973 to 22% in 1999 (Heng and Guan 2007). Consumption of FAFH has been documented to be more energy dense, higher in total fat, saturated fat and cholesterol, but lower in dietary fibre, calcium and iron on a per-calorie basis than FAH (Lin *et al.* 1999; Guthrie *et al.* 2002; Paeratakul *et al.* 2003; Bowman and Vinyard 2004). Food services are ubiquitous in Malaysia and include street/hawker stalls, restaurants, fast food outlets and many more (Tey *et al.* 2010). In addition, there is the proliferation of transnational supermarkets which has increased the accessibility of affordable imported processed foods (Hawkes 2010). The Malaysian government has amended the Foreign Investment Committee (FIC) guidelines to expand flexibility on foreign equity participation in local companies (PricewaterhouseCoopers 2005). These transnational supermarkets have been widely accepted, especially in urban areas counterparts, as a result of urbanisation and lifestyle changes that have occurred mostly in urban areas. To conclude, nutritional transition is marked by a shift away from relatively monotonous diets of varying nutritional quality towards a 'westernisation' diet that is usually more varied and includes more processed food, more food of animal origin, more added sugar and fat (Popkin *et al.* 2001a).

Substantial nutrition transition, with an increase of overweight and obesity alongside the co-existing problem of under-nutrition, has been observed in LMICs, leading to a "double burden of malnutrition" (Schmidhuber and Shetty 2005). Obesity is the challenging consequence of over-nutrition (Dugee *et al.* 2009). Malaysia, as well as other LMICs, has shown a rapid increase in the prevalence of overweight and obesity compared to higher income countries (HICs) (Popkin 2012). Economic growth in LMICs is likely to bring an 'obesogenic' environment (Swinburn *et al.* 2011). Whereas, 40 years ago, the major nutrition challenge in Malaysia was undernutrition, today the main challenge is dealing with it alongside the consequences of overnutrition.

In Malaysia in the 1960s and 1970s, there was widespread undernutrition in both rural and urban areas, especially among children (Dean 1959; Noor 1992; Norhayati *et al.* 1997). Overweight was a rare phenomenon during the period. Many children at that time were underweight, stunted, wasted and anaemic (Chong and Lim 1975; Chong *et al.* 1984; Chee 1992; Marjan *et al.* 1998; Tee *et al.* 1998; Khor 2005). Almost 30% of children had a low level of energy intake and faced micronutrient deficiencies in addition to protein energy malnutrition (Khor and Tee 1997). By contrast, overweight did not exceed 2% until 1990s (MOH 1996; Khor and Tee 1997). Meanwhile, adults were affected with chronic energy deficiencies (CED), particularly those who were living in rural areas. The prevalence of CED reported in the 1990s was still considered high (12.7% of men and 12.4% of women of all ages) and of almost similar magnitude as that reported from South and Southeast Asia (Khor *et al.*1999). Co-existing with the problem of CED was the problem of anaemia in women (Tee *et al.* 1998). Low intake of iron-rich food was one of the main contributions to anaemia. Women were reported to have an anaemia prevalence rate of 25% from 1992 to 1995 (Malaysia Ministry of Health 2005). Tee *et al.* (1998) stated that, based on the evidence, the prevalence of anaemia in 1998 was less severe than 10 years earlier. Micronutrient deficiency can affect physical growth and immunologic and cognitive maturation, with effects that may be permanent (Khor 2005). Therefore, the Malaysian Government has taken strong actions, including refinement of micronutrient-dense staple food, food fortification, use of supplements, and nutrition education, to combat over the protein-energy malnutrition and micronutrient deficiencies (Tee *et al.* 1998; Khor 2005). In the late 1990s, the prevalence of undernutrition and CED had fallen (Khor *et al.*1999). The economic growth in Malaysia had reached an enormous amount in a short time.

However, these favourable nutritional trends began to gradually reverse in the early 2000s. Children started to gain more weight than the norm and having more energy than required. Adults were having more foods that were energy dense, with high fat, sugar and salt content, causing overnutrition. The upward trends of overweight and obesity alarmed the Malaysian Government even as early as 2000 (Ismail *et al.* 2002). The first conducted national survey was the National Health Morbidity Survey I (NHMS) in 1996, which revealed that 4.4% of the population was obese. A repeat survey, conducted in 2006, found an alarming increase of obesity to 14.2% (MOH 2006). A systematic review by Khambalia and Seen (2010) revealed that there had been a small increase in Malaysian overweight adults (BMI > 25) in the years 1996, 2003 and 2006 (20.7%, 26.7% and 29.1%, respectively), but a much more dramatic increase in obesity (BMI > 30) (5.5%, 12.2% and 14.0%, respectively). It also revealed that overweight and obesity were higher among women; adults aged 40 to 59 years old; and in Indians, followed by Malays, Chinese and Aboriginals. This was supported by another study done in 2008 among 4428 adults (>18 years old) from five different selected regions in Peninsular and East Malaysia. The study applied World Health Organization (WHO) recommendations for body mass index (BMI) and showed that more females were obese (22.5%, 95% CI=20.9, 24.0) compared to males (14.1%, 95% CI=12.3, 15.9) and prevalence of obesity was highest among Indians (24.6%, 95% CI=20.3, 29.3), followed closely by Malays (23.2%, 95% CI=21.6, 24.8%) and was lowest among Chinese subjects (8.2%, 95% CI=6.2, 10.6) (Wan Mohamud 2011). Therefore, preventive action is crucial to slow down, and then reverse, the rising prevalence of overweight and obesity.

A large and growing body of literature has investigated the association between dietary intake and obesity (Kant *et al.*1995; Bray and Popkin 1998; Willett 2002; Sherafat-Kazemzadeh *et al.* 2010). In earlier dietary studies, researchers were concentrated more on single nutrients rather than assessing the dietary pattern as a whole (Jacobson and Stanton 1986; Bolton-Smith and Woodward 1994; Heitmann *et al.* 1995; Jeffery *et al.* 1995; Kant *et al.* 1995; Bray and Popkin 1998). However, epidemiological studies were unable to yield consistent results on the association between single nutrients and obesity (Lissner and Heitmann 1995; Seidell 1998). One plausible explanation is that intakes of certain foods are highly correlated; it becomes difficult to examine their effect separately. Only in the early 1970s did the dietary pattern approach emerge (Schwerin *et al.* 1982) and gain importance for researchers in studying obesity. A number of studies found a significant relationship between dietary pattern and obesity, and received wide agreement on the association (Togo *et al.* 2001; Dugee *et al.* 2009; Sherafat-Kazemzadeh *et al.* 2010; Kim *et al.* 2012).

However, it remains unclear what kind of change in dietary pattern relates to the increase of obesity, specifically in Malaysia, and how best to characterize such dietary patterns. Therefore, this study aims to fill this research gap by exploring dietary patterns and the relationship with obesity in the Malaysian Population.

1.2 Significance of the study

Since Malaysia is in a transition position, the country still has a chance to prevent further increases in overweight and obesity. If Malaysia knows what kind of dietary pattern approach is associated with overweight and obesity, this will aid public health in strengthening actions and strategies to combat the condition and its multiple adverse health consequences. Moreover, by characterising the dietary pattern that best predicts overweight and obesity, Malaysia will at least have a tool to monitor the nutritional status of the population.

There is a lack of data on consumption of highly processed foods in low and middle-income countries (LMICs). This study could contribute empirical data on the patterns of highly processed food consumption in LMICs. The data are crucially needed as there is a lack of evidence on the growth of highly processed foods in LMICs (Kearney 2010)

.

1.3 Summary

In summary, dietary patterns are changing rapidly in LMICs and these changes are having an effect on the nutritional quality of diets and, potentially, leading to an increase of overweight and obesity. Within an LMICs country such as Malaysia, it is not certain what aspects of dietary change are most closely related to the increasing rates of obesity, and whether different ways of characterising dietary patterns will be better able to predict these changes in obesity. To date, in many LMICs, the impact of processed foods has not been well studied. A number of approaches to classifying dietary patterns have been developed and used in HICs, but they have not yet been widely used in Malaysia.

There is now recognition of the importance of an unhealthy diet in the context of the rapid increase in obesity and related NCDs. To date, few data are available for a country in transition, such as Malaysia. The rationale for the present study is, thus, to characterize the dietary patterns of the population and then to explore the links between these dietary patterns and obesity.

1.4 Research Questions

The purpose of an inquiry or investigation begins with a problem. Hence, this study seeks to answer the following questions:

1. What are the current dietary patterns in this sample of study (data from Malaysia)?

2. What is the current nutritional status based on the BMI of this sample of study (data from Malaysia)?

3. Is there any relationship between dietary intake (energy intake and other nutritional indicators), dietary pattern and nutritional status (BMI) in this sample of study (data from Malaysia)?

1.5 Objectives of the study

The objectives of this study are:

1. To determine the current dietary patterns of this sample of study (data from Malaysia)

2. To determine BMI of this sample of study (data from Malaysia)

3. To determine the relationship between dietary patterns and BMI in this sample of study (data from Malaysia)

4. To explore different models of characterising dietary patterns to establish which is best at predicting nutritional status

1.6 Hypothesis Null

1. An increase in total energy intake over time is related positively to the increase in overweight and obesity in the Malaysian population

The principle of thermodynamics is that energy does not disappear. It is either in the foods eaten excreted through faeces or absorbed by the body. To understand that principle, one needs to understand the principle of energy requirement. Energy requirement basically depends on energy expenditure. Energy expenditure is based on basic metabolic rate (BMR), physical activity, metabolic cost of food and metabolic cost of growth. BMR is defined as the minimal rate of energy exchange in the body, but yet contributes the largest component of energy expenditure (National Coordinating Committee on Food and Nutrition 2005). The calculation of energy requirement is performed by multiplying BMR with a factor that covers the energy cost of increased muscle tone, physical activity, the thermic effect of food and, where relevant, the energy requirements for growth and lactation (FAO/WHO/UNU. 1985). There are many ways in which equations can be developed for predicting the BMR from the collected data (Schofield 1985; Henry 2005). In brief, BMR is calculated to estimate energy requirement.

After understanding the concept of energy expenditure and energy requirement (energy intake), another vital concept is energy equilibrium. If total energy intake is less than total energy expenditure, this may lead to negative energy balance, which means loss of body weight to achieve energy equilibrium. If total energy intake exceeds total energy expenditure, it will lead to increase of body weight. This concept of energy equilibrium generated the hypothesis "Increase in total energy intake is related to increase in overweight and obesity in the Malaysian population", wholly assuming that all respondents involved in this study have a sedentary lifestyle. Physical activity of respondents was not accounted in calculation of energy requirement.

1.7 Organisation of the Thesis

This thesis starts with a description of the various contents in which the research problems and the objective of the study are investigated. The next two chapters will review related literatures. In Chapter 4, the methodology of the research will be presented along with a discussion of the research design and the selection of the study areas and respondents. It will also describe the methods of data collection and analysis. Chapter 5, 6 and 7 will present the results of the study, focusing on the findings from the three dietary approaches applied Ultra Processed Products/Foods (UPP), Principal Component Analysis (PCA) and Diet Quality Index Revised (DQI-R). The last chapter, 8, consists of a summary and discussion of the main conclusions, providing insight into dietary pattern approaches.

Chapter 2: Literature Review

In this chapter, relevant literature related to the topic of dietary patterns and obesity in Malaysia will be presented. The chapter is divided into several sub-topics, namely: the socio-demographic background of Malaysia; main drivers of nutrition transition; the Malaysian nutrition transition from 1965 to 2009; and existing dietary pattern approaches. Firstly, Malaysia is introduced and described in details of its geography, economy and health status. This will give an insight into what Malaysia is like and its current situation, in order to understand the food/diet patterns and put them in context. Subsequently, the chapter will discuss the main drivers of nutrition transition, which will involve: (i) what is changing in nutrition; (ii) the emergence of processed foods; (iii) changes in the global food system; and (iv) trade liberalisation. After presenting the main drivers of nutrition transition, this chapter will focus on the causal pathway of obesity in Malaysia. As such, it will give an overview of nutrition transition in Malaysia from 1965 to 2009 and how this relates to the rise in obesity.

2.1 Socio-demographics of the Malaysian population

Malaysia is part of Southeast Asia and is located in two parts, as a peninsula and the northern one-third of Borneo, bordering Indonesia and the South China Sea, south of Vietnam, and connected to Singapore by a narrow causeway, as shown in Figure 2.1 (Economic Planning Unit 2004). It has a total landmass of 329,750 square metres, which makes Malaysia the 67th largest country in the world by total land area (Department of Statistics Malaysia 2013). Malaysia is a multi-ethnic country with 28.59 million population in 2010 (Ministry of Health Malaysia 2012). The population consists of three major ethnic groups: Malays (n = 14.77 million, % = 54.8), Chinese (n = 6.52 million, % = 24.2), Indians (n = 1.96 million, % = 7.26), and other bumiputra (certain non-Malay indigenous peoples and the natives of Sabah and Sarawak), which make up another 13% (3.5 million) (Department of Statistics Malaysia 2013). According to Ministry of Health, Malaysia (2012), 63.7% of the Malaysian population live in the urban areas, while the remaining 36.3% live in rural areas. Islam is the state religion, but it protects freedom of religion. Malaysia is the home of Muslims, Buddhists and Hindus, as well as other small religious groups of Sikhs, Catholics and other Christians, where Muslims are predominantly Malay (Department of Statistics Malaysia 2013).

Figure 2.1: An overview map of Malaysia covering Peninsular and West of Malaysia. Source: Economic Planning Unit (2004)

Malaysia has experienced economic growth and political stability since its independence, 52 years ago (Ministry of Health Malaysia 2012). The Malaysian economy is a rapidly growing market in the form of industrialisation with waning control of state regulators over its macroeconomic planning (Boulton *et al.* 1997). The fundamental economic measure, Gross Domestic Product (GDP), lists Malaysia as the 29th largest economy, as of 2011, according to the International Monetary Fund (IMF), with a total GDP of $447.3 billion, adjusted for purchasing power parity. However, utilising a similar source and accounting for the national population places Malaysia 58th in the individual income chart, with GDP per capita of $15,568, and it is regarded as a newly industrialised economy (Bozyk 2006). Meanwhile, the GNP for Malaysia had increased tenfold from US$ 20.6 million in 1980 to US$210 million in 2010. The per capita GNP rose from US$1494 to US$8345 during the same period, with the exception of 1985, when there was a virtual collapse of private investment, both domestic and foreign (Ismail 2002) (Table 2.1).

Table 2.1: Selected socio-demographic statistics, Malaysia (1980 – 2010)

	Year						
	1980	1985	1990	1995	2000	2005	2010
Population ('000)	11 442	12 981	14 620	20 689	23 263	26 130	28 590
Infant mortality rate (per 1000)	23.9	16.5	13.1	10.3	7.9	6.6	6.9
Crude birth rate (per 1000)	30.9	31.9	28.4	26.1	24.5	18.4	17.5
Crude death rate (per 1000)	5.3	5.0	4.7	4.6	4.4	4.5	4.8
Life expectancy (years)							
Males	66.4	67.4	68.9	69.4	70.2	71.4	71.9
Females	70.5	72.4	73.5	74.2	75.0	76.2	77.0
GNP (US$ '000)	20,556	28,735	43,046	83,238	124,326	137,163	209,538
Per capita GNP(US$)	1,494	1,832	2,417	4,023	5,344	5,008	8,345
Annual GDP growth rate (%)	+7.4	-1.4	+8.3	+9.5	+8.5	+5.0	+7.2

Note: US$ 1.00 = MYR2.50 (1980 – 1995), MYR3.80 (2000), MYR3.22 (2010). Source: Department of Statistics Malaysia (2012), Department of Statistics Malaysia (2008) and Ismail (2002)

Of 5.8 million households in Malaysia in 2007, half earned below MYR3,000 (or approximately US$950) a month, an indication of immense inequality in income distribution (Puah 2008). Malaysia was once the most dominant producer of palm oil, tin and rubber. Its economy now relies largely on the manufacturing sector. The economy is heavily involved in producing and exporting semiconductor components and devices, electrical goods, solar panels and information and communication technology (ICT) products. Commodity prices are kept below world market prices through government subsidies to sustain a modest cost of living.

Significant improvements were achieved in public health in Malaysia during the past few decades (Tee 1999). The dynamics of globalisation, staggering economic growth and a well-developed health care system were among several main reasons for the progressive shift in Malaysia's public health (Noor 2002a). These include the rise of life expectancy among the Malaysian population. The estimated life expectancy at birth in 2009 had increased to 72.0 years for males and 76.8 years for females, as compared to 70.0 years for males and 74.6 years for females as recorded in 2000. The mortality rates have also been decreasing for the past 41 years (1968-2009). In 2009, the estimated crude death rate per 1,000 populations had decreased to 4.5 as compared to 7.2 recorded in 1968. Besides that, infant mortality rate per 1,000 live births had improved from 41.4 in 1969 to 6.5 in 2009 (Ministry of Health Malaysia 2012). The percentage of the population aged 60 years and over has also increased over the years, from 5.2% in 1970 to 6.3% in y 2000 and is expected to progressively increase to 9.8% in 2020 (Mafauzy 2007).

Regardless of the successful achievement in the health system, Malaysia is apparently facing a "double burden" of disease. While Malaysians continue to face a minor, yet significant, burden of infectious disease (i.e. tuberculosis, dengue and malaria) and undernutrition, they are experiencing a rapid increase in NCDs risk factors such as obesity and overweight, particularly in urban areas (Noor 2002a). Non-communicable diseases (NCDs) are a group of conditions of long duration, generally slow progression and not passed from one person to another. The main types of NCDs are cardiovascular diseases (such as heart attacks and stroke), diabetes and cancer. NCDs in Malaysia have been seen to become significant in the past few decades (Noor 2002a; Ministry of Health Malaysia 2011). In Southeast Asia, NCDs now contribute to more than 60% of deaths. NCDs have been cited as one of today's top global risks (Keeling 2011). With high exposure to NCDs risk factors, the numbers of deaths from NCDs in Southeast Asia is calculated to increase to 4.2 million by 2030. When adjusted for age, Singapore, Brunei and Malaysia, with the highest gross national incomes, faced the highest proportions of deaths due to chronic NCDs in the Southeast Asian population aged 15 years and older (Dans *et al.* 2011).

The Ministry of Health, Malaysia (MOH) has gathered data on the number of admissions and number of deaths in MOH hospitals annually. The number of admissions in MOH Hospitals increased 37.6% from 1,555,133 in 2000 to 2 264,019 in 2012. Likewise, the number of deaths in MOH Hospitals for the period 2000-2012 increased 67.7%, from 30,319 in 2000 to 50,849 in 2012 (Ministry of Health Malaysia 2012). NCDs were ranked among the top ten principal causes of hospitalisation and number of deaths in MOH hospitals. NCDs are significantly related to dietary intake (Beaglehole *et al.* ; Popkin 2001; Popkin *et al.* 2001b; Noor 2002a; Joffres *et al.* 2007; Azizi *et al.* 2009). Interestingly, studies conducted in Malaysia revealed how certain NCDs and NCD risk factors varied by ethnicity (Khor 1994; Dunn *et al.* 2012; Rampal *et al.* 2012; Tan *et al.* 2012). It was reported that Indians suffer more from diabetes than Malays and Indians (Hallman *et al.* 1991; Khoo *et al.* 2000; Letchuman *et al.* 2010). Indian and Malay women were more at risk for high blood pressure, high blood cholesterol and overweight than the Chinese (Khor 1994; Zambahari 2004). In the Malaysian National Health Morbidity Survey conducted in 2006, Indians were reported to have

19.9% of diabetes prevalence, followed by Malays (11.9%) and Chinese (11.4%) (Letchuman *et al.* 2010). Indians were shown to have high susceptibility and familial aggregation towards diabetes mellitus (Ramachandran *et al.* 2001). A national dietary survey carried out in Malaysia in 2006 showed that the prevalence of metabolic syndrome was higher in Indians than that of Malays and Chinese, because Indians are more likely to have central obesity, higher fasting blood glucose and low high-density lipoprotein cholesterol. Meanwhile, there was no statistically significant difference in metabolic syndrome prevalence between Chinese and Malays (Tan *et al.* 2011). In the Malaysian Non-communicable Disease Surveillance-1, 2006, findings showed that Malays had the highest prevalence of overweight (33.7%), followed by Indians (28.9%) and Chinese (28.7%). Meanwhile, for obesity, both Malays and Indians had high prevalence of approximately 18% and Chinese had 11.9% prevalence of obesity (Tan *et al.* 2012). Many studies carried out in Malaysia reported that the Chinese were the affected by overweight and obesity than other ethnicities (Rampal *et al.* 2012; Tan *et al.* 2012). It is interesting to note that a study carried out by Seet *et al.* (2004) on differences of frequencies of the apoE alleles in the three ethnic groups, Malay, Chinese and Indian, in Malaysia. Apo-lipoprotein E (apoE) is a 34-kDa glycoprotein found in chylomicron remnants, very low density lipoprotein (VLDL), low-density lipoprotein (IDL) and high-density lipoprotein (HDL). The findings found that ε3 allele was found to be the most common, followed by ε4 and then ε2, across all ethnic groups. Indians had a higher frequency of ε4 (14.3%) than Malays (13.54%) and Chinese (9.6%). On the other hand, the Chinese had the highest frequency of ε2 allele (7.0%). The ε2 allele is relatively associated with lower level of cholesterol and may, hypothetically, reduce the risk of hypercholesterolemia. Meanwhile, ε4 allele is clearly related to elevated serum cholesterol levels. The findings corroborated findings from a study carried out by Hallman et al. (1991) where Indians had high frequency of ε4 allele compared to other ethnicity, and Chinese had the highest ε2 allele across all ethnicity. However, this study was limited to a small sample size and needs to be established by a larger-scale population study. This exciting finding of the different frequency of allele among the Malaysian population adds another insight into how ethnicity differs in nutritional status other than from a dietary pattern perspective. There is likely to be ethnic differences, meriting longitudinal studies of different ethnic groups to determine the significance of food patterns and risk factors for NCDs as a priority.

2.2 Drivers of nutrition transition

2.2.1 What is changing in nutrition, globally?

People today are starting to have an unbalanced dietary intake. More people are eating more fats, sugar and salt than required and consuming unknown ingredients. One of the biggest contributors to an unbalanced dietary intake is added sugar consumption. More people are having more unrequired sugar in daily consumption. Among the largest supply of sugar in people's dietary intake is that from sweetened beverages (Harnack *et al.* 1999; Malik and Hu 2012). In human evolution, humans have drunk water after breast milk for thousands of years. Water contains no calories and does not alter the daily dietary intake. The consumption of fruit juice and milk from domesticated animals has been a relatively small contribution to total energy intake. However, in the past 50 years, the arrival of Coca-Cola, Pepsi and other soft drinks, globally, has increased the proportion of calories coming from beverages. Coca-Cola and Pepsi (PepsiCo) are the main producers of more than half of the world's soft drinks (Moodie *et al.* 2013). Soft drinks are a part of the sweetened beverages group, alongside energy drinks, fruit drinks, tea, coffee and flavoured milk. Sweetened beverages are composed of derived caloric sweeteners, such as sucrose (50% glucose and 50% fructose), high fructose corn syrup (most often 45% glucose and 55% fructose), or fruit juice concentrates, in contrast to sugars found naturally in fruit, vegetables and dairy-occurring sugars, such as fructose, sucrose and lactose (Malik and Hu 2012). The proportion of calories from beverages has become bigger, as sweetened beverages have added approximately 137 kcal to daily dietary intake, which can cause a weight gain of 6.4 kg over a year (14.2 pounds) (Popkin 2007). This was supported by Hu and Malik (2010) whose findings revealed that consumption of sweetened beverages in the US between 1970 and 2006 had increased from 64.4 kcal/day to 141.7 kcal/day. This also accords with Miller et al.'s (2013) assessment of sweetened beverages consumption from data of the 2005–2008 National Health and Nutrition Examination Survey, where their findings showed that Americans aged over two years had a mean average of 171 kcal (8% of total kcal) per day from added sugars in SSBs; the high sources were from soda, fruit drinks, tea, coffee, energy/sports drinks, and flavoured milks. An inspection of soft drinks intake among 2719 young teenagers in New South Wales, Australia, found that more than half of the boys, and over one-third of the girls, drank soft drink, daily (Denney-Wilson *et al.* 2009). Astonishingly, near 40% of them reported having access to soft drinks in their home. These sweetened beverages are cheap and widely accessible, making them more greatly consumed among the population. They are extensively provided in every supermarket, groceries, food services and fast food restaurants, and even in vending machines. The cheap price of these sweetened beverages is a reason for the high global consumption of the products, which, in turn, has led to high sales revenue of this product for the big companies. High consumption of sweetened beverages has been shown to be positively associated with weight gain and an increased risk for development of type 2diabetes (Schulze *et al.* 2004; Palmer *et al.* 2008; Odegaard *et al.* 2010; Mozaffarian *et al.* 2011).

Next is fat and salt intake. Fat and salt intake increases as a result of frequent fast food, processed food consumption and eating food away from home. Fast food intake has shown a tremendous increase in fat and salt. A study was carried out by Stender et al. (2006) to determine the content of industrially-produced trans fatty acids in 43 servings of fast food bought in 20 countries between November 2004 and September 2005. The fast foods were French fries and nuggets bought from KFC and McDonald's food chains. Results showed that the content of trans fatty acids ranged from less than 1 g in Denmark and Germany to 10 g in New York (McDonald's) and 24 g in Hungary (KFC). About 50% of the 43 servings contained more than 5 g of trans fatty acid, which may be associated with risk of ischemic heart disease. Meanwhile, the cooking oil used for French fries in the US and Peru for McDonald's food services was 23% to 24% trans fatty acid, while, in European countries, it was less than 5%. Astonishingly, Stender *et al.* (2006) reported that KFC had some values for trans fatty acid that were above 30%. Thus, regular consumption of French fries or nuggets may lead to an average daily consumption of more than 5 g of trans fatty acid.

A widespread increase in sodium intake is a result of the proliferation of fast food restaurants and ready-to-eat processed foods (Institute of Medicine 2010). The sodium content in 78 fast food restaurant products in the US increased by 2.6% between the years 2005 to 2011 (Jacobson *et al.* 2013). Almost 80% of the sodium consumption comes from salt added during the processing and preparation of restaurant foods (Institute of Medicine 2010) while less than 20% were due to the saltshaker or the sodium that occurs naturally in foods (Jacobson *et al.* 2013). Salt is added to foods by manufacturers for several reasons: for flavouring, for longer shelf life, for preservation, for altering texture, for food processing and many others (Barr 2010). The current per capita sodium consumption of American adults is about 3300 mg/day, and up to 3800 mg/day when table salt is included, which is beyond the Dietary Guidelines for Americans, which advises consuming less than 2300 mg/day of sodium (Centers for Disease Control and Prevention 2012). An interesting study was carried out in Canada to determine the sodium levels of a wide variety of meal items, baked goods, side dishes and children's items in sit-down restaurant and fast food chain menu items (Scourboutakos and L'Abbe 2013). Findings from 65 fast food restaurants and 20 sit-down restaurants showed that the mean average of individual sit-down restaurant menu items contained 1455 mg sodium/serving. Meanwhile, 40% of all sit-down restaurant items exceeded the adequate intake level (AI) for sodium and more than 22% of sit-down restaurant stir fry entrées, sandwiches/wraps, ribs and pasta entrées with meat/seafood exceeded the daily tolerable upper intake level (UL) for sodium (2300 mg/day). Foods in fast food outlets showed a similar trend, although they had a slightly lower of sodium level than the sit-down restaurants. Overall, 69% of the food establishments in Canada exceeded the 2014 US National Sodium Reduction Initiative (NSRI) targets (1200 mg/serving). In the US, the mean average of daily sodium intake from all foods was lower for individuals who did not consume at a restaurant (2999 $\pm$ 658 mg) than those who did consume at least one food at a restaurant (3623 $\pm$ 671 mg) (Maalouf *et al.* 2013). Additionally, fast food triggers the overconsumption of salt intake in an individual dietary intake. A study done in Korea among young teenagers found that habitual consumption of fast food may associate with an increased preference for salt taste (Kim and Lee 2009). Fast food is not only associated with high fat and salt content, but is high in energy density (Prentice and Jebb 2003).

2.2.1.1 Emergence of processed foods

It will be ultimately difficult for the consumer to determine all the ingredients in food and sort out what is good and what is not, as it is too complex. The main thing that one needs to bear in mind, is that all these foods are products that undergo highly processed manufacturing. This is what we call 'ultra-processed foods/products' or highly processed foods, hereafter termed ultra-processed foods/products. Ultra-processed foods involve food products that undergo an extraction or refining process from whole foods, which produces processed substances with little or no whole food remaining (Moodie *et al.* 2013). The characteristics of ultra-processed foods are that they are attractive, hyper-edible, economical, ready-to-consume food products that are energy-dense, fatty, sugary and/or salty and generally obesogenic (Monteiro *et al.* 2013).

Traditionally, people needed to take the raw agricultural product and then change it to edible foods, but now technology has taken care of it (Cutler *et al.* 2003). The revolution in mass preparation of foods has enabled people to use 'less-time food preparation'. Innovations in food processing have hugely influenced food manufacturers in providing 'less time food preparation' (Beauman *et al.* 2005). Reductions in the time cost of food preparation have been achieved, but, somehow, this has led to an increased consumption of processed foods. People have less time to prepare food and are getting more involved with fast food, ready-to-eat food and buying and eating food outside the home. Other factors have contributed to the high and increasing intake of processed foods, including the global food industry, cheaper prices and aggressive marketing.

HICs have been exposed to these processed foods for longer than LMICs, as they have been subject to advances in technological change in the global food industry for longer. This was shown by Monteiro *et al.* (2010) through his analyses of two high-income countries, the United States (US) and the United Kingdom (UK). In the United States, the five most common foods were soft drinks, cakes and pastries, burgers, pizza and fries. These foods are all highly processed. Meanwhile, in the UK, almost 50% of total household purchased calories were from processed foods: breads, cakes, pastries, confectionery, biscuits, processed meats, cheeses and soft drinks. This was strongly supported by an increase of the share of processed food exports in total world exports from 44% in 1980 to approximately 63% in 2006 (Jongwanich 2009).

Consequent to these processed foods, a Brazilian team has classified foods that people consume according to the extent and purpose of the industrial processing used in their production (Monteiro *et al.* 2010). The foods are classified under three main groups: Group 1 - unprocessed and minimally processed foods; Group 2 - processed culinary or food industry ingredients; and Group 3 - ultra-processed food products. In light of the rise in consumption of processed foods, another similar study has been carried out by Slimani *et al. (2009)* to describe the contribution of highly processed foods to total diet, nutrient intakes and patterns in 10 countries involved in the European Prospective Investigation into Cancer and Nutrition (EPIC). They also proposed three main categories: Group 1 - Highly processed foods; Group 2 - Moderately processed foods; and Group 3 - Non-processed foods. Since foods are becoming much more processed, this novel approach to food classification is highly significant to public health. It is one way to simplify the contribution of processed food. The key messages conveyed are intended to guide consumers in selecting a balance of nutritional and healthy foods and limit processed food. This food classification departs from the norm of traditional methods of classifying foods, which were either food-based, nutrients-based or a combination of both. Until now, only a few countries (Brazil, Canada and some European countries) have really put any effort into adopting this novel approach of classification.

To date, there has been a lack of summary or critical appraisal of the body of literature over the past decade on the study of processed foods in Malaysia. Several papers have highlighted the likely impact of ultra-processed foods/products (UPP) on the nutritional status of populations (Slimani *et al.* 2009; Monteiro *et al.* 2011; Tavares *et al.* 2012). A study carried out in Canada on consumption of UPP and the likely impact on human health found that almost 62% of total dietary energy from 5643 respondents came from UPP. The overall diet exceeded WHO upper limits for total fat, saturated fat, free sugars and sodium density, with less fibre than recommended (Moubarac *et al.* 2012). Recent evidence from published studies shows that increasing consumption of processed foods was associated with the increase of NCDs, ecologically (Cutler *et al.* 2003; Monteiro *et al.* 2011; Moubarac *et al.* 2012). This is because the increased consumption of processed foods has an impact on nutritional status, hence indicating the incidence of NCDs (He *et al.* 2008; Ludwig 2011; Monteiro *et al.* 2011; Tavares *et al.* 2012). Tee (1999) raised a good question in a paper he wrote on 'Nutrition of Malaysians: where are we heading?' He asked, 'are we going to stop the increasing of obesity or are we going to have further deterioration in dietary pattern?' A similar question was pointed out by Khor *et al.* (1998a) and Ismail (2002). In brief, Malaysia could still take a notable step to prevent obesity from increasing as the Malaysian dietary pattern is still in nutrition transition and not yet fully immersed in the western dietary pattern of high UPP intake.

2.2.2 Changes of the global food system

Changes in the global food system appear to be one of the major drivers of the rise of the global obesity epidemic (Swinburn *et al.* 2011). One of these changes is the result of the high degree of penetration by transnational corporations (TNC), at first in HICs, and now in LMICs (Monteiro and Cannon 2012; Moodie *et al.* 2013). Notably, the growth of fast food and soft drinks has successfully raised the concepts of 'McDonaldization' and 'Coca-Colanization' in LMICs (Hawkes 2010). The burgeoning growth of TNC and the food industries reflects the economic growth in a country. The contribution of these TNC and food industries is huge and crucial, especially in LMICs, as shown in Figure 2.2 (Popkin 2008; Rayner and Lang 2012).

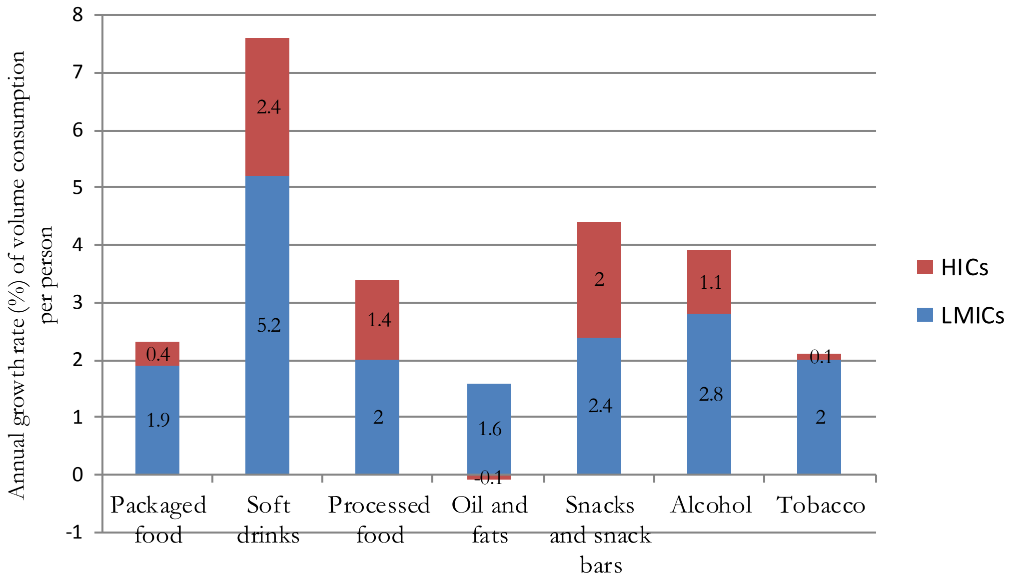


Figure 2.2: Annual growth rate (%) of volume consumption per person in low-income and middle-income countries, and high-income countries between 1997 and 2009

The most compelling framework of obesity determinants was that projected by the UK Foresight Programme in 2007 (Vandenbroeck *et al.* 2007). It showed a complex obesity system map that included the interrelation of physiology, individual behaviours and the environment ranging from local to global levels. However, Swinburn *et al.* (2011) offer a more structured and easy-to-understand map of obesity determinants. The obesity map demonstrated pathways to obesity and solutions to inhibit the growth of obesity. In the map, there are several factors that influence the high energy intake of a population, which include systemic drivers, environmental drivers, behaviour patterns and energy imbalance. Systemic drivers involve policy and economic systems in promoting high growth and high consumption of energy intake. The behaviour patterns are high food and energy consumption with associated low physical activity levels, while energy imbalance is high total energy intake driving imbalance. There are environmental moderators that accentuate or attenuate these drivers. Environmental moderators include the sociocultural, socioeconomic, recreation and transport environments. It was pointed out that systemic drivers, environmental drivers and environmental moderators required policy interventions. Meanwhile, health promotion programmes, social marketing and other related factors are needed to tackle the environmental moderators and behaviour patterns. The last solution is drugs or surgery to re-balance energy in a body.

That is why Swinburn *et al.* (2011) highlighted that TNC and the food industries are part of the economic drivers in 'obesity determinants and solution' that are hard to tackle. They proposed that economic drivers are the main core obstacles to tackling obesity, since they involve government participation with food industries and manufacturers, but, if this can be changed, it will have a big impact on population obesity. The most effective solution is the one that directly addresses the systemic drivers and environmental drivers. This is because the end result will involve the whole population, rather than focusing on a high risk minority population (the one with energy imbalance). However, the most effective solution is the most difficult to achieve as it requires political implementation.

2.3 Causal pathway of obesity in Malaysia

In Chapter 1, we introduced the law of thermodynamics:

> "… After understanding the concept of energy expenditure and energy requirement (energy intake), another vital concept is energy equilibrium. If total energy intake is less than total energy expenditure, this may lead to negative energy balance, which means loss of body weight to achieve energy equilibrium. If total energy intake exceeds total energy expenditure, it will lead to increase of body weight…"

Obesity is the result of excess energy intake (high energy input) and less energy expenditure (low energy output), according to the law of thermodynamics. This positive energy balance leads to excess of body adiposity (Caballero 2007). The factors that drive high energy input and low energy output are complicated and some are debatable (Popkin and Doak 1998). Therefore, this study proposes a causal pathway of obesity determinants in Malaysia to understand more about the drivers toward positive energy balance (see Figure 2.3). This causal pathway is the synthesis of findings from the literature identifying potential drivers of obesity in Malaysia

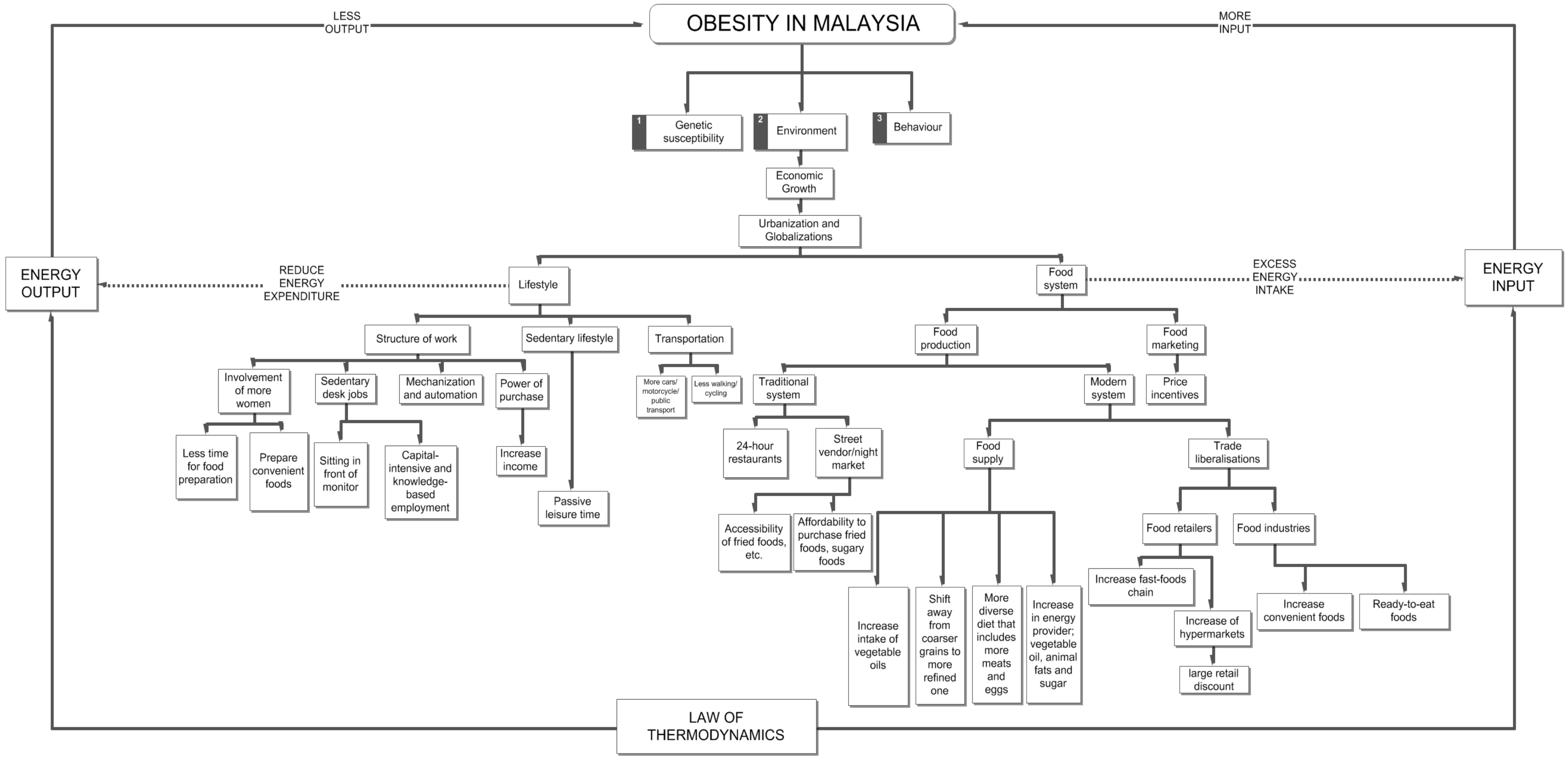


Figure 2.3: Synthesis of findings from the literature - Determinants of obesity in Malaysia

Generally, scholars agree that obesity may be triggered by several drivers, including genetic susceptibility (Kopelman 2000; Yang *et al.* 2007; Hu 2011), environment (Hawkes 2006; Popkin 2006; Bouchard 2007; Malik *et al.* 2013) and behaviour (Bouchard 2007; Dalle Grave *et al.* 2013). These drivers interact with one another (Romao and Roth 2008). Genetic susceptibility of obesity is likely to attenuate or exacerbate the non-genetic factors (Kopelman 2000; Ogden *et al.* 2007). Non-genetic factors include the surrounding environment that activates genetic susceptibility towards obesity (Prentice *et al.* 2005; Romao and Roth 2008; Parks *et al.* 2013). In Malaysia, inherited metabolic predisposition to fatness (a 'thrifty genotype') was shown to result in a greater threat of prevalence of obesity (Ismail *et al.* 2002). The thrifty genotype is a genotype that promotes fat storage during nutrient scarcity (Prentice *et al.* 2005). When this genotype meets an obesogenic environment, risk of obesity will increase. For example, the Pima Indian population of Arizona and Nauruan Polynesians are more prone to obesity as a result of overrepresentation of the thrifty genotype due to facing a repeated famine and feast cycle (Hu 2011). However, Hu (2011) said this was in contrast with Europeans, who have less susceptibility to the thrifty genotype as they are less affected by this cycle. In light of this, the Malaysian population needs to take more precautions as Malaysia is currently going through the 'rich' cycle (urbanisation development).

What are the environments that promote the growth of obesity? Urbanisation may have been one of the main drivers towards excess weight gain in Malaysia. Urbanisation has occurred because of the economic growth in Malaysia (Ismail 2002; Khambalia and Seen 2010; Khor 2012b). Increased economic growth symbolises the wealth of a country and such wealth is likely to create an 'obesogenic' environment in both LMICs and HICs (Noor 2002a; Pollan 2006; Monteiro 2010). Malaysia's gross national product (GNP) increased fourfold from US$ 20.6 million (US$1.00 = Malaysian Ringgits (RM) 2.50 in 1980–95) in 1980 to US$ 81.8 million in 2000 (US$1.00 = RM 3.80 in 2000), and there was an increase in the rate of urbanisation from 25% in 1960 to 41% in 1990 and was predicted to go beyond 60% in 2002 (Ismail 2002). Reclassifications of urban areas, natural increase of population and migration (internal rural to urban) were the spatial and demographic phenomena affecting the population change in Malaysia (Jaafar 2004). Population censuses show that the urbanisation levels in Malaysia are increasing rapidly (Department of Statistics Malaysia 2000). Urbanisation is a key factor that impacts the energy input and energy output of the Malaysian population (Ismail 2002; Ismail *et al.* 2002).

The effect of urbanisation and globalisation in Malaysia has been twofold: on lifestyle and on the Malaysian food system. The impact that it has on lifestyle may influence the outcome of the energy output, while the effects on the food system influence the energy input. These two distinct parts are helpful in understanding the complexity of obesity determinants in Malaysia. First, we look at how the effects of urbanisation on lifestyle influence energy output. A number of studies showed that urbanisation is associated with changing lifestyles (Hawkes 2006; Popkin 2006; Malik *et al.* 2013). Changes in lifestyle can clearly be seen through the structure of work, sedentary lifestyle and transportation in Malaysia. These changes are gradually shifting in most lower- and middle-income countries (Malik *et al.* 2013). The structure of work in Malaysia has become more sedentary, with office-based desk jobs and the implementation of more mechanisation and automation. This was highlighted by Caballero (2007) and others (Popkin *et al.* 2012; Malik *et al.* 2013) in explaining how mechanisation and automation largely reduce energy expenditure in human daily routine activity and at work. The increase in desk jobs was the result of capital-intensive and knowledge-based employment (World Health Organization 2003). These changes in the structure of work have led to less application of physical activity. Thus, it has reduced the energy expenditure and led to less energy output among the Malaysian population. Apart from structure of work, sedentary lifestyle, for example, passive leisure time (watching television, playing game stations, etc.) has contributed to less energy output. Malaysia has conducted several large scale studies reporting on the physical activity of Malaysian adults; only 11.6% of Malaysian adults who participated in the National Health and Morbidity Survey II (1996) were doing regular physical activity or adequate exercise, while, more recently, the Malaysia Non-communicable Diseases Surveillance-1 (MyNCDS-1) in 2005/2006 reported that 60.1% of adults (65.1% women and 55.4% men) were inactive (Poh *et al.* 2010). In addition, improvement of the transportation system has had a significant role in reducing energy expenditure. Most people own a car; the number of motor vehicles in Malaysia increased almost fourfold from 4.5 million vehicles in 1990 to 18 million vehicles in 2008 (Ong *et al.* 2012). Moreover, public transport provision (bus, rail) has also increased, especially in urban areas (Almselati *et al.* 2011). Hence, less people are now walking or cycling.

Interestingly, rapid economic development and urbanisation has opened job opportunities for women in Malaysia. Apart from urbanisation, they have been provided with a better chance for education while the Government's implementation of the New Economic Policy of 1970 has opened up women's entry into paid labour (Chattopadhyay 1997). Since Malaysia achieved its independence in 1957, women's entry into the paid labour force has grown surprisingly, from 30.8% in 1957 to 47.1% in 1995 (Noor 1999). This has been as a result of a better educational attainment among women (Mahpul and Abdullah 2011). This has changed the traditional male and female gender roles in Malaysia, where men worked in paid employment while women stayed at home, looking after the children and house (Noor 1999; Ng *et al.* 2009). Nowadays, many husbands and wives both work, especially in urban areas (Khalili *et al.* 2013). A study done among working women in urban areas in Malaysia showed that "economic needs" was the main reason why women chose to work (Noor 1999).

This illustrates the need for a higher income level to survive living in urban areas. However, regardless of employment status, the sociocultural values in Malaysia still assign wives the responsibilities for taking care of the home, family and children (Chattopadhyay 1997; Noor 2002b). Therefore, less time is left for household chores, including time for food preparation. It was reported that working women spend an average of 3.18 hours on household chores and 4.67 hours on childcare per day, while the husbands spent, on average, 1.36 hours and 3.32 hours daily on household chores and childcare, respectively (Noor 1999). Consequently, women tend to choose foods that are convenient and less-time consuming to prepare (Pingali 2007; Asma' *et al.* 2010). The most convenient way is buying food outside the home, or ready-to-eat processed foods. Working women have less time to prepare proper food at home (Mahpul and Abdullah 2011) and opt for cooking/re-heating convenience food or buying outside-foods (ready-cooked foods) or taking the family out to eat (Kamaruddin *et al.* 2012).

The increased demand for convenience food has opened up a big opportunity for the growth of transnational food corporations and food retail outlets. Urbanisation, together with an increase in convenience food demand, has changed the food system in Malaysia. This accords with a large and growing body of literature which shows that urbanisation is having a major impact on the food systems around the world (Kennedy *et al.* 2004; Caballero 2007; Popkin *et al.* 2012; Malik *et al.* 2013). As shown in Figure 2.3, food system changes can be seen through (i) food production and (ii) food marketing. Food production is separated into two groups: the modern system and the traditional system. First, the changes that have occurred in the modern system that can be seen from two-sides: food supply and trade liberalisations. The food supply in Malaysia has seen a profound shift from coarse grains to more refined ones, increased intake of vegetable oils, greater diet diversity that consists of more meats and eggs and an increase in energy providers (vegetable oil, animal fats and sugar) (Noor 2002a). These trends are similar to other LMICs countries that are experiencing transition of nutrition (World Health Organization 2003; Pingali 2007; Kearney 2010).

On the other hand, trade liberalisation has brought about an increased growth of food retailers and food industries in Malaysia (Okamoto 1994; Jomo and Sundaram 2007). Trade liberalisation has resulted in a higher growth of multinational fast food, increased availability and intake of meat, dairy products and processed foods since eliminating the barriers to foreign direct investment in food distribution (Thow and Hawkes 2009; Kearney 2010). Since the trade liberalisation implemented in Malaysia, the growth in imports of goods and services has increased, as well as foreign direct investment, from 1966 until 2011, as shown in Figure 2.4.

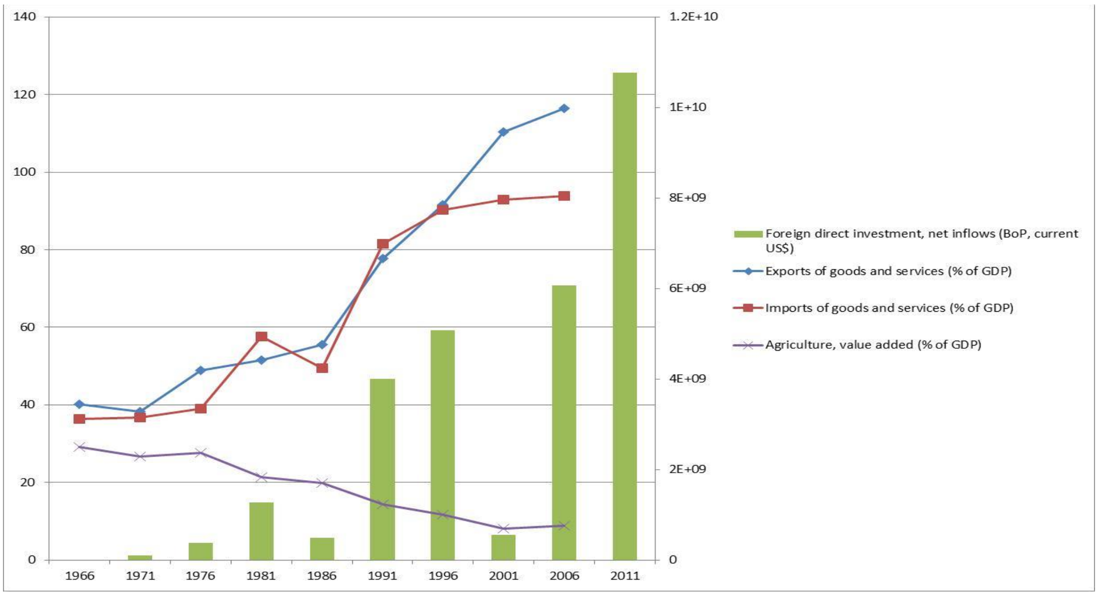


Figure 2.4: Trends in exports and imports of goods and services, agriculture and foreign direct investment over the 40-year period, 1966 – 2011, in Malaysia

Traditionally, Malaysians preferred home-cooked meals, however, due to urbanisation, Malaysians are consuming more fast food, especially those living in urban areas. Fast food has various definitions, but they unquestionably share similar meanings. Farzana *et al.* (2011) defined fast food as specialised food that can be prepared in a short time for immediate consumption, either on the premises or elsewhere, and which is relatively inexpensively. Malaysia offers a number of fast food brands, which include McDonald's, Kentucky Fried Chicken (KFC), Pizza Hut, A&W, Nando's, Kenny Roger and many more. Some of the fast food has been adapted to the local food requirements to suit the taste preference of the population. Nutrient analysis of fast food showed that it is high energy dense, with poor nutritional content, being especially low in micronutrient density (Burns *et al.* 2002; Paeratakul *et al.* 2003; Bowman and Vinyard 2004). A study done in the UK and Scotland found that fast food intake increased as the level of social deprivation increased (Cummins *et al.* 2005). Several studies done in the US found that the linkage between fast food and low-income neighbourhood was significantly positive (Block *et al.* 2004; Forsyth *et al.* 2012). Another study, carried out in Australia, studied the density of fast food outlets, with people living in areas from the poorest SES category having 2.5 times the exposure to outlets than people in the wealthiest category, and those living in the very richest areas actually having no exposure to fast food outlets within their postal districts (Reidpath *et al.* 2002). In contrast to HICs, fast food in LMICs was more widespread among the urban middle-income category than the low-income category, and less in the rural counterparts (Kaynak *et al.* 1996; Noor 2002a; Pingali 2007). Another reason is likely to be that young working parents in Malaysia prefer to take their children to fast food eateries, thus crafting a new generation of fast food lovers (Farzana *et al.* 2011). The young generation (which accounts for 41% of the population) in Malaysia perceives fast food restaurants as branded food outlets to spend time in and to dine in with family and friends. On the other hand, the working people see fast food as a quick meal solution that can shorten the period of waiting for food, as they have limited lunch hours (Farzana *et al.* 2011; Shaharudin *et al.* 2011). Fast food was considered affordable for the middle-income category in Malaysia, but not among the low-income group. This was contrary to the HICs countries, where fast food was cheap and accessible for the low-income groups. In essence, most of the fast food in Malaysia, for example, KFC, McDonald's, Kraft and Nestle, are all transnational food corporations (franchise and manufacturers) that have created the dramatic increase of the fast food market, processed foods and western dietary intake in LMICs (Kearney 2010). As well as the huge growth of fast food chains, the growth of transnational supermarkets, along with large-scale food manufacturers, has also increased (Hawkes 2010; Kearney 2010). The establishment of "super retailers" (or supermarkets) applied international standards along with international outsourcing of supplies and services under trade liberalisation (Arshad *et al.* 2006). Supermarkets improved the standards of food quality and safety at affordable prices (Kearney 2010). For example, the poor in Brazil now have access to cheap and safe milk (Kearney 2010) because supermarkets were instrumental in the development of ultra-heat treatment (UHT) for the pasteurisation of milk and, thus, a long life span (Popkin *et al.* 2012). However, supermarkets are also a major contributor to cheaper, less healthy foods, and a great source of processed foods with higher fat, sugar and salt content (Kearney 2010; Malik *et al.* 2013). This is because the growth of transnational supermarkets has provided incentives for increased imports of highly processed foods (Hawkes 2010).

Food marketing has had a significant role in promoting more consumption of convenience food (Kearney 2010; Malik *et al.* 2013). TV advertising and price incentives are among the factors responsible for obesity in America's youth (Kearney 2010), yet the effect of advertising on adults is scarce (Mills *et al.* 2013). Caballero (2007) points out that up to 60% of household income in LMICs is spent on food as a result of marketing campaigns and price incentives. This has also been occurring in Malaysia. The mean average monthly expenditure of Malaysian households on goods and services for 2009/10 was approximately MYR 2190. Out of this, nearly 70% was spent on four main groups, namely: MYR 495 (22.6%) on housing, water, electricity, gas and other fuels; MYR 444 (20.3%) on food and non-alcoholic beverages; MYR 327 (14.9%) on transport; and MYR 239 (10.9%) on restaurants and hotels (Department of Statistics Malaysia 2011). Thus, the average monthly expenditure of Malaysian households on food is near to 31%. Apart from the ordinary food marketing, there is also "Glocalization", which means the global marketing strategies of global fast food and soft drinks companies to local consumers. Hawkes (2002) explains further:

> "… Global marketing involves a company selling the same or similar products to multiple and diverse environments around the world. Strategically, therefore, it is a challenge, and one

> that differs significantly from domestic marketing. Articulating such a strategy requires an understanding of the economic, technical, political and socio-cultural spheres of influence that define the multitude of marketing environments. Moreover, global businesses have to deal with two apparently opposing forces: the push towards globalization and a simultaneous pull towards localization …"

Several "glocalization" strategies have been operating in Malaysia. KFC expanded the accessibility of KFC's food to customers living in inaccessible areas through KFC's "Meals on Wheels" programme in Malaysia. KFC is adapting menus to suit Malaysian tastes; it has introduced several spices to their chicken to suit local tastes, for example, Thai and curry spices in fried chicken dishes. McDonald's too has added a new menu, chicken rice porridge, and started to sell rice to compete with local food vendors. In order to be accepted by the Malaysian market, these fast food markets sell Halal chicken. The "glocalization" has been hugely successful in raising the sales of the fast food market and, in parallel, there has been a big increase in the consumption of fast food (Hawkes 2002).

The blooming of modern food retail outlets (supermarkets, hypermarket, fast food outlets, etc.) has not eliminated the traditional fresh markets or night markets, and local supermarket chains in Malaysia. Fresh market and night markets are still preferred as they are 'price sensitive' and cater for 'traditional diet' (Banwell *et al.* 2013). The existence of night markets in almost every area of Malaysia is another aspect of food access. The night market is based on the concept of open-air shopping, where street vendors 'take over' a designated street to set up shop, normally a busy one which is closed to traffic from the early evening to late at night (Ishak *et al.* 2012). Normally, night markets will be held at least once or twice a week, depending on the area. It holds the attraction of being a convenient stop where there is a large selection of ready-to-eat food, fresh fruits, raw fish and meat, as well as clothes and many more non-food products (Aziz and Yeng 2011). People can have their ready-to-eat dinner prepared without having to cook. In Taiwan, for example, the major reason for visiting night markets was the variety of food choices (72%) (Chang and Hsieh 2006). Night market is a food retailing style in East Asia among societies strongly collectivist in nature (Wu and Luan 2007). Considering the fact that night markets and other food away from home outlets do not provide any nutrition labelling, it is in the hands of the consumer to decide whether the food selected is considered healthy or not. In regard to food away from home, Blaylock *et al.* (1999) highlighted that people may be aware of the nutrient content of a particular food, but the situation somehow becomes more complex when foods and ingredients are combined in unknown portions with unknown preparation methods. Besides, most food street vendors in the night markets do not practise food related hygiene. Research by Huang (2008) showed that a large number of the food vendors at night markets had not heard about nor understood good handling practices (GHP) or hazard analysis critical control points (HACCP); they lacked knowledge about potentially hazardous food (PHF) and the prevention of food-borne illnesses. However, night markets offer freshly cooked foods. Consumers can buy stir-fried noodles, home-made rice dishes, fried chicken and many more that have been freshly cooked. Perhaps buying outside from a street vendor or at a night market may be a better option than buying fast food from fast food outlets. This requires further study.

In Malaysia, there are many varieties of food that one can buy outside the home. A growth in food stalls and restaurants has occurred during the past few decades. Malaysians eat at restaurants at least once a week and the choice can vary from full-service restaurants to fast food outlets and hawker stalls (Boo et al. 2008). The pattern of eating out in restaurants is getting closer to the Americans, as 82% of US adults eat out at least once a week (Wu and Sturm 2013). The Malaysian population eats at a restaurant at least once a week, and some can afford to eat out almost every day out of the week, where the choice varies depending on budget, from fine-dining, cafes and fast food joints to hawker stalls (PricewaterhouseCoopers 2005). However, a concern is raised in regards to the increase of 24-hour access to local restaurants. Malaysia has many restaurants and street stalls that are open until late at night or even 24-hours (Bakar and Farinda 2010). These local restaurants provide local meal dishes or meals upon request from the customers (Bharath *et al.* 2007). This 24-hour food availability may enhance the increase in energy intake.

All in all, the changes that have occurred in Malaysia's food system have contributed to excess of energy intake and led to more energy input. The situation in Malaysia is having a positive energy balance as a result of less energy output, but more energy input. This study has purposely selected energy input as a key factor in investigating obesity. According to Popkin *et al.* (2012):

> "…Such levels of physical activity may be too much to expect (to offset any increase of about 110 kcal of food or beverage in average daily energy intake, a woman weighing 54 kg must walk moderately fast for 30 min and a man weighing 82 kg for about 25 min), so **dietary modification** is a key approach to lowering obesity prevalence, particularly with the ongoing decline in physical activity and increase in sedentary time…"

That is why this study has focused on dietary approaches in relation to obesity in Malaysia.

2.4 Malaysia nutrition transition: from 1965 to 2009

Objectives:

1. To investigate nutrition intake for the past 45 years in Malaysia using existing data (Food Balance Sheet)

2. To describe trends of food supply products for the same time period

3. To observe any shortfall or surplus in Malaysians' energy and nutrient intake

This review will analyse data from the Food Balance Sheet (FBS) to observe Malaysian nutrition transition. This chapter will start by giving an introduction to FBS, the methodology used in calculating energy and nutrient intake, using FBS data 1965 to 2009. It will then present trends over the past four decades of food supply products in Malaysia. Food balance sheets (FBS) are generally used to determine food consumption at the national level and present a comprehensive picture of a country's food supply and utilisation. The Food and Agriculture Organization (FAO) are responsible for publishing national food balance sheets for 176 countries, annually (Gibson 1990). FAO defined a food balance sheet as:

"A comprehensive picture of the pattern of a country's food supply during a specified reference period, calculated from the annual production of food, changes in stocks, imports and exports, and distribution of food over various uses within the country" (FAO 2001a)

Therefore, food supply is determined from domestic food production plus imports and food taken from stocks (Gibson 1990). Exports and food added to stock are then subtracted from domestic food production. Food diverted for non-human-food use, such as animal feed, seed and sugar in the brewing industry, together with an estimate for waste, is subtracted from the gross food supply. The end result is the net food supply of food available for human consumption in a country.

Data for all years were downloaded from the FAOSTAT website (http://faostat.fao.org/site/368/default.aspx#ancor). The interface of the FBS website is shown in Figure 2.5.

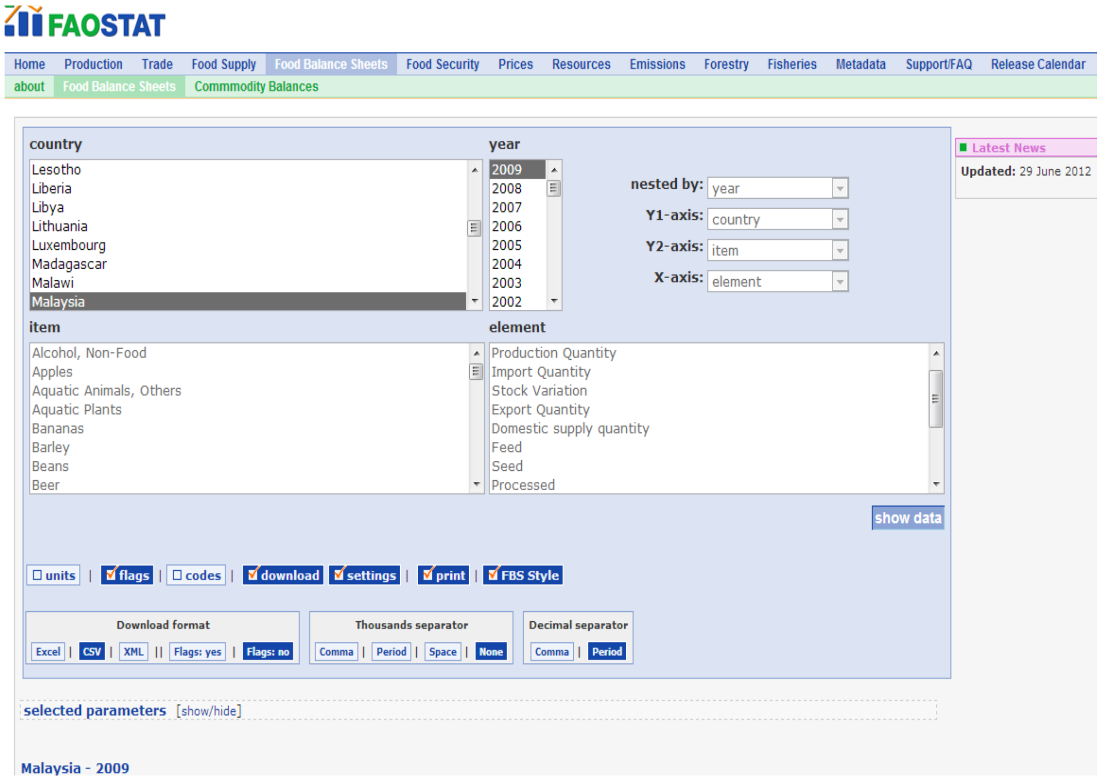


Figure 2.5: An overview of the Food Balance Sheet (FBS) database

Data were downloaded in excel form. The data for Malaysian FBS were available from 1965 until 2009. The years were then grouped into several groups, with a range of five years for each group (i.e. 1965-1969, 1970-1974, 1975-1979, 1980-1984, 1985-1989, 1990-1994, 1995-1999, 2000-2004 and 2005-2009). Since the aim of this section is to determine the food trends in Malaysia for the past four decades, a trend of food supply will, therefore, be analysed. First, it will analyse the estimation of total energy supply for the Malaysian population. This is measured in terms of calories (kcal/capita/day). The total energy is given by the grand total energy consumption of the total of vegetable and animal products. Vegetable and animal products consist of the following:

Table 2.2: List of vegetable and animal products for FBS

Vegetable products	Animal products
Cereals - Excluding Beer + (Total)	Meat + (Total)
Starchy Roots + (Total)	Animal Fats + (Total)

Sugarcrops + (Total)	Eggs + (Total)
Pulses + (Total)	Milk - Exduding Butter + (Total)
Treenuts + (Total)	Fish, Seafood + (Total)
Vegetable Oils + (Total)	Aquatic Products, Other + (Total)
Vegetables + (Total)	Offals + (Total)
Stimulants + (Total)	
Spices + (Total)	
Sugar & Sweeteners + (Total)	
Oilcrops + (Total)	
Fruits - Exduding Wine + (Total)	
Alcoholic Beverages + (Total)	
Miscellaneous + (Total)	

Source: Handbook of FBS (FAO 2001b)

Data used to develop the FBS come mainly from the governments of individual countries and are official estimates or counts which were published annually (FAO 2002). In FBS, each food item shows its primary commodity and the number of processed commodities that are potentially available for human consumption. The calculation of total quantity of foods is as follows:

"…The total quantity of foods produced in a country is added to total food imported and adjusted to any change in stocks that may have occurred during the specific period time. Meanwhile, the utilization includes the total quantities of food exported, fed to livestock, used for seed, processed for food used and non-food uses, and lost during storage and transportation…"

While per caput supply is obtained as follows:

"… dividing the respective quantity by the related data on the population participating. Data on per caput food supplies are expressed in terms of quantity and, by applying appropriate food composition factors for all primary and processed products - also in terms of caloric value and protein and fat content…" (FAO 2006)

Data collected for FBS information came from various sources. FAO recommended three basic conditions to achieve a consistency among the countries in terms of the data supplied to the FAO. These three conditions are illustrated in Figure 2.6. However, the available data normally doesn't meet either the second or third condition. The data supplied were from many different sources. The commonly used sources are summarised in Table 2.3.

Condition 1:
A country should have a comprehensive statistical system

↓

Condition 2:
Concepts of the information adapted should be those of the FBS concepts

↓

Condition 3:
Information available should be consistent, at least with respect to measurement

Figure 2.6: Ideal comprehensive statistical system to record FBS information. Source: Handbook of FBS (FAO 2001b)

Table 2.3: Sources of data for FBS data preparation

Data	Sources
Production and trade data	On-going national official statistics. It is based on direct enquiries or records, or estimated by Government agencies
Stock changes	Marketing authorities and factories or from farmer stock surveys
Industrial use	Industrial/manufacturing censuses/surveys
Feed and seeding rates	Cost of production surveys or estimated by the related Government agencies
Losses occurring in industrial processing	Manufacturing survey

Source: Handbook of FBS (FAO 2001b)

Since the fundamental data are obtained from various sources, they are prone to inconsistency. Adjustments to or estimation of the missing data are essential to derive consistency, completeness and reliability of the FBS data.

The grand total of energy supply of vegetable and animal products is presented for each average year. Next, this section will determine trends in total macronutrients (total carbohydrate, fat and protein) supplied by these animal and vegetable products and, finally, the pattern of the most consumed animal and vegetable products.

2.4.1 Trends over the past four decades of food supply products in Malaysia

This section will provide trends of total energy intake, total carbohydrate, total fat and total protein from the food supply in Malaysia.

2.4.1.1 Total energy intake in Malaysia

The total energy supply for the Malaysian population has been gradually increasing every 10 years from 1965 until 2004. However, it saw a slight drop of about 292kcal/capita/day for 2005-2009, as shown in Figure 2.7. In 2005-2009, there is a small decline in total food supply as well as in animal products supply. Animal products here include meats and offal, eggs, milk and products, excluding butter, animal oils and fats, and last, but not least, fish food. Meanwhile vegetable products consist of cereals, roots and tubers, sugar, syrups and honey, pulses, tree nuts, oil crops, vegetables, fruits, stimulants, spices and alcoholic beverages. Examining the share of vegetable and animal products in the total food supply, it can be observed that the contribution of animal products to the total food supply increased.

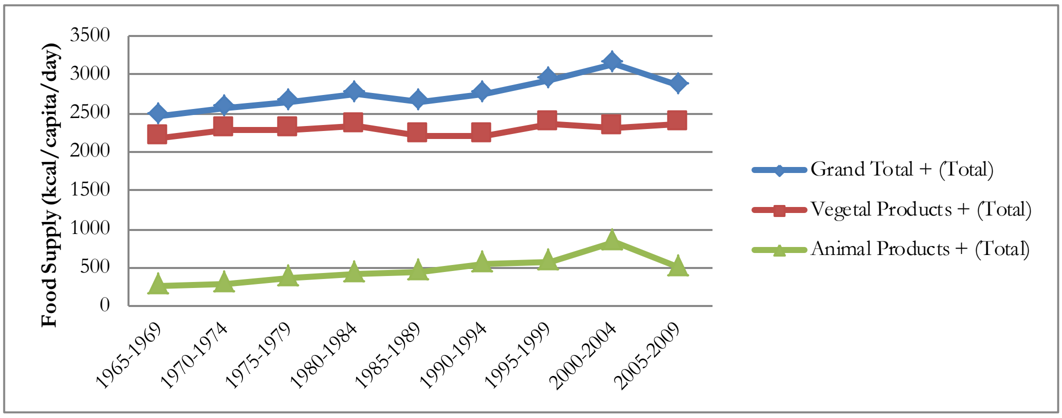


Figure 2.7: Daily per caput supply by products in terms of calories over the 45-year period, 1965 – 2009.

Although such average per capita supplies are derived from national data, they may not correspond to actual per capita availability, which is determined by many other factors, such as inequality in access to food. Likewise, these data refer to "average food available for consumption", which, for a number of reasons (for example, waste at the household level), is not equal to average food intake or average food consumption (WHO 2008).

2.4.1.2 Total carbohydrate intake in Malaysia

The most frequently consumed food among the Malaysian population is rice (MOH 2008). Therefore, this part will analyse a rice-related group of cereal products. Figure 2.8 shows the food supply by cereal products over the 45-year period, 1965 to 2009, which includes rice as well.

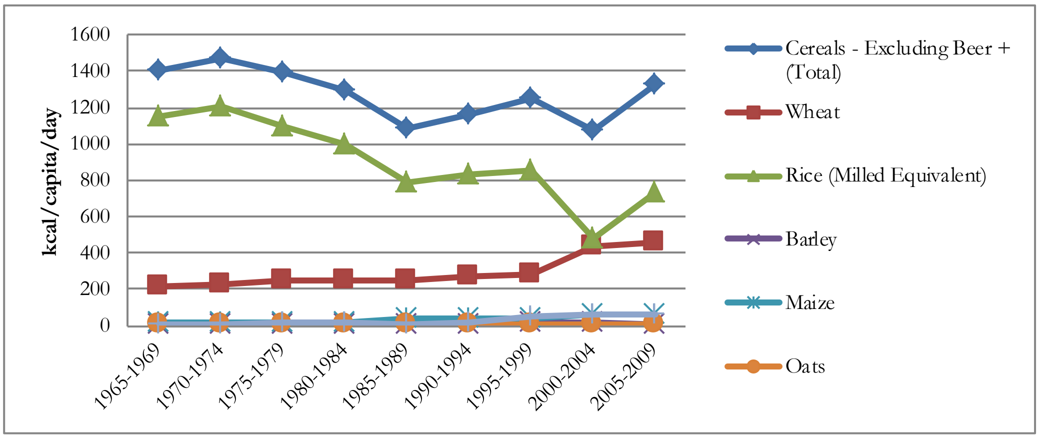


Figure 2.8: Cereal products supply over the 45-year period, 1965 – 2009

The supply from the grand total of cereals and total rice drastically dropped in 1995-1999 to 2000-2004. The trend in total rice supply reflects the trend in cereals, as rice is the main contributor and the food for the Malaysian population. However, rice supply gradually decreased from 999.4 kcal/capita/day in 1980-1984 to 785.6 kcal/capita/day in 1985-1989. Rice supply continued to decrease in 2000-2004, from 849.6 kcal/capita/day in 1995-1999 to 474.6 kcal/capita/day. This was similarly projected by Ismail (2002), based on a report by the Ministry of Agriculture, Malaysia. He showed that the rice per capita consumption had shown a downward trend from 102.2 kg year-1, 89.8 kg year-1, 86.9 kg year-1 and 85.7 kg year-1 from 1985, 1990, 1995 and 2000, respectively. A similar pattern was found in China and Thailand, where per capita consumption of rice declined (FAO 2006). On the other hand, wheat, maize, barley, oats, cereals and other per capita consumption steadily increased from 1985 onwards. Wheat (651 million tons) was the Third World's most produced cereals after maize (844 million tons) and rice (672 million tons) in 2010 (FAO 2010a). Wheat grain is generally used to make flour for leavened, flat and steamed breads, biscuits, pastry, pizza, cookies, cakes, breakfast cereal, pasta, noodles and much more. The slow divergences of diets away from the traditional staple of rice, and characterised by increased wheat, are the greatest consequence of globalisation and reflects the westernisation of the diet (Pingali 2007).

Sugar and sweeteners are important contributors to total carbohydrate supply, along with total cereals. Sugar and sweeteners products were grouped in the vegetable products by FAO. The total sugar and sweetener supply for Malaysia is shown in Figure 2.9. Sugar and sweeteners supply increased from 1965-1969 (290.6 kcal/capita/day) until 1995-1999 (469.6 kcal/capita/day). However, it dramatically dropped to 350.6 kcal/capita/day in 2000-2004.

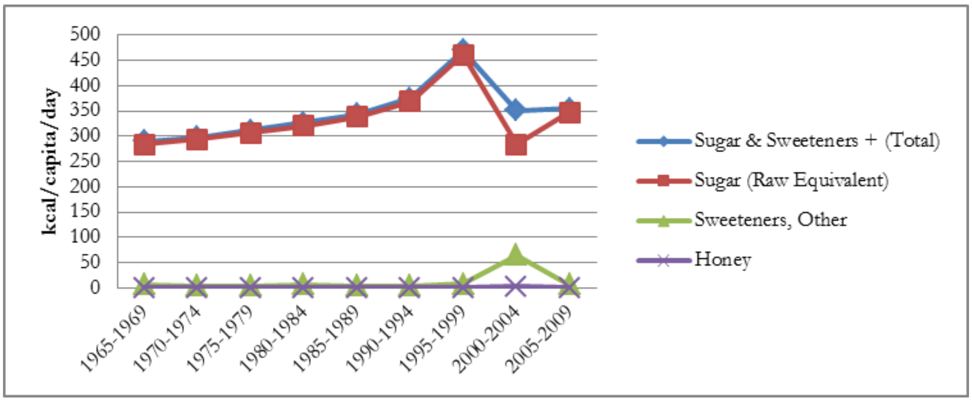


Figure 2.9: Sugar and sweeteners supply over the 45-year period, from 1965-2009

It was reported that, in 1993, Malaysia had higher sugar consumption (42.4 kg/person/year) than that other newly-industrialised countries (see Figure 2.10). India, Pakistan and Thailand had an average of 15 to 25 kg/person/year of sugar consumption, which was less than Malaysia (Ismail *et al.* 1997).

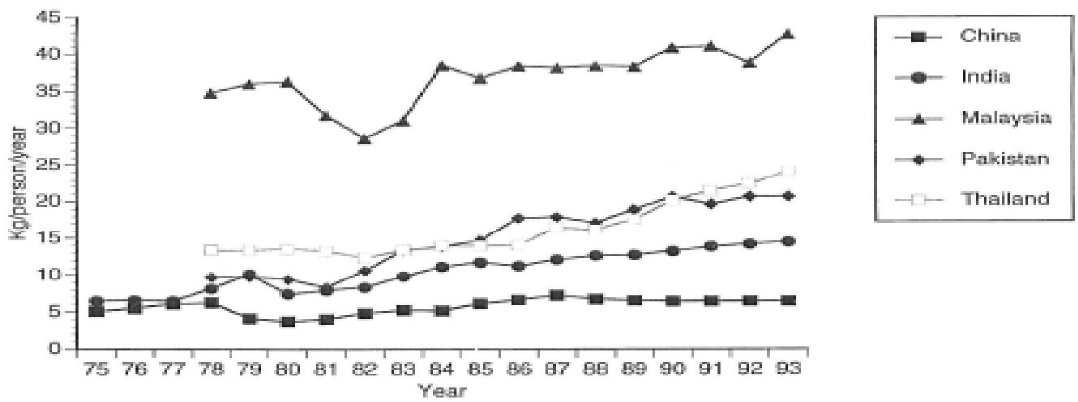


Figure 2.10: Average sugar consumption per person per year in China, India, Malaysia, Pakistan and Thailand

Most of the sugar consumed was hidden in manufactured/processed foods and drinks (Ismail *et al.* 1997; Monteiro 2009). Sugared drinks were the main contributor to the rise of sugars worldwide. The U.S.A and Canada were reported to be among the highest consumers of soft drinks (Monteiro 2010).

2.4.1.3 Total fat intake in Malaysia

Figure 2.11 shows the daily per caput food supply by grand total products, total vegetable products and total animal products in terms of total fat. The contribution of vegetable products was higher than the contribution of animal products over the 45-year period. Vegetable oil contributed almost three-quarters of the total fat content from vegetable product (FAO 2006).

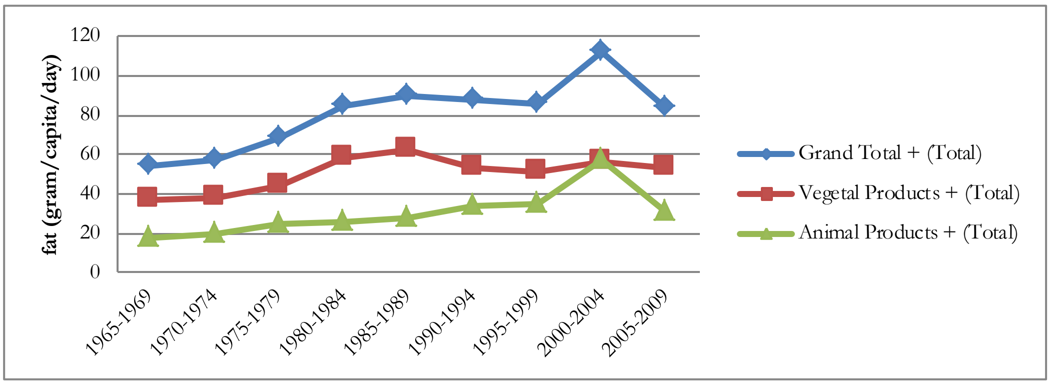


Figure 2.11: Daily per caput food supply by grand total (total vegetable + total animal products), total vegetable and animal products in terms of total fat

Palm oil was the highest source of vegetable oil among the Malaysian population over the past four decades. This was reflected in export and import in Malaysia, where Malaysia was among the largest producers and exporters of palm oil. In 2006, Malaysian exports steadily grew to 52% (26.3 million tonnes) of total world oils and fats exports (Sumathi *et al.* 2008). Palm oil was the most highly demanded vegetable oil in the world (Corley 2009). Similar findings were reported by USDA (2007), when total world vegetable oil consumption in 2006/2007 was 121 million tons (Mt) with palm ranked as the highest contributor; 37 Mt palm oil, followed by 35.5 Mt soya bean oil, 18 Mt rapeseed oil and 10.3 Mt sunflower oil.

There has been debate about the adverse effects of palm oil consumption on human health. Some studies have reported that the consumption of palm oil may increase blood cholesterol levels (Planning et al. 2001) and have other adverse effects on health. One of the plausible explanations is that palm oil is rich in palmitic acid, which contains carbon chain lengths of C16:0 (Bautista *et al.* 2001). Carbon chain lengths of C12:0 to C16:0 are a major determinant of the acceleration of serum low-density lipoprotein cholesterol (LDL-C) (Keys and Parlin 1966; Bautista *et al.* 2001; Kris-Etherton *et al.* 2001). Contrary to the allegation, studies done by other researchers found that palm oil significantly reduced the total cholesterol and the LDL cholesterol (Ng *et al.* 1991; Zhang *et al.* 1997; Ladeia *et al.* 2008) and was found to contain high vitamin E tocotrienols (Chong and Ng 1991; Srivastava and Gupta 2006), a powerful antioxidant, which acts as a natural inhibitor for the synthesis of cholesterol. Despite the soaring consumption of palm oil, studies on a linkage between palm oil and health are scarce, limited and conflicting. Therefore, more studies concerning the health effects of palm oil are needed (Kritchevsky 2000) as palm oil is part of the processed ingredient frequently and greatly used in Malaysia.

2.4.1.4 Total protein intake in Malaysia

Figure 2.12 shows the grand total protein from vegetable and animal products supply. Total protein from animal products supply (31.0 gram/capita/day) seems to surpass protein supply from vegetable products supply (28.4 gram/capita/day) in 1985-1989 and consistently increases, leaving protein supply from vegetable product behind.

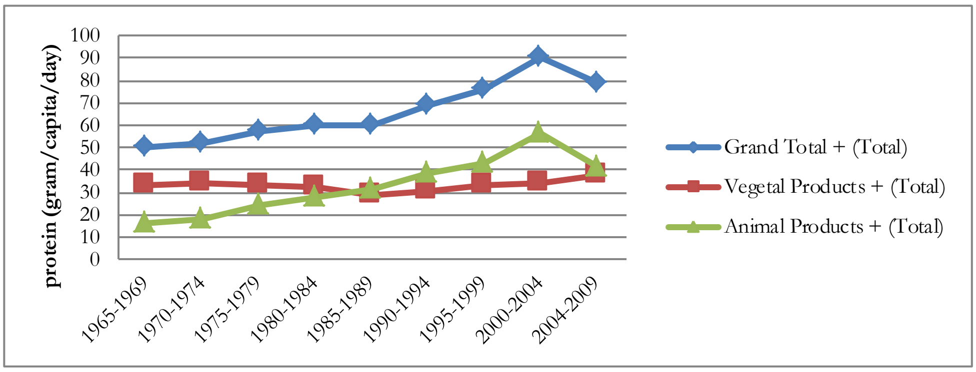


Figure 2.12: Daily per caput food supply by grand total (total vegetable + total animal products), total vegetable and animal products in terms of total protein

This might be because of Malaysian diet transition, which has been moving towards a diet higher in protein from animal products than vegetable products over the past few decades, leading to the characteristic of a 'westernisation diet' (Noor 2002a; Hawkes 2010).

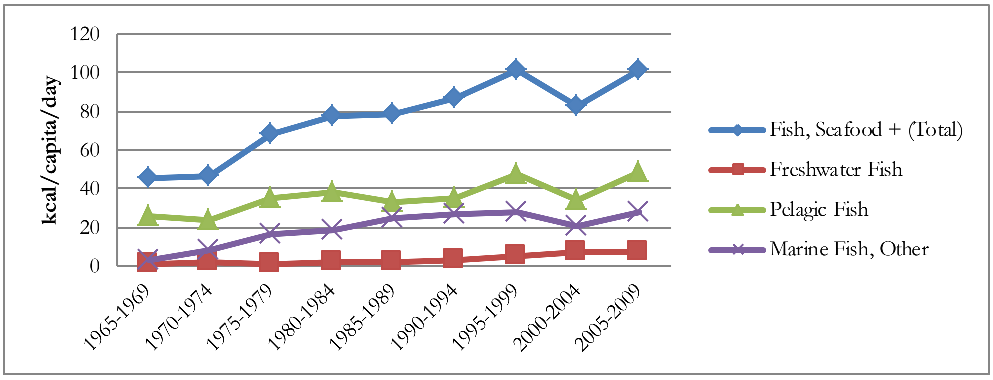


Figure 2.13: Food supply by fish over the 45-year period, 1965 - 2009

Figure 2.13 shows the food supply by fish over the 45-year period, from 1965 until 2009. Only the main contributors (freshwater fish, pelagic fish and marine fish) to the total fish food supply were included. Others (i.e. seafood and other negligible fish) were excluded because of the small percentage contribution. Consumption of fish (freshwater fish, pelagic fish and marine fish) has been progressively increasing over the past 45-year period, from 1965 to 2009. Fish has inevitably been the main source of economical and healthy protein for a large number of the world's population, especially those in Southeast Asia (Hajeb *et al.* 2009; FAO 2010).

In Malaysia, marine fish were consumed at about 59 to 62.5 kg per year and are in high demanded every year. Hajeb et al. (2009) highlighted that fish is a good source of n-3 fatty acids; calcium and phosphorus, iron, trace elements like copper and a fair proportion of the B-vitamins.

2.4.2 Summary of Malaysian Dietary Patterns

This review of food trends was to achieve the objective stated in this section, which was to assess the trends in dietary patterns. Since independence was achieved, Malaysia has shown an outstanding growth in gross national income (GNI) per capita, from U$350 in 1966 to U$5610 in 2006. The vital impact of economic and social drivers on diet is an increase in the amount of edible oils and sugar consumption. Malaysian food balance sheets showed that, from 1961 to 1997, the amount of calories obtained from sweeteners increased from 9.5% to 18%, and oils and fats from 11.4% to 14.8%, respectively (Noor 2002a). In Southeast Asia alone, annual sugar consumption doubled between 1990 and 2010 and annual palm oil consumption more than quadrupled in that same time period (McCloskey 2012). The outcome from such changes in the food system is a burgeoning of diets high in fat, salt and sugar. This is exactly what is currently occurring in Malaysia.

This review has found that the grand total of food supply (kcal/capita/day) increased from 1965 until 2004, but gradually declined until 2009. The total supply of animal products too increased over the past 45 years, but, in 2000-2004, began to drop. Meanwhile, the total supply of vegetable products was not much different over the past 45 years. The findings showed a strong positive relationship between GNI per capita and calories from total products, total vegetable products and total animal products.

This review has shown that fat supply from total vegetable products was higher compared to fat supply from total animal products. Vegetable oil was one of the main contributors of fat supply. This indicates that vegetable oil is the main supply for fat among the Malaysian population. This current finding will add substantially to the understanding that the Malaysian population is becoming to consume more oily foods. The next finding is that the total protein from animal products supply exceeded protein supply from vegetable products. Diets high in protein from animal products were strongly associated with the 'westernisation diet' pattern (Ablove *et al.* 2015).

Rice supply was slowly falling because of an increasing supply of wheat. It was strongly related to globalisation and is a sign of the westernisation of the diet (Pingali 2007) as well as an indication of enhancement in Malaysian society welfare (Sheng *et al.* 2008). It is one of the five main features characterising the changes in food demand in Asia alongside diet high in protein and energy dense food, and high demand for convenience food and beverages. This is part of the emerging increase in processed foods. This will be further discussed in the next few chapters.

The advantage of the food balance sheet (FBS) approach is data accessibility. It can be retrieved by anyone, as data have been made readily available online, and considerable documentation is available to users. The FBS contains almost all countries' food supply, with more than 180 countries (and territories) and about 100 different food commodities. Malaysia relied on food balance sheet analysis until the first national dietary survey was carried out in 2002. One study has been conducted using FBS for Malaysia from 1967 until 2007 to determine estimates and trends for the availability of foods and calories (Khor 2012a). However, FBS does not take into account the population intake individually, nor does it examine intake of each food type by the population. Perhaps the most serious disadvantage of FBS is how the foods have been classified. FBS categorised all foods into two groups, animal and vegetable supply. Our main concern is that not all sub-groups underlying animal and vegetable food supply were relevant. For example, vegetable oil was put under the vegetable group. This may lead to misinterpretation by those who do not have FBS knowledge. People may assume that vegetable food supplies only represented raw and fresh vegetables. To conclude, FBS may be beneficial in showing basic trends of food supply, but clearly not to assess the present dietary intake of a population.

Chapter 3: Dietary Pattern Approach

This chapter provides an overview of studies on dietary patterns published in Malaysia. Next, this chapter gives an account of introduction on dietary pattern approaches followed by types of dietary approaches, studies on association between dietary pattern and obesity, and finally a conceptual framework of the study along with research operational of this study.

3.1 Studies on Dietary Patterns in Malaysia

Several studies have been conducted on determining the dietary patterns of the Malaysian population. Some of the studies have gone further in studying the dietary patterns and diseases of the Malaysian population. Nevertheless, a search of electronic databases showed very few studies examining dietary patterns and obesity. Findings of all studies captured are presented below.

The objective was to review the evidence regarding dietary pattern studies and, if possible, its association with any diet-related diseases in the Malaysian population. Keywords were used for searching electronic databases on the theme. This was to ensure that all studies within the theme were captured. These keywords included dietary pattern, dietary approach, Healthy Eating Index (HEI), Diet Quality Index (DQI), food variety score, principal component analysis, factor analysis, cluster analysis, reduced rank regression, highly processed foods, nutritional status, BMI, overweight, obesity and diet disease relationship and Malaysia. Exposures in this case were defined as approaches available for examining dietary patterns including *a priori* and *a posteriori* methods. Outcome measures were any markers of nutritional status, or any diet related diseases.

Procedures in searching published studies

The procedures involved searching for studies using the keywords identified. It included searching studies from the earliest available until 2013. It was conducted systematically in order to capture all published studies within the scope of review. All relevant electronic databases, journals and books, and published papers were searched using the keywords to obtain all publications containing those keywords. The studies obtained were then combined and examined for any duplication and were limited to studies published in the English language.

Inclusion criteria

The following are the inclusion criteria used in selecting the studies:

- Study population: Malaysian population
- Study designs: both observational (prospective, cross-sectional and retrospective studies) and intervention studies
- Method/exposure: all dietary patterns analysed using any approaches (HEI, DQI, principal component analysis, factor analysis, cluster analysis, food variety score, reduced rank regression, etc.) are included
- Outcomes: outcomes measured should include any of the following: body mass index, waist circumference or any markers that indicate nutritional status, or any diet related diseases

Main Sources of Papers for Review

The keywords identified were used for finding studies relevant to the scope of study. These studies were searched from several main sources:

- Electronic databases: one of the most accessible and useful electronic databases used was the Social Sciences Citation Index (SSCI), which fully indexes over 1,700 major journals covering all social science disciplines (Bryman 2012). Another useful electronic database used was Pubmed. This was done through EndNote software. Together with SSCI and Pubmed, Medline and Embase were applied for search purposes. All searches were performed from 1st July, 2013 until 2nd August, 2013
- Hand and Reference Search: additional hand-searched sources included lists of reference from studies obtained from electronic sources and the Malaysian Journal of Nutrition from 1995 until 2013.
- University of Southampton Library journals (Soton Lib): published papers were searched through 'webcat soton', which provides the University's A to Z journal electronically

- Books on nutrition and public health at the University's Library were also searched for possible reports on dietary pattern approaches

Data extraction

A data extraction sheet was prepared for extraction of relevant information from the studies reviewed. The procedure of data extraction basically involved a panel of experts in methodology and theory meeting up regularly, discussing the boundaries of the review and carrying out the extraction independently. This was to ensure reliability of the review was achieved. However, this study omitted the procedure. This is because meeting supervisors regularly during the planning stage of literature review to discuss and define the boundaries of the research and identifying search key terms was considered sufficient and extremely valuable (Bryman 2012). Information extracted from the studies was:

- Details of publication
- Study design
- Sample size
- Methods of dietary approach
- Outcome of the studies (BMI, waist circumference, waist:hip ratio, cancer, diabetes, etc.)
- Main findings (related to the dietary approach and outcome of the studies)

Search results

A total of 14 studies met the inclusion criteria, which reported on dietary pattern approaches conducted among the Malaysian population. The flowchart of the screening articles is shown in Figure 3.1.

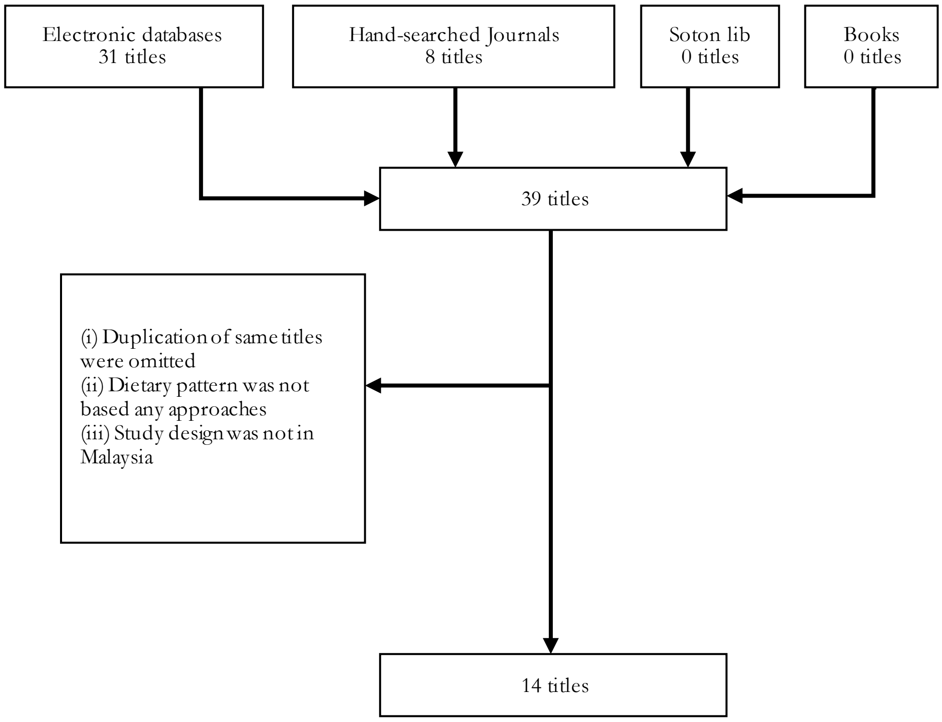


Figure 3.1: Flow chart of selection procedure for review

The studies omitted did not fulfil the inclusion criteria of review. These were studies that were conducted on dietary patterns, but did not apply any of the approaches (*a priori* or *a posteriori*) for assessing dietary patterns. Therefore, these studies were not included. Findings from the 14 studies were sorted according to methods of dietary approach applied in the study and also according to study determining an association between dietary pattern and nutritional status or diet-related diseases.

Number of studies assigned to methods of dietary approach (*a priori* or *a posteriori* or both)

- Dietary pattern via Food Variety Score (FVS) = 3 studies
- Dietary pattern via Diet Quality Index (DQI) = 1 study
- Dietary pattern via Diet Dietary Score (DDS) = 4 studies
- Dietary pattern via Healthy Eating Index (HEI) = 3 studies

- Dietary pattern via Principal Component Analysis (PCA) = 4 studies
- Dietary pattern via Cluster Analysis (CA) = 0 studies
- Dietary pattern via Reduced Rank Regression (RRR) = 0 studies

Number of studies determining association between dietary pattern and nutritional status or diet related diseases

- Dietary pattern and Body Mass Index (BMI) = 2 studies
- Dietary pattern and waist circumference (WC) = 1 study
- Dietary pattern and blood pressure, blood glucose and lipids = 1 study
- Dietary pattern and cancer = 2 studies

The overall description of the 14 studies is in Table 3.1. We can see that a great gap of knowledge exists on studies of dietary patterns in Malaysia. Most studies of dietary patterns in Malaysia were only assessing macronutrients and micronutrient intake. Those studies only saw diet quality as a comparison between nutrients intake and recommended level of nutrients. As long as the diet met the requirement for nutrients at a given level of energy intake, it could be addressed as high quality (Kant 1996b). A few applied *a priori* or *a posteriori* approaches in assessing dietary patterns (14 studies). Studies that applied dietary pattern approaches predominantly used *a priori* methods (11 studies) and less used *a posteriori* (4 studies) techniques.

Table 3.1: Studies related to dietary patterns in Malaysia

Author	**Year**	**Study design**	**Sample size**	**Methods of dietary approach**	**Outcome of measures**	**Findings**
Armstrong *et al.*	1998	Case-control study	282 Chinese patients with Nasopharyngeal carcinoma and matched with equal number for control	Principal Component Analysis	Nasopharyngeal carcinoma (NPC)	Intake from fresh fruits and vegetables associated with lower risk of NPC, salted, preserved foods, organ meats and alcohol intake were associated with higher risk
Shariff and Khor	2005	Cross-sectional study	200 rural respondents	Food Variety Score (FVS)	Body mass index (BMI) and waist circumference (WC))	Low FVS scores were associated with overweight and abdominal adiposity
Saibul *et al.*	2009	Cross-sectional study	182 Orang Asli (indigenous people) households (182 women and 284 children)	Food Variety Score (FVS)	Dual burden households (underweight child & overweight mother)	FVS of women were associated with dual burden households
Asma *et al.*	2010	Cross-sectional study	150 married couples	Diet Quality Index (DQI)	N.A	Diet quality of both were below satisfactory level

Yap *et al.*	2011	Cross-sectional study	179 Chinese Malaysian adults	Factor Analysis	BMI, blood pressure, blood glucose and lipids	Two dietary patterns: 'Balanced diet' and 'Meat, rice and noodles diet' (MRND) were extracted. MRND was associated with higher BMI, blood pressure, blood glucose and lipids
Zainal Badari *et al.*	2012	Cross-sectional study involving urban areas only	285 respondents; all ethnicities were included	Food Variety Score (FVS) and Diet Dietary Score (DDS)	N.A	Dietary patterns of the respondents were mainly protein- and energy-based foods
Helen *et al.*	2012	Case-control study	306 respondents	Principal Component Analysis (PCA)	Risk of oral cancer	Intake from the highest tertile of 'traditional' and 'combination' patterns predict stronger risk of oral cancer
Ey Chua *et al.*	2012	Cross-sectional study	216 children of Orang Asli (OA)	Diet Diversity Score (DDS)	N.A	DDS was significantly positively related to weight-for-age z-scores and height-for-age z-scores
Mohamadpour *et al.*	2012	Cross-sectional study	169 Indian women	Diet Diversity Score (DDS)	N.A	Subjects with higher intake of meat/fish/poultry/legumes and higher DDS was more likely to

						have less than 3 health risks.
Shahril *et al.*	2013	Case-control study	764 respondents (382 breast cancer cases and 382 healthy women)	Healthy Eating Index (HEI-2005)	Risk of breast cancer	Ability of HEI-2005 to predict breast cancer risk is poor
Loy and Jan Mohamed	2013	Cohort study	162 pregnant women	Principal Component Analysis (PCA)	N.A	Two major dietary patterns were derived; Healthy and Less-Healthy patterns among pregnant women
Teng *et al.*	2013	Intervention	25 healthy aging men	Healthy Eating Index (HEI)	Calorie intake	HEI showed a significant main effect for fat, saturated fat and cholesterol scores but low scores for food variability
Karupaiah *et al.*	2013	Case study	128 women	Healthy Eating Index (HEI)	N.A	Diet quality score was 79.3 ± 8.0 and considered as 'need improvement'
Ihab *et al.*	2013	Cross-sectional study	223 mother-child pairs	Diet diversity score (DDS)	N.A	Total diet diversity score of both types of mother-child pairs was low

N.A: No measures of association were conducted between dietary pattern and any diet related diseases

From Table 3.1, only two studies highlighted an association between dietary patterns and BMI. The first study was carried out by Shariff and Khor (2005). The main aim of the study was to examine the association between food insecurity and obesity among women in rural Malaysia. The study included an assessment of dietary patterns through food variety score (FVS). Two hundred Malay and Indian women participated in the study. From the findings, it showed low FVS, along with other factors (higher number of children, larger household size, longer time spent in leisure activities and food insecurity) were significant risk factors for overweight among women in rural areas.

The second study that examined the association between dietary patterns and obesity was done by Yap *et al.* (2011). The main aim of the study was to determine the association and interaction effects of vascular endothelial growth factor receptor-2 (VEGFR2) gene polymorphisms and dietary pattern on anthropometric and biochemical risk factors of chronic diseases among 179 Chinese Malaysian adults. Dietary pattern was assessed through component analysis. Two dietary patterns, 'Balanced diet' and 'Meat, rice and noodles diet' (MRND), were extracted from the component. MRND was found to be associated with higher BMI, blood pressure, blood glucose and lipids. However, a larger sample size is required to confirm the findings and, in addition, future prospective studies may be able to produce causal interpretations (Yap *et al.* 2012).

To conclude, studies on dietary patterns in Malaysia and obesity are scarce. With respect to most of the national dietary surveys conducted in Malaysia, there are no known studies that have been conducted to examine dietary patterns, either through *a priori* or *a posteriori* approaches. In addition, few studies have been done in determining the association between dietary patterns and obesity. Although some studies reported an association, they suffered from serious limitations. One major drawback of the studies is that they were restricted to specific ethnicity or gender. Malaysia is a multi-cultural country and, therefore, any study needs to consider capturing the whole ethnicity. All the studies reviewed so far, however, suffer from the fact that the sample size involved in each was small and may not be representative of the Malaysian population. Past studies would have been more interesting if the dietary pattern approaches were to be compared with one another and linked with overweight and obesity.

Therefore, the aim of this present study is to provide a more comprehensive study of dietary patterns that includes all groups of ethnicity and gender. A national dietary survey was used to reflect the Malaysian population in this study. More approaches to dietary patterns were applied to identify how different approaches interact with overweight and obesity.

3.2 Introduction of dietary pattern

"…Many parts are known, let us now grasp for the whole…" Werner Kollath (1949)

Schwerin *et al.* (1982) defined dietary patterns as a combination of different foods or food groups. The definition was generally accepted by other researchers as well (Hu 2002b; Kant 2004). Dietary patterns may be defined "theoretically, wherein nutritional variables (e.g., foods and nutrients) are grouped according to some *a priori* criteria of nutritional health, or empirically, in which variables are reduced into a smaller number of variables through statistical manipulation and evaluated *a posteriori*" (Newby and Tucker 2004). Researchers started to study dietary patterns rather than relying on single nutrients or foods (Moeller *et al.* 2007), as people do not eat only certain nutrients or foods, but rather a complex mixture of foods (Jones-McLean *et al.* 2010). This dietary pattern approach was initially suggested during the White House Conference on Food, Nutrition and Health in 1969 (Schwerin *et al.* 1981). However, in 1981, the US made its first attempt at applying the available data in studying the link between dietary patterns and nutritional status among the US population (Schwerin *et al.* 1981; Schwerin *et al.* 1982). It was a new way of exploring diet and health rather than sticking to the traditional analyses used in the nutritional epidemiology of evaluating the effect of single foods or nutrients on the risk of developing various chronic diseases (Hu 2002b; Kant 2004; Kourlaba and Panagiotakos 2009).

Studies have long relied solely on single or individual nutrients of foods in linking to development of disease (Sacks and Kass 1988; Kant 1996b; Sherafat-Kazemzadeh *et al.* 2010; Oude Griep *et al.* 2013) and biological markers (Hoffmann 2003). In the past few decades, researchers have placed a lot of attention on the shortage of certain nutrients as many people were showing low adequacy of certain nutrients. Understandably, therefore, the primary dietary goal during that time was avoiding deficiency diseases (Messina *et al.* 2001). Asia, before the second half century, experienced several nutritional disorders, such as beriberi, pellagra and protein energy malnutrition of young children. Micronutrient deficiencies of iron, iodine and vitamin A were also high at that time, leading to a high number of adolescents and adults who were undernourished (World Health Organization 1998). They even continued to experience deficits in nutrients intake, especially in vitamin A, iron, calcium, riboflavin and iodine. It was reported that approximately half of all vitamin A deficiency in the world occurs in South and Southeast Asia (Khor 2005). This led to rigorous empirical studies conducted and establishing the link between nutrients and single conditions. For example, studies between iron and anaemia (Batu *et al.* 1972; Lynch 1997), folic acid and neural tube defects (Bower and Stanley 1989; Toriello 2005) and certain saturated fatty acids and risk of cardiovascular disease (Erkkila *et al.* 2008; Siri-Tarino *et al.* 2010b, 2010a). This was to ensure that certain nutrient deficiency could be well-recovered by understanding the link between a single nutrient and its disease. In Indonesia, for example, there was a legal mandate of folic acid addition to foods and also fortification of B-vitamins, zinc and iron to flour and rice (Solomons 2008), since the population had a high number of people facing micronutrient malnutrition (Gross and Schultink 1997; Atmarita 2005). Because the human body cannot produce these essential micronutrients or be made less dependent on them, they must be gained from foods or supplements (Underwood 1998).

However, linking between a specific nutrient and a diet related disease is not appropriate, as people do not consume certain foods or nutrients only (Hoffmann 2003). It is because nutrients/foods do interrelate with one another (Kant 1996b; Hu 2002b; Kant 2004). Moeller et al. (2007) added that these nutrients/foods from meals consumed are likely to be interactive or synergistic. This was supported by Messina *et al.* (2001) who stated that one should recognise the significant effects of the whole food and the attendant interactions that occur among its constituents. Lynch and Cook (1980) demonstrated that the percentage of iron absorption differs when consumed in a meal consisting of two or more additional foods. They illustrated that soybean irons were better absorbed than black bean irons if consumed separately; nonetheless, a similar percentage of iron is absorbed from both bean sources when consumed together. This shows how overall composition of meals affects the absorption of nutrients. Additionally, many nutrients are highly correlated, which makes it hard to distinguish the effect of one nutrient (Moeller *et al.* 2007). An example of this is the non-heme iron absorption, which is enhanced by the presence of vitamin C (ascorbic acid) (Péneau *et al.* 2008). Vitamin C helps the non-heme iron to remain in the ferrous (Fe^{2+}), which is better absorbed, than the ferric (Fe^{3+}) form (Lynch and Cook 1980). It is recommended that the intake of vitamin C be equal to iron intake. This will enhance the non-heme iron absorption up to sixfold (Lynch 1997). Meanwhile, fibre, phytates and oxalates are dietary factors that inhibit the non-heme iron absorption (Péneau *et al.* 2008; Sanz-Penella *et al.* 2012). They prevent non-heme iron absorption by binding iron in the gastrointestinal tract (GI). Non-heme iron is supposedly transferred to the blood from the GI tract and bound to transferrin to be delivered to bone for synthesising haemoglobin. This shows the interaction of nutrients with one another (Bothwell

1995). Nutrient interaction was greatly discussed among researchers and how it may mislead the effect of a single nutrient on a specific health outcome (Kant 1996b, 2004).

Another strong reason is that the effect of a single nutrient may be too small to detect, but the cumulative effects of multiple nutrients included in a dietary pattern may be sufficiently large to be detectable (Hu 2002b). Hu (2002) added that analyses based on a large number of nutrients or food items may produce statistically significant associations simply by chance. That is why it is important to assess the whole dietary pattern of the individual and relevantly link it to overall nutritional wellbeing (Messina *et al.* 2001). Then, it may make sense to have a linkage between the current diet of the population and certain disease. For example, studies conducted on fat intake and body mass index (BMI) showed a significant positive association between these two variables (Bray and Popkin 1998). However, it may not be significantly sound, as other foods may also contribute to the BMI. Another example is studies done between maternal plasma zinc levels and birth weight, which have shown a positive relationship (Neggers *et al.* 1990). The finding shows that pregnant women with the lowest quartile of serum zinc concentrations had significantly higher prevalence of low birth weight compared to pregnant women with upper three quartiles of serum zinc concentration during pregnancy. Nevertheless, zinc is not the only contributor to birth weight and other nutrients may have an interrelation, which might affect the birth weight also. This is illustrated by the case of 538 mothers living in Southampton, UK, who delivered at term. Findings showed that high carbohydrate intake in early pregnancy and low protein intake in late pregnancy have a negative relationship with placental growth (Godfrey *et al.* 1996).

The introduction of the dietary pattern above provides justification for assessing the dietary pattern rather than relying on single nutrients or foods to link with overall nutritional wellbeing and explore diet-disease relationship. However, limitations still exist among the dietary pattern approach in regards to dietary data collection (Esmaillzadeh *et al.* 2008) and analytic issues that may need further research (Jones-McLean *et al.* 2010). The main focus in this thesis is the importance of the dietary pattern approach and its association with obesity.

3.3 Types of dietary approaches

Kant (2004), Arvaniti and Panagiotakos (2008) and Wirt and Collins (2009) have done great work on reviewing literature on dietary patterns and health outcomes. Most of the findings showed that the studies had used at least one of the two methods to determine dietary patterns in nutritional epidemiology: *a priori* and *a posteriori* methods.

The *a prio*ri method is based on diet indexes or scores that assess compliance with prevailing dietary guidelines, while *a posteriori* is a data-driven method that applies factor or cluster analysis to derive dietary patterns. In regards to diet indexes, there are three major approaches in constructing diet quality scores: (i) indexes from nutrients only, (ii) indexes from foods or food groups, and (iii) indexes from combination of nutrients and food groups (Kant 1996b). A few years back, the combination of nutrients and foods/food groups had been widely used in nutritional epidemiology studies because of the promising findings emerging in relation to dietary pattern and disease (Kourlaba and Panagiotakos 2009). Patterson et al. (1994) contributed an index containing both nutrients and foods, which was named as the diet quality index (DQI). This index was based on weighting of the selected nutrient and food intake recommendation of the Food and Nutrition Board. Similar to DQI is the healthy eating index (HEI), which consists both of nutrients and foods. HEI was constructed by the US Department of Agriculture (Kennedy *et al.* 1995). DQI and HEI are both useful in assessing overall diet quality.

Apart from the indexes, a novel food classification will be applied to the food intake. This novel approach, the ultra-processed products/foods (UPP), was developed by a Brazilian team (Monteiro *et al.* 2010). It was mainly classified according to the hierarchy of processed foods; from unprocessed foods or minimally processed foods to highly processed foods. The UPP is considered under a *priori* group, as it is based on criteria not data-driven. This approach places priority on processed foods that seem to be relatively neglected in some of the existing dietary guidelines. This approach is as important as the other approaches and becoming more prominent as the consumption of processed foods drastically increases. This novel approach was used in this present study to determine the status of processed food consumption in Malaysia.

Meanwhile, principal component analysis (PCA) is the most commonly used statistical technique compared to cluster analysis in *a posteriori* method. PCA deducts dietary variables through aggregation and produces a unique factor solution. These factor solutions were selected based on certain cut-off points of the Eigen-value. The remaining factor solution will usually be concluded by naming of the factors. Many studies have determined the association of patterns derived from PCA with nutrient intake, lifestyle factors and biological outcomes (Kant 2004). Although there seems to be significant impact of *a posteriori* application in assessing dietary patterns, this method has not been much practised in Malaysian studies.

A recent new approach in nutritional epidemiology is the reduced rank regression method (RRR) or maximum redundancy analysis (Hoffmann *et al.* 2004). It is a combination of both *a priori* and *a posteriori* methods. RRR is a statistical method that determines linear functions of predictors (foods) by maximising the explained variation in response (disease-related nutrients). Hoffman et al. (2004) illustrate the strength of RRR compared to the existing *a priori* and *a posteriori* methods. The main advantage of RRR is that it is more predictable for disease outcomes.

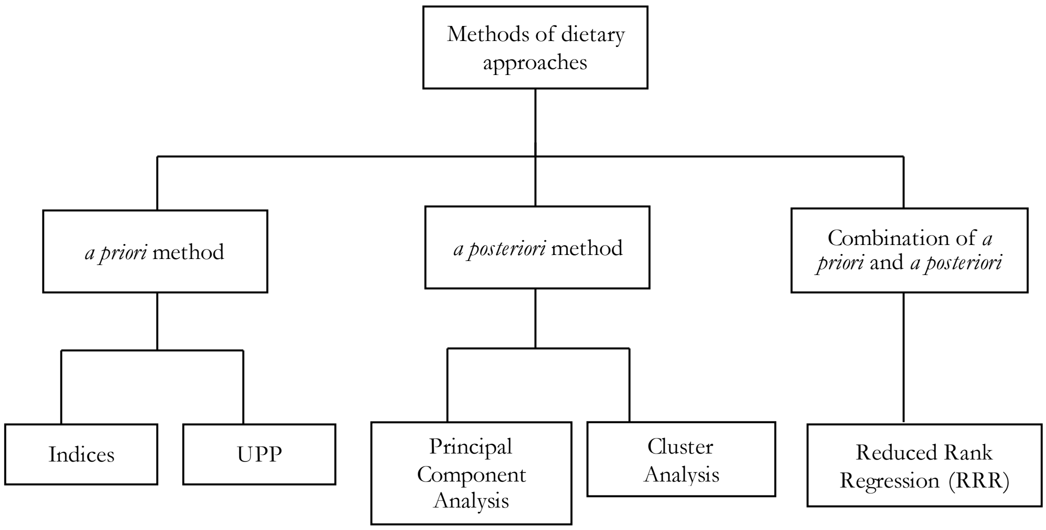


Figure 3.2: Methods of dietary approaches

To conclude, this study will assess the dietary patterns of the Malaysian population using *a priori* and *a posteriori* methods. Diet Quality Index (DQI), Ultra-Processed Products/Foods (UPP) and principal component analysis (PCA) were selected to represent the methods, respectively. The dietary pattern assessment did not include RRR approach, so as to focus solely on *a priori* and *a posteriori* methods. The main reason was because Malaysia lacks studies using *a priori and a posteriori* approach PCA. However, in future studies, RRR will be absolutely included to determine the strength of RRR compared to the two distinct methods. Description of the methods used in this study is provided in the next sub-section.

3.4 *a priori* approach

3.4.1 Indices

Many researchers have analysed dietary patterns using numerous indices; for example Healthy Eating Index (HEI), Alternate Healthy Eating Index (AHEI), Diet Quality Index Revised (DQI-R), Recommended Food Score (RFS), Diet Variety Score (DVS), Food Variety Score (FVS) and the alternate Mediterranean Diet Index (aMED) (Kant 2004). Most of the indices are based on national nutrition recommendations and national dietary guidelines (Kourlaba and Panagiotakos 2009) and specific to the country where the tool was developed (Kim *et al.* 2011). Most were constructed in the US. HEI and DQI were developed in the US and were among the most applied indices in nutritional epidemiology studies (Kant 1996b; Arvaniti and Panagiotakos 2008).

HEI consists of 10 components with possible scores ranging from 0 to 100 and, in 2005, it was revised to meet the US 2005 Dietary Guidelines and renamed HEI-2005 (Guenther *et al.* 2008a). Recently, HEI-2005 was updated to HEI-2010 with few changes and retains several features of the 2005 version (Guenther *et al.* 2013). Table 3.2 shows the difference between HEI, HEI-2005 and HEI-2010. HEI consists of 10 components and both HEI-2005 and HEI-2010 comprise of 12 components. All bring total scores of 100 points for total perfect scores. HEI-2005 is different from HEI in a number of respects. HEI-2005 had several additional components developed, which involved: (1) forming whole fruits, in accordance with the 2005 Dietary Guidelines' recommendation that it is better to consume more whole fruit rather than fruit juice; (2) adding dark green and orange vegetables, as those intakes were the lowest in the recommended level; (3) forming whole grains, because dietary guidelines recommended that at least half of the grain consumed must come from whole grain; (4) adding oil as a component; (5) and calories from solid fats, alcoholic beverages and added sugars were grouped as a component in the role of discretionary calories (Guenther *et al.* 2008a).

Table 3.2: Components of HEI, HEI-2005 and HEI-2010

HEI		**HEI-2005**		**HEI-2010**	
Component	**Range of Score**	**Component**	**Maximum score**	**Component**	**Maximum score**
Adequacy		Adequacy		Adequacy	
Total fruit	0 – 10	Total fruit	5	Total fruit	5
Total vegetables	0 – 10	Whole fruit	5	Whole fruit	5
Total grains	0 – 10	Total vegetables	5	Total vegetables	5
Milk	0 – 10	Dark green and orange vegetables and legumes	5	Greens and beans	5
Meat (and beans)	0 – 10	Total grains	5	Whole grains	10
Variety	0 – 10	Whole grains	5	Dairy	10
		Milk	10	Total protein foods	5
		Meat and beans	10	Seafood and plant proteins	5
		Oils	10	Fatty acids	10
Moderation		Moderation		Moderation	
Sodium	0 – 10	Saturated fat	10	Refined grains	10
Saturated fat	0 – 10	Sodium	10	Sodium	10
Total fat	0 – 10	Calories from solid fats, alcoholic beverages and added sugar	20	Empty calories	20
Cholesterol	0 - 10				

*Criteria for perfect score for HEI and HEI-2005 according to Kennedy et al. (1995), Guenther et al. (2008a) and Guenther et al. (2013)

However, only a few changes were made in HEI-2010 from the existing HEI-2005. The changes include: (1) greens and beans components substituted for the dark green and orange vegetables and legumes; (2) adding a seafood and plant proteins component to capture explicit selections from the protein group; (3) forming fatty acid component to replace oils and saturated fat, as suggested by guidelines to replace saturated fat with monounsaturated and polyunsaturated fatty acids; and (4) in the moderation component, refined grains substituted the adequacy component, total grains, to determine over-consumption. Components for calories from solid fats, alcoholic beverages and added sugars in HEI-2005 were revised and renamed as Empty calories, a more concise term that may assist in delivering this concept to the population (Guenther *et al.* 2013).

Table 3.3: Components of DQI and DQI-R

DQI		**DQI-R**	
Components	**Range of score**	**Components**	**Range of score**
Total fat < 30% energy intake	0 – 2	Total fat < 30% energy intake	0 – 10
Saturated fat < 10% energy intake	0 – 2	Saturated fat < 10% energy intake	0 – 10
Dietary cholesterol < 300 mg/day	0 – 2	Dietary cholesterol < 300 mg/day	0 – 10
Eat ≥ 5 servings daily of a combination of vegetables and fruits	0 – 2	2 – 4 servings fruit per day, % recommended servings	0 – 10
Eat ≥ 6 servings daily of breads, cereals, and legumes	0 – 2	3 – 5 servings vegetables per day, % recommended servings	0 – 10
Maintain protein intake at moderate levels	0 – 2	6 - 11 serving grains per day, % recommended servings	0 – 10
Limit total daily intake of sodium to 6 g (2,400 mg) or less	0 – 2	Calcium intake as % AI for age, % recommended servings	0 – 10
Maintain adequate calcium intake (approximately RDA levels)	0 – 2	Iron intake as % 1989 RDA for age, % recommended servings	0 – 10
		Dietary diversity score	0 – 10
		Dietary moderation score	0 – 10

*Criteria for perfect score for DQI and DQI-R according to Patterson *et al.* (1994) and Haines *et al.* (1999)

DQI consists of 10 components as shown in Table 3.3. It was then revised and updated to DQI-R. In DQI, a score of zero was given to individuals who met the diet and health goal, but those who did not achieve the goals, but had a fair diet, were given one point and those who had poor diets were given two points. The total score was added up and scores ranged from zero (excellent diet) to 16 (poor diet) (Patterson *et al.* 1994). Whereas in DQI-R, scale of scoring was changed to a total possible score of 100 points to improve interpretability, lower scores reflect poorer achievement of dietary recommendations, while higher scores reflect better dietary quality. One of the changes made was that fruit and vegetables were separated from a single component and formed as two individual components, and number of serving size for total grains, fruit and vegetable was adjusted to reflect intake as a proportion of the number of servings recommended for the appropriate energy level.

The inclusion of iron intake in DQI-R was to target specific population at risk, which included pregnant and young women, children and families with limited resources. The last two scores, diversity and moderation, were new components developed to reflect differences in dietary intake and behavioural patterns, respectively.

Whilst HEI and DQI were developed in the US, there are a reasonable number of studies that modified the existing indexes to adapt to a specific population. For example, China developed an index modified from DQI. Due to dual burden disease in China, the main concern for the development of the China DQI was to assimilate all elements of Chinese dietary guidelines into the Chinese DQI, except for the last guideline, 'Avoid unsanitary and spoiled foods'. The Chinese guidelines were constructed to highlight these two-dimensional needs, under and overnutrition. Components indexing aspects of under or overnutrition obtained either positive or negative scores. In regards to the importance of under and overnutrition-related problems, the components of China DQI consist mainly of negative scores rather than positive scores. This is an aspect that differs from the original DQI. The Chinese DQI score was found to be significantly correlated with food and nutrient intakes, BMI, urban residence and income. In the context of nutrition transition surveillance, Chinese DQI is a useful tool, as it appears to be sensitive to under and overnutrition, as well as socio-demographic variables for the Chinese population (Stookey *et al.* 2000). Meanwhile, researchers from Taiwan incorporated the HEI concept for developing Taiwan diet quality index as the Overall Dietary Index (ODI), which was revised in 2008 and became the Overall Diet Quality Index Revised (ODI-R) (Lee *et al.* 2008). ODI-R had several additions compared to HEI, namely, diet moderation, soy and fish. This was due to the proliferation of studies showing that fish and soy have many healthy aspects (Schmidt *et al.* 2000; Villegas *et al.* 2008). Initial ODI had a weak relationship with health status, but the revised ODI-R echoes food quality more appropriately than ODI in regard to micronutrients. To conclude, ODI-R is more sensitive than ODI in assessing dietary quality.

France also adapted the DQI in assessing dietary patterns among 473 men and 491 women in three age classes in Mediterranean southern France (Scali *et al.* 2001). The DQI was converted to a Mediterranean DQI (MDQI) with several adjustments to fit with a population living in a Mediterranean area (Gerber 2006). Protein intake in one of the DQI components was replaced with meat intake. This was because protein intake did not show any increases in scores compared to meat intake. Meat intake included processed and fresh-cut beef, veal, mutton, lamb and pork, while fish was categorised in another group (Scali *et al.* 2001). This was because meat and fish consumption were shown to have opposite interactions for cardiovascular diseases and some cancers (Daviglus *et al.* 1997; Hsing *et al.* 1998; Bessaoud *et al.* 2008). Olive oil was added in MDQI (Gerber 2006) as the result of epidemiological findings showing its potential benefit in relation to cardiovascular disease and some cancers (Lairon 2007; Bessaoud *et al.* 2008). Therefore, there are two different sources of fat intake; saturated fat and olive oil (Gerber 2006). Findings showed poor MDQI were associated with smokers and younger age among men and women, and while more obesity was seen with poor MDQI among the women. MDQI have potential capabilities in confirming the strong association between smoking, heavy wine drinking and obesity with poor dietary habits. MDQI also managed to capture the disappearance of traditional foods in the study population (Scali *et al.* 2001). It was also tested against an array of nutritional biomarkers, β- and α-carotenes, vitamin E, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) and markers of fish intake, and findings showed that each biomarker was associated with the MDQI (Gerber 2001).

Apart from the US, there were other countries that adopted HEI and DQI without any adjustments or just a minor adjustment (Mirmiran *et al.* 2006; Frackiewicz *et al.* 2010). In Malaysia, the revised HEI (HEI-2005) was used in determining association between dietary pattern and risk of breast cancer in Malaysia. Findings showed that there was weak association between dietary pattern and risk of premenopausal and postmenopausal breast cancer among Malaysian women (Shahril *et al.* 2013).

A considerable amount of literature has been published on the advantages and disadvantages of each index. Fung et al. (2005) carried out a study to assess the association between several diet-quality scores and plasma concentrations of markers of inflammation and endothelial dysfunction. Endothelial dysfunction is highly related to risk of cardiovascular disease development. Diet quality scores assessed were Healthy Eating Index (HEI), Alternate Healthy Eating Index (AHEI), Diet Quality Index Revised (DQI-R), Recommended Food Score (RFS) and the alternate Mediterranean Diet Index (aMED). Findings showed AHEI and aMED were significantly related to lower concentrations of most biomarkers, whereas RFS was significantly associated with lower concentration of E-selectin. The study concluded that higher AHEI and aMED may be beneficial as guidelines for levelling-off the risk of diseases involving such biological pathways. Fung et al. (2006) attempted another study on assessing the diet quality scores. This time, they studied the association between diet quality scores and risk of breast cancer among postmenopausal women. They found that women with high scores of AHEI, RFS and aMED had significantly lower risk of breast cancer. The findings might have been far more persuasive if the researchers had considered other ethnicity and age groups and involved the participation of men and women, especially in the first study. The study was restricted to US women aged 43–69-years-old with no history of cardiovascular disease, cancer or diabetes at the time blood was drawn.

Nutritional epidemiological studies revealed that HEI and DQI-R were useful in assessing dietary patterns. A study done by Neuhouser et al. (2003) support that DQI is excellent in measuring dietary patterns. A study conducted among 102 healthy postmenopausal women in the USA assessed the association between DQI and selected nutritional biomarkers. Women who scored better DQI had higher plasma concentrations of vitamin C, a-tocopherol and b-cryptoxanthin. They also had lower proportions of plasma phospholipid fatty acids of two potentially atherogenic fatty acids; stearic acid and behenic acid. Neuhouser *et al.* (2003) highlighted the association between an array of biomarkers and DQI scores, which suggested that DQI is a relevant tool in measuring total diet.

The extensive amount of DQI-R's potential benefit compared to HEI was highlighted by Haines et al. (1999) Also, diet quality index is more relevant to the Malaysian population when compared to HEI and revised Healthy Eating Index (HEI-2005 and HEI-2010). Haines *et al.* (1999) listed the commonalities and differences between DQI-R and Healthy Eating Index. The commonalities between DQI-R and HEI/HEI-2005/HEI-2010 are listed below:

1) Both indices are a combination of nutrients and food groups
2) Both indices have a total possible score of 100 points
3) Both indices include recommended number servings of fruits, vegetables and grains
4) Both indices measure percentage energy from fat, saturated fat and dietary cholesterol
5) Both measure dietary variety, but the definition differs between both the indices

Dietary variety in HEI was counted only if the intake contributed at least half a serving in any of the food groups, whereas, in DQI-R, it was counted if intake is at least one-half serving during a two day survey period of any 23 food categories. The variety component in DQI-R was constructed to reflect intake across 23 broad food categories, which included grain-based products, vegetables, fruit and juices and animal-based products. However, in HEI-2005 and HEI-2010, the key feature of variety was omitted.

On the other hand, the differences between both indices, as listed by Haines *et al.* (1999), are:

1) The HEI is reported for person aged 2 years and older, while results of the DQI-R are reported for persons aged 18 years and older.

2) DQI-R is less correlated with energy than is HEI. Low correlations between energy and the DQI-R scores would suggest independence of the diet quality to diet quantity. This is because nutrient intake is positively correlated with energy intake; a diet quality index could overrate high-calorie diets, especially if nutrient adequacy is weighted more heavily than moderation and if intakes are measured in terms of absolute amounts rather than as densities (Guenther *et al.* 2008b).

3) HEI measures meat and milk, but DQI-R measures iron intake and calcium. Calcium can be derived from other sources, since milk is not the only source for calcium in certain countries. Kim et al. (2003) argued that intake of dairy foods alone would considerably under-represent the true intakes of calcium-rich foods in developing countries. Since Malaysians have habitually low dairy consumption, selecting calcium as a component is preferable to avoid underestimating calcium intake among the Malaysian population.

4) DQI-R method of measuring servings of fruits, vegetables and grains, which uses the Pyramid Servings Database, is currently more reproducible than the commodity equivalent method used in the HEI.

5) Iron intake was included in DQI-R and was absent in HEI. Iron is an essential component to be included for the Malaysian population. Level of iron intake was low among susceptible groups in Malaysia, which included young females, pregnant mothers and women of childbearing age (Foo *et al.* 2004). Surveys such as that conducted by Loh and Khor (2010) have shown that, when mean intake of iron among 388 women aged 20-40 years in Malaysia was compared to the Malaysian Recommended Nutrient Intake (RNI), assuming 10% iron bioavailability, it was seen that only 15.5% met the RNI level for iron. Approximately 76.5% of the respondents did not meet two-thirds of the RNI. It was reported that mean intake of total iron was at 14.4 mg/day, 49.7% of the Malaysian recommended nutrient intake (RNI).

Indian women had the highest intake of iron (16.0mg/d), while Chinese women had the lowest (11.3 mg/d). Hassan et al. (2005) conducted a study among 52 Malay women attending prenatal clinic in Kelantan, Malaysia, and found that the majority of respondents were mildly anaemic (90%). The prevalence of iron deficiency anaemia in pregnant women was 21.2%, which corroborated findings from other developing countries. Foo *et al.* conducted a study to examine iron status and dietary iron intake of adolescents from a rural community in Sabah, Malaysia. Findings revealed that dietary iron intake of the adolescents was poor, about 98% of respondents did not meet the Malaysian RDA level. Nearly all the female respondents (91%) had dietary iron intake below two-thirds of the RDA level compared to a smaller proportion for the male adolescents (68%). In conclusion, iron intake is an important component to be included.

We can now see how DQI-R fits in Malaysian dietary guidelines. Table 3.4 shows the Malaysian Dietary Guidelines (MDG) and how DQI-R corresponds to each key message in MDG.

Table 3.4: Malaysian dietary guidelines-2005 and the corresponding components in DQI-R

Malaysian Dietary Guidelines	**Corresponding component(s) in DQI-R**
(1) Eat a variety of foods within your recommended intake	Diet variety
(2) Maintain body weight in a healthy range	
(3) Be physically active everyday	
(4) Eat adequate amount of rice, other cereal products (preferably whole grain) and tubers	Recommended servings of grains per day
(5) Eat plenty of fruits and vegetables everyday	Recommended servings of fruits and vegetables per day
(6) Consume moderate amounts of fish, meat, poultry, egg, legumes and nuts	Diet variety
(7) Consume adequate amounts of milk and milk products	Calcium intake
(8) Limit intake of foods high in fats and minimise fats and oils in food preparation	Total fat, saturated fat and dietary cholesterol Dietary moderation : Discretionary fat
(9) Choose and prepare foods with less salt and sauces	Dietary moderation : Sodium intake

(10) Consume foods and beverages low in sugar	Dietary moderation : Teaspoon of added sugar
(11) Drink plenty of water daily	
(12) Practise exclusive breastfeeding from birth until six months and continue to breastfeed until two years of age	
(13) Consume safe and clean foods and beverages	
(14) Make effective use of nutrition information on food labels	

The first key message is to eat a variety of foods within one recommended intake. This can be retrieved by the diet variety component in DQI-R, which covered 23 food sub-groups. The 23 food sub-groups were likely to represent the Malaysian food pyramid, as shown in Figure 3.3.

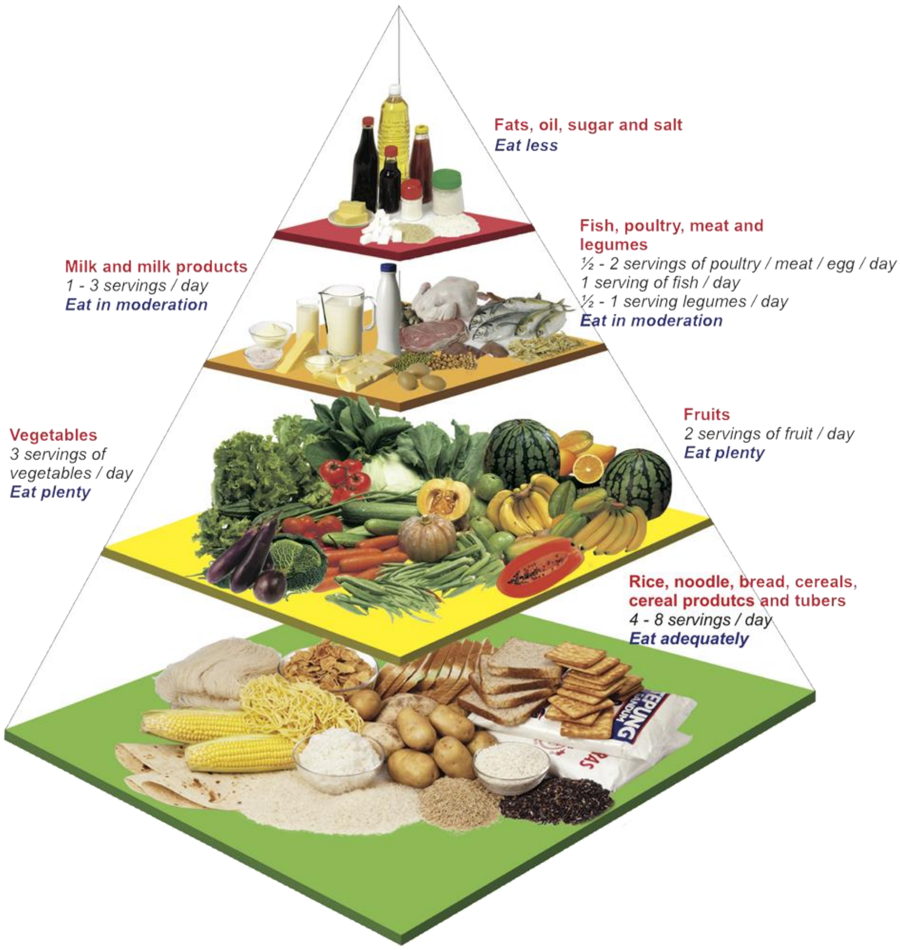


Figure 3.3: Malaysian Food Pyramid

The Malaysian food pyramid consists of five groups placed at four levels. Each group has a recommended number of serving sizes. The advised number of servings is the average amount that individuals are recommended to eat each day. The number of servings is based on 60% carbohydrate (50% complex carbohydrate and 10% sugar), 15% protein and 25% fat. Therefore, the number of these macronutrients intake is calculated based on 1500 kcal, 2000 kcal and 2500 kcal per day. The number of servings recommended for the base level of the pyramid, which is the cereals, tubers and grains group, is 4 to 8 servings per day. One serving of food in this group equals to 30g of carbohydrate. The number of serving sizes differed from the previous MDG. The previous food pyramid recommended 8 to 12 servings per day, with one serving equal to 15 g carbohydrate. The reason for the changes was the misleading messages among consumers. The terminology "serving size" was commonly mistaken by the consumer. Consumers took a misleading message about consuming the base level group (cereals, tubers and grains group) (Monteiro 2011). To be able to receive higher scores in diet variety/diversity, one needs to consume at least one and a half servings of the foods per day listed under diet variety/diversity.

Recommended servings of grains, fruits and vegetables were selected to evaluate intake of rice, other cereal products (preferably whole grain) and tubers, and fruits and vegetables, respectively. Diet variety was again selected to match the key message for consuming moderate amounts of fish, meat, poultry, egg, legumes and nuts. Meanwhile, calcium intake and total fat, saturated fat and dietary cholesterol were selected to address the number of milk and milk products and to observe intake of foods high in fats, and fats and oils in food preparation, respectively. Dietary moderation was addressed to reflect foods with less salt and sauces, and foods and beverages low in sugar.

As for future consideration in improving the MDG, some limitations could be identified. Most dietary guidelines place a general guidance on eating a healthy diet. A healthy diet is a combination of foods, of which some foods may be more likely to be healthy than others (Scarborough *et al.* 2007b). Furthermore, there is a debatable argument about the clear-cut definition of 'unhealthy'/'less healthy' and 'healthy'/'healthier' food, and other nutrients as well (Arambepola *et al.* 2008). It becomes more confusing for the consumer when this is used by food retailers, food manufacturers and others in labelling food products, as for example, 'low-fat' or 'healthy' (Scarborough *et al.* 2007a; Arambepola *et al.* 2009). Thus, a nutrient profile model was developed to generate definitions for 'healthy' and 'unhealthy', as applied to foods based on nutritional content (Scarborough *et al.* 2007b). Rayner *et al.* (2013) defined nutrient profiling as stated by the WHO in the Guiding Principles and Framework Manual for the development or adaptation of nutrient profile models, as:

> '… The science of classifying or ranking foods according to their nutritional composition for reasons related to preventing disease and promoting health …'

Scarborough et al. (2007b) developed the nutrient profile model in a systematic, transparent and logical step, unlike the previous criteria, which was on an ad hoc basis. In this study, they developed a nutrient profile model for comparing breakfast cereals and found that when a certain score from the continuous score was set to define 'high in fat, sugar and salt', some foods that were high in salt were not included. On the other hand, the continuous score was more sensitive to medium levels of fat, salt and sugar, not just including high levels of these nutrients when categorising. To date, there are hundreds of published nutrient profile models which are detailed in catalogue and will be subsequently published by the WHO (Rayner *et al.* 2013). This nutrient profile will, perhaps, be another forthcoming contemplation in Malaysia for improving dietary guidelines, food labelling and food marketing advertisements.

3.4.1.1 UPP dietary approach

A Brazilian research team recently developed an approach towards a new food classification by including processed foods (Monteiro *et al.* 2010). The new food classification was based on the nature, extent and purpose of food processing. All the foodstuffs were classified into three groups:

Group 1- unprocessed or minimally processed foods;

Group 2- processed culinary ingredients; and

Group 3- ultra-processed products

Group 1 is briefly explained as minimal modifications of whole foods to prolong their duration, enable storage and reduce time/effort in their culinary preparation, while Group 2 is the extraction of substances from whole foods, enabling the manufacture of highly storable ingredients used in the culinary elaboration of dishes/meals made from whole foods (e.g. refined oil, fat, sugars, etc.). Finally, Group 3 is defined as the processing of a mix of Group 2 ingredients and Group 1 foodstuffs, or, more precisely, an extraction of substances from whole foods followed by their subsequent assembling (usually with lots of additives and little or no whole food), thereby enabling the manufacture of long shelf-life, ultra-palatable and ready-to-eat products (e.g. biscuits, cake, chicken nuggets, etc.) (Monteiro 2012).

The Brazilian research team found that Brazilian household consumption of unprocessed and minimally processed food groups has been surpassed by consumption of the ultra-processed food group among both the lower- and upper-income groups across all of society. The consumption of UPP contributes more added sugar, more saturated fat, more sodium, less fibre and much higher energy density (Monteiro *et al.* 2011). Another ongoing study by the Brazilian team, along with several countries, is developing an international comparative study to assess time trends in food consumption according to this new classification system. The results of this study will be the first international comparison study from Southeast Asia in assessing time trends in food consumption. In addition, in Malaysia, no study to-date has yet conducted research on developing a more evidence-based and critical approach model by grouping foods based on the food processing experiencing from Brazil and other countries. This model will subsequently be tested for an association with obesity.

3.4.2 *a posteriori* approach

If an *a priori* approach builds upon previous knowledge concerning the positive or adverse health effects of various dietary components and works through the calculation of a score that recognises groups with 'good' or 'poor' nutritional intakes, then the *a posteriori* approach is constructed through the observed dietary data in order to extract components, by means of an appropriate exploratory statistical methodology (Bamia *et al.* 2005). The means of appropriate exploratory statistical methodology are: principal component analysis (PCA), cluster analysis and, most recently, reduced rank regression or partial least-squares regression as well as the treelet transform dimension-reduction method that combines the strength of PCA and cluster analysis (Varraso *et al.* 2012).

Principal component analysis (PCA) is a test to identify the interrelationships between a large set of observed variables and then go through a process of data reduction to group the observed variables into smaller dimensions or factors that have common characteristics (Pett *et al.* 2003). The ultimate goal in using PCA is to be able to reduce and group the food items and describe the clustered food items in a concise and understandable manner (Pett *et al.* 2003; Sherafat-Kazemzadeh *et al.* 2010). Once the internal structure of a construct has been found, PCA scores will be used to identify external variables (e.g. gender, BMI, etc.) that appear to relate to various dimensions of the construct of interest (Pett *et al.* 2003). On the other hand, cluster analysis is used to categorise persons into naturally existing, mutually exclusive groups based on similarity (each subject can belong to only one cluster) and regularities in their food intake (Bamia *et al.* 2005; Cunha *et al.* 2010). Cluster analysis is normally performed using the k-means algorithm (Hearty and Gibney 2009).

Bamia *et al.* (2005) applied PCA and cluster analysis to identify the prevailing dietary patterns of 99,744 participants, aged 60 and above, from nine European countries who had participated in the European Prospective Investigation into Cancer and Nutrition (EPIC-Elderly cohort). The principal analysis resulted in two dietary patterns: (i) 'vegetable-based' diet with an emphasis on foods of plant origin, rice, pasta and other grain rather than on margarine, potatoes and non-alcoholic beverages; and (ii) 'sweet- and fat-dominated' diet with a preference for sweets, added fat and dairy products, but not meat, alcohol, bread and eggs. The 'vegetable-based' diet was predominant in younger ages, higher level of education, a higher BMI, a lower waist:hip ratio and never and past smoking. This was contrary to the 'sweet- and fat-dominated' diet, where it was associated with older age, lower level of education, never smoked, a lower BMI and waist:hip ratio and lower levels of physical activity. Results from cluster analysis showed similar dietary patterns generated from PCA. Both analytical approaches shared similar findings about the dietary patterns of the populations. More studies were also conducted to compare PCA and cluster analysis in determining dietary patterns of a population (Newby *et al.* 2004b; Newby and Tucker 2004). Interestingly, most of those studies revealed similar dietary patterns when using the same dataset (Costacou *et al.* 2003; Newby and Tucker 2004). Hearty and Gibney (2009) determined the dietary patterns of 1,379 Irish adults, aged 18–64, involved in the North/South Ireland Food Consumption Survey 1997–1999. They found that both approaches resulted in 'Traditional Irish', 'Healthy' and 'Unhealthy' dietary patterns.

In another major study, Cunha et al. (2010) compared three statistical methods in assessing the dietary patterns of 1,009 adults, aged 20 to 65, living in the Metropolitan Region of Rio de Janeiro, Brazil. This cross-sectional study applied component analysis, cluster analysis, and reduced rank regression (RRR) in identifying dietary patterns of the subjects. Findings showed that all three methods resulted in similar dietary patterns, where two distinct dietary patterns were revealed: "mixed" dietary patterns characterised by cereals, leafy greens, vegetables, roots, meat, eggs, sausage and caffeinated beverages; and "traditional" dietary patterns consisting of rice, beans and bread. The component analysis also yielded a "western" dietary pattern characterised by fast food, soft drinks, juice, milk and dairy, sweets, cakes and cookies. Some of the food items matched those that were in the "mixed" dietary pattern resulting from cluster analysis and RRR. All in all, the aforementioned studies revealed that dietary patterns resulting mainly from PCA and cluster analysis were highly comparable. Therefore, applying either method was considered to be closely reflecting the other.

3.4.3 Dietary Pattern and Obesity

Despite a considerable number of studies on assessment of dietary patterns and health outcomes, studies examining the association between dietary patterns and obesity are vague, doubtful and controversial (Togo *et al.* 2001). One study has already drawn attention to the paradox in meriting association between dietary patterns and obesity. Guo *et al.* (2004) carried out a cross-sectional study among 10,930 adults, a representative sample of the US population, who participated in the Third National Health and Nutrition Examination Survey. The findings showed that low scores in HEI were significantly related to overweight and obesity. The odds ratio of obesity increased across the HEI category (good diet, need improvement, poor diet) when adjusted for age, gender, ethnicity, physical activity, smoking, alcohol use, income and education. Low scores in HEI in this study were a good predictor of overweight and obesity, even though HEI was not specifically designed to prevent or reduce obesity. On the other hand, high scores of HEI are apparently associated with an indicator of a good diet; however, the association with obesity is unknown, whether high scores are also favourably associated with obesity. Guo's study recommends further investigation of the association between dietary patterns and obesity among different populations, especially population outside the US.

Togo *et al.* (2001) carried out a systematic review of patterns of food intake examined by diet index, component analysis or cluster analysis, and their relationship with body mass index or obesity (BMI/Ob). Findings showed inconsistency in the association between dietary patterns and BMI/Ob. Ten studies that categorised food patterns as fatty, sweet or energy dense foods were found to be more positively related to BMI/Ob than other food patterns; vegetables, fruit, whole grain and low-fat foods, and high intake of alcohol. However, similar food patterns, 'fatty, sweet or energy dense foods' were found to be negatively associated with BMI in four other studies. Unexpectedly, dietary index scores showed a consistent negative association with BMI/Ob. Moreover, eleven of the 30 studies reviewed showed no significant correlation between dietary patterns and BMI/Ob. Meanwhile, association between factor or cluster analysis and BMI/Ob was vague in regards to dietary patterns. Togo concluded that inconsistencies in the association between dietary patterns and BMI/Ob appeared regardless of diet index, factor or cluster analysis. Togo proposed that heterogeneity of dietary intake patterns derived by such analyses and lack of gold standards in applying the techniques might be a plausible explanation for the inconsistency of the results between dietary patterns and BMI/Ob.

In contrast to the inconsistencies of association between dietary patterns and obesity reviewed by Togo (2001), Dugee *et al.*'s (2009) work showed a clear-cut association between those two variables among Mongolian men and women. Principal component analysis (PCA) was applied to generate their dietary intake and revealed three dietary patterns: (1) transitional high in processed meat and potato; (2) traditional rich in whole milk, fats and oils; and (3) healthy with greater intake of whole grains, mixed vegetables and fruits. Findings showed that respondents in the higher quintile of the transitional pattern had significantly greater risk of obesity ($BMI \geq 25 kg/m^2$: OR=2.47; 95% CI=1.04-5.86), while respondents in the higher quintile of healthy pattern had significantly lower risk of obesity (OR: 0.49; 95% CI=0.25-0.95). Another interesting finding was that women in the upper quintile of the traditional pattern had greater odds of having abdominal obesity (WC≥80cm: OR=4.59; 95% CI=1.58-13.30) than those in the lowest quintile.

Among the few studies on Asian population in regards to dietary patterns and obesity, there is one study done by Kim *et al.* (2012) on the Korean population. They carried out a cross-sectional study among 10,089 Korean adults aged 19 years and older who had participated in the second and third Korean National Health and Nutrition Examination Surveys. PCA was performed and resulted in four dietary patterns: (1) white rice and kimchi pattern; (2) high-fat, sweets, and coffee pattern; (3) meat and alcohol pattern; and (4) grains, vegetables, and fish pattern. Western dietary pattern, consisting of high-fat, sweets and coffee, had a significant positive association with obesity after adjustments for socio-demographic and lifestyle factors. Therefore, this study concluded that this dietary pattern was associated with obesity among the Korean population.

Okubo *et al.* (2008) also conducted a cross-sectional study in linking dietary patterns and obesity among the Japanese population. They applied PCA and discovered four dietary patterns from the 3,760 Japanese female respondents: the healthy pattern, Japanese traditional pattern, Western pattern and coffee and dairy products pattern. The findings showed that there were associations between dietary patterns and obesity among the Japanese population for healthy pattern, Japanese traditional pattern and Western pattern, even among a relatively lean young Japanese female population. Healthy pattern, which was characterised by high intake of vegetables, mushrooms, seaweeds, potatoes, fish and shellfish, soy products, processed fish, fruit and salted vegetables, showed an inverse relationship with BMI. Meanwhile, Japanese traditional pattern, which consisted of rice, miso soup and soy products, and Western pattern, which comprised meats, fats and oils, seasonings, processed meats and eggs, had a positive relationship with BMI. In another study, the Japanese traditional pattern was also found to be significantly associated with impaired glucose tolerance (P for trend = 0.048) (Mizoue *et al.* 2006). Okuba *et al.*'s finding would have been more convincing if they had considered including both male and female, even though the sample was relatively large and homogenous. All in all, a certain type of dietary pattern is related to obesity among the Japanese population.

Sichieri (2002) brought attention to the association between dietary patterns and obesity among the Brazilian population. The study involved 2,589 adults, aged 20 to 60, living in Rio de Janeiro. After performing PCA on the dietary intake of the population, three dietary patterns were derived: (1) 'mixed pattern', which consisted of all food groups except rice and beans; (2) 'traditional pattern', characterised by rice and beans; and (3) 'western diet' comprises of butter and margarine and added sugar (sodas). In this study, traditional diet showed a significant negative association with overweight/obesity after being adjusted for dieting, age, leisure physical activity and occupation.

A study in Iran has contributed to the findings of association between dietary pattern and obesity. This finding is crucial for the Middle-East as there is a high prevalence of obesity (Esmaillzadeh *et al.* 2008). Sherafat-Kazemzadeh *et al.* (2010) conducted a prospective cohort study in Tehran, involving 141 subjects for a 6-year follow-up study. The study performed reduced rank regression analysis (RRR) in deriving dietary patterns. Five patterns were revealed from the RRR: traditional pattern, fibre and PUFA pattern, fibre and dairy pattern, dairy pattern, and egg pattern. The traditional pattern showed a positive association with obesity indices (BMI, WC, and WHR); it consisted of sources of hydrogenated and saturated fat, egg, red and processed meat, refined carbohydrates, vegetables, whole grain and starchy vegetables. In the light of Sherafat-Kazemzadeh *et al.* (2010) work, it reveals that only a certain type of dietary pattern is associated with obesity among the Iranian population.

Foreseeing the staggering consumption of highly processed foods in transition countries, some recent studies have emerged in studying dietary patterns consisting of highly processed foods and obesity. One such study was carried out by Tavares et al. (2012) involving eleven metropolitan areas in Brazil. They classified the food intake as unprocessed or minimally processed foods (Group 1), processed culinary and food industry ingredients (Group 2) and ultra-processed foods (Group 3). Findings showed that there was association between high consumption of highly processed foods (Group 3) and the metabolic syndrome. A limitation of this study is that it only involved adolescents.

Summary of dietary patterns and obesity

Interestingly, some studies have shown that traditional dietary patterns have an inverse relationship with obesity, while in others positive association was observed between dietary patterns and obesity. Therefore, consumption of “traditional diet” cannot be generalised and promoted because of the different characterisation of traditional diet in each population. A “traditional diet” does not necessarily entail high diet quality. Most studies applied a data-driven method rather than indexes in assessing dietary patterns. All findings required further investigation involving other populations and more prospective studies were needed to determine causal relationship between dietary patterns and obesity. Surprisingly, no studies were found to be conducted among the Malay or Indian population, either in Indonesia, Singapore or even in Malaysia.

Performing such a study among the Malaysian population would be of great interest, as Malaysian culture is unique because it consists of different ethnicities, namely Malays, Chinese and Indians. Investigating and improving dietary patterns in a multi-ethnic population is one of the most challenging tasks in the overall effort to improve better nutrition. More perplexing is to investigate the association between dietary patterns and obesity among the multi-ethnic population. In light of the few studies on the relationship between dietary patterns and obesity, this study will make an attempt at discovering the relationship between Malaysian dietary patterns and obesity through three distinct approaches: ultra-processed foods/products (UPP), PCA and DQI-R. This may support the use of such patterns to assess risk of obesity and, potentially, to assist as guidelines for healthy food consumption (Fung *et al.* 2001).

3.5 Conceptual framework of the study

The conceptual framework of the association between dietary pattern approaches and obesity is based on the previous review. The red box in Figure 3.4 highlights the conceptual framework that will be applied in this study. This study purposely focuses on dietary intake as the main component to be associated with obesity. There are other components or variables that influence obesity, but these will not be discussed in this study as the main objective of this study is to examine solely dietary pattern approaches that better predict obesity.

Central to the dietary intake of a population is factors that influence the pattern of consumption. A considerable amount of literature has revealed that socio-demographic (gender, marital status, level of education, ethnicity, age, income adequacy and region), lifestyle (dietary behaviour, physical activity, working/school environment) and other variables (mass media, government food policy, trade liberalisation and nutrition information accessibility) influence dietary intake. In any related statistical analysis, these variables will be treated as confounding variables. Turning now to the main focus of this study, which is examining the role of dietary pattern approaches in predicting obesity among the Malaysian population. The dietary approaches applied in this study involved three distinct types: *a priori* method (diet quality index revised), a novel approach of food classification (ultra-processed foods or products), and *a posteriori* (principal component analysis). Thus, these dietary approaches will be used to examine whether dietary pattern is a good predictor of obesity among the Malaysian population.

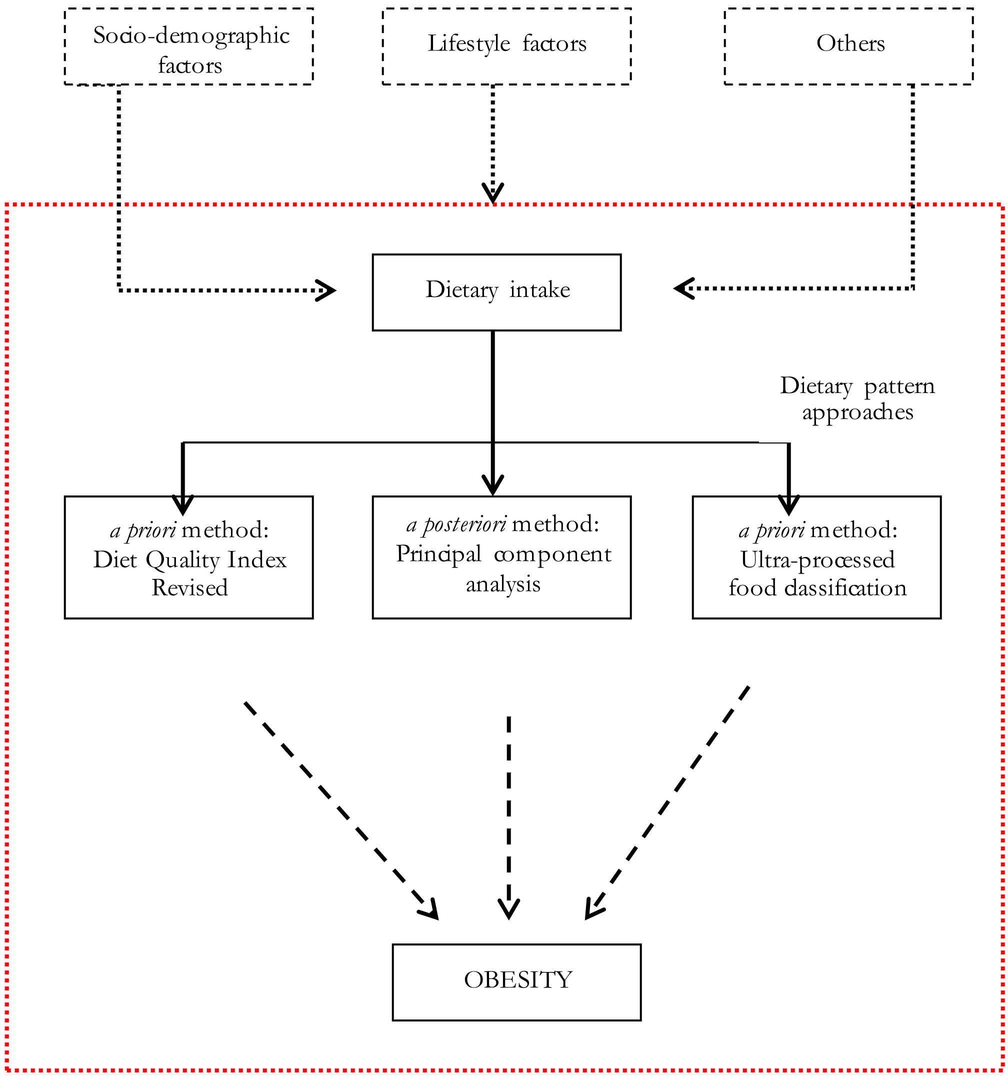


Figure 3.4: Conceptual framework of association between dietary pattern approaches and obesity

3.6 Summary (Research Operational)

RESEARCH GAP: Lack of studies done in investigating the association between dietary patterns and obesity using various dietary approaches in Malaysia

WORKING TITLE: An Exploration of Dietary Patterns and the Relationship with Obesity in the Malaysian Population

PROBLEM STATEMENT:

(1) It remains unclear what kind of dietary pattern (processed foods pattern, high sugar pattern, etc.) relates to the increase of obesity in Malaysia
(2) Lack of studies in characterising dietary patterns in Malaysia
(3) Lack of studies in determining association between dietary pattern and obesity in Malaysia

OBJECTIVES:

(1) To determine the current dietary patterns in Malaysia
(2) To determine BMI of the Malaysian population
(3) To determine the relationship between dietary patterns and BMI
(4) To explore different models of characterising dietary patterns to establish which is best at predicting nutritional status

RESEARCH QUESTIONS	INSTRUMENT	ANALYSIS
What are the current dietary patterns in Malaysia?	*a priori* method *a posteriori* method	UPP approach DQI-R approach PCA approach
What is the current nutritional status?	Body Mass Index	WHO classification
What is the relationship between dietary patterns and BMI among the Malaysian population?	UPP approach PCA approach DQI-R approach	Pearson product moment correlation

RESEARCH DESIGNS: Malaysian Adult Nutrition Survey (MANS)

SAMPLING TECHNIQUE: Cross-sectional study

CONTRIBUTION TO THE BODY OF KNOWLEDGE:

Insight into dietary patterns of Malaysian population that relates to obesity

Malaysia will at least have an insight into what tool to use to monitor the nutritional status of the population by characterising the dietary pattern that best predicts obesity

Contributed to empirical data on the patterns of highly processed foods in Malaysia

Chapter 4: Methodology

The previous chapter summarised the relevant literature related to dietary patterns and obesity. This chapter will explain the data set used to achieve the research objective of the study. This thesis is a secondary analysis of data from the Malaysian Adult Nutrition Survey (MANS). The MANS data were used for determining dietary patterns through selected approaches and investigating their association with body mass index (BMI). Apart from the MANS data, a dataset from a small scale study was used as a pilot study in applying ultra-processed food classification, one of the selected dietary pattern approaches. The latter dataset will be explained at length in Chapter 5. This chapter will mainly focus on the MANS data.

4.1 Malaysian Adult Nutrition Survey (MANS)

MANS was the first Malaysian national nutrition survey, carried out in 2002-3, covering the Peninsular Malaysia, Sabah and Sarawak, and funded by the Malaysian Ministry of Health. It was carried out to determine the nutritional status and food consumption of Malaysian adults from 18 to 59-years-old. Previously, Malaysia had relied on the food balance sheet (FBS) to assess food consumption among the Malaysian population in the absence of nationwide food consumption surveys (Noor 2002a). MANS was selected because it has the complete set of semi-quantitative FFQ and was approved for data usage by the Ministry Health of Malaysia. The flowchart in Figure 4.1 shows the procedure that was followed in the process of obtaining the MANS data.

The custodianship of the MANS data was made the responsibility of the Institute of Public Health, Malaysia (IPH). The dataset request was approved after the second attempt, wherein the research proposal was presented to Dr. Hamid Jan from the University of Science, Malaysia (USM). He was part of the team for MANS. He gave positive feedback to the proposal presented and agreed to put the proposal forward to IPH. Once again, the research proposal was presented to a representative of IPH, En. Ahmad Ali Zainuddin. He was then requested to write a letter to the Director General (DG) of IPH after receiving positive feedback from a group of reviewers regarding the proposal of this study. Therefore, a letter was sent to the DG. The DG finally approved the usage of the MANS data in this study. An agreement was signed between the researcher and IPH for data agreement usage (see Appendix A for data agreement).

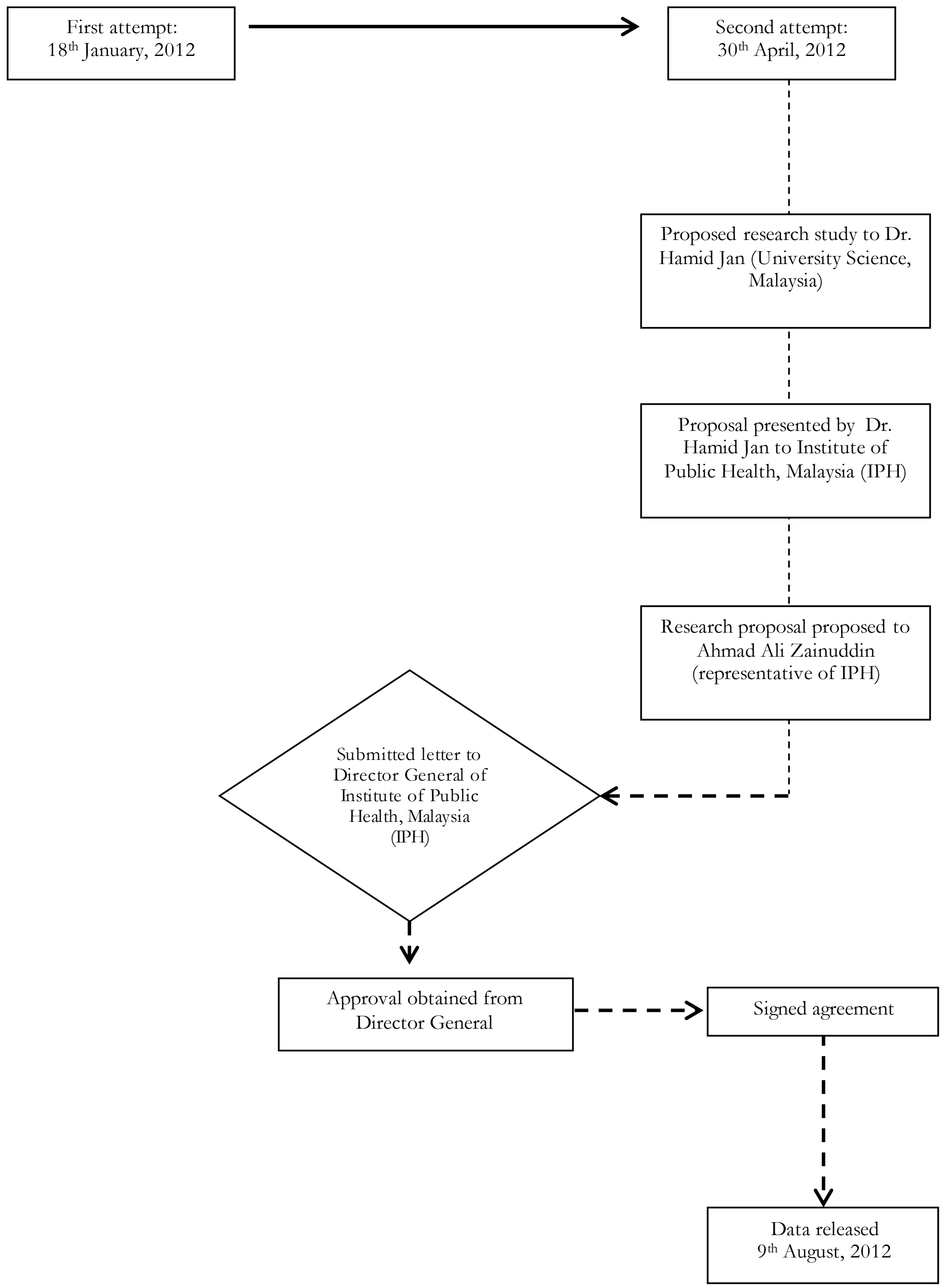


Figure 4.1: Flowchart for obtaining MANS data

As outlined, the procedure of obtaining the data was not straightforward. MANS data usage is restricted and is not open access data available for all. Therefore, the procedure of obtaining the data goes through several rigorous steps before data are released.

This present study used secondary data analysis rather than primary data for several reasons:

(i) The first reason is because of the requirement to represent the national level. A large sample size and complex sampling is needed to obtain precise and representative estimates of Malaysian dietary intake that covers a wide area of the regions of Malaysia. An analysis of national level is required to identify dietary patterns, nutritional status and the association between both among all ethnicities. Therefore, MANS data is one of the data that fits these criteria.

(ii) The second is because of the quality of MANS data. MANS was fully coordinated by the Nutrition Section of the Family Health Development Division (NSFHD) under the Ministry of Health, Malaysia. NSFHD developed a technical committee that was responsible for the development of the survey design and the survey questionnaire, monitoring the quality of the survey data, analysing the data and preparing reports. The technical committee consisted of members from several divisions in the Ministry of Health, the Health Departments of the states of Johor and Selangor, the Institute of Public Health (IPH), the Institute of Medical Research, the Institute for Health Systems Research and academicians from local universities. There was also high quality laboratory work in analysing food samples to complement the data in the current Malaysian Food Composition Tables, which was used in the analysis of certain food items not in the database. MANS is high-quality data as they are generated and supervised by highly experienced researchers and collected by well-trained nutritionists and enumerators.

(iii) MANS data contain the variables needed in conducting this present study. The variables required are shown in Table 4.1. Additionally, MANS was capable of answering all research questions other than just the questions for which the data were initially collected (Vartanian 2010).

Table 4.1: Variables available from MANS for usage in the present study

No.	Variable	Sub-variable	
1.	Socio-demography	1 -	Sex
		2 -	Ethnicity
		3 -	Religion
		4 -	Marital status
		5 -	Date of birth
		6 -	Educational level
		7 -	Occupation
		8 -	Individual income and
		9 -	Family income
2.	Food Frequency Questionnaire	1 -	Frequency of each food item intake by day, week, month, year or not eaten at all
		2 -	Serving size of each food item
		3 -	Number of servings consumed each time the food item was eaten
		4 -	Portion sizes of all foods and drinks consumed by survey respondents in grams
			*including also the additional questions on the use of sugar, cooking oil and salt by the members of the household in a month
3.	Anthropometry	Body Mass Index (BMI)	

Although secondary analysis offers beneficial advantages, it does carry with it several limitations. First is the lack of familiarity with data. Since secondary analysis is based on data collected by others, not by the researcher, the period of familiarisation is substantial. The familiarisation process with MANS included reading all the MANS technical manuals on methodology, implementation of the survey, data management (data entry, coding, data cleaning and data analysis) and operational definitions used in MANS.

Second is the complexity of data. MANS data were a large data set with more than 2,700 variables and initially involved more than 6,000 respondents. All missing values were to be identified and addressed and a method was selected to handle the missing data. Several basic steps in analysing secondary data suggested by Koziol and Arthur (2012) were applied. The steps involved:

(i) Determine software specifically developed for analysing complex survey data

(ii) Based on the research question, identify appropriate statistical analysis

(iii) Examine descriptive statistics to identify coding errors

(iv) Conduct diagnostic analyses (identify outliers, non-normality, etc.)

4.2 Study design

MANS has a cross-sectional design, the first survey was carried out nationwide between 2002 and 2003. It covered both urban and rural areas in West and East Malaysia. Only households in private living quarters (LQs) were included, it excluded institutional households of those living in hostels, hotels, hospitals, prisons, etc. which comprised only 1% of the total households at that time.

Living quarters (LQ) are defined by the Department of Statistics, Malaysia (2000) as a place which is structurally separated and independent and is intended for living. The terms, 'separate' and 'independent', mean: a structure is defined as separate if it is surrounded by walls, fence, etc. and is covered by a roof. A structure is considered to be independent if it has direct access via a public staircase, communal passageway or landing (that is, occupants can come in or go out of their living quarters without passing through someone else's premises).

4.3 Sampling frame

The sampling frame used the Enumeration Blocks (EBs) created for the 2000 Population and Housing Census. EBs were obtained from the Department of Statistics' National Household Sampling Frame (NHSF). The survey covered both urban and rural areas in Malaysia, except the Orang Asli Enumeration Block (EBs). The EBs in the sampling frame were classified by urban and rural areas, as defined in the 2000 Population and Housing Census. Urban areas were gazetted areas with their adjoining built-up areas with a combined population of 10,000 or more at the time of the 2000 Population and Housing Census. All other gazetted areas with a population of less than 10,000 persons and non-gazetted areas were classified as rural. Built-up areas were defined as areas contiguous to a gazetted area and having at least 60% of their population (aged 10 years and over) engaged in non-agricultural activities, as well as having modern toilet facilities in their housing units (Department of Statistics, Malaysia2000). The first stage of the sample unit was the EB, while the sample unit in stage two was the LQ, in particular EB. EBs were selected using the 'probability proportionate to size' (PPS) method. This means that EBs with a bigger LQ size have a higher probability of being selected. The second stage of the sample unit was the LQ in the selected EBs (see Figure 4.2).

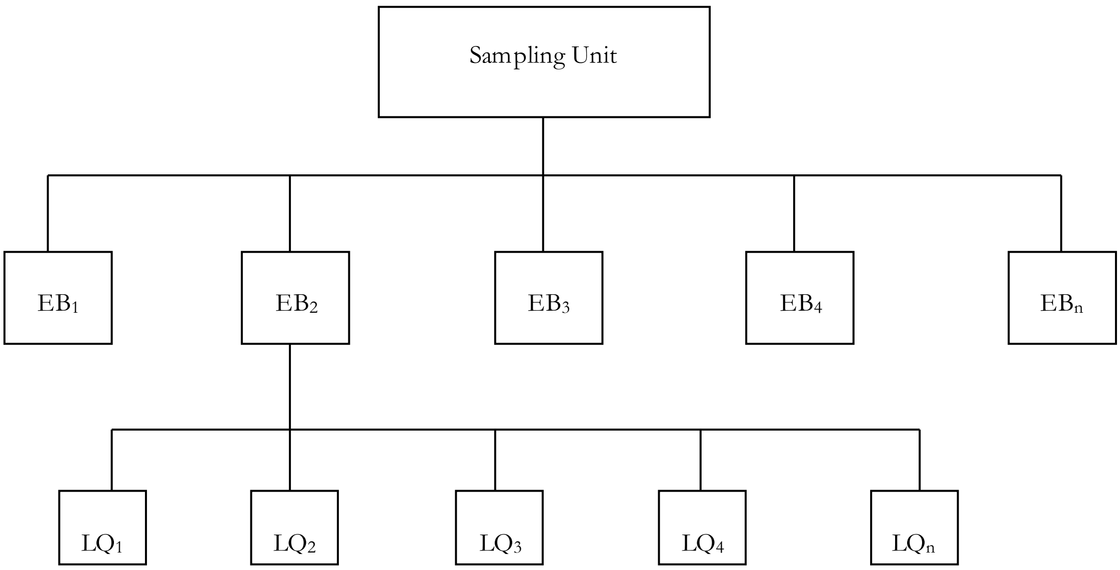


Figure 4.2: Example of sampling unit

Table 4.2: Total selected number of EBs and LQs in the MANS study

Zone	Total	
	EBs	LQs
Northern	152	1194
Central	368	2735
Southern	203	1624
East coast	172	1291
Peninsular Malaysia	**895**	**6844**
Sabah (including the Federal Territory of Labuan)	128	981
Sarawak	102	816
Malaysia	**1125**	**8641**

Eight LQs were to be selected from every EB. It might be less or more, depending on the size of the EB once the latest listing had been completed (see Table 4.2). For example, EBs in the Northern region were 152. One hundred and fifty-two EB multiplied by eight is 1,216 LQs. However, as seen in Table 4.2, the LQs obtained were 1,194. The selected LQs only consisted of private LQs. Those living in institutional LQs (such as hotels, hospitals, etc.), vacant EBs which presented high risk and those which were inaccessible were removed from the sampling frame. For every selected LQ, all households in the particular LQ were invited to participate (Department of Statistics, Malaysia 2011).

4.4 Sample size

The appropriate sample size to determine the prevalence of a variable of interest for a population-based survey is determined largely by three factors: estimated prevalence of the variable of interest, the level of confidence and the acceptable margin of error. Therefore, the MANS sample size was determined based on the estimated prevalence of a nutrition-related variable, the level of confidence and the margin of error desired. The prevalence of overweight adult population was selected for the sample size calculation. It was the only nutrition-related variable available at the national level. The sample size required can be calculated according to the following formula.

$$n = (z_{1-\alpha/2})^2 \frac{(1-p)}{\varepsilon^2 p}$$

Description:

n = required sample size

$z_{1-\alpha/2}$ = confidence level at 95% (standard value of 1.96)

p = estimated prevalence of variable of interest

ε = margin of error at 5% (standard value of 0.05)

The prevalence of overweight and obesity among the adult population was 21%, based on the Malaysian National Health and Morbidity Survey (NHMS II) findings. At 95% confidence interval and a 5% level of precision, the sample size required for the survey was calculated as follows:

n = 1.962 x (1-0.21)/ (0.05)2 x0.21

= 5,780

To avoid a low response rate of not less than 50%, the minimum sample size eligible for people to be invited was increased to 8,670. The Department of Statistics provided the distribution of the sample size. Based on the size of the EB, around eight LQs were chosen from each EB. From each household, one adult was randomly selected to participate in the study.

The power calculation above was carried out for the primary purpose of MANS, which was to assess the nutritional status and dietary intake of the Malaysian population. Therefore, the strength of this study is similar to the MANS study, as one of its main aims is assessing dietary intake and nutritional status.

4.5 Study population

The respondents were those who fulfilled the inclusion and exclusion criteria. The criteria for the study were: aged between 18 to 59-years-old, a Malaysian citizen, not deaf, dumb or bedridden and staying in living quarters (LQ) for at least two weeks.

4.6 Data collection

The data collection was carried out from October 2002 to July 2003 for Peninsular Malaysia and for Sabah and Sarawak from January to December 2003.

4.7 Survey questionnaire

The research instrument for data collection was in the form of survey questionnaire and written in both Malay and English. It was designed based on the objectives of the survey and took into consideration certain limitations and constraints, including financial resources, capacity of MOH staff and the willingness and ability of household members to be interviewed to provide the desired information. The survey questionnaire was conducted by well-trained enumerators in each survey team appointed. Each survey team had a nutrition officer, a research assistant/nurse and a number of scouts. The nutrition officers, research assistants or nurses were appointed as the interviewers while the state nutrition officers were appointed as the survey team leaders. The senior state role was as the survey supervisor. They were designated to provide the state survey supplementation plan, survey schedule and work allocation for each survey team in the given area. All questionnaires were verified and checked for completeness.

The questionnaire consisted of five sections:

a) Socio-demography

b) 24-hour Diet Recall and Meal Pattern

c) Habitual Physical Activity and 24-Hour Physical Activity Recall

d) Anthropometry

e) Frequency of Food Intake and Frequency of Supplement Intake

However, only socio-demography, anthropometry and frequency of intake will be explained at length. Those sections were selected because of the contribution of those data (socio-demography, anthropometry and frequency of intake) in fulfilling the requirement for analysis of this study. Other parts of the questionnaire have been explained elsewhere (Norimah *et al.* 2008; Zalilah *et al.* 2008; Azmi *et al.* 2009; Poh *et al.* 2010). Additionally, the Institute of Public Health, Malaysia, only gave permission for socio-demography, anthropometry and frequency of food intake to be used in this study.

Section A: Socio-demography

The aspects covered in this section include respondent's identification number (ID) and socio-demographic data, i.e. gender, ethnicity, religion, marital status, date of birth, education, occupation, nutritional status, individual income and family income.

Section B: Frequency of food intake

The MANS study used a Food Frequency Questionnaire (FFQ) to assess frequency of food intake among the respondents. FFQ was first developed to give descriptive qualitative information about usual food consumption patterns. With the addition of portion size, along with a computerised self-administered questionnaire, FFQ became semi-quantitative, permitting calculation of energy and nutrient intake (Gibson 1990). An FFQ lists a variety of foods, and the respondent is asked to estimate the frequency with which they consume each item or food (Smolin and Grosvenor 2003). The food list may extend to a longer list of foods, allowing estimates of total food intake frequency to be measured daily, weekly, monthly, or yearly, depending on the study objective (Gibson 1990). Therefore, it can represent usual food intakes over an extended period of time. As well as estimating usual food intake over a certain period of time, FFQ can also calculate the diet quality of a population (Kennedy *et al.* 1995; Kant and Thompson 1997; McCullough *et al.* 2002; Kim *et al.* 2003), diet diversity (Katanoda *et al.* 2006) and recommended food score (Kant 1996a; McCullough *et al.* 2002).

The MANS study used the semi-quantitative FFQ, a widely used device in dietary assessment (Gibson 1990) and mainly used in large cohort studies. A semi-quantitative FFQ was planned and structured to determine the intake of common food groups, energy and nutrients over the previous year (Malekshah *et al.* 2006). Most large cohort studies implemented the FFQ for assessing dietary intake because it is inexpensive (Schatzkin *et al.* 2003) and convenient (Schatzkin *et al.* 2003; Cade *et al.* 2004). Much of the current evidence on the relationship of food intake and nutritional status/diet-related disease has been gathered from such studies (Zhang *et al.* 2003; McKeown *et al.* 2009; Chan *et al.* 2012; Cohen *et al.* 2012; Hartmann *et al.* 2012; Martinez-Gonzalez *et al.* 2012; Oka and Alley 2012; Vidal *et al.* 2012; Zhang *et al.* 2012) and some have shown a significant association between food intake and nutritional status (Liu *et al.* 2001; Zhang *et al.* 2003; Eshak *et al.* 2012; Hosseinpour-Niazi *et al.* 2012). However, regardless of the substantial benefits in terms of ease of management and analysis, FFQs may be restricted in their reliability and validity, and, through poor design and unsuitable use, may not obtain the vital information (Cade *et al.* 2004). However, Margetts and Nelson (1997) stated that no dietary method can measure dietary intake without an error. Thus, the causes of error need to be taken into consideration (Cade *et al.* 2004).

The semi-quantitative Food Frequency Questionnaire (FFQ) used in the MANS study was adapted from a list of foods and beverages in previous local studies conducted among the Malaysian population (Norimah *et al.* 2008). Previous local studies had developed and validated the FFQ against 24-hour dietary recall (Shahril *et al.* 2008) because it is more accurate, more practical and less burdensome (Shanita *et al.* 2012). In the development phase of FFQ, 24-hour dietary recall was conducted among subjects to obtain prioritization of a food list and grouping of the food items. Prioritization of the food list was based on foods that contributed at least 90% of total energy, macronutrients and micronutrients intake (Chong and Norimah 2002). Two-day 24-hour dietary recall (a weekday and weekend dietary recall) was used in the validation phase of the FFQ at two-week intervals, as it is one of the most suitable methods to assess validity (Loy and Jan Mohamed 2013), compared to a weighed food record method for multiple days (Cade *et al.* 2002a). The adapted FFQ was subsequently pre-tested to evaluate the comprehensibility, clarity and duration of questioning in the MANS study. The pre-test was conducted among a community in Pangkor district. As a result of the pre-test, the MANS FFQ contained 126 food items, categorised under 15 food groups, which listed all the foods that were commonly consumed throughout the year among the Malaysian population (Ministry of Health Malaysia 2008). The MANS FFQ consisted of three main columns: food item list, frequency of intake and serving size of foods, as shown in Appendix B. The food item list consisted of 126 food items. The frequency intake of each food list had a choice of five options: whether the food consumed was per day, per week, per month, per year or never. A standard serving size was provided for each food item listed in the FFQ. The standard serving size was based on the 'Serving size of Malaysian Foods'

Album' (*Album Saiz Sajian Makanan, Malaysia*) and also the list of food item weights in household measures (Food Portion Sizes of Malaysian Foods Album, 2002/2003) (Ministry of Health Malaysia 2008). The full MANS FFQ can be referred to in Appendix B.

The survey was divided into three divisions. The first division was conducted in Peninsular Malaysia from October 2002 until July 2003. Meanwhile, the second division, involving Sabah (West Malaysia), was held from January until May 2003 and the last division, Sarawak (West Malaysia), ran from July until December 2003. The data were collected in 2002/3 and may not reflect the current situation of Malaysian dietary intake. This limitation was discussed in Chapter 7 under limitations of the study.

The FFQ used in MANS was a list of 126 food items, which were categorised into 13 food groups. The list of 126 food items is as below;

1	Rice	43	Mushrooms	85	Spirit
2	Corn	44	Bean Sprouts	86	Liquor
3	Glutinous rice	45	Baby corn	87	Chocolate Drink
4	Rice porridge	46	Root/Tuber Vegetables	88	Malted Drink
5	Chicken	47	Pumpkin	89	Cordial Drink
6	Beef	48	Prawn	90	Fruit Juices
7	Goat	49	Cuttlefish	91	Energy drink
8	Duck	50	Mollusc	92	Soy drink
9	Ham	51	Crab	93	Breads
10	Bacon	52	Chicken Egg	94	Buns
11	Luncheon	53	Duck Egg	95	Sweets
12	Pork	54	Quail Egg	96	Cakes
13	Ground Nut	55	Coffee	97	Ice Cream
14	Soybean	56	Tea	98	Jelly Custard
15	Pulses	57	Botanical herbs	99	ABC/ice pop
16	Fermented Soy	58	Sago	100	Peanut
17	Sea Fish	59	Honey	101	Seri Kaya
18	Freshfish	60	Noodles	102	Jam
19	Plain water	61	Vermicelli	103	Cream cheese
20	Banana	62	Pasta	104	Soft drinks
21	Apple	63	Lohshifun	105	Salted Fish
22	Mandarin orange	64	Sago	106	Salted Egg
23	Orange	65	Vegetable fat (margarine)	107	Anchovy
24	Watermelon	66	Animal fats (butter)	108	Shrimp sauce
25	Grape	67	Traditional Malay Cake/Delicates	109	Anchovies sauce
26	Mango	68	Roticanai	110	Shrimp cencaluk
27	Honey Dew	69	Capati	111	Kicap pekat (Thick soy sauce)
28	Papaya	70	Dosai	112	Kicap cair (Light soy sauce)
29	Guava	71	Keropok lekor	113	Ketchup sauce
30	Star Fruit	72	Flavoured Yogurt	114	Oyster sauce

31	Pineapple	73	Condensed Milk	115	Fish sauce
32	Jackfruit	74	Evaporated Milk	116	Prawn paste
33	Pear	75	Powdered Milk	117	Cheeses
34	Durian	76	Biscuits	118	Snacks
35	Longan segar	77	Meat Burger	119	Cereals
36	Laychee segar	78	Chickenball	120	Ready To Eat Cereals
37	Rambutan	79	Fish Ball	121	Pizza
38	Milk	80	Hotdog	122	Canned fish
39	Leafy Vegetables	81	Nugget	123	Dried cuttlefish
40	Cabbage	82	Syandi	124	Salt vegetables
41	Non Leafy Vegetables	83	Beer	125	Canned fruits
42	Ulam	84	Wine	126	Dried fruits

There were a total of four main columns in the FFQ; the first column contained a list of food items, and the second column showed the frequency intake by day, week, month and year or not eaten at all. The frequency of intake was based on the habitual food intake during the past year. The third column described the serving size of each food item, while the fourth column described the number of servings consumed each time the food was eaten (Ministry of Health Malaysia 2008). The 13 food groups were as below:

A. Cereals and cereal products (17 food items)

B. Meat and meat products (12 food items)

C. Fish and seafood (12 food items)

D. Eggs (4 food items)

E. Legumes and products (4 food items)

F. Milk and milk products (6 food items)

G. Vegetables (10 food items)

H. Fruits (20 food items)

I. Beverages (11 food items)

J. Alcoholic beverages (5 food items)

K. Confectioneries (8 food items)

L. Spreads (6 food items)

M. Condiments/Miscellaneous (11 food items)

N. There were additional questions on the use of sugar, cooking oil and salt by the members of the household in a month.

4.8 Dietary intake

Dietary intake is given in Chapter 4, along with the socio-demographic characteristics of the respondents. It includes findings of energy and the macronutrient and micronutrient intake of the respondents.

4.8.1 Converting FFQ to daily energy and other nutrients

The calculation is based on a conversion factor used to estimate food intake based on frequency of intake (according to Wessex Institute of Public Health 1995). Details of the methodology are fully described in Chapter 4.

4.8.2 Comparing with RNI

Energy and the macronutrients and micronutrients of the respondents were compared with Malaysian Recommended Nutrient Intake (RNI). The RNI is the daily intake which meets the nutrient requirements of almost all (97.5%) apparently healthy individuals.

4.9 Dietary pattern approaches

Three dietary approaches are applied:

(i) Ultra-processed foods classification

(ii) Principal Component Analyses (PCA) classification

(iii) Diet Quality Index Revised

The details of the methodology will be further elaborated in the respective chapters.

4.10 Anthropometric measurement

'Seca' digital platform scales (Model 880) were used to measure weight. The scales were able to measure up to 200 kilograms. These scales were calibrated every morning before measurements were done using standard weights of 10 kilograms. The scale was placed on a hard and level surface. A portable Seca body meter (Seca 208) taped to a vertical wall and perpendicular to a level floor was used for height measurements. The tape was graded in centimetres with one millimetre divisions. This portable body meter was very light (200 gm), small and able to measure up to 200 centimetres. Body mass index (BMI) was calculated from the weight and height measurement and respondents were classified as underweight, normal weight, overweight or obese based on the BMI readings. The formula used for BMI calculation was as follows: BMI = Weight (kg)/Height^2 (m). The readings will be compared to the WHO (2000) classification:

Table 4.3: Classification of adults according to BMI and risk of co-morbidities

Classification	BMI	Risk of co-morbidities
Underweight	< 18.50	Low
Normal range	18.50 – 24.99	Average
Overweight:	≥ 25.00	
Pre-obese	25.00 – 29.99	Increased
Obese class I	30.00 – 34.99	Moderate
Obese class II	35.00 – 39.99	Severe
Obese class III	> 40.00	Very severe

Source: WHO (2000)

4.11 Data analysis

All analyses were conducted using SPSS version 21 and reported using APA 6th style. Details of each analysis are described at length in each respective chapter. Nutritionist Pro software (Axxya, USA) was used to analyse the dietary intake obtained from FFQ.

Chapter 5: General Findings

The purpose of this chapter is to present the descriptive characteristics and dietary intake of the respondents from the MANS study. Body mass index (BMI) has also been summarised for the respondents. Finally, this section presents how socio-demographic variables and total energy intake predicted BMI in this study population.

5.1 Dietary intake

Total energy intake was first calculated and used for data screening and cleaning. The procedures of analysing dietary intake (including total energy intake) are described below. The analysis of dietary intake through Food Frequency Questionnaire (FFQ) involves assessing the total energy intake, macronutrients and micronutrients of the individuals.

5.1.1 Methodology of Converting FFQ to Energy Intake and Other Nutrients

The Malaysian National Dietary Survey consists of a semi-quantitative Food Frequency Questionnaire (FFQ). Semi-quantitative FFQs can be used to calculate daily energy intake and other nutrients as well. The calculation is based on a conversion factor which is used to estimate food intake based on frequency of intake, adapted from the Wessex Institute of Public Health (1995)

Amount of food consumed per day (g) = conversion factor (y) x type of serving size x total no. of serving size x weight of food in one serving

Below are details of coding used in the MANS data and how the semi-FFQ data were converted to daily energy and other nutrients. ‘Groundnut’ (*kacang tanah*) is selected as an example for detailing how the conversion of daily energy and other nutrients intake was done.

Coding – e.g. groundnut (*kacang tanah*)

First step: Calculating conversion factor (y) to determine daily intake

Semi-quantitative FFQ consists of food frequency for daily, weekly, monthly and yearly consumption. Therefore, all food frequency consumption (weekly, monthly and yearly) needs to be converted to daily frequency. The coding for frequency of groundnuts consumption is listed as below:

Frequency of intake	
ee4h	Frequency consumption of groundnut daily
ee4m	Frequency consumption of groundnut weekly
ee4b	Frequency consumption of groundnut monthly
ee4t	Frequency consumption of groundnut yearly
ee4tm	Do not eat groundnut

All variables above were converted to daily intake using the conversion factor (y). The table for conversion factor is as below:

Table 5.1: Conversion factor (y)

Frequency of intake	**Frequency**	**Conversion factor**
Per day	Once	1
	Twice	2
	3 times	3
Per week	Once	1/7
	Twice	2/7
	3 times	3/7
	4 times	4/7
Per month	Once	1/30
	Twice	2/30
	3 times	3/30

Therefore, the new variables for conversion factor are as below:

ee4hh	groundnuts: daily
ee4mh	groundnuts: weekly to daily
ee4bh	groundnuts: monthly to daily
ee4th	groundnuts: yearly to daily

Second step: Calculating Y (type of serving size total x no. of serving size x weight of food in one serving)

The next step, after converting all food frequency to daily frequency, is calculating Y. Y is determined by multiplying the number of serving size by the weight of food in that one serving.

Variable	Description
ee4k1	serving size used – tablespoon
weight of serving size used for ee4k1	16.2g (based on MANS data)*

All conversion of food serving size to grams was based on the 'habitual food intake' report published by MANS, as shown in the table below:

Table 5.2: Conversion of food serving to grams

	Type of food	**Serving size**	**Weight (g)**
1.	Rice	Plate	120
2.	Rice porridge	Bowl	300
3.	Glutinous rice	Scoop	100
4.	Noodles	Plate	288
5.	Vermicelli rice	Plate	330
6.	Loh Shi Fun	Chinese bowl	141
7.	Groundnut	Spoon	16.2

Therefore, Y = ee4k1 x 16.2 g

Thus, the new variable for Y, named ee4k1g, is total weight of groundnuts that one person has consumed (in grams) based on the number of serving size.

<u>Third step: Deriving formula for the calculation of the total amount of groundnuts (*kacang tanah*) per person, per day</u>

A formula was calculated to obtain the total amount of groundnuts that a person consumed per day. The formula is shown as below:

Formula = [(ee4hh * ee4k1g) + (ee4mh * ee4k1g) + (ee4bh * ee4k1g) + (ee4th * ee4k1g)]

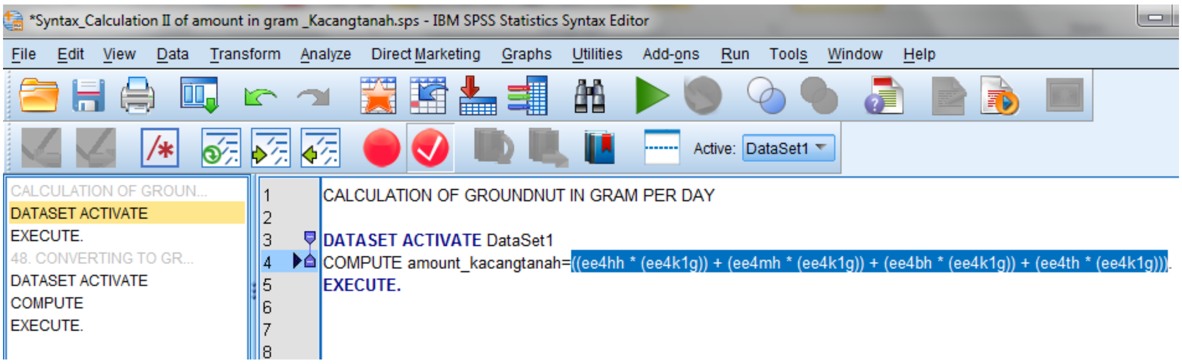


Figure 5.1: Snapshot of syntax for calculation of total amount (in grams) of groundnuts

The formula was created as it is hard to manually calculate the total amount of groundnuts consumed per person, per day, since it involves a large number of respondents. The total amount of groundnuts derived is known as *'kacangtanah'*. SPSS syntax is used to help in calculating the total amount of groundnuts consumed (in grams). Syntax is a command used for statistical analyses and data manipulations. The syntax for calculation of groundnuts in grams per day is shown in Figure 5.1 above.

<u>Fourth step: Converting the amount of groundnuts to daily energy</u>

After finding the total amount of groundnuts (*'kacangtanah'*) consumed per person, per day, daily energy intake can be calculated. Since 100g of groundnut = 543.22 kcal, the formula for the total energy of groundnuts will, therefore, be as below:

energy_*kacangtanah* = ((543.22 * *kacangtanah*)) / 100.

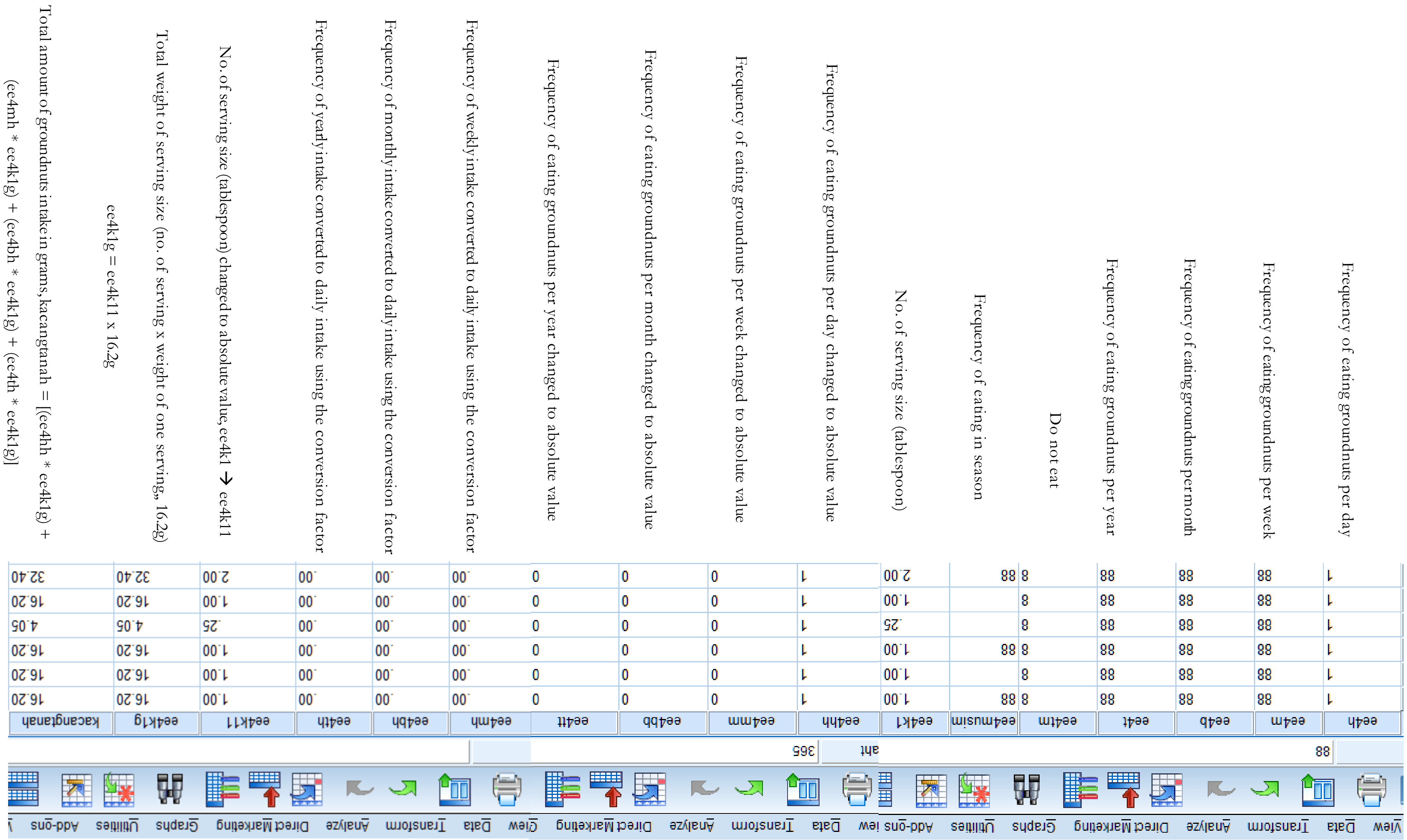
The composition data are derived from Malaysian Food Composition (*"Nutrient Composition of Malaysian Foods"*) using a diet software called Nutritionist Pro (Axxya, USA) . The hardcopy version of Malaysian Food Composition is also referred to as the source documents. Nutritionist Pro software (Axxya Systems-Nutritionist Pro, Stafford, TX, USA), a computerised dietary analysis program, is a nutrient database that consists of data from the Continuing Survey of Food Intake of Individuals (Spencer *et al.* 2005) and other sources, including Asian countries. Malaysian Food Composition data were also included in the program (Tony Jr 2010). Many diet analyses of Malaysian foods have used this program (Karupaiah *et al.* 2008; Ramadas and Kandiah 2010; Hejazi *et al.* 2013; Nisak *et al.* 2013). This program converts reported food consumption data into an estimate of daily nutritional intake information (Mays *et al.* 2011). The food items were entered in the program and were then given a serving size to be filled up. Then, all the nutrients selected were produced as an output referred to as nutrient profiles. If the foods were brand-specific (e.g. McDonald's French Fries), and provided they were not included in the Malaysian database, other resources from Nutritionist Pro were selected. The results were presented as total energy intake (kcal), carbohydrates (g), proteins (g), fats (g), calcium (mg), iron (mg), zinc (mg) and other selected nutrients.

The 4th edition of the Malaysian Food Composition database was released in 1997. It consists of a total of 783 foods, with a complete nutrient database. From the 783 foods, 580 items were raw and processed foods while the remaining 203 foods were cooked foods. The grouping of foods, nomenclature and description of all 783 foods were well described in the Malaysian Food Composition database (Tee *et al.* 1997).

<u>Fifth step: Apply to other 125 food items</u>

The same steps are repeated for the other 125 food items. More detail of the SPSS's interface for groundnuts is shown in Figure 5.2.

Figure 5.2: SPSS's interface for groundnuts calculation involving all variables



5.1.2 Results

5.1.2.1 Cleaning data and removing outliers identified through total energy intake of respondents

The mean energy intake of the 6,929 respondents was 2,046 ± 833 kcal, as shown in Table 5.3. This result shows a standard deviation of 800 kcal. This means that the energy intake of many respondents was quite far from the mean. It gave a flatter distribution, which is spread out. Meanwhile, the standard error (SE) is 10.reflecting large sample size and shows that the true value of total energy (has about 95% chance of being within ±2SE = 20 of the estimated total energy intake and is almost certain to be within ± 3SE = 30 of it.

Table 5.3: Descriptive statistics of total energy intake of respondents

	N	Maximum	Mean		Std. deviation
	Statistic	Statistic	Statistic	Std. Error	Statistic
Total energy	6,929	9,625.32	2,045.77	10.01	832.85

The maximum energy intake was 9,625 kcal for 6,969 respondents. This was considered as an extremely high energy intake, even after some cleaning up of data was performed. During previous data cleaning, it was found that groundnuts were contributing to a high percentage of total energy intakes after finding several cases of respondents having more than 10,000 kcal intakes per day. It is apparent that one of the reasons was because of the weight used for representing one tablespoon of groundnuts. This is because, in the MANS report, it was written that one tablespoon is equal to 162 grams. Basically, the volume of one tablespoon using water is equal to 15 grams. Therefore, an average of one tablespoon of groundnuts was self-weighted and an explanation from the MANS' principal investigator was requested. An average of one tablespoon of groundnuts was 15.3 after being weighted. It may be that there was an error in the decimal point for the MANS serving size of groundnuts. It was subsequently confirmed by the principal investigator that there was a decimal point error for the weight of one tablespoon of groundnuts. The actual weight should be 16.2 grams for a tablespoon of groundnuts instead of 162 grams.

The total energy of the respondents was grouped to see the frequency of each group. The total energy was grouped as below:

Less than 1000=1, 1000.001 thru 1500=2, 1500.001 thru 2000=3, 2000.001 thru 2500=4, 2500.001 thru 3000=5, 3000.001 thru 3500=6, 3500.001 thru 4000=7, 4000.001 thru 4500=8, 4500.001 thru 5000=9, 5000.001 thru 5500=10, 5500.001 thru 6000=11, 6000.001 thru 6500=12, 6500.001 thru 7000=13, 7000.001 thru 7500=14 7500.001 thru 8000=15, 8000.001 thru 8500=16, 8500.001 thru 9000=17, 9000.001 thru 9500=18 and 9500.001 thru 10000=19

Table 5.4: Groups of total energy intake (kcal/day)

Total energy intake (kcal/day)	Frequency	Percent	Valid Percent	Cumulative Percent
Less than 1000	389	5.6	5.6	6.3
1000.001 thru 1500	1,411	20.4	20.4	26.0
1500.001 thru 2000	1,955	28.2	28.2	54.2
2000.001 thru 2500	1,518	21.9	21.9	76.1
2500.001 thru 3000	859	12.4	12.4	88.5
3000.001 thru 3500	420	6.1	6.1	94.6
3500.001 thru 4000	203	2.9	2.9	97.5
4000.001 thru 4500	89	1.3	1.3	98.8
4500.001 thru 5000	38	.5	.5	99.3
5000.001 thru 5500	28	.4	.4	99.7
5500.001 thru 6000	6	.1	.1	99.8
6000.001 thru 6500	5	.1	.1	99.9
7000.001 thru 7500	3	.0	.0	99.9
7500.001 thru 8000	3	.0	.0	100.0
8500.001 thru 9000	1	.0	.0	100.0
9500.001 thru 10000	1	.0	.0	100.0
Total	6,929	100.0	100.0	

Total energy groups with less than 10 respondents were eliminated. This was because of the implausible energy intake reported. Other researchers had also excluded respondents with an implausible reported energy intake. Kim *et al.* (2012) had excluded respondents with total energy intake of less than 500 kcal or more than 8,000 kcal in their study among Korean adults (19 years or older) who participated in the second and third Korean National Health and Nutrition Examination Surveys.

Using z-scores to find outliers

The data of total energy intake of respondents were converted to z-score to identify outliers. SPSS can convert total energy intake of respondents to z-score via descriptive statistics. We can then identify how many z-scores fall within certain important limits. All the z-scores need to be converted to absolute value. As in a normal distribution, it is expected that 5% of absolute values will be greater or less than 1.96 SE, 1% to have absolute values greater or less than 2.58 SE and no absolute values to be greater than about 3.29. All the absolute values of z-scores were recorded as: 3.29 thru highest =1, 2.58 thru highest=2, 1.96 thru highest=3 and lowest thru 1.95=4. The recorded absolute values were then labelled as follows: 4 = normal range, 3 = potential outliers (z > 1.96), 2 = probable outliers (z > 2.58) and 1 = Extreme (z > 3.29).

Table 5.5: Z-scores of total energy intake

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extreme (z>3.29)	59	.9	.9	.9
	Probable Outliers (z>2.58)	79	1.1	1.1	2.0
	Potential Outliers (z>1.96)	172	2.5	2.5	4.5
	Normal range	6,615	95.5	95.5	100.0
	Total	6,925	99.9	100.0	
Missing	System	4	.1		
Total		6,929	100.0		

Table 5.5, above, shows the percentage of z-score absolute values. The column labelled *Cumulative Percent* tells us the corresponding percentage for total energy intake; 0.9% of cases were above 3.29 (extreme cases), 2.0% had values greater than 2.58, which was expected to be less than 1.0%, and 4.5% had expected values greater than 1.96, which was within the 5% expected absolute value. Of the remaining cases, 95.5% were in the normal range, as expected.

Therefore, after identifying the outliers, all cases within normal range were selected. The normal range of total energy intake was selected to test normality. To test normality, a histogram was plotted to observe the frequency and shape of distribution. From Figure 5.3, the bell-shaped curve is almost representing the normal distribution. Therefore, the assumption is that the data reached normality. Therefore, a parametric test can be applied.

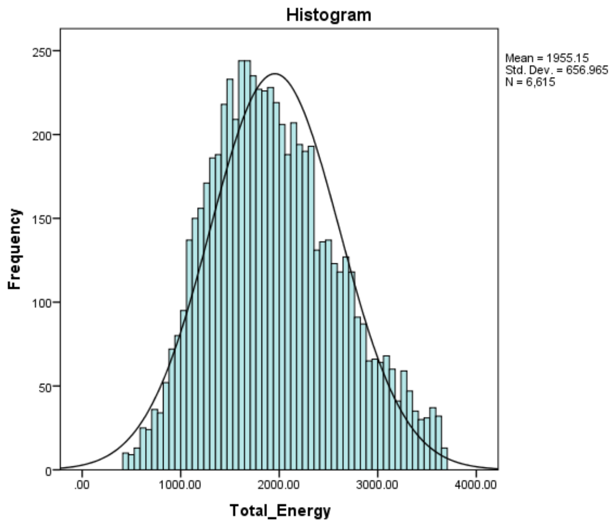


Figure 5.3: Frequency distribution of energy intake

After excluding all the outliers, the mean total energy intake of the respondents was 1,955 kcal ± 657 SD, as shown in Table 5.6.

Table 5.6: Descriptive results of total energy intake (n = 6,615)

	N	Mean		SD	Skewness		Kurtosis	
		Statistic	S.E	Statistic	Statistic	S.E	Statistic	S.E
Energy	6,615	1,955.15	8.0775	656.96477	.365	.030	-.364	.060

Under-reporting of energy intake

The current mean energy intake of respondents was 1,955 kcal (SD = 657). However, we have not yet excluded the under-reporting of energy intake among the respondents. Under-reporting of energy intake is a well-documented phenomenon in self-dietary assessment (Rennie *et al.* 2007). Empirical studies have mostly reported that under-reporting of energy intake was mainly among overweight and/or obese individuals, compared to that of normal weight individuals (Briefel *et al.* 1997; Subar *et al.* 2003; Ford and Dietz 2013). It is crucial to identify under-reporting as it is part of a consideration in determining an association between energy intake, the macronutrients and micronutrients in foods and nutritional status (Rennie *et al.* 2007). This occurs when energy intakes were underestimated compared to measured energy expenditure. The underlying principle is that:

Energy intake (EI) = Energy expenditure (EE) + changes in body stores. The assumption is that changes in body stores can be ignored, leading to this equation:

EI = EE (Black 2000a)

Energy expenditure can be measured either by the doubly labelled water (DLW) technique or by calculating a specific cut-off limit for the ratio between EI and basal metabolic rate (Black 2000b). Even though the DLW is the gold standard for determining EE, it is expensive and not applicable in a large scale study (Rennie *et al.* 2007). Therefore, most studies have applied the calculation of the ratio between EI and basal metabolic rate (BMR) in determining EE; known as the Goldberg method. The Goldberg method compares energy intake (EI) against BMR. The principle is that BMR will be equal to or less than EI. Goldberg introduced the cut-off point for the EI: BMR calculation to distinguish between under-reporting and acceptable reporting. EI: BMR ratio below 1.2 was considered as inadequate for the maintenance of body weight to identify low energy reporters based on Goldberg's cut-off value. A further distinction was made between under-reporting and over-reporting using alternative cut-off points. EI: BMR was calculated for each respondent and classified under cut-off values for EI: BMR of $\leq$ 1.34 (under-reporting), 1.35–2.39 (normal range) and $\leq$ 2.4 (over-reporting). The first value was proposed as the minimum value of habitual energy intake that fulfils a normal, not bedridden, lifestyle and can be representative of long-term habitual intake (Goldberg *et al.* 1991). Because the MANS questionnaire measured habitual intake during the past year, this study used the value 1.34, as suggested by Goldberg *et al.* (1991). Meanwhile, the third value, $\geq$ 2.4, was proposed as the maximum value to sustain life (Black *et al.* 1996; Johansson *et al.* 1998). However, these cut-off points do not reflect the true energy expenditure of respondents (Johansson *et al.* 1998). Several studies have applied these cut-off points, $\leq$ 1.34 and $\geq$ 2.4, to report the under and over-reporting of individuals; for example, among Tehran (Azizi *et al.* 2005) and Jamaican populations (Mendez *et al.* 2004).

BMR can be measured based on different equations, e.g. Schofield's equation (Ramirez-Zea 2005) and Henry's equation (Henry and Rees 1991). In 1985, the FAO/WHO/UNU Committee introduced BMR as the basis for calculating the energy requirement for over 10years-old. The FAO/WHO/UNU applied Schofield's equation in computing the BMR of individuals according to age (0-3 years, 3-10 years, 10-18 years, 18-30 years, 30-60 years and >60 years), gender and body weight (WHO 1985). However, Schofield's predictive equation corroborated with only 5.2% of other parts of the world, while the rest were mainly from Europe and North America (Ismail *et al.*

1998). Another issue was that the Italian population was over-represented in the data (47%) and had higher BMR values compared to the other populations (Ramirez-Zea 2005). Therefore, Henry and Rees (1991) developed a new series of predictive equations to calculate the BMR of tropical people. They found that the current FAO/WHO/UNU predictive equations had overestimated the BMR of tropical peoples by 8%. It was also tested among the Malays and Chinese populations and pointed to a lower BMR value than the predicted FAO/WHO/UNU equation. Ismail *et al.* (1998) developed predictive equations specifically to compute BMR for the Malaysian population as shown in Table 5.7.

Table 5.7: BMR-predictive formula for Malaysian men and women subjects

Age Group	**n**	**Formula**	**% Differences**
Male			
18-30	84	0.0550(W) + 2.480	13%WHO 6%H
30-60	223	0.0432(W) + 3.112	13%WHO 4%H
Total	**307**		
Female			
18-30	131	0.0535(W) + 1.994	9%WHO 6%H
30-60	218	0.0539(W) + 2.147	9%WHO 2%H
Total	**349**		

Source: Ismail *et al.* (1998)

Ismail *et al.* (1998) generated this predictive BMR equation through a measurement of 656 Malaysian adults (men = 307, women = 349), aged from 18 to 60-years-old, using the Douglas bag technique. The technique is described as below:

> "… BMR was measured using the Douglas bag technique. Douglas bag (Harvard, UK) outlets were equipped with accessories (e.g. tube, air-valves and mouthpieces) procured from Hans Rudolph, USA, which are smaller and more convenient to use. Samples of air collected using the technique were analysed using Oxygen analyser (Model 570A, Servomex Ltd., England), which was calibrated regularly using oxygen free nitrogen. Volume of expired air (corrected to STP) was measured using a digital dry gas meter (Harvard Ltd, UK). Barometric pressure was measured daily using an aneroid barometer. The energy expenditure of subjects was derived using the Wier (1949) formula. The pulse rate and respiration rate of subjects were recorded while BMR was being measured. The BMR values were considered to be technically valid when the intra-subject coefficient of variation (cv) was < 2.5% or less. Measured BMR of each subject was compared to the FAO/WHO/UNU (1985) and Henry & Rees (1991) predictive equations …"
>
> (Ismail *et al*., 2008)

The findings determined a regression equation of BMR that included weight (WT) and age (AGE) with a significant value of $p < 0.05$.

Male: BMR (MJ/d) = 0.047(WT) – 0.035 (AGE) + 3.083

Female: BMR (MJ/d) =0.054(WT) – 0.027 (AGE) + 1.985

However, ANOVA analysis showed that only WT contributed significantly to BMR for both male and female subjects. Height and age did not contribute towards the BMR variable and therefore both variables, height and age, were not included in the predictive equation of BMR (see Table 5.7).

When compared to the FAO/WHO/UNU (1985) predictive equations, it overestimated the BMR of adult Malaysians by an average of 13% and 9% in men and women, respectively, while 4 to 5% difference was observed when compared to Henry's equations, as shown in Table 5.7. Therefore, this study computes BMR based on Ismail's predictive equations based on body-weight.

The mean BMR of the respondents in MANS was 5.64 $\pm$ 0.01 MJ/day (1,348 $\pm$ 2.5 kcal/day); while the mean BMR of men and women was 6.05 $\pm$ 0.01 MJ/day (1,445 $\pm$ 2.9 kcal/day) and 5.25 $\pm$ 0.01 MJ/day (1255 $\pm$ 3.1 kcal/day), respectively. Reports from several studies in Malaysia have reported that average BMR was from 5.66 to 5.85 MJ/day and from 4.77 to 4.70 MJ/day, for men and women, respectively (National Coordinating Committee on Food and Nutrition 2005). It was slightly less compared to this study's finding for men, and vice versa for women.

The ratio between EI and basal metabolic rate (BMR) was computed using the BMR values calculated. The findings showed that the mean average of EI: BMR for all respondents was 1.48 $\pm$ 0.5 SD. The mean average falls under the category of normal reporting of total energy intake. Meanwhile, mean average EI: BMR for men and women was1.43 $\pm$ 0.5 SD and 1.52 $\pm$ 0.6 SD, respectively. Again, mean average of the ratio between EI and BMR falls under the normal reporting of total energy intake. Table 5.8 shows the distribution of under-reporting ($\leq$1.34), normal reporting (1.35 – 2.39) and over –reporting ($\geq$ 2.4) among the respondents. About 46% (n = 2,965) of all respondents were under-reporting, with 24% (n = 1,534) and 22% (n = 1,431) of men and women under-reporting, respectively. This was contrary to findings from a study done in Malaysia where more women (58%) were under-reporting than men (51%) (Mirnalini *et al.* 2008). Many studies have reported that women were more likely to under-report than men (Johansson *et al.* 1998; Asbeck *et al.* 2002; Ferrari *et al.* 2002; Mendez *et al.* 2004; Azizi *et al.* 2005; Mendez *et al.* 2011). The reason for this is not clear, but it may relate to interviewer rapport developed during the dietary intake interview. A good rapport may enhance good cooperation between respondents and interviewer, which may improve the accuracy of the food recall. Besides, it may be that these women recalled the food intake more clearly as they probably prepared the food at home and knew the full details of the food intake. Meanwhile, 7% of total respondents (men = 2%; women = 5%) over-reported total energy intake. Most under-reporters were observed among the overweight and obese groups, with a total of 24.5%. The same goes for men and women, where the highest reports of under-reporting were among the overweight and obese groups (men = 23.8%; women = 25.2%). All the under and over-reporting were excluded.

Table 5.8: Mean average of age, energy, BMR, body weight & height and percentage of respondents' BMI according to groups' underlying ratio of EI: BMR

	Total respondents			Men			Women		
	≤ 1.34 (n = 2965)	1.35 – 2.39 (n = 3063)	≥ 2.4 (n = 428)	≤ 1.34 (n = 1534)	1.35 – 2.39 (n = 1493)	≥ 2.4 (n = 127)	≤ 1.34 (n = 1431)	1.35 – 2.39 (n = 1570)	≥ 2.4 (n = 301)
Age (y)	37.2 ± 0.2[a]	34.5 ± 0.2	35.5 ± 0.5[a]	36.9 ± 0.3	34.5 ± 0.3	30.5 ± 0.9	37.5 ± 0.3	34.4 ± 0.3	32.3 ± 0.6
Energy (kcal/d)	1,425.6 ± 6.6[a]	2,293.6 ± 7.7	3,144.1 ± 16.2[a]	1,523.3 ± 9.1	2,471.8 ± 10.6	3,366.0 ± 19.2	1,320.9 ± 8.8	2,124.9 ± 9.4	3,050.4 ± 19.2
BMR (kcal/d)	1,409.3 ± 3.7[a]	1,312.9 ± 3.2	1,175.6 ± 6.3[a]	1,485.2 ± 4.6	1,417.1 ± 3.6	1,294.4 ± 7.5	1,327.8 ± 5.1	1,214.4 ± 3.7	1,125.5 ± 6.4
Body weight (kg)	67.4 ± 0.3[a]	60.0 ± 0.2	50.5 ± 0.4[a]	70.3 ± 0.4	64.4 ± 0.3	53.5 ± 0.6	64.2 ± 0.4	55.8 ± 0.3	49.2 ± 0.5
Body height (cm)	160.3 ± 0.2[a]	159.6 ± 0.2	156.1 ± 0.4[a]	165.9 ± 0.2	165.9 ± 0.2	163.7 ± 0.6	154.3 ± 0.2	153.6 ± 0.2	152.9 ± 0.3
% of respondents:									
BMI (kg/m^2)									
< 18.5	2.0	5.3	1.8	2.4	5.2	1.2	1.7	5.4	2.4
18.5 – 24.9	19.2	26.2	4.0	22.4	26.5	2.7	16.2	25.7	5.3
25.0 – 29.9	15.3	12.5	0.7	16.6	12.8	0.2	14.1	12.1	1.2
> 30.0	9.2	3.7	0.1	7.2	2.8	0	11.1	4.5	0.2

[a]Significantly different from EI: BMR category 1.35–2.39, $P < 0.05$ (one-way ANOVA with Bonferroni correction)

5.1.2.2 Dietary Intake of Respondents

The Malaysian Ministry of Health has adopted 'Recommended Nutrient Intake' (RNI) as the nomenclature for reference to dietary recommendation (National Coordinating Committee on Food and Nutrition 2005). RNI is one of the terms commonly used with reference to dietary recommendations as well as recommended dietary allowances, recommended daily allowances and recommended daily amounts. RNI is the daily intake that covers the nutrient requirements of almost all (~ 97.5%) apparently healthy individuals. EAR sets an estimate of the average requirement for a nutrient in a population defined by age and gender – if average intake for a population is close to the EAR, it is possible that everyone in the population is meeting their nutrient needs. Meanwhile, the tolerable upper intake level (UL) is the maximum level of continuing daily nutrient intake that is likely to present no risk of adverse health effects in almost all individuals in the specified life stage group (National Coordinating Committee on Food and Nutrition 2005). To achieve better dietary requirements, one should not go below EAR or beyond UL; RNI is the ideal option.

After excluding all under and over-reporting of energy intake, the total mean energy intake of all respondents was 2,293 kcal $\pm$ 657 SD. Recommended Nutrients Intakes (RNI) for energy and other nutrients are age and gender-dependant. Therefore, we categorize men and women into age groups to look at the mean percentage of RNI achieved for each age group, as shown in Table 5.9 and Table 5.10. Total energy intake for men (n = 1,493) and women (n = 1,570) was 2,472 kcal $\pm$ 411 SD and 2,125 kcal $\pm$ 374 SD, respectively. Recommended Nutrient Intake (RNI) for total energy intake for the Malaysian population is around 2,440 kcal to 2,460 kcal, and 2000 kcal to 2,180 kcal for men and women, respectively. Significant difference of mean energy intake was found between men and women, t (3,009) =24.5, $p < 0.001$, with men having higher energy intake than women. Table 5.11 shows the distribution of total energy intake and other nutrients intake among Malays, Chinese and Indians. The mean average of total energy intake was higher among Malays (M = 2,307 kcal, SE = 10.6), followed by Chinese (M = 2,287, SE = 15.8) and Indians (M = 2,254, SE = 28). However, there was no significant difference in the total energy intake between Malays, Chinese and Indians.

Table 5.9: Nutrients intake of men in a day by age group and comparison of nutrients intake with Recommended Nutrients Intake (RNI)

Dietary Intake	**Mean ± S.E.**				**RNI**	**RNI achievement Mean % RNI**
	18 – 29 years (n = 580)	**30 -50 years (n = 765)**	**51 – 60 years (n = 151)**	**Total (n = 1493)**		
Energy intake (kcal)	2,463 ± 18.0	2,491 ± 14.1	2,408 ± 33.6	2,472 ± 10.6	2,440 – 2,460	101
Carbohydrates (g)	461 ± 4.2	463 ± 3.3	447 ± 7.5	460 ± 2.5	NA[b] (55 – 70 % of TE)	74.4[b]
Proteins (g)	110 ± 1.5	114 ± 1.5	106 ± 3.2	112 ± 1.0	62g (15 – 20 % of TE)	180.4
Fats (g)	65 ± 1.9	67 ± 2.1	58 ± 4.4	65 ± 1.4	54g – 82g (20 – 30 % of TE)	120.7
Calcium (mg)	788 ± 13.3	800 ± 11.7	782 + 25.8	794 ± 8.3	1000	79.4
Iron[a] (mg)	19 ± 0.3	20 ± 0.2	19 ± 0.6	19 ± 0.2	14	138.9
Zinc (mg)	9 ± 0.3	9 ± 0.3	8 ± 0.7	9 ± 0.2	6.7	135.8
Thiamine (mg)	2 ± 0.0	2 ± 0.1	2 ± 0.1	2 ± 0.0	1.2	153.5
Riboflavin (mg)	2 ± 0.0	2 ± 0.0	2 ± 0.1	2 ± 0.0	1.3	170.9
Niacin (mg NE)	19 ± 0.6	20 ± 0.6	17 ± 1.2	19 ± 0.4	16	120.2
Vitamin C (mg)	120 ± 3.3	129 ± 3.3	132 ± 8.3	126 ± 2.3	70	179.9
Vitamin A (μg)	580 ± 152.1	631 ± 130.7 *	653 ± 378.6	614 ± 97.2	600	102.3
Vitamin E (mg)	12 ± 0.4	14 ± 0.4 *	13 ± 0.9	13 ± 0.3	10	103.2
Selenium (μg)	44 ± 1.0	40 ± 0.8 *	36 ± 1.8 *	41 ± 0.6	33	124.3

[a] The recommended iron is based on a 10% iron bioavailability level
[b] NA: recommendation is based on percentage of total energy intake (TE)
* Significantly different from age group 18 – 29-years-old, P < 0.05 (one-way ANOVA with Bonferroni correction)

Table 5.10: Nutrients intake of women in a day by age group, and comparison of nutrients intake with Recommended Nutrients Intake (RNI)

Dietary Intake	Mean ± S.E.				RNI	RNI achievement
	18 – 29 years (n =607)	30 -50 years (n =814)	51 – 60 years (n =161)	Total (n =1570)		Mean % RNI
Energy intake (kcal)	2,083 ± 14.9	2,159 ± 13.3 *	2,112 ± 28.1	2,125 ± 9.4	2,000 – 2,180	100.8
Carbohydrates (g)	393 ± 3.5	403 ± 3.1	391 ± 7.2	397.5 ± 2.2	NA[b] (55 – 70 % of TE)	74.9[b]
Proteins (g)	91 ± 1.1	97 ± 1.2 *	91 ± 1.9	94.1 ± 0.8	55 (15 – 20 % of TE)	171.2
Fats (g)	52 ± 1.4	53 ± 1.5	42 ± 1.5 *	51.4 ± 0.9	46 – 70 (20 – 30% of TE)	111.8
Calcium (mg)	705 ± 11.0	723 ± 10.0 **	659 ± 22.9	709 ± 7.1	800 (18 – 50 years) 1,000 (51 – 60 years)	87.0
Iron[a] (mg)	17 ± 0.2	18 ± 0.2 *	17 ± 0.4	17 ± 0.1	29 (18 – 50 years) 11 (51 – 60 years)	69.0
Zinc (mg)	7 ± 0.2	7 ± 0.2	5 ± 0.2	7 ± 0.2	4.9	143.7
Thiamine (mg)	1 ± 0.0	2 ± 0.0 **	1 ± 0.0	1 ± 0.0	1.1	133.5
Riboflavin (mg)	2 ± 0.0	2 ± 0.0	2 ± 0.0	2 ± 0.0	1.1	174.7
Niacin (mg NE)	15 ± 0.4	16 ± 0.4	14 ± 0.6	15 ± 0.3	14	110.4
Vitamin C (mg)	126 ± 3.5	128 ± 3.1	118 ± 7.3	126 ± 2.2	70	180.5
Vitamin A (μg)	552 ± 138.4	601 ± 123.8	570 ± 275.6	579 ± 87.7	500	115.9
Vitamin E (mg)	11 ± 0.3	12 ± 0.3 *	10 ± 0.5	11 ± 0.2	7.5	105.0
Selenium (μg)	36 ± 0.8 **	35 ± 0.6 **	33 ± 1.7	35 ± 0.5	25	140.5

a The recommended iron is based on a 10% iron bioavailability level,

b NA: recommendation is based on percentage of total energy intake (TE)

* Significantly different from age group 18 – 29-years-old, $P < 0.05$ (one-way ANOVA with Bonferroni correction)

** Significantly different from age group 51 – 60-years-old, $P < 0.05$ (one-way ANOVA with Bonferroni correction)

Table 5.11: Distribution of nutrients intake according to ethnicity in Malaysia (n = 3,063)

Dietary Intake	**Mean ± S.E.**			
	Malays (n = 1,602)	**Chinese (n = 746)**	**Indians (n = 252)**	**Others (n = 436)**
Energy intake (kcal)	2,307 ± 10.6	2,287 ± 15.8	2,254 ± 28	2,281 ± 20.1
Carbohydrates (g)	430 ± 2.4	428 ± 3.5	433 ± 6.1	419 ± 4.4
Proteins (g)	106 ± 0.9	99 ± 1.1	88 ± 2.0	105 ± 1.8
Fats (g)	61 ± 1.2	53 ± 1.5	54 ± 2.5	60 ± 2.5
Calcium (mg)	786 ± 8.0	696 ± 9.7	741 ± 18.7	718 ± 13.7
Iron[a] (mg)	19 ± 0.2	18 ± 0.2	16 ± 0.3	19 ± 0.3
Zinc (mg)	9 ± 0.2	7 ± 0.2	6 ± 0.4	9 ± 0.4
Thiamine (mg)	2 ± 0.03	2 ± 0.03	2 ± 0.06	2 ± 0.06
Riboflavin (mg)	2 ± 0.8	2 ± 0.7	2 ± 0.7	2 ± 0.8
Niacin (mg NE)	18 ± 0.4	17 ± 0.4	16 ± 0.7	18 ± 0.7
Vitamin C (mg)	126 ± 2.2	128 ± 3.2	120 ± 5.2	127 ± 4.0
Vitamin A (µg)	568 ± 86.0	633 ± 133.2	468 ± 159.1	698 ± 198.0
Vitamin E (mg)	14 ± 0.3	10 ± 0.3	9 ± 0.5	14.0 ± 11.7
Selenium (µg)	38 ± 0.5	40.0 ± 0.7	37 ± 1.3	35 ± 1.0

[a] The recommended iron is based on a 10% iron bioavailability level,

Macronutrients

The mean carbohydrate intake of men and women was 460g and 398g, respectively (see Tables 5.9 and 5.10), which contributed approximately 64 - 65% of the total energy intake, as shown in Table 5.12. The RNI suggestion is to have a carbohydrate intake within the range of 55% to 70%. The mean carbohydrate intake among Malays (M = 430, SE = 2.4), Chinese (M = 428, SE = 3.5) and Indians (M = 433, SE = 6.1) differed slightly between each other.

Table 5.12: Mean distribution of nutrients to the total energy intake

Macronutrients	RNI recommendation	Men Mean (%) $\pm$ SE	Women Mean (%) $\pm$ SE
Carbohydrate	55%-70%	64.0 $\pm$ 9.9	65.0 $\pm$ 8.9
Protein	10%-15%	16.0 $\pm$ 4.1	16.0 $\pm$ 3.1
Fat	20%-30%	20.0 $\pm$ 12.6	19.0 + 8.6

Meanwhile, the mean protein intake of men and women was 112g and 94g, respectively, which contributed 16% of energy intake in both. The mean fat intake of men and women was 65g and 51g, respectively, which contributed 20% and 19% of total energy intake, respectively. Carbohydrate and fat are within the RNI recommendation for both men and women in this study.

A one-way between-group analysis of variance was conducted to explore the differences between macronutrients intake among Malays, Chinese and Indians. Statistical significant differences at $p < .05$ were found in protein and fat intake. Hence, a two-way between-groups analysis of variance was performed to explore the impact of gender on protein and fat intake among Malays, Chinese and Indians. The interaction effect between gender and ethnicity group was not statistically significant for protein intake (*gender*ethnicity = 0.501*). This indicates that there is no significant difference in the effect of gender on protein intake for Malays, Chinese and Indians; F (3, 3,055) = 0.79, $p = .50$. There was a statistically significant main effect for ethnicity, F (3, 3,055) = 21.3, $p < .001$; however, the effect size was small (partial eta squared = .02).

Next, two-way between-groups analysis of variance was performed on fat intake among Malays, Chinese and Indians to assess the impact of gender. The interaction effect between gender and ethnicity group was not statistically significant for fat intake (*gender*ethnicity = 0.233*). However, there was a statistically significant main effect of fat intake for ethnicity, F (3, 3,055) = 4.075, $p < .05$, where the effect size was very small (partial eta squared = .004).

Micronutrients

Men achieved RNI of more than required for total energy intake and other nutrients, except for calcium intake, as shown in Table 5.9. The mean intake of calcium for men (M = 794 mg, SE, = 8.3) was slightly less than the recommended1,000 mg. However, the mean average for women was less for calcium (M = 709 mg, SE = 7.1) and iron intake (M = 17 mg, SE = 0.1) than other nutrients intake, corresponding to 87% and 69% from RNI, respectively.

Chinese (M = 696 mg, SE = 9.7) had a lower calcium intake than the Malays (M = 786 mg, SE = 8.0) and Indians (M = 741, SE = 18). Two-way between-group analysis of variance was carried out to determine the impact of gender and ethnicity on calcium intake. Results showed that the interaction effect between gender and ethnicity on calcium was not statistically significant (*gender*ethnicity = 0.1*). There was a statistically significant main effect for ethnicity, F (3, 3,055) = 16.3, $p < .001$; however, the effect size was small (partial eta squared = .02).

For iron intake, Indians (M = 16, SE = 0.3) had a lower intake than Malays (M = 18, SE = 0.2) and Chinese (M = 19, SE = 0.2). When two-way between-group analysis of variance was conducted to identify the impact of gender and ethnicity on calcium intake, no significant difference was found. This indicates that there is no significant effect of gender on iron intake for Malays, Chinese and Indians; F (3, 3,055) = 0.89, $p = .45$. There was a statistically significant main effect for ethnicity, F (3, 3,055) = 9.74, $p < .001$; however, the effect size was small (partial eta squared = .009).

5.1.3 Discussion on findings of dietary intake

In this study, men were found to have higher energy intake than the women as shown in Figure 5.4. This result matches the RNI, where total energy requirement for men is higher (from 2,440 kcal to 2,460 kcal) than for women (from 2,000 kcal to 2,180 kcal).

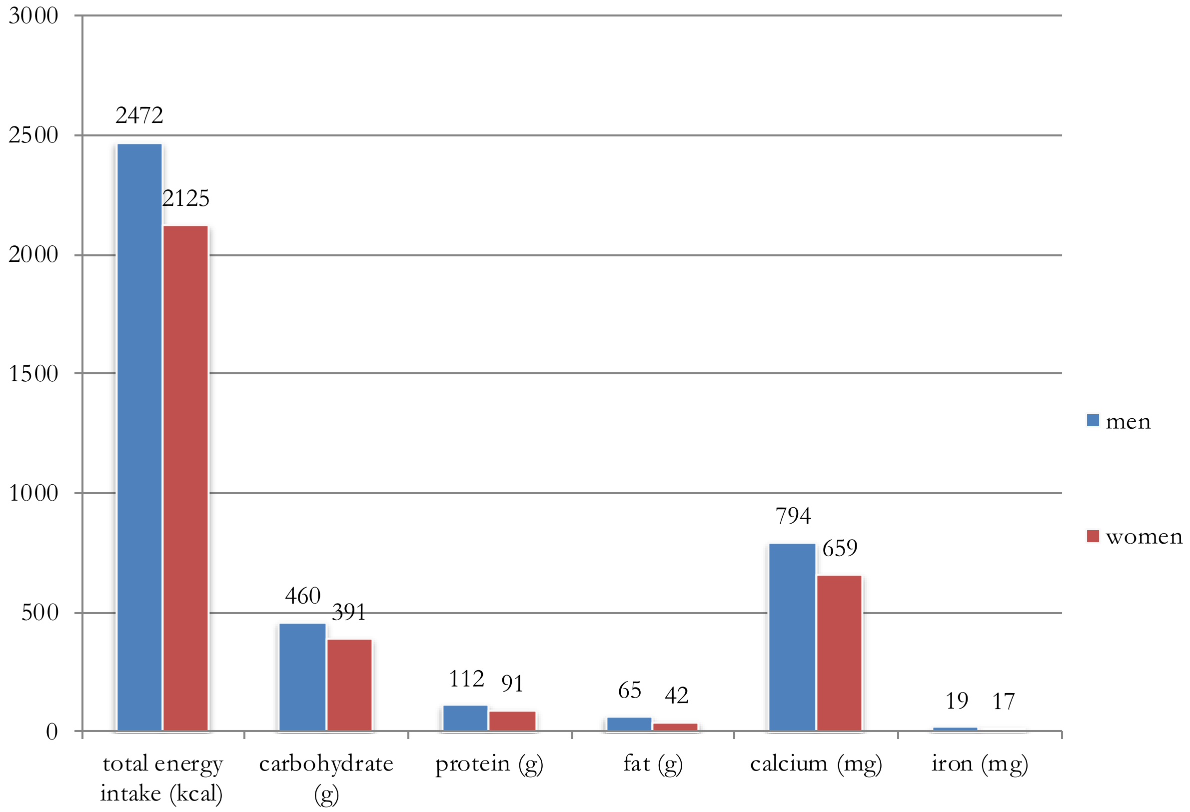


Figure 5.4: Summary of men and women dietary intake (n = 3,063)

Total energy intake was higher in Malays, followed by Chinese and Indians as shown in Figure 5.5. Both men and women had carbohydrate, protein and fat intake that was beyond the recommendation. The mean of total carbohydrate intake was higher in Malays, followed by Indians and Chinese. There was a significant difference of protein and fat intake among Malays, Chinese and Indians after being adjusted for gender. However, both had a small size effect.

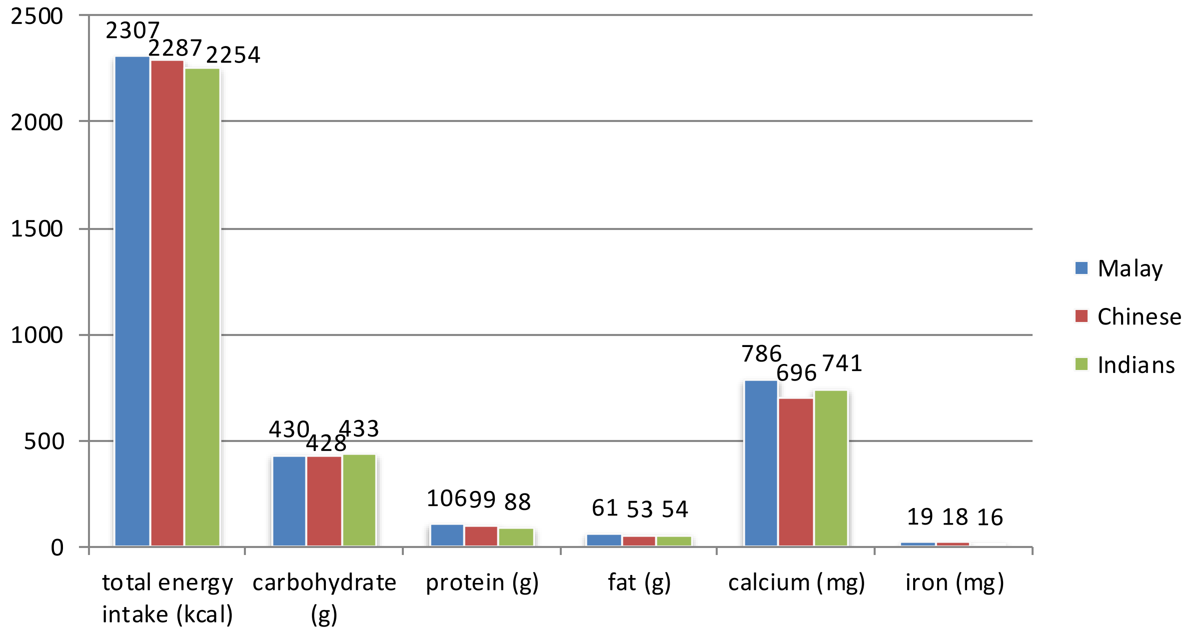


Figure 5.5: Summary of Malay, Chinese and Indians dietary intake (n = 3,063)

For micronutrients intake, men had intake less than the required calcium intake, while women had a lower intake of iron and calcium than recommended. This accords with a previous study which showed that men did not meet the recommended dietary allowance (RDA) for calcium (M = 333 mg, SD = 161) and women had calcium (M = 255 mg, SD = 133) and iron (M = 12, SD = 7) intake of less than two-thirds of the RDA (Chee *et al.* 1997). Other food consumption studies have also reported low consumption of calcium intake of less than 500 mg/day (Noor 1992; Khor and Sharif 2003) and low intake of iron in women (Khor and Sharif 2003). One plausible explanation for the low intakes of such nutrients is the low consumption of meat, vegetables (Chee *et al.* 1997) and milk products (Haron *et al.* 2010).

Among the Malaysian population, Chinese scored the lowest for calcium intake while Indians scored the poorest for iron intake, after adjusting for gender. Low calcium intake among Chinese may support findings from an earlier study in Malaysia that showed that the incidence of hip fractures is higher among the Chinese (63%), followed by Malays (20%) and Indians (13%). This is because low calcium intake is one of the main risk factors for hip fractures (Lau *et al.* 2001). Findings from that study also show that fracture rates are highest among the Chinese (160 per 100,000), followed by Indians (150 per 100,000) and Malays (30 per 100,000) (Lee and Khir 2007).

Indians have poor iron intake, which may be due to less intake of red meat. This can be confirmed by the lowest protein intake among Indians compared to Malays and Chinese. Most Indians do not consume beef because of religious beliefs. Inadequate iron intake will lead to iron deficiency (ID) and iron deficiency anaemia (IDA) (Goddard *et al.* 2011). The adverse effects of IDA have been related to premature birth, low birth weight, small for gestational age of new-born and lower mental development of children (Allen 2000; Chang *et al.* 2013). Therefore, Loh and Khor (2010) carried out a study to investigate the prevalence of ID and IDA among 388 Malaysian women. Findings showed that the Indian subjects had higher mean daily iron intake (16.0mg/day) than the Chinese (11.3 mg/day) and Malays (15.8 mg/day), which was in contrast with findings in this study. However, interestingly, the Indian subjects were the ones that had the highest prevalence of anaemia and IDA, despite having a higher mean of daily iron intake. Loh and Khor (2010) proposed that this might be the result of low bioavailability of iron from dhal and other legumes, which are most consumed by Indians. The bioavailability of iron decreased to less than 5% due to the presence of inhibitors of iron absorption, including phytate (Hurrell and Egli 2010). However, cabbage and oranges, which are rich sources of vitamin C, may combat this problem (Gibson *et al.* 2010). Generally, Indians have higher susceptibility to iron deficiency.

To conclude, the nutrients intake varied across ethnicity among the Malaysian population. It is vital to understand the variation of nutrients intake in the different ethnic groups, as it is a reflection of the cultural, religious, geographical, genetic and other differences of each ethnicity (Lee and Khir 2007). In addition, these findings further support the idea of examining dietary patterns rather than relying on a single nutrient. For example, the interaction that occurs between iron and phytate, which will determine iron absorption. This will subsequently assist in public health guidelines in combating diet disease-related problems.

5.2 Socio-demographic background

The socio-demographic background of the respondents is presented in Table 5.13. These data also include individuals who were excluded from the analysis (the under– and over-reporting of total energy intake). There was no major significant difference in the socio-demographic background of respondents before and after being excluded from the analysis. This is an important point that needs to be considered, as it may have an implication for the work presented in the thesis. If there were to be a huge significant difference before and after exclusion, it may not represent the original data set and may misinform the final results. In addition, eliminating respondents may lead to biased estimates or estimates with higher standard errors because of the reduced sample size (Gelman and Hill 2007). In addition, the original dataset represented the Malaysian population; however, after the exclusion of respondents, this may no longer be the case.

Table 5.13: Frequencies and percentages for the socio-demographic characteristics of the respondents before (n=6,615) and after exclusion (n=3,063) of under- and over-reporting.

	Before exclusion of respondents		**After exclusion of respondents**	
	Frequency	**Percent (%)**	**Frequency**	**Percent (%)**
State of Malaysia				
Peninsular	5,269	79.7	2,373	77.5
Southern	1,281	19.4	577	18.8
Central	2,247	34.0	987	32.2
East coast	893	13.5	424	13.8
Northern	848	12.8	387	12.6
Sabah	687	10.4	360	11.8
Sarawak	659	10.0	330	10.8
Strata				
Urban	3,556	53.8	1590	51.9
Metropolitan city	2,602	39.3	1139	39.1
Big city	954	14.4	453	14.8
Rural	3,059	46.2	1,473	48.1
Small town	829	12.5	380	12.4
Village	2,230	33.7	1,093	35.9
Gender				
Men	3,168	47.9	1,493	48.7
Women	3,447	52.1	1,570	51.3
Ethnicity				
Malay	3,565	53.9	1,602	52.3
Chinese	1,532	23.2	746	24.4
Indian / Punjabi	614	9.3	252	8.2
Others	904	13.7	463	15.4
Religion				
Islam	4,054	61.3	1,859	60.7

Buddha	1,289	19.5	621	20.3
Christian	513	7.8	210	6.9
Hindu	617	9.3	308	10.1
Others	141	2.1	65	2.1
Marital Status				
Single	1,756	26.5	894	29.2
Married	4,624	69.9	2,074	67.7
Divorced/Separated	83	1.3	36	1.2
Widowed	146	2.2	56	1.8
Age (Mean age)	35.4 $\pm$ 11.1 years (SD)		34.5 $\pm$ 11.1 year (SD)	
18-19	393	5.9	223	7.3
20-24	993	15.0	499	16.3
25-29	949	14.3	460	15.0
30-34	908	13.7	411	13.4
35-39	990	15.0	454	14.8
40-44	862	13.0	418	13.6
45-49	632	9.6	244	8.0
50-54	490	7.4	208	6.8
55-59	398	6.0	146	4.8
Level of Education				
Primary school	1,373	20.8	607	19.8
Lower secondary school	1,414	21.4	642	21.0
Upper secondary school	2,196	33.2	1,076	35.1
Post-secondary	344	5.2	176	5.7
College/University	940	14.2	436	14.2
Others	340	5.1	126	4.1
Employment Status				
Working	4,148	62.9	1,968	64.2
Retired	89	1.3	28	9.2
Student	303	4.6	164	5.4
Housewife	1,661	25.1	735	24.0
Unemployed	250	3.8	108	3.5
Others/refused to answer	145	2.2	60	2.0
Monthly Household Income (Mean)	MYR 1981.3 $\pm$ 3469 (SD)		1992.61 $\pm$ 2752.8 (SD)	
<MYR 1500	3,755	56.8	1,695	55.3
MYR 1500 – MYR 3500	1,946	29.4	954	31.1

> MYR 3500	913	13.8	414	13.5
Body Mass Index (BMI)	24.6 ± 3.5 (SD)		23.5 ± 4.3 (SD)	
Underweight	767	11.1	333	10.9
Normal	3,196	48.3	1,691	55.2
Overweight	1,843	27.9	806	26.3
Obese	840	12.7	233	7.6

After taking consideration, the under- and over- reporting were excluded, as some studies have shown that dietary trends or the magnitude of the estimates of intake were affected by the exclusion of under-reporting (de Castro 2006; Warwick 2006). If not, this may result in spuriously low estimates of respondents' nutrient intake (de Castro 2006). One Australian study involving female university students from 1988 to 2003 showed an increase of the trend for total energy, protein and carbohydrate intake when under-reporting was excluded from the analysis. Without removing the under-reporting, there was a lack of increase in total energy intake, protein and carbohydrate intake. It was suggested that this was probably due to a disproportionate skewing of the results by the very low energy intake in under-reporting (Warwick and Reid 2004).

After exclusion, the national survey covered all states of Malaysia, including Sabah and Sarawak, a total of 3,063 respondents. Almost 80% of the respondents came from the Peninsular Malaysia while the remainder were from Sabah and Sarawak. In the Peninsular Malaysia, 32% were from the central region. This is where Kuala Lumpur, the capital of Malaysia, is situated. Malaysian citizens mainly work in Kuala Lumpur and its surrounding areas, the Klang Valley, including the outskirts of Kuala Lumpur, the Federal Territory of Putrajaya. Therefore, the central region is concentrated and contains the highest population compared to the other zones, with 1,588,750 population in Kuala Lumpur alone (Department of Statistic Malaysia 2010). Therefore, a possible explanation for the high contribution of respondents from the central region of Peninsular Malaysia is the high population concentrated in that zone compared to the others.

However, there was only a slight difference between the percentage of respondents from the urban area (52%) and the rural area (48%), and also between men (49%) and women (51%). The urban population rose from 62.0% in 2000 to 62.5% in 2003, during the review period of Malaysia Eight Plan, 2001-2003, while the rural population declined from 38.0%in 2000 to 37.0%in 2003. This was slightly different from the proportion obtained from MANS. Despite the differences, urban respondents were still higher than their rural counterparts due to an increase of migration, growth in new urban areas and the extension of administrative urban boundaries (Economic Planning Unit 2001). Of the total respondents, 52% were Malay, 24% were Chinese, and 8% were Indian. The remaining were Bumiputra Sabah and Sarawak and indigenous people. The pattern differed from the Economic Planning Unit (2001), which estimated that more than 65% of Malaysians population in 2003 were Malay, followed by 25.6% Chinese and 7.5% Indian.

About 61% of the respondents were Muslim, followed by 20% Buddhist, with the others being Christian (7%) and Hindu (10%). Generally, the respondents were married (68%) and had a mean average age of 34.5 $\pm$ 11.1 years. Most of them had a level education of upper secondary school (35%), followed by lower secondary school (21%). Only a few respondents had education until tertiary level (14.2%). For comparison, a report of student enrolment in Malaysia's local public institutions in 2003 found that 50.2% of the population were enrolled in primary school, followed by 21.1% in lower secondary school, 13.7% in upper secondary school, 2.0% in post-secondary (pre-diploma and pre-university courses), 4.2% in tertiary education and 8.8% others.

A large percentage of the respondents sample had an occupation (64%). The Mid-Term Review of The Eighth Malaysia Plan showed that the working age group, 15-64, constituted 62.7%in 2003, those below the age of 15 accounted for 33.2%, while the population in the age group 65 and above was 4.1%. Thus, the MANS survey on the percentage of working respondents reflected the Eighth Malaysia Plan review (Economic Planning Unit 2001).

The mean average household income for respondents was MYR 1,992.61, roughly GBP 385 (1 GBP = 5.15 MYR), with approximately 55% having household income of less than MYR 1,500. The mean household income matched that observed in a study carried out by Haron *et al.* (2005). Haron *et al.* (2005) conducted a study in the state of Selangor, which is the most developed and urbanised state in Malaysia, and found that the average monthly household income was MYR 1730.11. Surprisingly, both monthly household incomes were lower than the national average income of MYR 2,472 (Economic Planning Unit 2001). The low household income was parallel with the respondents' education attainment, predominantly upper secondary level.

Overall, most of the respondents were living in urban areas, women, Malays, married, working, had secondary education and a household income of less than MYR 1,500, and comparison with the variances in other national sources suggested that the socio-demographic in this study represented the Malaysian population.

5.3 Body Mass Index (BMI)

BMI can be classified under several cut-off points. The most widely used for grouping BMI is by applying the WHO 1998 classification. BMI was calculated for all of the respondents. Mean average BMI for all the respondents (those with normal reporting energy) was 23.5 $\pm$ 4.3 SD, as shown in Table 5.14. No significant difference of mean BMI was found between men (M = 23.4, SD = 4.1) and women (M = 23.6, SD = 4.4), $p > 0.000$. The BMI of both men and women was classified as normal weight, according to the WHO classification. The majority of total respondents had normal weight (55%) regardless of gender, followed by overweight (26.3%), underweight (11.0%) and obese (7.6%).

Table 5.14: Mean average of BMI and number of respondents according to BMI classification (n=3,063)

	Frequency (%)		
	All respondents (n = 3,063)	Men (n = 1,493)	Women (n = 1,570)
Mean of BMI	23.50 $\pm$ 4.3	23.39 $\pm$ 4.1	23.60 $\pm$ 4.4
Underweight (<18.5)	333 (10.9)	160 (10.7)	173 (11.0)
Normal (18.5 – 24.9)	1,691 (55.2)	839 (56.2)	852 (54.3)
Overweight (25.0 – 29.9)	806 (26.3)	404 (27.1)	402 (25.6)
Obese (> 30)	233 (7.6)	90 (6.0)	143 (9.1)

The distribution of BMI by socio-demographic characteristics is shown in Table 5.15. The BMI of rural respondents is slightly higher than their urban counterparts. However, there was no significant difference in BMI for urban and rural population. Again, there was no significant difference in BMI between men and women. Malays had the highest mean BMI compared to other ethnicity in this study. The mean BMI of Chinese differed significantly from the mean BMI of Malays at $p < .001$. The mean BMI for age above 30 was higher than the mean BMI for 29 years and younger. In regards to education level of respondents, that the majority that had had tertiary education had better BMI than those that only attained secondary education or lower. There was a statistically significant difference in BMI for level of education. Post-hoc comparisons using Tukey HSD indicated that the mean BMI of high school graduate, college or associate degree and bachelor degree was significantly different from respondents that received education below high school level.

Table 5.15: Mean BMI by socio-demographic characteristics (n=3,063)

	N (%)	Mean BMI ± SD	*p*-value
Region			
Rural	1,473 (48.1)	23.7 ± 4.3	> 0.000
Urban	1,590 (51.9)	23.3 ± 4.3	> 0.000
Gender			
Men	1,493 (48.7)	23.4 ± 4.1	> 0.000
Women	1,570 (51.3)	23.6 ± 4.4	> 0.000
Ethnicity			
Malay[a]	1,602 (52.3)	23.8 ± 4.5	0.000[ab]
Chinese[b]	746 (24.4)	22.9 ± 3.8	
Indian	252 (8.2)	23.3 ± 4.3	
Others	463 (15.1)	23.4 ± 4.1	
Age			
18 – 29 years[a]	1,182 (38.6)	22.1 ± 4.2	0.000[abc]
30 – 50 years[b]	1,572 (51.3)	24.4 ± 4.1	
51 – 60 years[c]	308 (10.1)	24.4 ± 4.3	
Education level			
Less than high school[a]	1,249 (40.8)	23.9 ± 4.3	< 0.05[abcd]
High school graduate[b]	1,076 (35.1)	23.4 ± 4.3	< 0.05[bc]
College or associated degree[c]	176 (5.8)	22.6 ± 3.9	< 0.05[ce]
Bachelor degree[d]	436 (14.2)	22.7 ± 4.0	< 0.05[de]
Others[e]	125 (4.1)	24.0 ± 4.3	
Marital status			
Single[a]	894 (29.2)	21.6 ± 3.9	< 0.05[abcd]
Married[b]	2,074 (67.7)	24.3 ± 4.1	

Divorced/Separated[c]	36 (1.2)	24.0 ± 4.7
Widowed[d]	56 (1.8)	24.3 ± 4.5
Household size		
< 5	1,184 (38.6)	23.7 ± 4.3
5 – 10	1,791 (58.5)	23.4 ± 4.2
> 10	88 (2.9)	22.9 ± 4.5
Household income		
< MYR1500	1,695 (55.3)	23.4 ± 4.3
MYR1500 - MYR3500	953 (31.1)	23.7 ± 4.3
> MYR3500	414 (13.5)	23.5 ± 4.1

[axxx] Significantly different from *a*, $P < 0.05$ (one-way ANOVA with Bonferroni correction)
[bxxx] Significantly different from *b*, $P < 0.05$ (one-way ANOVA with Bonferroni correction)
[cxxx] Significantly different from *c*, $P < 0.05$ (one-way ANOVA with Bonferroni correction)
[dxxx] Significantly different from *d*, $P < 0.05$ (one-way ANOVA with Bonferroni correction)

On average, single respondents were shown to significantly have the lowest BMI compared to married, divorced/separated and widowed respondents. Meanwhile, households with less than five members had the highest mean BMI, followed by households of five to 10 members while the lowest mean BMI was for households of more than ten members. However, there was essentially no association of BMI for each group of household size. This was similar to the household income group, where no significant difference of BMI was found between respondents with household income of less than MYR 1,500, MYR ,1500 to MYR 3,500 and MYR 3,500. All in all, this finding shows that Malays, aged 30 and above, having education below high school level and married/widowed, predominantly had the highest BMI.

Table 5.16 shows the frequency and percentage of underweight, normal, overweight and obese respondents by gender, household income and ethnicity. The majority of Malay men and women with household income of less than MYR 1,500 were of normal weight, followed by overweight, underweight and obese. This was similar to the Chinese (54%), Indians (47%) and others men (70.4%) with household incomes of less than MYR 1,500, where most of them fell under the normal weight group. It is apparent that, regardless of gender, household income and ethnicity, the majority of all respondents fall under the normal BMI classification, except for three categories: Malay men with household income of MYR 1,500- MYR 3,500, Others men with household income of more than MYR 3,500 and Indian men with household income of more than MYR 3,500. All these three categories were predominantly overweight.

Table 5.16: Frequency and percentage of underweight, normal, overweight and obese respondents by gender, household income and ethnicity (n=3,063)

Gender	**Household Income (MYR)**	**Ethnicity**	**BMI classification**				**Total**
			Underweight	**Normal**	**Overweight**	**Obese**	
Men	< MYR1500	Malay	56 (10.0%)	344 (61.2%)	131 (23.3%)	31 (5.5%)	562 (100.0%)
		Chinese	17 (12.0%)	77 (54.2%)	41 (28.9%)	7 (4.9%)	142 (100.0%)
		Indian	18 (29.0%)	29 (46.8%)	12 (19.4%)	3 (4.8%)	62 (100.0%)
		Others	11 (6.8%)	114 (70.4%)	31 (19.1%)	6 (3.7%)	162 (100.0%)
	MYR1500 – MYR3500	Malay	14 (9.3%)	59 (39.1%)	63 (41.7%)	15 (9.9%)	151 (100.0%)
		Chinese	8 (5.8%)	82 (59.9%)	39 (28.5%)	8 (5.8%)	137 (100.0%)
		Indian	4 (12.9%)	13 (41.9%)	10 (32.3%)	4 (12.9%)	31 (100.0%)
		Others	0 (0.0%)	13 (37.1%)	17 (48.6%)	5 (14.3%)	35 (100.0%)
	>MYR3500	Malay	18 (18.4%)	47 (48.0%)	26 (26.5%)	7 (7.1%)	98 (100.0%)
		Chinese	4 (6.1%)	42 (63.6%)	18 (27.3%)	2 (3.0%)	66 (100.0%)
		Indian	2 (8.3%)	10 (41.7%)	11 (45.8%)	1 (4.2%)	24 (100.0%)
		Others	8 (34.8%)	9 (39.1%)	5 (21.7%)	1 (4.3%)	23 (100.0%)
Women	< MYR1500	Malay	41 (12.5%)	168 (51.4%)	82 (25.1%)	36 (11.0%)	327 (100.0%)
		Chinese	20 (16.8%)	76 (63.9%)	16 (13.4%)	7 (5.9%)	119 (100.0%)
		Indian	9 (15.8%)	25 (43.9%)	21 (36.8%)	2 (3.5%)	57 (100.0%)
		Others	9 (8.3%)	54 (50.0%)	34 (31.5%)	11 (10.2%)	108 (100.0%)
	MYR1500 – MYR3500	Malay	7 (10.8%)	28 (43.1%)	23 (35.4%)	7 (10.8%)	65 (100.0%)
		Chinese	9 (12.9%)	48 (68.6%)	9 (12.9%)	4 (5.7%)	70 (100.0%)
		Indian	0 (0.0%)	5 (55.6%)	3 (33.3%)	1 (11.1%)	9 (100.0%)
		Others	1 (9.1%)	8 (72.7%)	1 (9.1%)	1 (9.1%)	11 (100.0%)
	>MYR3500	Malay	31 (7.8%)	203 (50.9%)	109 (27.3%)	56 (14.0%)	399 (100.0%)
		Chinese	25 (11.8%)	139 (65.6%)	41 (19.3%)	7 (3.3%)	212 (100.0%)
		Indian	8 (11.6%)	31 (44.9%)	26 (37.7%)	4 (5.8%)	69 (100.0%)
		Others	13 (10.5%)	67 (54.0%)	37 (29.8%)	7 (5.6%)	124 (100.0%)

Summary of main findings

A one-way analysis of variance (ANOVA) was conducted to evaluate the relationship between SES and BMI as shown in previous Table 5.15. There were four factors that were found to be significant in BMI;

1. Ethnicity

   Ethnicity consists of four levels: 1= Malay, 2 = Chinese, 3 = Indians and 4 = others. The result indicated that ANOVA was significant, $F (3, 3059) = 7.47$, $p < .001$ at .05 alpha level. Meanwhile, the strength of relationship between ethnicity and BMI as assessed by eta squared ($\eta^2 = .007$) was very small with ethnicity accounting 0.7% of the variance of the BMI. Follow-up tests were conducted to evaluate pairwise differences among the means. Because the Levene test was not significant, we choose to assume that the variances were homogenous and conducted post hoc comparisons with the use of Tukey HSD test, a test that does assume equal variances among the four groups. There was only a significant difference in the means between Malay and Chinese. Malay showed a greater increase in BMI.

2. Age

   Age was grouped into three categories: 1= 18 - 29 years, 2 = 30 – 50 years, and 3 = 51 – 60 years. The result indicated that ANOVA was significant, $F (2, 3059) = 106.72$, $p < .001$ at .05 alpha level. Meanwhile, the strength of relationship between age and BMI as assessed by eta squared ($\eta^2 = .07$) was very small with age accounting 7% of the variance of the BMI. Follow-up tests were conducted to evaluate pairwise differences among the means. Because the variances were homogenous, we conducted post hoc comparisons with the use of Tukey HSD test. There was a significant difference in the means between group age of 18 – 29 and 30 – 50, and 18 – 29 and 51 – 60, but, no significant difference between 30 – 50 and 51 – 60. The group of age 51 – 60 showed a greater increase in BMI.

3. Level of education

   Level of education has five levels: 1 = less than high school, 2 = high school graduate, 3 = some college or associate degree, 4 = bachelor degree and 5 = others. The result indicated that the ANOVA was significant, $F (4, 3057) = 9.29$, $p < .001$ at .05 alpha level. Meanwhile, the strength of relationship between the level of education and BMI as assessed by eta squared ($\eta^2 = .012$) was very small with the level of education accounting 1.2% of the variance of the dependent variable. Follow-up tests were conducted to evaluate pairwise differences among the means. Because the variances were homogenous, we conducted post hoc comparisons with the use of Tukey HSD test. There was a significant difference in the means between less than high school and high school graduate, less than high school and college, less than high school and degree. There was a significant difference in the means between high school graduate and degree. There was a significant difference in the means between college and others. There was a significant difference in the means between degree and others. The groups that received other education and had less than high school education showed a greater increase in BMI.

4. Marital status

   Marital status has four categories: 1= single, 2 = married, 3 = separated and 4 = widowed. The result indicated that ANOVA was significant, F (3, 3056) = 89.71, $p < .001$ at .05 alpha level. Meanwhile, the strength of relationship between marital status and BMI as assessed by eta squared ($\eta^2 = .08$) was very small with marital status accounting 8% of the variance of the BMI. Follow-up tests were conducted to evaluate pairwise differences among the means. Because the variances were homogenous, we conducted post hoc comparisons with the use of Tukey HSD test. There was a significant difference in the means between single and married, single and separated, and single and widowed. The group of married and widowed showed a greater increase in BMI.

5.3.1 Discussion on findings of BMI

The average of BMI in this study was 23.5 and similar for both men and women; although there were more obese women than men (9.1% compared with 6%). Malays aged 30 and above, having education below the high school level and who were married/widowed generally had the highest BMI. In accordance with the present results, previous studies have demonstrated that Malays have a high prevalence of overweight compared to other ethnic groups (Tan *et al.* 2011; Dunn *et al.* 2012; Tan *et al.* 2012). There are similarities between the association of BMI and education in this study and those described by Wardle *et al.* (2002), Dunn *et al.* (2012) and Corella *et al.* (2012). All of them showed that higher educational achievement was associated with a lower risk of obesity in a population.

Dunn *et al.* (2012) found that education is likely to have an inverse association with BMI distribution, after BMI is estimated through the use of quantile regression. In a study of 1,580 Caucasian subjects from three independent Mediterranean samples, Corella *et al.* (2012) found that the association of fat mass with greater BMI and obesity risk in the subjects was strongly modulated by education. In their study involving 110,333 Brazilian adults, Monteiro *et al.* (2001) showed that education was unlikely to have any effect on obesity in less developed countries. The better educated men in the more developed countries were more likely to be less obese, while, the women, regardless of coming from developed or less developed countries, had a strong inverse relationship between education and risk of obesity. McLaren (2007) highlighted an interesting point in her review of 333 published studies, representing 1,914 primarily cross-sectional associations, between socioeconomic status (SES) and obesity between 1988 and 2004. She found that the risk of obesity shifted from inverse to positive association, as transition occurs from high levels of socioeconomic development to countries with medium and low levels of development. She pointed out that people in the highly developed countries were more prone to negative association by having lower SES, but larger body size, while people in the medium and low development countries were more susceptible towards positive association by having higher SES and larger body size. As one moved from high- to medium- to low-socioeconomic development countries, it could be seen that the percentage of negative associations decreased and the percentage of positive associations increased. The negative associations among people in the high socioeconomic development countries were most related to education and occupation SES indicators, while the positive associations among those in low- and medium- socioeconomic development were most related to income and material possessions SES indicators. McLaren's review also showed that the negative associations were reflected by 63% of women in high socioeconomic development. However, the percentage of this negative association was far more less than the findings by Sobal and Stunkard (1989) which showed 93% and 75% negative associations for women in the United States and other developed countries, respectively. However, it still shows that negative associations do occur in high socioeconomic development countries.

But what about Malaysia, which is a country of medium socioeconomic development? Dinsa *et al.* (2012) reviewed studies specifically on the association between SES and obesity in low- and middle-income countries. All of the studies reviewed had been adjusted for age and gender. The results showed a positive association between SES (education attainment indicator) and obesity among people in low socioeconomic development countries, while there was a greater mix of association and positive association for men and women, respectively, in medium socioeconomic development countries. Malaysia was one of the countries reviewed by Dinsa *et al.* (2012) and they found that Malaysia, as a medium socioeconomic development country, had a positive association between SES and obesity. People in Malaysia were found to be more prone to the positive associations (higher SES, larger body size). Dinsa *et al.* (2012) proposed an explanation for this positive association in medium socioeconomic development countries, suggesting that many of the middle income countries have greater access to food supply than the lower income countries. However, these middle income countries have less access to healthy foods than high income countries. Healthy foods, which were mainly low-calorie diets, were found to be more expensive than the more energy-dense diet in middle income countries. In addition to food consumption, urbanization in middle income countries has meant less energy expenditure among workers and this has led to a more sedentary lifestyle. It is, therefore, likely that such positive associations exist between higher SES and larger body size in Malaysia.

However, Dinsa et *al.'s* (2012) results for Malaysia were based upon data from a study that was conducted in only one region of Malaysia (i.e. Selangor) and it is unclear whether this is representative of the whole population of Malaysia. The finding raised more questions as the association between SES (education attainment as key indicator) and BMI in this present study were found to have negative association. However, our result agrees with the findings of other studies, wherein education and risk of obesity had a strong inverse relationship in medium socioeconomic development countries (Monteiro *et al.* 2001). However, one should bear in mind that educational attainment and obesity may show different directions with other socio-demographic factors (Cohen *et al.* 2013). It is surprising that, in their studies, Dunn *et al.* (2012) concluded that the higher levels of income that develop along with economic development will likely not eliminate obesity inequality. This was similar to findings in this study, which show that income does not affect obesity inequality among the Malays, Chinese and Indians. This scenario supports the result of this study, where educational attainment compared to other SES indicators may act as a protective barrier to risk of obesity. In addition, obesity in Malaysia, as a developing country, can no longer be regarded as a disease of people of higher SES, as the burden of obesity is gradually shifting toward people of lower SES (Monteiro *et al.* 2004)

Next, it is well-understood that the metabolism of the human body will decrease as age increases. Age was found to have a positive association with BMI in this study. As age increases, BMI also increases. This finding is supported by a study done by Sidik and Rampal (2009) which found that obesity was significantly associated with age among adults in Selangor, Malaysia. This result is consistent with The National Health and Morbidity Survey II, conducted by the Malaysian Ministry of Health in 1996 and 1997. A study involving a large sample size of UK adults, aged 18 to 99, also found an association between age and BMI (Meeuwsen *et al.* 2010). The observed association between age and BMI could be attributed to a decrease in height and lean mass as age increases

(Ablove *et al.* 2015). This has been proposed by Lim *et al.* (2000) as one of the reasons why BMI increases with age in Malaysia.

Last, but not least, there was an association between marital status and weight gain. Sobal *et al.* (2003) suggest that individuals entering or leaving marriage may influence body weight. Meanwhile, Averett *et al.* (2008) found evidence supporting the social obligation and marriage market hypotheses that BMI increases for both men and women during marriage and in the course of a cohabiting relationship. The 'social obligation' hypothesis is that those in married life may have richer, denser and more regular meals as a result of social obligations which may arise due to marriage, while the marriage market hypothesis stated that, when an individual exits the marriage market, they may not maintain a healthy BMI, because doing so is costly and they are in a stable union. Ball *et al.* (2002) revealed in their study that both married men and women, mainly men (OR=1.6, 95% CI 1.4-2.0), were at a higher risk of overweight. The present findings, which showed higher BMI among married respondents, seem to be consistent with all the aforementioned studies, that marital status may influence body weight gain.

In summary, this finding revealed that certain socio-demographic characteristics may influence the risk of obesity among the Malaysian population. It was perceived from the findings that the mean BMI of the married Malay, aged 30 years and above and with a lower level of education showed the highest BMI. Nevertheless, the mean BMI of each socio-demographic was still below 24.5, which is within the acceptable range for normal BMI according to WHO (1998) (normal range for BMI; 18.5 – 24.9). The socio-demographic characteristics of those with higher BMI in this study were in agreement with other studies that had similar findings, as discussed above. Those studies showed that subjects with low education, aged more than 30-years-old and married, had higher BMI.

5.4 Dietary Intake and Body Mass Index (BMI)

A Pearson product-moment correlation coefficient was computed to assess the relationship between total energy intake and BMI. Several assumptions were tested prior to the determination of Pearson Correlation. These assumptions must be not violated so as to give a valid result. The first assumption is that there needs to be a linear relationship between these two variables; total energy intake and BMI. Therefore, a scatter diagram is plotted between total energy intake and BMI, as shown in Figure 5.6. The second assumption is to eliminate any outliers. It is important to have no outliers or to keep to the minimum, as Pearson Correlation is sensitive to outliers. The last assumption is that the data must be normally distributed. Spearman's rho was also presented, which is nonparametric and, therefore, not subject to the same concerns about normality.

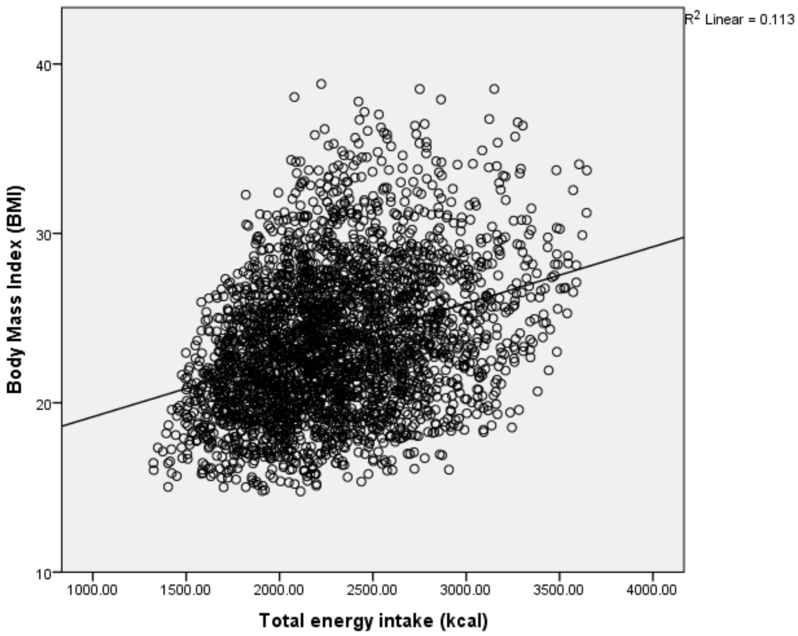


Figure 5.6: A scatter diagram of total energy intake against BMI

Both Pearson (r = 0.343, n = 3,063, $p < 0.01$) and Spearmen (rho = 0.311, n = 3,063, $p < 0.01$) had showed a moderate positive correlation between total energy intake and BMI. Squared of Pearson's r, r^2, was calculated to determine the coefficient of determination. The coefficient of determination is the portion of variability in one of the variables that can be accounted for by variability in other variables. The coefficient of determination r^2, is 0.113. This means that 11.3% of the variability in BMI can be explained by total energy intake of the 3,063 respondents with more accurate energy reporting (excluding under reporting of energy intake). The remaining 88.7% of the variability in BMI is explained by other factors in this study. To conclude, increases in total energy intake correlated with increases in BMI.

Table 5.17: Partial correlation between total energy intake of respondents and BMI (adjusting for age and gender)

		Total Energy
	Pearson Correlation	.35**
BMI	Sig. (2-tailed)	.000
	N	3063

**. Correlation is significant at the 0.01 level (2-tailed).
Controlled for age and gender

The results in regards to the distribution of mean total energy intake by BMI classification are presented in Figure 5.7. A one-way analysis of variance (ANOVA) was conducted to evaluate the relationship between BMI and total energy intake. The factor; BMI has four groups: 1 = underweight, 2 = normal, 3 = overweight, and 4 = obese. The dependant variable was the mean total energy intake of the respondents. The result indicated that the ANOVA was significant, F (3, 3,059) = 100.93, $p < 0.01$ at .05 alpha level. Meanwhile, the strength of relationship between the BMI groups and total energy intake as assessed by eta squared ($\eta 2 = .09$) was very small with the BMI groups accounting 9% of the variance of the dependant variable.

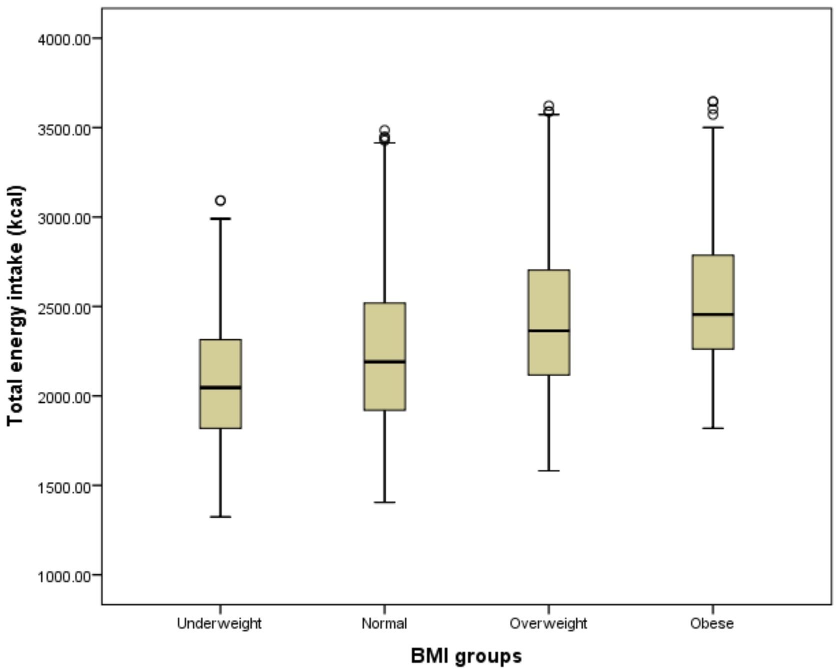


Figure 5.7: Distribution of total energy intake for the underweight, normal, overweight and obese respondents (n = 3,063)

Follow up test were conducted to evaluate pairwise differences among the means. Post-hoc comparisons using the Tukey HSD found that there was a significant difference in the means between underweight and normal, underweight and overweight and underweight and obese. There was a significant difference in the means between normal and overweight, normal and obese, and overweight and obese. The obese group showed a greater increase in total energy intake. The 95% confidence intervals for the pairwise differences, as well as the means and standard deviation are reported in the Table 5.18.

Table 5.18: Means, standard deviation and confidence intervals for the BMI pairwise differences

			Differences (95% CI)			
BMI groups	M	SD	Underweight	Normal	Overweight	Obese
Underweight	2,073	363.5	-	-228.3, -102.4*	-422.9, -286.1*	-561.6, -382.3*
Normal	2,239	411.4	102.4, 228.3*	-	-234.1, -144.2*	-379.9, -233.2*
Overweight	2,428	422.9	286.1, 422.9*	144.2, 234.1*	-	-195.6, -39.3*
Obese	2,545	397.4	382.3, 561.6*	233.2, 379.9*	39.3, 195.6*	-

*the mean difference is significant at the .05 alpha level

As the groups of BMI classification go from underweight up to obese, total energy increases as well (from 2074 kcal to 2551 kcal). This was parallel with the aforementioned result; increase in total energy intake is correlated with increase in BMI. Taken together, these results suggest that the BMI groups, underweight, normal, overweight and obese, do have a difference in terms of total energy intake. Specifically, this result suggests that perhaps the amount of energy consumed by respondents may contribute in determining their BMI group in this sample of study.

The association between selected nutrients and BMI using Pearson product-moment correlation coefficient is shown in Table 5.19. There was a small, positive correlation between total carbohydrate (r = .296), total fat (r = .062), total sodium (r = .122), total dietary fibre (r = .082), total sugar intake (r = .088) and BMI at p < .05 (2-tailed). The r- value refers to the strength of association between nutrients and BMI. The association between carbohydrate and BMI had the highest r- value than the other nutrients. This result may be explained by the fact that total carbohydrate intake was the major source of energy in the diet as it contribute around 64% to 65% of total energy intake among men and women in this study.

Table 5.19: Pearson Correlation between selected nutrients intake and BMI (n = 3,063)

		BMI	Total Carbohydrate	Total Fat	Total Sodium	Total Dietary fibre	Total Sugar	Total Protein
BMI	Pearson Correlation	1	.296**	.062**	.122**	.082**	.088**	.184**
	Sig. (2-tailed)		.000	.001	.000	.000	.000	.000
Total Carbohydrate	Pearson Correlation	.296**	1	.300**	.171**	.272**	.394**	.365**
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.000
Total Fat	Pearson Correlation	.062**	.300**	1	.154**	.895**	.259**	.824**
	Sig. (2-tailed)	.001	.000		.000	.000	.000	.000
Total Sodium	Pearson Correlation	.122**	.171**	.154**	1	.127**	.194**	.342**
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.000
Total Dietary Fibre	Pearson Correlation	.082**	.272**	.895**	.127**	1	.297**	.746**
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000
Total Sugar	Pearson Correlation	.088**	.394**	.259**	.194**	.297**	1	.211**
	Sig. (2-tailed)	.000	.000	.000	.000	.000		.000
Total Protein	Pearson Correlation	.184**	.365**	.824**	.342**	.746**	.211**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	

5.4.1 Discussion on findings of association between dietary intake and BMI

The findings above supported the hypothesis of this study that increase in total energy intake is correlated with an increase in BMI. The result also suggests that perhaps the amount of energy consumed by respondents may determine their BMI group. There was a small significant positive correlation between total carbohydrate, total fat, total sodium, total dietary fibre, total sugar intake and BMI. However, further discussion of the association between dietary intake and BMI is discussed in detail in the following chapters on dietary pattern approaches:

(i) Ultra-processed foods and obesity – Chapter 5

(ii) Principal component analysis and obesity – Chapter 6

(iii) Diet quality index revised and obesity – Chapter 6

Chapter 6: Exploration of Ultra-Processing Food/Product (UPP) Approach and Its impact on Diet Quality and Obesity

6.1 Ultra-processing classification

This chapter is divided into two parts. The first covers a pilot test of the Ultra-Processing Food/Product (UPP) approach. A pilot is crucial to test the suitability of the UPP model to the Malaysian dietary pattern. Suitability is defined as the extent to which the classification of the model fits what Malaysians consume and whether it can capture the pattern of processed foods in Malaysia. The second part is the result of applying UPP to the dietary intake of the Malaysian population based on Malaysian Adult Nutrition Survey (MANS) dataset. At the end of this chapter, we would want to see:

1. The suitability of UPP for classifying Malaysian foods
2. Relative contribution of UPP groups to total energy intake
3. Pattern of total energy from UPP groups according to socio-demographic factors
4. Nutrient markers in each of the UPP groups
5. Association between UPP groups and BMI

6.2 Pilot Study

This pilot study aimed:

1. To test if Malaysian food could be classified by the degree of processing, building on experience from Brazil
2. To investigate the consumption of the ultra-processed foods/products of the pilot study
3. To compare nutrient indicators of the overall diet by the quintile of the contribution of ultra-processed products to total energy

6.2.1 Introduction

This pilot study used a dietary survey of 300 people. This was derived from a study of the food choice of men and women in Bandar Baru Bangi, Malaysia, carried out between August 2008 and December 2008 by the researcher herself and several trained enumerators. The methodology is as described below. The research was ethically approved by the Faculty of Medicine, Universiti Putra, Malaysia.

6.2.2 Methodology

Data were acquired on 300 subjects (150 women and 150 men) from a selected urban area in Malaysia participating in the "*Food Choice Men and Women in Bandar Baru Bangi, Malaysia* (FOOD CHOICE)" study. The FOOD CHOICE study was carried out to identify reasons for food choices among the population in Bandar Baru Bangi, Malaysia. Inclusion criteria required that all respondents be between the age of 20 and 59 years, and must voluntarily agree to participate in this study. Exclusion criteria included a diagnosis of chronic disease, being on medication, pregnant women and stated intention to travel during the second stage of the study (the nutritional assessment follow-up).

Sample size was determined based on G*Power 3, a statistical power analysis program for the social, behavioural and biomedical sciences (Faul, Erdfelder, Lang & Buchner, 2007). After selecting the type of power analysis (i.e. compute required sample size – given α, power, and effect size) all the inputs were entered as follows:

t tests - Means: Difference between two independent means (two groups)

Analysis:	A priori: Compute required sample size	
Input:	Tail(s)	= One
	Effect size d	= 0.5
	α err prob.	= 0.05
	Power (1-β err prob.)	= 0.95
	Allocation ratio N2/N1	= 1

The input parameters specifying a one-tailed t test, a medium effect size of d = .5,

α = .05, (1- β) = .95, and an allocation ratio of n2/n1 = 1 resulted in a total sample size of N=176, with 88 sample size in each group, as shown in the output below:

Output:	Noncentrality parameter δ	= 3.3166248
	Critical t	= 1.6536580
	Df	= 174
	Sample size group 1	= 88
	Sample size group 2	= 88
	Total sample size	= 176
	Actual power	= 0.9514254

The minimum sample size for these two groups (men and women) was found to be 88 in each group. However, I was able to recruit 150 respondents in each gender. In order to ensure that every household had an equal chance of being selected, systematic selection was utilised. That is, in each street within the selected housing area, houses with odd numbers were selected. In order to achieve 150 married couples, every odd-numbered house was approached in each section with the help of trained enumerators. Details of the methodology can be found elsewhere (Asma *et al.* 2010a).

Those who met the inclusion criteria and voluntarily agreed to participate in both stages of the study were each given a set of questionnaires, including the respondent's information sheet and the informed consent form. The ethical approval for this "FOOD CHOICE" study was granted by the Medical Research Ethics Committee, Faculty of Medicine and Health Sciences, Universiti Putra, Malaysia.

The questionnaire included the demographic and socioeconomic characteristics of the respondents. It also contained a semi-quantitative questionnaire derived from the MANS study. The semi-quantitative FFQ was used to determine the total energy intake and food frequency consumption of the respondents. The FFQ used in this pilot study was the same as that used in the MANS study. The details of the FFQ are as described in the previous chapter.

The foods listed in the FFQ were classified according to the ultra-processed food classification, a novel approach by Monteiro *et al.* (2010). This was used as a preliminary experiment to test this novel approach on a small sample of Malaysian respondents before analysing using the large Malaysian Adult Nutrition Survey (MANS) data, which is a national dietary survey involving a larger scale of respondents.

Method of applying the UPP to the foods consumed in Malaysia

Monteiro (2010) grouped all foodstuffs according to the nature, extent and purpose of food processing. This methodology includes the creation of three categories of foods: unprocessed or minimally processed foods (Group 1), processed culinary ingredients (Group 2), and ultra-processed food products (Group 3). The definition of food processing defines how the food, drink and associated industries turn whole fresh foods into food products (Monteiro *et al.* 2010; Monteiro *et al.* 2011).

Group 1 consists of unprocessed and minimally processed foods. Unprocessed foods are defined as parts of animals that have recently been slaughtered and parts of plants after being reaped or gathered. Minimally processed foods are unprocessed foods subjected to processes, mostly physical, that do not extensively change the nutritional properties and uses of the original foods (Moubarac *et al.* in progress). These processes include cleaning and removal of inedible parts, portioning, grating, flaking, drying, chilling, freezing, pasteurization, fermentation, fat reduction, vacuum and gas packing, squeezing, and simple wrapping. Group 1 includes fresh or frozen meat, fresh or pasteurised milk and plain yogurt, whole or polished grains, fresh, frozen or dried fruits and unsweetened fruit juices, fresh and frozen vegetables, whole or peeled roots and tubers, unsalted nuts and seeds, and tea and coffee (Monteiro *et al.* 2010).

Group 2 consists of ingredients for household or industrial use. They are extracted and purified from one specific component of Group 1 foods to produce culinary and/or food industry ingredients. The processes used include both physical and chemical processes, such as pressure, refining, milling, hydrogenation and hydrolysis that substantially alter the nutritional properties and uses of the original whole food. Ingredients include oils, fats, sugar and sweeteners, flours and pastas (when made of flour and water) and starches. Typically, ingredients are inedible or unpalatable by themselves. They are depleted of nutrients and essentially provide energy. They are used in households, and also in restaurants, in combination with Group 1 foods, to make dishes and meals. They are also used by industry to make Group 3 ultra-processed products (Moubarac *et al.* 2011; Moubarac *et al.* in progress).

Group 3 consists of ultra-processed products that are ready to eat or ready to heat with little or no preparation. Their manufacture involves Group 2 ingredients, usually combined with small or even insignificant amounts of Group 1 foods, and often with cosmetic as well as other chemical additives. The use of solid fats, sugars, processed starches and preservatives gives them a long 'shelf life'. They are typically formulated to be ready-to-eat or ready-to-heat, to be intensely attractive to the senses, and often to be habit-forming. Specific processes used in their manufacture include baking, deep frying, curing, smoking, pickling, sugaring and salting. They can be consumed as dishes, snacks or drinks virtually anywhere; for example, at work as well as at home, in the street, while watching television, while driving or at the computer desk. Many of these products are now able to make health claims, as such, as a result of containing added synthetic micronutrients or dietary fibre. Ultra-processed products include bread, cakes, cookies (biscuits), baked goods in general, sweet and salty snacks, candies (confectionery), burgers, sausages and other processed meats, pizzas, 'nuggets', cheeses, chips (crisps), French fries (chips), soft drinks, and ready-to-heat meals, dishes and snacks (Moubarac *et al.* in progress).

For the purpose of applying this new food classification, the FFQ of the respondents were converted into daily energy (kcal), and other nutrients as well, using the Nutritionist Pro software, which contains the food composition of Malaysians' foods. FFQ data were transformed into daily frequencies (Cade *et al.* 2002b) and multiplied by the weight of the household measurement used in the FFQ to convert the values to grams. In the second step, an individual's daily intakes of energy and nutrients were assigned to one of the three food groups defined above and to specific foods or products within each group. Table 6.1 shows the food classification based on the extent and purpose of industrial processing modified for Malaysian foods. It consists of three main food groups, Group 1, Group 2 and Group 3, and each of these groups has eleven (have 41 foods), eight (have 8 foods) and twelve sub-groups (have 32 foods), respectively.

Table 6.1: Food classification based on the extent and purpose of industrial processing modified for Malaysian foods

Food Group	Foods	Food belonging to subgroups		
Group 1	Grains	1. Rice	2. Corn	3. Glutinous rice
	Meats	4. Chicken	5. Meat	6. Goat
		7. Duck		
	Fish	8. Fish		
	Seafood	9. Prawn	10. Cuttlefish	11. Mollusc
		12. Crab		
	Beans	13. Groundnut	14. Soybean	15. Pulses
		16. Fermented soy	17. Milk	18. Banana
		19. Apple	20. Orange	21. Watermelon
		22. Grape	23. Mango	24. Honeydew melon
		25. Papaya	26. Guava	27. Star fruit
		28. Pineapple		
	Roots and tubers	29. Root/Tuber	30. Pumpkin	
	Vegetables	31. Leafy vegetables	32. Cabbage	33. Non-leafy vegetables
		34. *Ulam*	35. Mushrooms	36. Beansprouts
	Eggs	37. Chicken egg	38. Duck egg	39. Quail egg
	Other	40. Coffee	41. Tea	
Group 2	Sugar	42. Sugar		
	Vegetable oil	43. Vegetable oil		
	Manioc flour	44. Manioc flour		
	Wheat flour	45. Wheat flour		
	Pasta	46. Pasta		
	Vegetable fats	47. Margarine		
	Animal fats	48. Butter/lard/cream		
	Other	49. Cereals		
Group 3	Breads	50. Bread	51. Biscuit	52. Sweets
		53. Ice-cream	54. Jelly custard	
	Soft drinks	55. Carbonated drink		
	Cheese	56. Cheese		
	Salted food †	57. Salted food	58. Salted egg	59. Anchovy
	Processed meat	60. Meat burger	61. Chicken ball	62. Fish ball
		63. Hotdog	64. Nugget	
	Processed dairy products †	65. Flavoured yogurt	66. Condensed milk	67. Evaporated milk
	Processed beverages	68. Chocolate milk	69. Malted drink	70. Cordial drink
		71. Fruit juices		
	Snacks	72. Snacks		
	Spreads	73. Peanut	74. Seri kaya	75. Jam
	Traditional dishes	76. Traditional Malaysian sweet delicacies		77. Roti canai
		78. Capati	79. Dosai	
	Others	80. Ready to eat cereals	81. Pizza	

† Additional added foods

Several modifications were made to Monteiro's classification, but it was possible to classify all Malaysian food and drinks into the three main food groups, Group 1, 2 and 3. Several foods (salted foods, processed dairy products and Malaysia traditional dishes) had to be added as food subgroups to highlight the food patterns of the Malaysian population. These added foods were not highlighted in Monteiro's original version as they were not frequently consumed or were not consumed at all in their study population in Brazil. Therefore, these foods were added as they were quite frequently consumed among the Malaysian population (Norimah *et al.* 2008).

In the next step, estimations for the relative percentage contribution of each food group (Group 1, 2 and 3) and subgroup to total energy intake were calculated. The sample mean of each food varies from sample to sample; the way this variation occurs is described by the "sampling distribution" of the mean. By calculating the standard error (SE), an estimation of how much the sample means of food will vary from the standard deviation of this sampling distribution will be determined. Standard error is also used as a measure of precision of the sample mean (Altman and Bland 2005).

Malaysian Adult Nutrition Survey (MANS) data will be applied for further assessment of food grouping in using a larger scale of data that are representative of the Malaysian population. The MANS study included all the ethnic groups and regions (urban and rural areas) in Malaysia. A similar procedure was used as described for the pilot, but with more advanced statistical analysis and involving additional analysis of the relationship between this new food grouping and the nutritional status of the population.

6.2.3 Result of pilot study – part I:

<u>To test if Malaysian food could be classified by the degree of processing, building on experience from Brazil</u>

From the pilot study, the diet of the Malaysian population can be applied to Monteiro's food classification, with several modifications.

1. Differences in food belonging to the three main UPP groups

Monteiro grouped individual foods purchased under three major food groups (Group 1, 2 and 3) and to specific foods or products within that major group. There are ten specific foods or products in Group 1, eight in Group 2 and ten in Group 3. However, from the pilot study analyses, Malaysian foods had a different number of specific foods or products in each group: eleven specific foods/products in Group 1, eight in Group 2 and twelve in Group 3. In Group 3, two specific foods/products were added; salted food and processed dairy products (see Table 6.2). These were added after seeing that the contribution of these products to the relative energy intake was significant. For instance, processed dairy products contributed 9.08 % to total energy intake of the respondents, as seen in Figure 6.4 later.

Table 6.2: Foods and specific foods/products in Group 3 (Ultra-processed foods/products)

Foods	**Food belongs in subgroups**
Breads	Bread
Biscuits	Biscuit
Sweets/Ice cream	Sweets
	Ice-cream
	Jelly custard
Soft drinks	Carbonated drink
Cheeses	Cheese
Salted food †	Salted fish
	Salted egg
	Anchovy
Processed meat	Meat burger
	Chicken ball
	Fish ball
	Hotdog
	Nugget
Processed dairy products †	Flavoured Yogurt
	Condensed milk
	Evaporated milk
Processed beverages	Chocolate drink
	Malted drink
	Cordial drink
	Fruit juices
Snacks	Snack
Spreads	Peanut
	Seri Kaya
	Jam
Others	Ready to eat cereals
	Pizza

† additional subgroup

2. Food Purchased vs. FFQ

Monteiro used individual food purchased for the food's grouping. Data of food purchased were obtained from the Brazilian Household Budget Survey (HBS). Monteiro pointed out that the data used for the classification only included food at home. Food away from home was not included because data collected by HBS on food away from home were insufficient to estimate the type and quantity of the food. However, this study will classify foods from semi-quantitative FFQ. The reason for being that, it shows the actual intake of the individual food consumption rather than the food purchased. The pilot study shows that the FFQ can replace the food purchasing data to adopt Monteiro's food classification. Hence, Monterio's classification can be applied to the FFQ and the FFQ has the advantage of capturing food out of home. This is important, because the larger scale MANS study (Malaysian Adult Nutrition Survey) was based on FFQ data as well.

6.2.4 Result of pilot study - part II:

6.2.4.1 To investigate the consumption of ultra-processed foods/products of the pilot study

Relative contribution of all food items (categorised under each food group) to total energy intake

The total mean energy intake of the 300 subjects was 2435.85 kcal (SE = 35.5). Figure 6.1 shows the relative contribution of all food items (categorised under each food group) to total energy intake (percentage of energy). It reveals that about 57% of total energy came from unprocessed or minimally processed foods (Group 1), 5.2% from processed culinary ingredients (Group 2), and 38% from ultra-processed foods (Group 3).

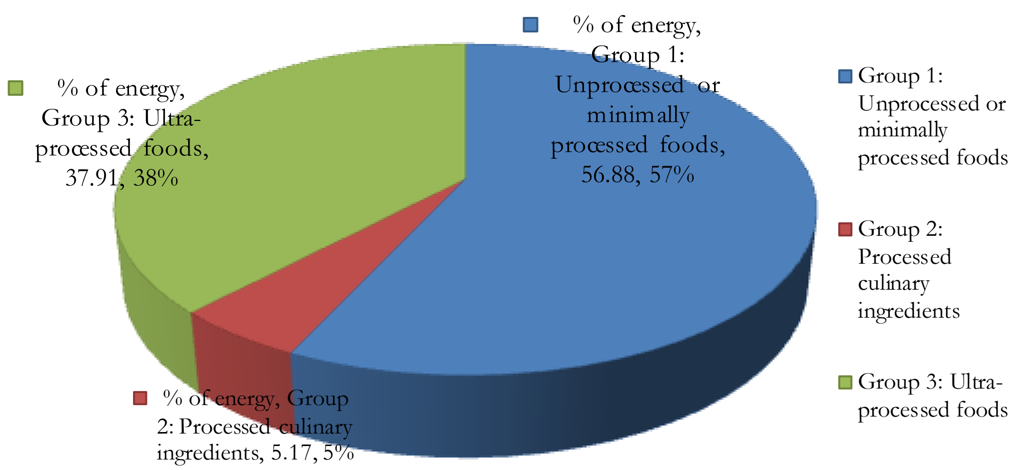


Figure 6.1: Relative contribution of UPP classification to total energy intake (percentage of energy); urban areas of Selangor, Malaysia (n = 300)

In Group 1, grains contributed 14% of total energy, which was the highest contribution of energy, as shown in Figure 6.2. Meat was the second highest contribution (9.5%) in Group 1 to total energy intake. This was followed by beans (7%), fish (6%), fruits (5%), milk (4%), vegetables (4%), seafood (3%), eggs (2%), roots and tubers (1%) and others (0.2%).

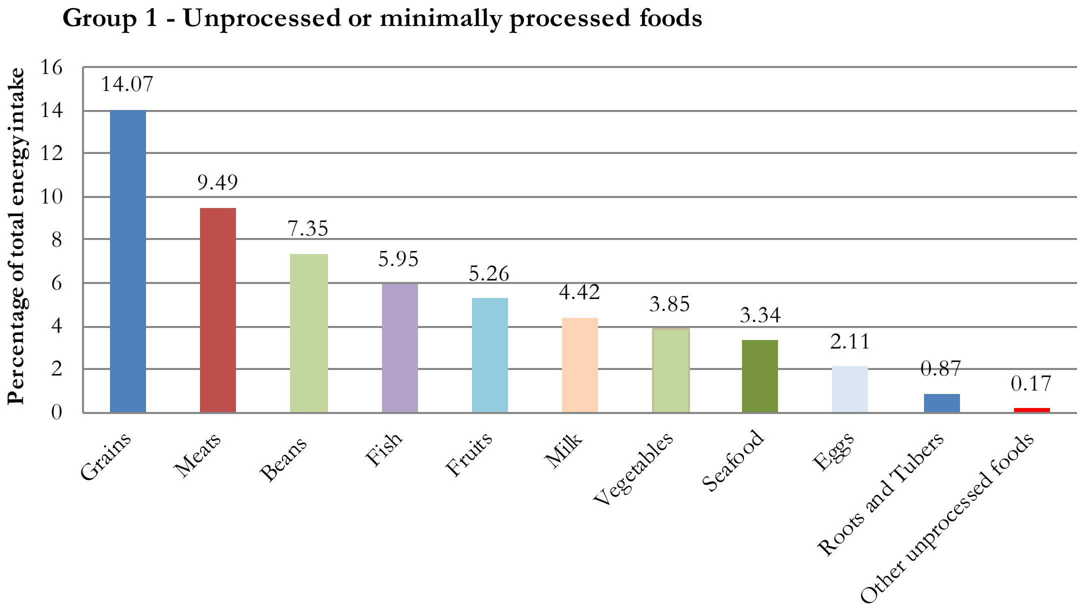


Figure 6.2: Food items in Group 1 (unprocessed or minimally processed foods) contributing to percentage of total energy intake

The main caloric shares for Group 2 were from pasta (3%), animal fats (0.9%) and vegetable fat (0.7%), as shown in Figure 6.3. Noodles, vermicelli and pasta were all grouped under pasta. The main caloric shares for Group 3 were from processed dairy products (9%), biscuits (9%), traditional dishes (5%), processed meat (5%), processed beverages (3%) and breads (2%).

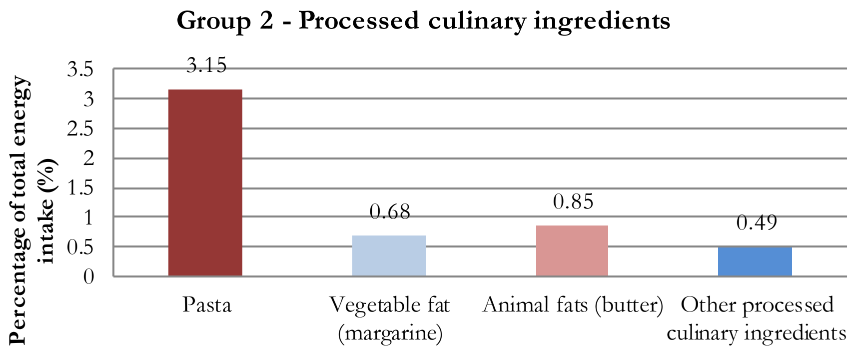


Figure 6.3: Food items in Group 2 (processed culinary ingredients) contributing to percentage of total energy intake

Rice was the main contributor from the grains subgroup, which contributed 13.3% to total energy consumption. Chicken was the most consumed (7.8%) in the meat subgroup compared to meat (1%), goat (0.4%) and duck (0.2%). Fish contributed almost 6% to total caloric share.

Interestingly, beans contributed 7.4%, with more than half being from groundnut contribution (4.31%), followed by soybean (2.29%), pulses (0.73%) and fermented soy (0.02%). This was then followed by fish, with a contribution of about 6%. Therefore, chicken contributed more in terms of caloric share than fish.

The caloric share from fruits and vegetables were 5.26% and 3.85%, respectively. Banana (0.92%), apple (0.91%) and orange (0.88%) was the main caloric share for fruits, while leafy vegetables (2.12%) were the main caloric share for vegetables. For milk, the caloric share was 4.42%, whereas seafood, eggs, roots and tubers and other unprocessed or minimally processed foods contributed to less than 3.5% of caloric share, respectively.

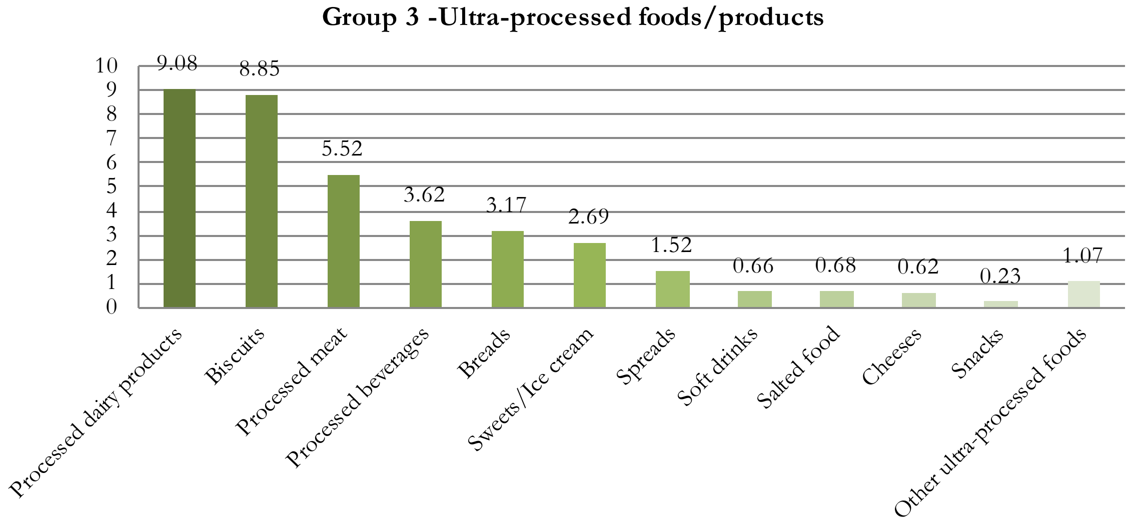


Figure 6.4: Food items in Group 3 (ultra-processed foods) contributing to percentage of total energy intake

In Group 3, two food subgroups, processed dairy products and biscuits, were the main contributors to total energy intake, with more than 8% contribution each, as shown in Figure 6.4. The caloric share from processed dairy products was from flavoured yogurt (5.77%), condensed milk (3.22%) and evaporated milk (0.09%). This was then followed by caloric share from biscuits, 8.85%. Meanwhile, the rest contributed less than 5%, respectively.

6.2.4.2 Contribution of Ultra-Processed Products to Total Energy

Overall, 38% of total energy in the pilot sample was from Group 3. Visual binning was used to break down the percentage of total energy from Group 3 in the 300 individuals into five percentiles. With the help of visual binning in SPSS, five percentiles were automatically built based on number of cut-off points required, as shown in Figure 6.5.

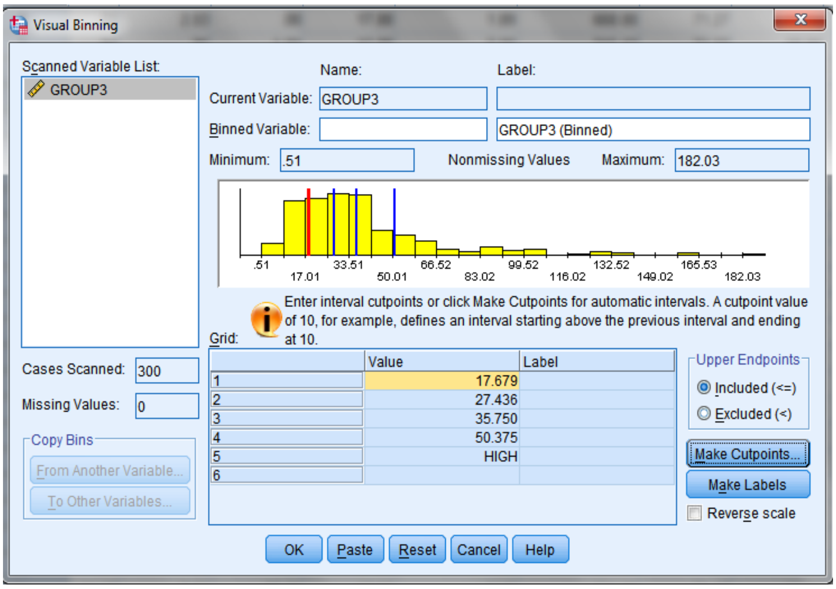


Figure 6.5: Visual binning of percentage of total energy from Group 3

The five percentiles obtained were labelled as below;

Percentile 1 = '≤ 17.68
Percentile 2 = '17.69- 27.44'
Percentile 3 = '27.45- 35.75'
Percentile 4 = '35.76- 50.38'
Percentile 5 = '≥ 50.39'

Figure 6.6 shows nutrient indicators, which vary depending on the amount of ultra-processed products in total energy intake. The lowest percentile of Group 3 was compared with the highest percentile. The highest percentile of Group 3 consumption was found to be higher in in added sugar (9.51% compared to 1.12%), saturated fat (12.02% compared to 7.71%) and sodium (1.98g/1000kcal compared to 1.12g/1000kcal) compared to the lowest percentile. Meanwhile the fibre content was lower in the highest percentile of Group 3 consumption than the lowest percentile of Group 3 consumption (1.1g/1000 kcal compared to 1.76g/1000 kcal). There is a significant linear trend across all percentiles for all these four indicators ($p < 0.01$).

This pilot study shows that as UPP consumption increase, the worse diet that people have as added sugar, saturated fat and sodium level increased but fibre intake decreased.

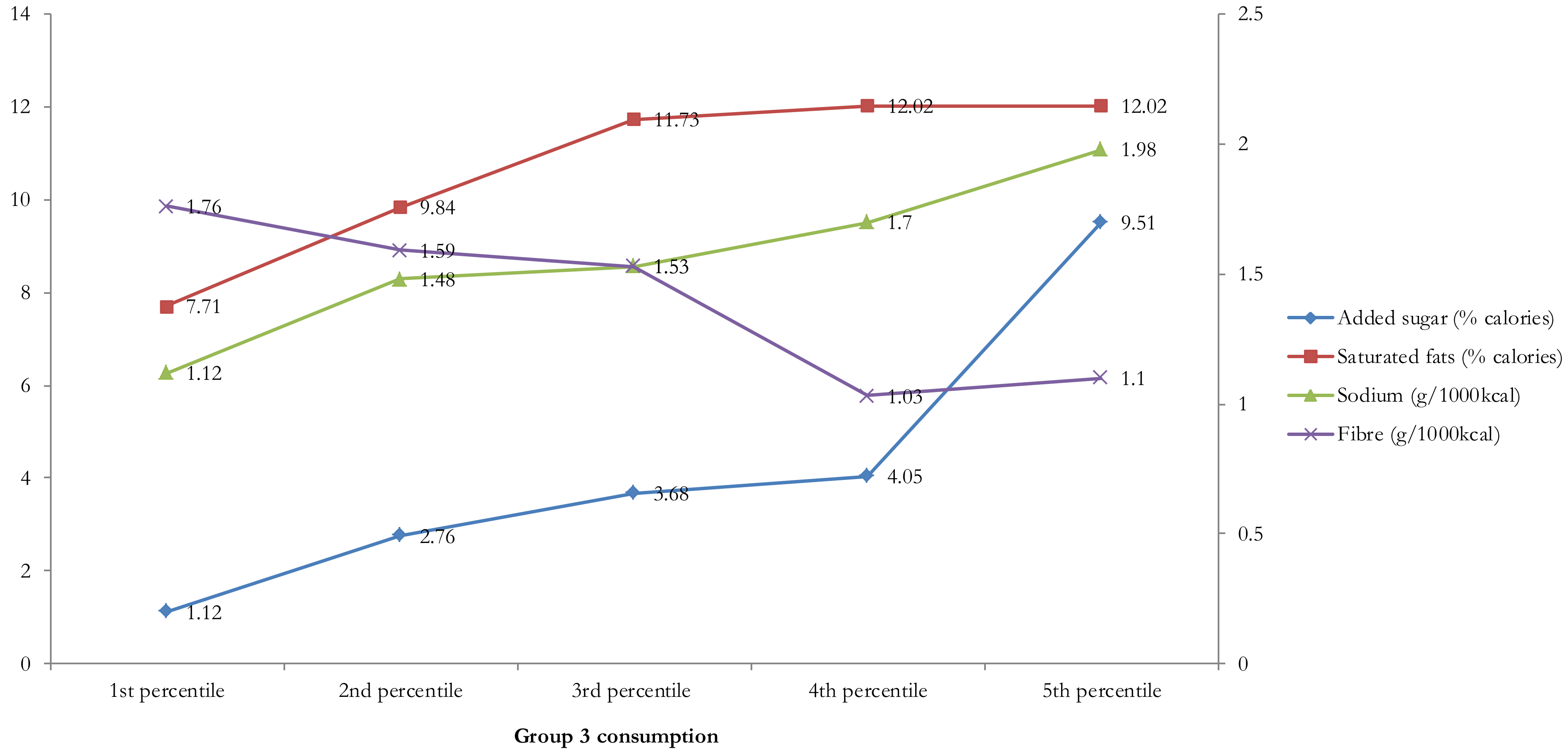


Figure 6.6: Nutrient profile indicators of the overall respondents' diet by the percentile of the contribution of ultra-processed products to total energy intake (n = 300)

6.2.5 Discussion of pilot study

<u>**Ultra-Processed Products in Malaysia**</u>

In the pilot study (n = 300), all foods were able to be classified into Group 1, 2 or 3. More than 60% of the caloric share came from Group 1 and Group 2. Less than 40% came from Group 3. Rice, as the main staple for the Malaysian population, contributed the highest percentage of a single food to total energy consumption.

The next point focuses on the 40% of TE from the UPP Group 3. Somewhat surprising was that processed dairy products (flavoured yogurt, condensed milk and evaporated milk) contributed more of the caloric share from Group 3 than other ultra-processed foods. This is the extra subgroup added in Group 3, as these are not foods consumed in Brazil and, therefore, not in Monteiro's classification. Therefore, the pilot was helpful in revealing this key point. The high caloric share of processed dairy products is because sweetened condensed milk or evaporated milk is usually added to beverages (tea, coffee, milo, etc.), or in ice balls (*ais kacang*), or can be provided as a dip (for example, to eat with 'roti canai'). In Malaysia, '*Teh tarik*' (literally "pull tea") is a hot Indian milk tea beverage, normally found in restaurants, outdoor stalls and cafes (Bakar and Farinda 2010). The name comes from the process of pouring or "pulling" the drink during preparation. It is a drink prepared from black tea along with added condensed milk and evaporated milk and mixed to frothy perfection (Rodgers 2008). *'Teh tarik'* is part of the heritage of Malaysian food and beverages, according to the government of Malaysia, and is a well-loved drink amongst Malaysians (Chong 2009). However, *'Teh tarik'* normally tends to be served sweet and is considered extremely sweet by Western standards (Rodgers 2008). Uncontrollable consumption of *'Teh tarik'* will affect individual sugar intake. Generally, to make a glass of *'Teh tarik'*, you will need at least three to four tablespoons of sweetened condensed milk.

Biscuits were the second highest contribution (8.85%) to Group 3 ultra-processed foods. They were also the third largest contribution to total energy after grains (including rice), meats and processed dairy products. The present findings are consistent with a study done on food consumption patterns among 6,742 subjects, comprising 3,274 men and 3,468 women, of the Malaysian population (Norimah *et al.* 2008). That study showed that biscuits were among the highest food consumed daily, with 16.3% of the population consuming them every day, with an average of five pieces a day. This is reflected in the increasing growth of biscuit sales in Malaysia, from RM641.5 million in 2007 to RM663.4 million in 2008 (Norhayati *et al.* 2011). Biscuits were highly consumed among Malaysians during afternoon tea (Zalilah MS *et al.* 2008) and were preferred as a convenient snack (Euromonitor International 2011). It was reported in another study that the Malaysian population rated convenience as one of the three most important food choice motives in food selection (Asma' *et al.* 2010). In addition, the Malaysian population was reported to consume cream crackers rather than wholegrain wheat-based biscuits and cereal-based biscuits (Euromonitor International 2011). Perhaps, this is one of the factors that contributed to the high energy consumption from biscuits towards the total energy intake. Some studies have been done to look at the nutritional content of the biscuits commercially available in the Malaysian market. Norhayati *et al.* (2011) conducted a study determining the trans fatty acid (TFA) of common and popular biscuits and less popular biscuits, both local and imported brands. The findings showed that total TFA for local packed biscuits, local unpacked biscuits and imported biscuits ranged between 0.00 – 0.52 g/100 g total fatty acids, 0.12 – 0.68 g/100 g total fatty acids, and 0.03 – 3.09 g/100 g of total fatty acids, respectively. The recommendation for TFA is that there should be less than 2 % of the total fat as trans (WHO, 1993; 2007) and, therefore food industries, were advised to abide by the rules in their products (FAO, 2000).

The key highlights learnt from the pilot are:

1. All 126 foods consumed by the Malaysian population were able to be classified in Group 1, 2 or 3 (including additional subgroups – salted foods, processed dairy products and Malaysian traditional dishes).

One of the objectives in conducting the pilot study was to determine the suitability of the Malaysian foods with the new food classification, 'UPP food classification'. This is the first study done in Malaysia in classifying Malaysian foods through the UPP classification; therefore, a lot of things need to be looked at before undertaking a larger scale analysis of national data. The pilot study used the same FFQ questionnaire that is used in the MANS. The FFQ had 126 food items, which was based on Malaysian habitual food intake. The FFQ development was explained in Chapter Three (p. 86). The challenge was to group all the 126 food items into the three groups of UPP classification. The foods were grouped according to the definition of each group: Group 1 – unprocessed and minimally processed foods, Group 2 – culinary ingredients and Group 3 – highly processed/ultra-processed foods. There were several subgroups underlying each group. For the classification of Malaysian foods in Group 3, three subgroups were added: salted foods, processed dairy products and Malaysian traditional dishes. These subgroups were added to highlight the food patterns of the Malaysian population. These added foods were not highlighted in Monteiro's original version of UPP classification, as they were not frequently consumed or were not consumed at all in their study population in Brazil. Therefore, these foods were added, as they were among the habitual food intake among the Malaysian population (Norimah *et al.* 2008).

2. This study was able to classify foods from semi-quantitative FFQ rather than depending on food budget survey.

Monterio *et al.* (2010) used a Brazilian food budget survey in classifying food through the UPP classification. The main limitation of a food budget survey, however, is that it does not include food away from home. Another problem with this food budget survey is that it fails to take individual daily food consumption into account. Therefore, this current study used the individual food consumption data obtained from the food frequency questionnaire (FFQ). The results showed that FFQ may be used and was found to fit well for the UPP classification.

This pilot study has several limitations. One of the limitations is that its participants were all Malays. Other ethnicities (Chinese and Indians) were not included in this study. The next limitation is that it involved only the urban area, and excluded rural areas. The income of this pilot study was mainly from the middle income group. This will restrict the variations in income group. Next, this pilot does not include nutritional status. The MANS data include the nutritional status (body mass index) to determine association between this new food classification and nutritional status.

6.3 Second part - National Dietary Survey (MANS data)

6.3.1 Introduction

The main objectives were:

1. To determine the relative contribution of UPP groups to total energy intake with more representative and larger sample size by applying the MANS data

2. To determine patterns of socio-demographic and nutrient intake to percentage of total energy (TE) from UPP groups with more representative and larger sample size by applying MANS data
3. To determine association between UPP classification and obesity (body mass index), for which the BMI data were not available in the pilot

6.3.2 Methodology

The detail of the MANS study, including study design, sampling frame, sample size, study population, data collection and survey questionnaire, was described earlier in Chapter 3.

Classifying Ultra-Processed Products/Foods (UPP)

We had to make further modification of the UPP groups from the pilot study. The previous classification consisted of three main groups: Group 1 (unprocessed or minimally processed foods), Group 2 (processed culinary ingredients) and Group 3 (ultra-processed foods). However, we proposed an addition of a new group, addressed as Group 1&2. This Group 1&2 includes traditional Malay Cake/Delicacies, Roticanai, Capati, Dosai and Keropok lekor. In the pilot study, we had categorised Roticanai, Capati and Dosai under bread, while keropok leko was under the fish category and nasi lemak under rice. These foods were among the most frequent foods people buy outside home. The preparation of these foods includes a pretty high amount of oil, sugar and margarine. Therefore, it is interesting to determine the significance of this group, purely on its own, to the association with BMI. Group 1&2 was termed traditional prepared foods. Hence, the foods listed in the MANS FFQ were classified according to the new ultra-processed food classification as follows:

Group 1: unprocessed or minimally processed foods

Group 2: processed culinary ingredients

Group 1&2: traditional prepared foods

Group 3: ultra-processed foods

The same method as used in the pilot was applied to MANS to derive the relative percentage contribution of each food group (Group 1, 2 and 3) and subgroup to total energy intake. Then, the distribution of total energy intake (in percentage) from each group was grouped according to selected socio-demographic factor. A chi-square was performed to evaluate differences between selected socio-demographics and the UPP groups. A chi-square test of independence was employed to compare the difference in the UPP groups for selected socio-demographics.

A Pearson Product Moment Correlation Coefficient was computed to assess the relationship between selected nutrient markers (i.e. carbohydrate, protein, fat, added sugar, saturated fats, sodium and dietary fibre) and UPP groups. Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity and homoscedasticity.

The percentage of total energy intake of Group 3 was divided into five percentiles. This was to observe any difference between the selected nutrient markers and percentiles of Group 3. Visual binning was used to break down the percentage of total energy from Group 3 into five percentiles. With the help of visual binning in SPSS, five percentiles were automatically built based on number of cut-off points required. The five percentiles are shown in Figure 6.7.

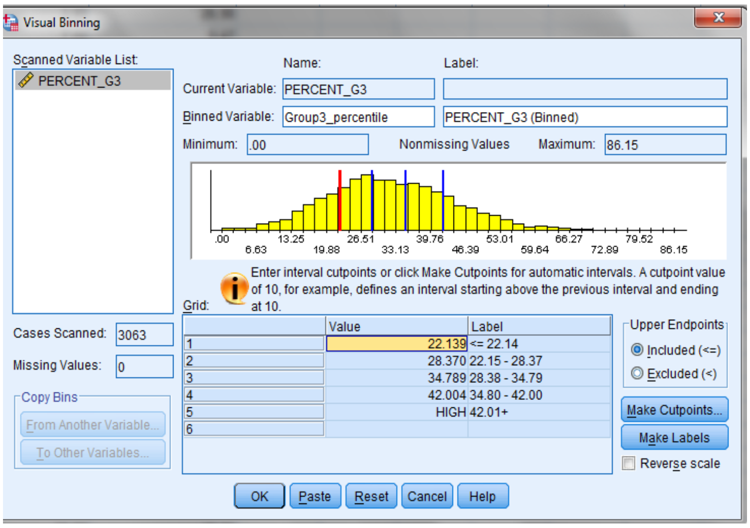


Figure 6.7: Visual binning of percentage of total energy from Group 3

The five percentiles obtained were labelled as below;

Percentile 1 = '$\leq$ 22.14'

Percentile 2 = '22.15 - 28.37'

Percentile 3 = '28.38 - 34.79'

Percentile 4 = '34.80 - 42.00'

Percentile 5 = '$\geq$ 42.01'

A one-way between-groups analysis of variance was performed to determine the differences between the selected nutrient markers and percentiles of Group 3 (ultra-processed products).

A standard multivariate regression analysis was conducted to find the influence of the selected independent variables on the BMI of respondents in this study in respect of the analysis between UPP and BMI. Several demographic variables needed to be recorded as dummy variables prior to the regression analysis. This was because regression analysis works with either continuous or dichotomous independent variables. All discrete data involved were converted into a set of dichotomous independent variables. The number of groups will be subtracted by 1 (k-1). A group will be selected as the baseline group. For example, marital status has five groups. The number of dummy variables for marital status will be four groups (k-1). The baseline category was the 'single' respondents. The 'single' were given a code of 0. Other marital status was combined into two groups, as follows: married =1 and others = 0; separated =1 and others = 0; widowed =1 and others = 0; others =1 and others =0.

The same goes for the other non-continuous variables, gender, ethnicity and education. The regression equations estimated take the following linear form:

$$Y = B_o + B_1X_1 + B_2X_2 + B_3X_3 \ldots\ldots\ldots\ldots\ldots\ldots + B_kX_k + e \qquad (1)$$

Where:

Y = Body Mass Index (BMI)

B_o = Intercept

X_i = Independent variable

B_j = Partial regression coefficients, $j = 1, \ldots\ldots\ldots, k$

The specific linear regression model used in this study is denoted as below:

$$Y = B_o + B_1X_1 + B_2X_2 + B_3X_3 + \ldots\ldots\ldots\ldots\ldots.. + B_{18}X_{18} + e \qquad (2)$$

Y = Body Mass Index (BMI)

B_o = Intercept

B_1 to B_{18} = Regression coefficient of each variable

X_1 = Gender

X_2 = Age

X_3 = less than high school vs. high school

X_4 = less than high school vs. college

X_5 = less than high school vs. degree

X_6 = less than high school vs. others

X_7 = Malay vs. Chinese

X_8 = Malay vs. Indian

X_9 = Malay vs. others

X_{10} = single vs. married

X_{11} = single vs. separated

X_{12} = single vs. widowed

X_{13} = single vs. others

X_{14} = Total energy intake

X_{15} = Total energy intake from Group 1

X_{16} = Total energy intake from Group 2

X_{17} = Total energy intake from Group 1&2

X_{18} = Total energy intake from Group 3

e = Error

The selected variables, namely gender, age, education, ethnicity, marital status, total energy intake and total energy intake from Group 1, Group 2, Group 1&2 and Group 3, were regressed on the dependent variable, body mass index (BMI).

6.3.3 Results

Relative contribution of all food items (categorised under each food group) to total energy intake (percentage)

The results of the relative contribution of each group to total energy intake (expressed in percentage) are shown in Figure 6.8. It can be seen that Group 1 (unprocessed or minimally processed foods) contributed 45.5% of total energy, Group 2 (processed culinary ingredients) provided 19.7% of total energy, Group 1&2 (traditional prepared foods) contributed 5.8% of main caloric share and, finally, Group 3 (ultra-processed products/foods) contributed 29.8% of total energy intake (i.e. lower than the pilot).

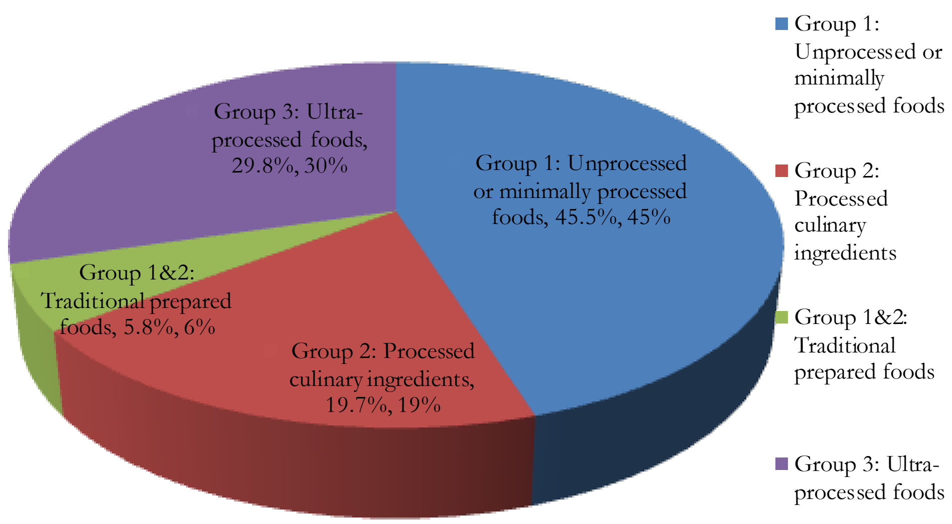


Figure 6.8: Relative contribution of UPP classification to percentage of total energy intake (n = 3,063)

Rice, as the Malaysian staple food, had the highest caloric share in Group 1, followed by fish and chicken, as shown in Table 6.3. Meanwhile, noodles, vermicelli rice and sugars were among the highest percentage contributors to the total energy intake of Group 2. Roti canai and traditional Malay cake/delicacies were top contributors to total energy intake from Group 1 and 2. Group 3 revealed that breads, biscuits, condensed milk, chocolate drink, buns and soy drink were the highest caloric share contributors to total energy intake. Interestingly, the total percentage of total energy from processed beverages was higher than soft drinks among the Malaysian population.

Table 6.3: Relative contribution of all food items (categorised under each food group) to total energy intake (percentage)

Food group			Mean	S.E
Group 1: Unprocessed or minimally processed foods			45.53	0.22
	Rice		19.07	0.12
	Grains		1.73	
		Corn	1.17	0.03
		Glutinous rice	0.56	0.02
	Meats		6.74	
		Chicken	2.07	0.03
		Meat	0.29	0.09
		Goat	0.05	0.00
		Duck	0.06	0.01
		Ham	0.02	0.00
		Bacon	0.03	0.00
		Luncheon	0.15	0.01
		Pork	0.56	0.02
	Beans		3.02	
		Groundnut	1.04	0.03
		Soybean	1.36	0.03
		Pulses	0.45	0.01
		Fermented soy	0.17	0.01
	Fish		4.69	
		Sea dish	4.37	0.06
		Fresh fish	0.32	0.01
	Fruits		4.91	
		Banana	0.96	0.02
		Apple	0.83	0.02
		Mandarin orange	0.22	0.01
		Orange	0.45	0.00
		Watermelon	0.09	0.00
		Grape	0.11	0.00
		Mango	0.27	0.01
		Honeydew melon	0.15	0.00
		Papaya	0.42	0.01
		Guava	0.23	0.00
		Star Fruit	0.06	0.00
		Pineapple	0.14	0.00
		Jackfruit	0.06	0.00
		Pear	0.28	0.01
		Durian	0.24	0.01
		Longan segar	0.03	0.00
		Laychee segar	0.03	0.00
		Rambutan	0.21	0.01
	Milk		0.12	0.01
	Vegetables		2.22	
		Leafy vegetables	0.53	0.01
		Cabbage	0.18	0.00

		Non-Leafy vegetables	0.27	0.00
		Ulam	0.02	0.00
		Mushrooms	0.08	0.00
		Beansprouts	0.10	0.00
		Babycorn	0.03	0.00
		Root/Tuber vegetables	0.97	0.02
		Pumpkin	0.09	0.00
	Seafood		0.65	
		Prawn	0.07	0.00
		Cuttlefish	0.35	0.01
		Mollusc	0.10	0.00
		Crab	0.13	0.00
	Eggs		1.87	
		Chicken egg	1.79	0.02
		Duck egg	0.05	0.00
		Quail egg	0.03	0.00
	Other unprocessed or minimally processed foods		0.48	
		Coffee	0.11	0.00
		Tea	0.10	0.00
		Botanical herbs	0.01	0.00
		Sago	0.16	0.01
		Honey	0.10	0.00
Group 2: Processed culinary ingredients			19.74	0.19
		Noodles	5.96	0.09
		Vermicelli	9.55	0.13
		Pasta	0.24	0.02
		Lohshifun	0.06	0.01
		Sugar	3.05	0.05
		Vegetable fat (margarine)	0.45	0.01
		Animal fats (butter)	0.43	0.01
		Other processed culinary ingredients		
Group 1 and 2: Traditional prepared foods			5.84	0.08
	Traditional Malay Cake/Delicacies		2.07	0.03
	Roticanai		2.58	0.05
	Capati		0.43	0.03
	Dosai		0.37	0.02
	Keropok lekor		0.38	0.01
Group 3: Ultra-processed foods			29.76	0.21
	Processed dairy products		3.74	
		Flavoured yogurt	0.10	0.01
		Condensed milk	3.40	0.06
		Evaporated milk	0.12	0.01
		Powdered milk	0.12	0.03
	Biscuits		3.54	0.06
	Processed meat		1.47	
		Meat burger	0.46	0.01
		Chicken ball	0.02	0.00
		Fish ball	0.27	0.01
		Hotdog	0.43	0.01
		Nugget	0.29	0.01
	Alcohol		0.09	
		Syandi	0.02	0.00
		Beer	0.03	0.01
		Wine	0.01	0.00
		Spirit	0.01	0.00
		Liquor	0.02	0.00
	Processed beverages		6.04	
		Chocolate drink	2.79	0.06
		Malted drink	0.42	0.02
		Cordial drink	0.44	0.01

		Fruit juices	0.62	0.02
		Energy drink	0.41	0.02
		Soy drink	1.36	0.03
	Breads		6.01	
		Breads	3.89	0.06
		Buns	2.12	0.05
	Sweets/Ice cream/Cakes		2.78	
		Sweets	0.34	0.01
		Cakes	0.71	0.02
		Ice-cream	0.26	0.01
		Jelly custard	0.90	0.02
		ABC/ice pop	0.57	0.02
	Spreads		0.89	
		Peanut	0.25	0.01
		Seri Kaya	0.30	0.00
		Jam	0.30	0.01
		Cream cheese	0.02	0.00
	Soft drinks		0.67	0.02
	Salted food		1.00	
		Salted fish	0.17	0.01
		Salted egg	0.27	0.01
		Anchovy	0.56	0.01
	Flavourings		0.83	
		Shrimp sauce	0.01	0.00
		Anchovies sauce	0.05	0.00
		Shrimp cencaluk	0.01	0.00
		Kicap pekat (Thick soy sauce)	0.29	0.01
		Kicap cair (Light soy sauce)	0.11	0.00
		Ketchup sauce	0.32	0.00
		Oyster sauce	0.03	0.00
		Fish sauce	0.001	0.00
		Prawn paste	0.01	0.00
	Cheeses		0.05	0.00
	Snacks		0.89	0.03
	Other ultra-processed foods		1.74	
		Cereals	0.23	0.01
		Ready To Eat Cereals	0.46	0.02
		Pizza	0.10	0.00
		Canned fish	0.19	0.00
		Dried cuttlefish	0.35	0.00
		Salted vegetables	0.07	0.00
		Canned fruits	0.03	0.00
		Dried fruits	0.31	0.02
All foods			100.00	

Pattern of total energy from processed foods according to socio-demographic factors

All the UPP were grouped according to socio-demographic status. This was to give an overview of the consumption of unprocessed/minimally processed (Group 1), culinary processed (Group 2), traditionally prepared (Group 1&2) and highly processed foods (Group 3) among the Malaysian population. As can be seen in Table 6.4, when comparing men to women, men had less total energy from Group 3 (men = 31.2%, women = 33.2%), but more total energy from Group 1&2 (men = 7.2, women = 5.0). Respondents living in the metropolitan and city areas had higher consumption of Group 3 than that of respondents living in towns and rural areas. On the other hand, energy intake from Group 1 was higher among rural/village than town, city or metropolitan.

Indians had the highest total energy intake from Group 3 compared to other ethnicities, while Chinese had the lowest consumption from Group 3. However, others ethnicity (including Sabah, Sarawak and indigenous people) had the highest consumption of total energy from Group 1, followed by Chinese, in contrast to other ethnicities. It is noteworthy that Indians had the highest consumption of energy from Group 1&2 (traditional prepared foods) compared to other ethnicities. Single respondents had a higher percentage of energy consumed from Group 3 than the married, divorced/ separated and widowed respondents. Surprisingly, the divorced/separated respondents had a higher percentage of energy consumed from Group 1 than other marital status. Respondents that held a Bachelor's degree consumed more energy from Group 3 than the other levels of education, while those who had less than a high school education were among the group that had the highest percentage energy from Group 1.

Table 6.4: Total energy intake (in percentage) for each group according to selected socio-demographic factors, univariate analysis (n = 3,063)

	Percentage (%)			
	Group 1	**Group 2**	**Group 1&2**	**Group 3**
Gender				
Men (n = 1493)	46.1	15.5	7.2	31.2
Women (n = 1570)	46.8	15.1	5.0	33.2
p-value	.128	.233	.000*	.000*
Region				
Metropolitan (n = 1139)	44.7	16.0	6.0	33.3
City (n = 453)	45.3	15.7	6.4	32.6
Town (n = 380)	47.2	15.6	6.0	31.1
Rural/Village (n = 1093)	48.5	14.2	6.0	31.2
p-value	.000*	.000*	.639	.000*
Ethnicity				
Malay (n = 1602)	44.3	15.2	7.3	33.2
Chinese (n = 746)	49.6	17.8	3.0	29.6
Indian/Punjabi (n = 252)	37.1	16.1	11.8	35.0
Others (n = 463)	54.1	11.0	3.7	31.2
p-value	.000*	.000*	.000*	.000*

Marital status				
Single (n = 894)	44.4	15.1	6.8	33.7
Married (n = 2074)	47.3	15.4	5.8	31.5
Divorced/Separated (n = 36)	50.1	13.5	5.1	31.4
Widowed (n = 56)	47.5	15.5	4.3	32.7
p-value	.000*	.708	.000*	.000*
Level of education				
Less than high school (n =607)	48.2	14.9	6.0	30.9
High school graduate (n = 1718)	45.0	15.4	6.5	33.1
Some college or associated degree (n = 176)	45.9	15.2	5.7	33.2
Bachelor degree (n = 436)	43.9	16.3	5.7	34.1
Others (n =126)	51.8	14.3	4.8	29.2
p-value	.000*	.120	.004	.000*
Household income				
< MYR 1500 (n = 1695)	47.6	14.6	6.3	31.5
MYR 1500 – MYR 3500 (n = 954)	45.1	15.9	5.9	32.9
> MYR 3500 (n = 414)	45.0	16.5	5.2	33.4
p-value	.000*	.000*	.001	.001
BMI groups				
Underweight (n = 333)	45.5	13.8	6.5	34.2
Normal (n = 1691)	47.2	15.0	5.7	32.1
Overweight (n = 806)	45.7	15.9	6.4	32.0
Obese (n = 233)	45.5	17.4	6.3	30.8
p-value	.008	.000*	.013	.004

* There is a significant difference at $p < .001$

Respondents with household income of less than MYR 1500 had the highest percentage of energy from Group 1 (47.6%). As household income increases, percentage of energy in Group 2 increases as well as in Group 3. The obese respondents had the highest percentage of energy in Group 2 (17.4%) compared to other BMI groups.

To conclude, on univariate analysis a higher percentage of Group 3 consumption was seen among women, living in urban areas, Indian, single, having a Bachelor's degree, and having household income more than MYR 3500. Meanwhile, a high percentage of Group 1 consumption was among those living in rural counterparts, other ethnicities, divorced/separated, less than high school education, household income less than MYR 1500 and normal weight. The most striking findings of Group 1&2 were that the highest percentage energy came from Indian ethnicity and the lowest from Chinese ethnicity. Obese people did not have a higher percentage of Group 3 consumption.

Nutrient markers of each ultra-processed food/products (UPP) groups

Table 6.5 shows that Group 1 is positively associated with carbohydrate, protein, fat and dietary fibre intake, but has no association with added sugar, saturated fats and sodium. This result may be explained by the fact that Group 1 comprises of unprocessed or minimally foods that are higher in these nutrients.

Table 6.5: Pearson Correlation Coefficient (*r*) in assessing association between selected nutrient markers and total energy from UPP groups

Nutrient marker	Density value (SE)	Group 1	Group 2	Group 1&2	Group 3
Carbohydrate (g)	428.2 (1.7)	0.316**	0.365**	0.199**	0.344**
Protein (g)	102.8 (0.7)	0.454**	0.068**	0.127**	0.157**
Fat (g)	58.1 (0.8)	0.288**	-0.058	0.130**	0.176**
Added sugar (g)	65.6 (0.6)	0.002	0.085**	0.122**	0.398**
Saturated fats (g)	10.6 (0.1)	0.234	-0.044*	0.062**	0.219**
Sodium (mg)	2177.2 (21.8)	0.139	-0.052**	0.125**	0.303**
Dietary fibre (g)	9.5 (0.1)	0.294**	-0.069**	0.050**	0.092**

** Correlation is significant at $p < 0.01$ level (2-tailed).

* Correlation is significant at $p < 0.05$ level (2-tailed)

Foods in Group 1 (i.e. rice, grains, meats, beans, fish, fruits, milk, vegetables, seafood and eggs) were most likely to have higher carbohydrate, protein, fat, and fibre value than the other groups. The r- value showed greater strength of association between Group 1 and these nutrients, compared with the association between other groups and the nutrients. A possible explanation for this result may be because of the unprocessed or minimally processed foods in Group 1 compared to foods in other groups that were processed.

Added sugar, saturated fat and sodium were selected as a proxy for identifying the existence of processed foods. On the other hand, high dietary fibre was a marker of lower intake of processed foods. Total energy from Group 1 showed no association with added sugar, saturated fats or sodium, as predicted. There was a moderate, positive association between total energy from Group 1 and dietary fibre; $r = .3$, n = 3063, $p < .001$. This shows that the more Group 1 is consumed, the higher is the dietary fibre intake. This finding suggests that a diet rich in Group 1 may help promote healthier diet to people rather than the consumption of other groups, as consumption of Group 1 is found to be more nutrient-dense (e.g. higher dietary fibre, higher protein, etc.) than the other groups. Group 2 is had moderate positive association with carbohydrate, $r = .36$, n = 3063, $p < .001$. Group 1&2 showed a very weak, positive association with all the selected nutrient markers.

There is moderate, positive correlation between total energy from Group 3 and added sugar, $r = .4$, n = 3063, $p < .001$; and sodium, $r = .3$, n = 3063, $p < .001$. Meanwhile, there is a weak, positive correlation between total energy from Group 3 and saturated fats, $r = .02$, n = 3063, $p < .001$; and dietary fibre, $r = .09$, n = 3063, $p < .001$. This shows that the more Group 3 is consumed, the more sugar and sodium there is in the dietary intake. Even though Group 3 showed a positive association with dietary fibre, it was a very weak one.

Nutrient markers by the quintiles of highly-processed foods group (Group 3)

Figure 6.9 depicts the nutrient markers by percentile of contribution of consumption of Group3 (ultra-processed products/foods). One-way between-groups analysis of variance was performed to determine the differences between the selected nutrient markers and the percentiles of Group 3 (ultra-processed products). There is a statistically significant difference at $p < .001$ in added sugar, F (4, 3058) = 57.0, $p < .001$p < 0.001; saturated fats, F (4, 3058) = 8.0, $p < .001$, sodium; F (4, 3058) = 23.2, $p < .001$; and dietary fibre, F (4, 3058) = 4.8, $p < .001$ for the Group 3 percentiles. It is apparent from the figure that the value of added sugar, saturated fats and sodium increases as it goes from the 1st percentile to the 5th percentile. However, dietary fibre intake at the 1st percentile decreased as it approached the 5th percentile. The 1st percentile of added sugar was 52.4 g and increased to 76.8 g. The recommended nutrient intake (RNI) for sugar should be not more than 15% of total energy (approximately 75 g to 85 g). Based on RNI, regardless of percentiles, sugar consumption did not exceed the RNI, even in the highest Group 3 group.

Meanwhile, the percentage of saturated fat for the 1st percentile was 9.1 %, in contrast to the 5th percentile, which was 11.0%. The RNI for saturated fat is advisable to be 10% of total energy intake, which means the 5th percentile of Group 3 had a slightly higher percentage of saturated fat than recommended. Sodium intake levelled-up from 1854.8 mg in the 1st percentile up to 2394.2 mg in the 5th percentile. For dietary fibre, there was a decrease in amount of intake from the 1st percentile to the 5th percentile, 9.0 g and 8.5 g, respectively. However, intakes of dietary fibre were much lower than recommended by RNI, which should be 20 – 30 g of dietary fibre per day for all groups. All in all, Figure 6.9 shows that as people consume more of UPP they increase possibility of having worse diet as the unhealthy foods contribute more (i.e. saturated fat, sodium, and added sugar).

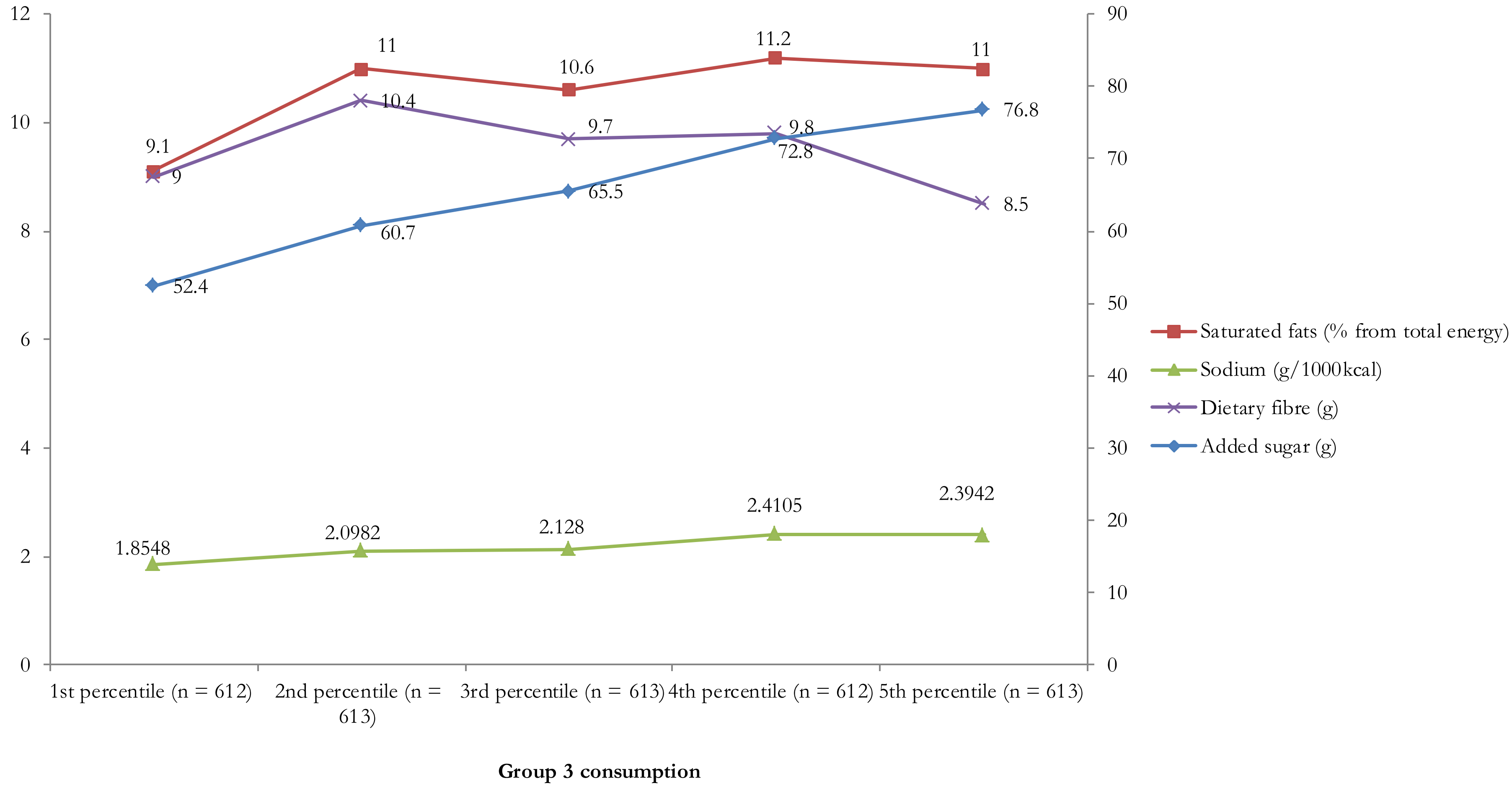


Figure 6.9: Nutrient marker indicators of the overall diet by percentile of the contribution of ultra-processed products to total energy intake (n = 3,063)

UPP classification and BMI

Table 6.6 shows the association between UPP classification (Group 1, Group 2, Group 1&2 and Group 3) and BMI. Results showed that there was a weak, positive association between BMI and Group 1, $r = .16$, n = 3063, p <.001; Group 2, $r = .17$, n = 3063, p <.001; Group 1&2, $r = .09$, n = 3063, p <.001; and Group 3, $r = .10$, n = 3063, p <.001. As there was a significant association, a subsequent analysis, multivariate analysis of the relationship between UPP and BMI, was conducted after this part.

Table 6.6: Correlation between BMI and total energy intake (n = 3,063)

		BMI	Total energy	Energy from Group 1	Energy from Group 2	Energy from Group 1&2	Energy from Group 3
BMI	Pearson Correlation	-	.336**	.159**	.166**	.088**	.098**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
Total energy	Pearson Correlation		-	.437**	.391**	.271**	.434**
	Sig. (2-tailed)			.000	.000	.000	.000
Energy from Group 1	Pearson Correlation			-	-.226**	-.117**	-.172**
	Sig. (2-tailed)				.000	.000	.000
Energy from Group 2	Pearson Correlation				-	-.020	-.219**
	Sig. (2-tailed)					.280	.000
Energy from Group 1&2	Pearson Correlation					-	.084**
	Sig. (2-tailed)						.000
Energy from Group 3	Pearson Correlation						-
	Sig. (2-tailed)						

**. Correlation is significant at the 0.01 level (2-tailed).

Multivariate analysis of the relationship between UPP and BMI

Care is needed with respect to the UPP-BMI analyses. Since socio-demographics are somehow related to UPP consumption and BMI, as previously shown in Table 6.4, a multivariate model is presented. A standard multivariate regression analysis was employed to determine the influence of the selected independent variables on the BMI of respondents in this study in respect to the analysis between UPP and BMI. The assumptions of the data were checked through Table 6.8. One of the assumptions was to observe absence of multicollinearity among the variables. Multicollinearity exists when the independent variables (IVs) are highly correlated (r = .9 and above). Table 6.7 shows that none of the IVs were highly correlated. Therefore, the assumption for the absence of multicollinearity among the variables was met.

Table 6.7: Correlation between selected independent variables

	gender	age in yrs	Malay vs. Chinese	Malay vs. Indians	Malay vs. others	single vs. married	single vs. separated	single vs. widowed	less than high school vs. highschool	less than high school vs. college	less than high school vs. degree	less than high school vs. others	Total energy intake	ENERGY _G1	ENERGY _G2	ENERGY _G1G2	ENERGY _G3
Pearson correlation																	
gender	-	-.003	.028	.014	.010	.114	.058	.109	-.013	.050	-.048	.109	-.409	-.189	-.123	-.251	-.090
age in yrs		-	.094	-.033	-.007	.471	.057	.176	-.194	-.121	-.182	.224	.035	.124	.054	-.034	-.098
Malay vs. Chinese			-	-.170	-.239	-.008	.002	.002	-.080	.014	.061	-.067	-.009	.066	.109	-.287	-.146
Malay vs. Indian				-	-.126	-.040	-.011	.030	.006	-.018	-.034	-.002	-.028	-.190	.025	.272	.053
Malay vs. others					-	.050	.013	.004	-.070	-.034	-.086	.171	-.013	.203	-.166	-.169	-.036
single vs. married						-	-.158	-.198	-.053	-.073	-.192	.054	.002	.092	.006	-.059	-.059
single vs. separated							-	-.015	-.023	-.027	-.018	-.007	-.001	.037	-.016	-.017	-.006
single vs. widowed								-	-.075	-.023	-.042	.132	-.045	-.016	-.004	-.044	-.018
less than high school vs. highschool									-	-.182	-.300	-.152	.023	-.055	.020	.053	.052
less than high school vs. college										-	-.101	-.051	-.044	-.023	-.009	-.024	.000
less than high school vs. degree											-	-.084	.024	-.060	.043	-.013	.075
less than high school vs. others												-	-.072	.035	-.033	-.058	-.067
Total energy intake													-	.437	.346	.271	.434
ENERGY_G1														-	-.208	-.117	-.172
ENERGY_G2															-	.011	-.184
ENERGY_G1G2																-	.084

ENERGY_G3																	-
Sig. (1-tailed)																	
gender	.	.425	.058	.222	.283	.000	.001	.000	.235	.003	.004	.000	.000	.000	.000	.000	.000
age in yrs		.	.000	.032	.340	.000	.001	.000	.000	.000	.000	.000	.027	.000	.001	.029	.000
Malay vs. Chinese			.	.000	.000	.322	.464	.455	.000	.227	.000	.000	.304	.000	.000	.000	.000
Malay vs. Indian				.	.000	.014	.279	.048	.367	.163	.032	.462	.062	.000	.080	.000	.002
Malay vs. others					.	.003	.233	.420	.000	.031	.000	.000	.238	.000	.000	.000	.024
single vs. married						.	.000	.000	.002	.000	.000	.001	.458	.000	.363	.001	.001
single vs. separated							.	.205	.100	.068	.154	.346	.488	.021	.187	.177	.378
single vs. widowed								.	.000	.099	.011	.000	.007	.181	.402	.008	.166
less than high school vs. highschool									.	.000	.000	.000	.103	.001	.130	.002	.002
less than high school vs. college										.	.000	.002	.007	.100	.312	.088	.494
less than high school vs. degree											.	.000	.088	.000	.009	.232	.000
less than high school vs. others												.	.000	.025	.033	.001	.000
Total energy intake													.	.000	.000	.000	.000
ENERGY_G1														.	.000	.000	.000
ENERGY_G2															.	.268	.000
ENERGY_G1G2																.	.000
ENERGY_G3																	.

Another procedure to confirm non-existence of multicollinearity is by 'collinearity diagnostics' via Tolerance and VIF (variance inflation factor), which can determine the absence of multicollinearity (Pallant 2007). If the value of Tolerance is < .10 or VIF > 10, it means that the multiple correlations with other IV are high, showing the presence of muliticollinearity. In this case, the tolerance value for all respondents was more than .10 and VIF value less than 10, which indicates the absence of multicollinaerity, as shown in Table 6.8.

Table 6.8 also shows which of the variables included in the model contributed to the prediction of the BMI. The B (Unstandardised Coefficients) and Beta (Standardised Coefficients) value, as shown in the table, can determine the unique contribution of each significant variable included in the model to the prediction of BMI at $p < .05$. Prior to evaluating each of the independent variables to the prediction of BMI, the model was evaluated first. This was done by looking at R square in the Model Summary (see Table 6.11).

Table 6.8: Coefficients

Model		Unstandardised Coefficients		Standardised Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	9.324	.606		15.388	.000		
	Gender	1.484	.156	.174	9.539	**.000**	.748	1.336
	Age in yrs	.064	.008	.164	7.960	**.000**	.586	1.707
	Malay vs. Chinese	-1.091	.181	-.110	-6.032	**.000**	.751	1.332
	Malay vs. Indian	-.308	.262	-.020	-1.175	.240	.875	1.142
	Malay vs. others	-.340	.212	-.029	-1.604	.109	.785	1.273
	single vs. married	1.606	.185	.176	8.702	**.000**	.608	1.644
	single vs. separated	.884	.650	.022	1.360	.174	.923	1.084
	single vs. widowed	1.108	.554	.035	2.002	.050	.823	1.215
	less than high school vs. highschool	.052	.163	.006	.317	.751	.744	1.344
	less than high school vs. college	-.110	.309	-.006	-.356	.722	.878	1.139
	less than high school vs. degree	-.085	.221	-.007	-.384	.701	.760	1.315
	less than high school vs. others	-.378	.364	-.018	-1.040	.299	.874	1.144
	Total energy intake	.004	.000	.439	9.223	**.000**	.110	9.104
	ENERGY_G1	.000	.000	-.036	-.965	.334	.183	5.458
	ENERGY_G2	.000	.001	.017	.517	.605	.228	4.380
	ENERGY_G1G2	.000	.001	.000	-.014	.989	.467	2.142
	ENERGY_G3	-.001	.000	-.070	-2.007	.045	.206	4.863

Energy_G1 – Total energy intake from Group 1
Energy_G2 – Total energy intake from Group 2
Energy_G1&2 – Total energy intake from Group 1&2
Energy_G3 – Total energy intake from Group 3

R square in the Model Summary, as shown in Table 6.9, indicates how much of the variance in the dependent variable (BMI) is explained by the model. The R square value is 0.242, which is then presented as a percentage, 24.2%. Hence, it suggested that the model explains 24.2% of the variance in BMI.

Table 6.9: Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.492[a]	.242	.237	3.7243005

a. Predictors: (Constant), ENERGY_G3, less than high school vs. college, single vs. separated, single vs. widowed, Malay vs. others, Malay vs. Indian, gender, less than high school vs. degree, less than high school vs. others, ENERGY_G2, Malay vs. Chinese, age in yrs, ENERGY_G1, ENERGY_G1G2, less than high school vs. highschool, single vs. married, total energy intake

The total variance explained by the model as a whole was 24.2%, F (17, 3045) = 57.1, $p < .001$. The F statistic for the overall goodness of fit of model, which was 57.1 and significant at α =0.000, indicates that the combination of the independent variables significantly predicts BMI (see Table 6.10).

Table 6.10: Anova

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13460.665	17	791.804	57.086	.000[b]
	Residual	42235.412	3045	13.870		
	Total	55696.077	3062			

a. Dependent Variable: bmi
b. Predictors: (Constant), ENERGY_G3, less than high school vs. college, single vs. separated, single vs. widowed, Malay vs. others, Malay vs. Indian, gender, less than high school vs. degree, less than high school vs. others, ENERGY_G2, Malay vs. Chinese, age in yrs, ENERGY_G1, ENERGY_G1G2, less than high school vs. high school, single vs. married, total energy intake

Next, is the determining of the unique contribution of each significant variable included in the model to the prediction of BMI (refer to Table 6.10). A standardised coefficient was used because it has been converted to a scale that can be compared with all selected variables. Based on coefficient results, the beta value for energy from total energy intake, which was .439, is the largest beta coefficient compared to other selected IVs. This indicates that total energy intake makes the strongest unique contribution to explaining the BMI, when the variance explained by all other variables in the model is controlled for. The beta value for marital status (married vs. single respondent) was the second largest contribution to BMI, followed by gender (men vs. women), age, and ethnicity (Chinese vs. Malay). Unfortunately, total energy from each group in UPP had no statistically significant contribution to BMI at $p < .05$.

For each one unit increase in total energy intake, the BMI of the respondents increased by .439. Married respondents had BMI .176 higher than single respondents, while, for men vs. women, men had BMI .174 more than women. For each one unit increase in age, the BMI of respondents will increase by .164. On average, Chinese had .11 lower BMI than Malays.

6.3.4 Discussion

Very little was found in the literature on the question of highly processed foods consumption in Malaysia. This chapter set out with the aim of determining the consumption of highly processed foods among the Malaysian population via UPP classification and its association with obesity. The results of this analysis of the MANS survey study show that the proportion of each UPP group to total energy intake in this sample study was: 45.5% from Group 1 (unprocessed or minimally processed foods); 19.7% from Group 2 (processed culinary ingredients); 5.8% from Group 1&2 (traditional prepared foods); and 29.8% from Group 3 (ultra-processed products/foods). Since consumption of Group 1 and Group 2 was more than 60% compared to consumption of highly processed foods, which was approximately 30%, it shows that the Malaysian population consumes Group 1 and Group2 more than Group 3. This result accords with the earlier observations from the pilot test, which showed that unprocessed/minimally processed foods and processed culinary ingredients were more greatly consumed than ultra-processed foods in Malaysia. The Brazilian population demonstrated a relatively similar proportion of caloric share to Malaysia for unprocessed foods and processed foods to total energy intake (Monteiro *et al.* 2010). It had consumption of Group 1 of 40% from total energy intake, Group 2 about 38% of total energy intake and Group 3 approximately 20%. Both countries, Malaysia and Brazil, had consumption of highly processed foods below 30% of total energy intake. Brazil is one of the countries that has undergone what Malaysia is experiencing now, industrialisation and rapid economic growth, and both are upper middle income countries (GNI per capita $4,086 - $12,615). These two countries are addressed as a 'newly industrialized country' (NIC) (Schatzl *et al.* 1997), a term given to countries whose economies have not yet reached "advanced" or "developed" status, but have outshone their developing counterparts (World Bank 2013). What is remarkable is that these countries shared similarities in economic status and proportion of caloric share of unprocessed and processed foods. If we were to compare with high income countries (HICs), Canada, for example, had more than 60% of energy from highly processed foods (Group 3), 25.6% from Group 1 and 12.7% from Group 2 (Moubarac *et al.* 2012). In other HICs, the Netherlands, the United Kingdom, Denmark and Sweden, these countries had more than 60% of their total energy intake from highly processed foods (Slimani *et al.* 2009). It is noticeable that there is a variation of highly processed foods consumption between low- and middle- income countries (LMICs) and HICs. This discrepancy may be explained by the fact that the development of intensive and massive food production and industrialisation, which started earlier in the United States and in Europe during the eighteenth century, resulted in urban-industrialised food systems in HICs (Slimani *et al.* 2009). In the late 90s, the United States held the position as the largest food manufacturing sector ($384 billion), followed by Germany, France, the UK, Canada and Australia (Henderson *et al.* 1996). However, LMICs are starting to experience changes in food systems, leading to similar urban-industrialised food systems. The interjection of big transnational corporations (TNC) and the great growth of giant food industries has begun to replace traditional food systems in LMICs (Reardon *et al.* 2003; Hawkes 2010; Monteiro 2010). However, Malaysia, as a country in a nutrition transition, is still placing unprocessed foods or minimally processed foods as the main preference rather than the highly processed foods, which means that Malaysia still maintains traditional local dietary habits. Pingali (2007) highlighted that diets do diversify in Asian countries at the beginning of diet transformation, but sustain traditional features.

One of the plausible reasons for low purchase of highly processed foods among the Malaysians is price. Ready-to-eat foods, for example, chicken nuggets, pizza and burgers, are not that cheap compared to the UK, the US and other HICs countries. A box of breakfast cereals in Malaysia costs around MYR 11 to MYR 15, which is considered fairly expensive (Farzana *et al.* 2011). According to Cohen and Garrett (2010), a higher income allows the purchase of higher added-value processed foods. This low purchase of highly processed foods among the Malaysians due to its high-cost proves that income is one of the factors that shape consumer preference, as well as lifestyles and evolving cultural preferences (Regmi and Gehlhar 2005). The second reason is due to food satiety that underlies the motive for food consumption among the Malaysian population. The Malaysian population perceives processed foods as leisure foods, not as a main meal (Lipoeto *et al.* 2012). They prefer main meals that include rice or noodles. Only certain groups in Malaysia frequently consume fast-foods. According to Khor *et al.* (1998b), approximately half of the urban Chinese in Malaysia who were in the middle income group ate take-away foods more than once a week, which were most likely Western fast foods (fried chicken, burgers or pizza). Khor *et al.* (1998b) also highlighted that the consumption of fast foods was more predominant in younger age groups, whilst the rest of the population preferred traditional local foods. That is why rice was the highest caloric share in Group 1, followed by fish and chicken.

The results of the relative contribution of each group to total energy intake have shown that rice has contributed the highest percentage of a single food to total energy consumption, 19.07%. Even though the rice per caput supply, as discussed earlier in Chapter Two, has gradually decreased, rice still dominates the dietary pattern of the Malaysian population.

Main meal components in Malaysia, Indonesia and Philippines

	Meal components (core items only)		
	Malaysia	**Indonesia**	**Philippines**
Breakfast			
Rural	**Rice**/***nasi lemak****, egg, fish, *teh tarik*	**Steamed rice** Hot fried dish (normally fish) Coconut milk dish	**Rice**, bread, egg, fish, instant coffee
Urban	***Nasi lemak***/*roti canai**/bread, egg, *teh tarik**, coffee	**Steamed rice** Hot fried dish (normally fish) Coconut milk dish	**Rice**, bread, fish, egg, coffee
Lunch			
Rural	**Rice**, vegetables, fish	Minimal variation from breakfast to evening meals	**Rice**, vegetable, fish/pork/chicken
Urban	**Rice**, vegetables, chicken, meat and fish	Minimal variation from breakfast to evening meals	**Rice**, vegetable, fish/pork/chicken
Dinner			
Rural	**Rice**, vegetables, fish	Minimal variation from breakfast to evening meals	**Rice**, vegetable, fish/pork/chicken
Urban	**Rice**, vegetables, chicken, meat and fish	Minimal variation from breakfast to evening meals	**Rice**, vegetable, fish/pork/chicken

**Nasi lemak* = rice cooked with coconut milk; *roti canai* = flat bread; teh tarik = 'pulled tea'.

Figure 6.10: Main meal components for breakfast, lunch and dinner for Malaysia, Indonesia and the Philippines. Source: Lipoeto *et al.* (2012)

This is similar to the Brazilian population where rice contributed around 16.6 % of total energy intake, followed by meats (8.2%), beans (6.3%) and milk (4.9%) (Monteiro *et al.* 2010), despite the decreasing consumption of Brazilian staple foodstuffs, including rice, beans, meat, lard and butter (de Oliveira 1997). The contribution of rice to total energy intake in metropolitan areas in Brazil consistently attenuated between 1987-8 (16.3%), 1995-6 (16.0%) and 2002-3 (14.6%) (Monteiro *et al.* 2011). A cross-sectional study was carried out between 2008 and 2009 in three South-East Asian countries, Malaysia, Indonesia and the Philippines, to determine food consumption patterns and nutrition transition in South-East Asia (Lipoeto *et al.* 2012). Findings from the study showed that Malaysians, Indonesians and Filipinos still embraced many aspects of their traditional diets in daily life. Figure 6.10 depicts how rice is habitually consumed in the daily life of these three countries.

Fish contributed approximately 5% of total energy intake from Group 1. Fish was the second highest contributor from Group 1 to total energy intake. This was followed by consumption of chicken, which was 2% of main caloric share. Based on the results, the Malaysian population apparently consumes fish or chicken with rice. In Chapter Two, it was highlighted that fish consumption progressively increased over the 45-year period from 1965 to 2009. Fish was consumed more in rural areas compared to urban counterparts in Malaysia, while chicken intake was higher among urban dwellers. This difference has been highlighted in several studies conducted in Malaysia (Norimah *et al.* 2008; Lipoeto *et al.* 2012). Urbanisation has had a significant positive effect on the demand for animal-derived foods (Rae 1998). This is reflected in Figure 6.11, showing that Malaysia had a discernible increase of percentage share of all foods from animal products, from 12.0% in years 1970 - 1975 to 17.7% in years 1990 – 1995. Malaysia outstripped other selected countries (China, Indonesia, Korea, the Philippines and Thailand) in regards to consumption of the animal products share of all foods.

Consumption of animal products and its share of the total diet

Country	Animal Products (kcal capita^{-1} day^{-1})			All Food (kcal capita^{-1} day^{-1})			Animal products as % share of all food		
	1970–1975	1980–1985	1990–1995	1970–1975	1980–1985	1990–1995	1970–1975	1980–1985	1990–1995
China	128	195	391	2062	2491	2730	6.2	7.8	14.3
Indonesia	57	81	116	1970	2302	2618	2.9	3.5	4.4
R. Korea	147	293	445	2999	3083	3224	4.9	9.5	13.8
Malaysia	308	408	490	2560	2704	2766	12.0	15.1	17.7
Philippines	244	243	318	1836	2190	2369	13.3	11.1	13.4
Thailand	196	205	236	2215	2212	2308	8.9	9.3	10.2

Figure 6.11: Consumption of animal products and its share of the total diet among selected East Asian countries. Source: Rae (1998)

Secondary meal components in Malaysia, Indonesia and Philippines

	Meal components (secondary items)		
	Malaysia	**Indonesia**	**Philippines**
Breakfast			
Rural	Banana (fried)	Cassava, corn, sago or noodles	Noodles (fried), hotdog
Urban	Noodles (fried), high-fibre bread, cereal, Chocolate milk	Cassava, corn, sago or noodles	Quaker oats, crackers, *champorado**, hotdog, meatloaf, chocolate drink
Lunch			
Rural	Noodles	Cassava, corn, sago or noodles	Noodles
Urban	Noodles	Cassava, corn, sago or noodles	Noodle, sweet potato, sardines
Dinner			
Rural	Noodles	Cassava, corn, sago or noodles	Noodles
Urban	Noodles	Cassava, corn, sago or noodles	Noodle, sweet potato, sardines

**Champarado* = glutinous rice and coconut milk.

Figure 6.12: Secondary meal components for breakfast, lunch and dinner for Malaysia, Indonesia and the Philippines. Source: Lipoeto *et al.* (2012)

Eggs provided 1.8% of total energy intake from Group 1. Soybean and groundnut contributed around 1% (~ 23 to 25 kcal), respectively. This illustrates that soybean and groundnut also form a part of Group 1's habitual consumption.

Noodles, vermicelli rice and sugars had the highest percentage contributor to total energy intake of Group 2. Noodles are frequently consumed as the secondary item choices for the Malaysian population after rice (as shown in Figure 6.12). Most noodles are often fried for serving. Vermicelli rice is traditionally cooked fried or complemented with a non-cream soup. Sugar, which is in Group 2, is considered highly consumed among the Malaysian population. Looking back at Chapter Two, under food trends, sugar consumption has shown an increase for the last few decades in Malaysia. Moreover, it was reported that most sugars were extensively added in manufactured/processed foods and drinks (Ismail *et al.* 1997). The result for consumption of sugar intake agrees with the findings of other studies, wherein sugar was frequently consumed, with weekly scores often being as almost high as rice consumption (Zainal Badari *et al.* 2012). Another study also showed that almost 60% of the Malaysian population consumed sugar every day (Norimah *et al.* 2008). Similar findings were observed among rural counterparts in Malaysia, where sugar was highly consumed, as well as rice intake (Chee *et al.* 1997).

Roti canai and traditional Malay cake/delicacies were top contributors to total energy intake from Group 1& 2. These two foods are frequently consumed in a week, along with other traditional foods (nasi lemak and others) (Khor and Sharif 2003). Traditional Malay cakes, which are usually made from rice/glutinous/wheat flour, can be high in sugar and/or fat as many are deep-fried or mixed with coconut, milk and sugar (Saibul *et al.* 2009). 'Roti canai', also known as prata, is a type of a type of unleavened flatbread of India origin (Hasimah *et al.* 1991). The roti canai is a mixture of white flour, oil and water (Saibul *et al.* 2009). The mixture is then kneaded, flattened and then oiled, before being folded repeatedly. Roti canai is normally served with dhal curry (Yoshino 2010) or can be eaten with sugar (Thai *et al.* 2011). Roti canai provides a high calorie intake as it uses a high amount of fat in its preparation. Therefore, it is not surprising that roti canai alone contributed the highest energy for Group 1&2. A study was carried out to determine the trans fatty acid (TFA) content in selected foods in Malaysia and found that roti canai had a high amount of TFA (0.03 -5.70 g/100 g lipid or 0.00-0.62 g/100 g food) as a result of the large amount of margarine often added during preparation to achieve crispness (Akmar *et al.* 2013). Many countries, including the US and Canada, have prohibited sales of foods comprising TFA of more than 2 g /100 g lipid, as it has an adverse effect on human health (Food Safety Authority of Ireland 2008). At present, there is still no mandatory legislation of TFA levels in Malaysia (Akmar *et al.* 2013). The addition of this Group 1&2, referred to as "traditional prepared food", is to distinguish it from the processed or non-processed food groups. Although it does not belong under processed foods, the contribution of energy and nutrients for some of these traditional foods towards the total energy intake is not to be underestimated.

Breads, biscuits, condensed milk, chocolate drink and soya drink were the highest caloric share contributors of Group 3 to total energy intake. Breads contributed 6% of total energy intake of the Malaysian population. A study carried out in Malaysia also showed that bread was among the top ten of moderately consumed foods (score = 58%) (Zainal Badari *et al.* 2012). This was then followed by consumption of biscuits. This supported findings from the pilot study where biscuit consumption was ranked as the second highest consumption from Group 3. The reasons may be as were explained in previous pilot test discussions. Condensed milk was the third that contributed most of the caloric share from Group 3. Condensed milk is highly consumed, as it is often added to beverages (tea, coffee, milo, etc.). Further explanation has already been discussed in earlier results from the pilot study, which shared relatively similar findings. Interestingly, the total percentage of total energy from processed beverages was higher than the percentage from soft drinks among the Malaysian population. This showed that the consumption of soft drinks among the Malaysian population is considered relatively lower than other HICs countries, where soft drinks were among the top consumed food and drinks. This was similar in regards to the consumption of processed meat, which was not high when compared to other HICs. Consumption of processed meats is high in HICs, as discussed in length in the literature review. However, the trend for processed meat is gradually increasing in Malaysia. This led Babji and Yusof (1995) to carry out a study in regards to the quality of selected processed meat products in Malaysia, including their proximate composition, meat quality, use of non-meat proteins and binders, and the use of additives in the formulation of burgers, frankfurters, nuggets, bologna, chicken and beef balls. Through proximate analysis, their study found that the raw resources used in the products' preparation contained high fat and low protein. In addition, the meat content was found to be lower than the minimum amount specified by the food regulation. From their observation, a number of by-products from the animal industry from non-conventional sources are increasingly being used in the manufacture of processed meat product. However, this is still a debatable argument, since there is a lack of studies on processed foods in Malaysia to clarify the actual nutritional composition of such processed products (Babji and Yusof 1995; Babji *et al.* 2000).

It is not something to take for granted, as Malaysia may follow the trend as other HICs if no preventative action is taken. As we can see in Figure 6.13, the bar graph shows that the annual retail food sales rapidly grew in the lower and upper middle income countries between 1996 and 2002. The HICs' growth retail in food sales was only 2% compared to the lower and middle income countries.

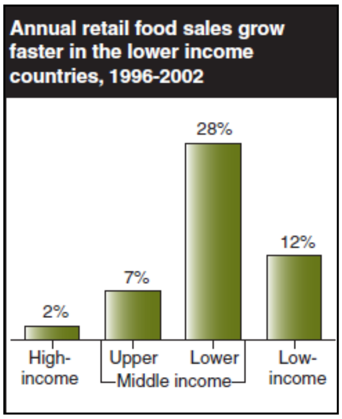


Figure 6.13: Bar graph of annual retail food sales in HICs and LMICs. Source: Regmi and Gehlhar (2005)

Next, the UPP groups were categorised according to socio-demographic status. The highest percentage of highly processed foods consumption is among women, living in urban areas, Indian, single, more educated and with household income more than MYR 3500. This pattern of living in the urban and owning household income of more than MYR 3500 somewhat reflects a 'westernization diet' consumer (Pingali 2007). Many studies have shown that this pattern of lifestyle in the LMICs is a driver leading to a dietary intake of more processed foods, as they are more exposed to the accessibility of fast food and can afford to buy it (Heng and Guan 2007). In China, it was found that, with increasing income and a faster pace of life, more families are frequently eating out (Zhang *et al.* 2014). In India, respondents from a high-income area were more likely to have Western -style fast food than low-income areas (Aloia *et al.* 2013). Meanwhile, a Malaysian study showed that 82% of urban population ate out compared to only 59% from the rural areas (Heng and Guan 2007). This is in contrast to the HICs, where residential areas with low income and high deprivation levels were more likely to have fast food than in affluent areas (Zainal Badari *et al.* 2012; Schneider and Gruber 2013). Thus, there is a discernible difference between urban/rural area, income level and eating processed food/fast food among the HICs and LMICs. It is somehow not surprising to find that single people were the ones to consume the highest level of processed food as they are the ones least prepared to cook food at home (Casini *et al.* 2013). They opt to buy more food away from home (Lee 2008). One plausible explanation for Indians having the highest consumption of processed food may be 'teh tarik' consumption. Condensed milk, which is among the highest contributors to Group 3 (highly processed foods), is a substance added in 'teh tarik' preparation. Since 'teh tarik' is one of the most highly consumed foods among the Malaysian population, especially Indians, it may, therefore, explain the reason why Indians have the highest highly processed foods compared to the other ethnicities (Bakar and Farinda 2010).

Meanwhile, the highest percentages of unprocessed or minimally processed food consumption were found among those living in rural areas, were divorced/separated, had lower education, household income less than MYR 1500 and normal weight. Compared to urban areas, people living in the rural areas had slightly more raw vegetables, home-cooked foods and less fast food. A study carried out in Malaysia showed that there was a significant difference in nutrient intake between urban and rural areas, but the respondents in the urban and suburban areas were financially able to afford to consume more fruits and vegetables compared to the rural areas (Chee *et al.* 1997). This was in contrast to the findings of this study. In view of the above contrast, perhaps low household income in rural areas has led to more growing of vegetables rather than purchasing from the markets. The most striking findings of traditionally prepared foods are that the highest percentage energy of traditionally prepared foods (Group 1&2) comes from Indian ethnicity and the lowest from Chinese ethnicity. This is because of the roti canai consumption, which was the highest contributor of energy to Group 1&2, which is higher among Indians than the other ethnicities, whereas the Chinese dominated Group 2 as they consume more noodles and vermicelli rice as their meals.

Nutrient markers (i.e. carbohydrate, protein, fat, added sugar, saturated fats, sodium, and dietary fibre) were grouped by total energy intake from UPP groups. A Pearson Product Moment Correlation Coefficient was computed to assess the relationship between selected nutrient markers and UPP groups. Results showed that there was a moderate, positive association between total energy from Group 1 and dietary fibre. This makes sense, since Group 1 comprised of mostly raw and minimally processed food. The unprocessed or minimally processed foods, which encompass all grains, meats and dairy products, vegetables and fruit, are nutrient-dense foods (Drewnowski 2005). Nutrient-dense are foods that provide relatively more nutrients than calories. The Food and Drug Administration (FDA) has recommended nutrient-dense foods as they provide more beneficial nutrients than calories to overall diet (Drewnowski 2005). In the USA, the bottom and the top of the US Department of Agriculture (USDA) Food Guide Pyramid were largely nutrient-poor (Frazao and Allshouse 2003). This gives an insight that the first-base of the food pyramid encompasses grains that are less nutrient-dense, and, therefore, should be taken less than they are. This is in contrast with the food pyramid message for people to eat more of the foods at the bottom of the pyramid. It is, therefore, likely that the food grouping in the food pyramid needs to be reviewed, as this may mislead public understanding of healthy food, as discussed in Chapter Two. These results provide further support for the justification of classifying foods according to the nature, extent and purpose of processing, the UPP classification.

It is interesting to note that Group 1&2 showed a positive association with all the selected nutrient markers. However, these results had a very weak association, showing little of practical significance. Meanwhile, there is a moderate, positive correlation between total energy from highly processed food

(Group 3) and added sugar and sodium. This finding supports previous research that showed highly processed foods correlates positively with levels of sugar and sodium in a population (Monteiro 2009, 2010; Moubarac *et al.* 2012). This provides an insight that Group 3 consumption may promote nutrient-poor intake, as it associates with sugar, sodium and fat.

The study then observed the difference between the selected nutrient markers and percentiles of Group 3. Results showed that the amount of added sugar, saturated fats and sodium increased as it went from the 1st percentile to the 5th percentile of Group 3, whereas dietary fibre intake at the 1st percentile decreased as it approached the 5th percentile. This highlights that, as the consumption of foods in Group 3 increases from low range to the high range, the added sugar, saturated fats and sodium increase as well, except for dietary fibre. This will be sound evidence to promote more consumption of Group 1 and less of Group 3. Based on Malaysians' recommended nutrient intake (RNI), regardless of percentiles, sugar consumption did not exceed the RNI. Meanwhile, saturated fat in the 5th percentile of Group 3 had a slightly higher percentage than recommended than the other percentiles. Sodium intake did not exceed the upper tolerable sodium intake of 2400mg/day in any of the percentiles in Group 3. Sodium intake of more than 2300 mg has been shown to be associated with increase in blood pressure (Mugavero *et al.* 2013). Even though there was an increase of sodium from the 1st to the 5th percentile, the intake level did not go beyond recommendation.

UPP classification may not be a suitable dietary approach for predicting obesity in this sample of study. There is no difference in BMI, regardless of the amount of Group 3 consumption in this study. In other words, it can be said that BMI is not affected by Group 3 consumption. However, the UPP classification may be more beneficial in predicting nutrient-value or nutrient-density in an individual dietary intake as there is an association between UPP and selected nutrient markers. Hence, as people consume more UPP they have a worse diet, or the unhealthy foods contribute more, so that although BMI may not be affected as still most energy comes from Group 1, in terms of overall NCD risk these data suggest that as people moving to eating more Group 3 their diets get worse.

A standard multiple linear regression analysis was conducted to evaluate how well a set of predictors predicted BMI. The predictors were gender, age, level of education, ethnicity, marital status, total energy intake and total energy intake from all groups in the UPP classification, while the criterion variable was the BMI. The sample multiple correlation coefficient was .49 indicating that approximately 24.2% of the variance in the BMI can be explained by a set of predictors (total energy intake, marital status (married vs. single), gender, age and ethnicity (Chinese vs. Malay). Based on standardised coefficient results, total energy intake, marital status (married vs. single), gender, age and ethnicity (Chinese vs. Malay) have a statistically significant contribution to the prediction of BMI. Total energy intake ($\beta = .439, p < .05$) has the strongest contribution to the BMI, followed by marital status (married vs. single, $\beta = .176, p < .05$), gender (men vs. women), age and ethnicity (Chinese vs. Malay). However, none of the total energy from each groups in UPP (Group 1, Group 2, Group 1&2, and Group 3) had statistically significant contribution to BMI at $p < .05$. The multiple regression results suggesting that the BMI of the respondents in this study will increase if total energy intake increases were married rather than single, were older and were Malay rather than Chinese.

In summary, this study has been unable to demonstrate that high consumption of processed foods is associated with increase in BMI (or to obesity). This might be related to the concentration of normal weight in these respondents compared to other BMI groups, as the mean BMI of the sample study is normal (M = 23.50, SD = 4.3). Besides, the Malaysian population consumes more energy from Group 1 and Group 2 than Group 3. Future studies need to have more of a case–control; Group eating non-processed vs. Group eating processed foods. This might then explain the difference in BMI of the two groups. What we can say at the end of this chapter is that Group 3 has foods that are higher in sugar, sodium and fat level compared to the other groups of UPP. There is also no harm in saying that Group 3 consumption may promote nutrient-poor intake, as it associates with sugar, sodium and fat.

6.4 Summary of Chapter Six (Ultra-Processing Food/Product Approach)

1. The pilot study fulfilled the objective to determine the suitability of Malaysian foods with the new food classification, 'UPP food classification'.

2. The relative contribution of each group to total energy intake for MANS is as follows:
   Group 1 (unprocessed or minimally processed foods) – 45.5%
   Group 2 (processed culinary ingredients) – 19.7%
   Group 1&2 (traditional prepared foods) – 5.8%
   Group 3 (ultra-processed products/foods) – 29.8%

3. UPP classification from the perspective of socioeconomic status (SES)
   Group 1 consumption was higher among those living in rural counterpart, other ethnicities, divorced/separated, less than high school education, household income less than MYR 1500 and normal weight.
   Group 2 consumption was the highest among the obese respondents.
   Group 1&2 consumption was the highest among Indians, followed by Malay and Chinese.

Group 3 consumption was higher among women, living in urban areas, Indian, single, had a Bachelor's degree, and household income more than MYR 3500.

4. UPP classification from the perspective of contribution to nutrient intake
   Group 1 is positively associated with carbohydrate, protein, fat and dietary fibre intake, but has no association with added sugar, saturated fats and sodium.
   Group 3 is positively associated with added sugar, sodium and saturated fat.
   Group 1&2 is positively associated with all the selected nutrient markers

5. UPP classification from the perspective of Group 3 intake (ultra-processed products/foods)
   Added sugar, saturated fats and sodium intake increase, but dietary fibre intake decreases as consumption of Group 3 increases from the lowest to the highest consumption.

6. UPP classification from the perspective of BMI
   There was a weak, positive correlation between Group 1, Group 2, Group 1&2, Group 3 and BMI.

7. Contribution of SES and UPP to BMI
   Total energy intake was the most influential predictor variable for the BMI of the respondents. This was followed by marital status (married vs. single), gender, age and ethnicity (Chinese vs. Malay). However, UPP groups were unable to predict BMI in the multivariate model. UPP may not be a suitable approach in predicting obesity. However, UPP may have more advantages in estimating nutrient value or nutrient density in an individual dietary intake.

Chapter 7: Exploration of PCA and DQI-R Approach and Their Impact on Diet Quality and Obesity

In previous chapter, we have explored the UPP approach and its impact on diet quality and BMI of Malaysian population. For this chapter, we will explore dietary pattern approaches by *a posteriori* and *a priori* methods and their relationship with nutrient intake (*diet quality*) and body mass index (BMI). The *a posteriori* is a data-driven method that applies factor or cluster analysis to derive dietary patterns, while *a prio*ri method is based on diet indexes or scores that assess compliance with prevailing dietary guidelines (Kant 2004). As mention earlier in Chapter Two, this study will assess *a posteriori* and *a priori* methods through principal component analysis (PCA) and Diet Quality Index Revised (DQI-R) respectively. We will later make a comparison between these three approaches (UPP, PCA and DQI-R) in Chapter Seven.

This chapter is divided into two main sub-headings; **(6.1) is on PCA approach** and **(6.2) is on DQI-R approach**. At the end of this chapter, we would want to see:

PCA approach

1. Type of dietary patterns derived by PCA approach
2. Correlation between all dietary patterns derived by PCA and selected nutrient intake and BMI in this sample of study
3. The ability of new predictors (dietary patterns derived from PCA) to predict BMI
4. The baseline characteristics of dietary patterns derived by PCA for all respondents

DQI-R approach

1. Diet quality of respondents in this sample of study
2. Relationship between each DQI-R component and DQI-R scores
3. Relationship between DQI-R and BMI of respondents in this sample of study
4. The baseline characteristics of the respondents according to DQI-R score

7.1 PCA approach *(a posteriori)*

7.1.1 Introduction

Principal Component Analysis (PCA) is *a posteriori* approach that has been applied in determining dietary patterns among a population. PCA, or the generic term referred to as Factor Analysis (FA), is a consolidation technique constructed to confer as much information as a larger data set based upon a smaller number of variables (Flood *et al.* 2008). This section presents the application of PCA to determine the dietary patterns of the respondents and then uses the factor scores on each of the patterns to identify their relationship with obesity. This aim was to identify the combinations of foods (derived from PCA) that are associated with the risk of obesity.

7.1.2 Methodology

7.1.2.1 Procedures of conducting PCA to derive dietary patterns

7.1.2.1.1 Grouping foods

The semi-quantitative Food Frequency Questionnaire (FFQ) in the Malaysian Adult Nutrition Survey (MANS) consists of 126 food items. It contains a large number of variables to run the PCA. To run a PCA, the food data need to be aggregated into groups (Schoenaker *et al.* 2013) to ease the interpretation of factor components (Hearty and Gibney 2009). Therefore, the 126 food items were grouped into 17 food item groups according to similarity of nutritional characteristics, (Crozier *et al.* 2006; Cunha *et al.* 2010) common classification (Bamia *et al.* 2005), and similarity to MANS food groupings (Ministry of Health Malaysia 2008). Appendix C shows the factor groupings used in the dietary pattern analysis for this study. This method of food aggregation follows other studies in preparing food data for PCA analysis (Hu 2002a; Newby *et al.* 2004a; Martinez-Ortiz *et al.* 2006; Mullie *et al.* 2010; Varraso *et al.* 2012). For example, Slimani *et al.* (2002) classified food data for the European Prospective Investigation into Cancer and Nutrition (EPIC) study (a large cohort representing about half a million individuals in 10 Western European countries (Denmark, France, Germany, Greece, Italy, Norway, Spain, Sweden, the Netherlands and the UK)) into 17 main groups according to their plant or animal origins and their degree of food processing to facilitate the comparison between dietary patterns across centres. A study by Cunha *et al.* (2010) classified 82 food items from the FFQ into 21 groups before running the PCA. There are studies that grouped 100 food items from the FFQ into 49 food groups according to similar nutritional composition and comparable usage (Robinson *et al.* 2004; Crozier *et al.* 2006; Borland *et al.* 2008). A study done in Tehran grouped 125 food items into 31 food groups before performing the PCA (Safari *et al.* 2013).

A study by Hearty and Gibney (2009) grouped food data into 33 food groups before running the PCA while Hoffmann *et al.* (2004) had his 148 food items grouped into 49 separate food groups.

7.1.2.1.2 Choosing weight (gram per day)

The analysis was based on gram per day weightage. This standard was used in several studies (Bamia *et al.* 2005; Hearty and Gibney 2009). No significant difference was found between weightage, adjusted energy, and percentage of energy contribution in determining factor loadings of PCA (Smith *et al.* 2013). Therefore, g/day has been selected as the weight for this PCA analysis.

7.1.2.1.3 SPSS procedure on conducting the analysis

Prior to employing PCA for analysis, the food items (in g/day) consumed by all respondents were observed for missing values. No respondents had missing values. There are three main considerations in PCA (Pallant 2007). The first one is to ensure the suitability of the data for analysis. This is in reference to sample size and strength of relationship among the variables (or items). There is a debatable argument about how large a sample should be; however, the larger the sample size, the better it is. Small sample sizes may have a less reliable correlation coefficient among the variables and the factors obtained may be less generalized from samples derived from larger samples. Some authors have suggested a certain minimum number for sample size to fit the PCA and some are more concerned with the ratio of subjects to items (Tabachnick and Fidell 2007). The strength of inter-correlations is reflected by a correlation coefficient of more than 0.3 among the items. Two statistical measures are computed by SPSS (statistics software) to aid in determining the factor-ability of the data which are the Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Pallant 2007). Bartlett's test of sphericity should be $p < 0.05$ for the factor analysis to be considered appropriate and KMO values ranging from 0 to 1 and 0.6 are advised as the minimum values for a good factor analysis (Tabachnick and Fidell 2007).

The second consideration to address is factor extraction. This is the process of deciding on how many factors to retain. There are several approaches in deciding on the number of factors to keep, for example, principal components, principal factors, image factoring and maximum likelihood factoring (Pallant 2007). The most commonly used approach is the principal component analysis (PCA) that is used in this study. There are a number of techniques used to assist in the decision to determine the number of factors to retain. These include the Kaiser's criterion, scree test and parallel analysis. The rule for Kaiser's criterion is to use all eigenvalues of more than 1.0 for determining number of factors (Pett *et al.* 2003). The theory behind this is that each retained factor should explain more variance compared with that of the original variable in the data set (Marchioni *et al.* 2005). The factors will be retained for further investigation in the scree test. The scree test involves plotting each of the eigenvalues of the factors using SPSS. The factors will be determined by finding a point at which the shape of the curve changes direction and becomes horizontal. These factors contribute most to the explanation of the variance in the set. These two factors are important in assessing the number of factors to retain.

The third consideration is factor rotation and interpretation. The factors retained are rotated in order for it to be possible to interpret them. The varimax method was applied for rotation to derive factor loadings. This gives a pattern of loadings that is easy to interpret without changing the underlying solution. The first factor extracted addressed the maximum possible variance in the dataset, while the second factor, which is dependent on the first, accounts for the largest possible share of the remaining variance and so on (Newby *et al.* 2004a; Venkaiah *et al.* 2011). The factors are uncorrelated with each other, maintaining the axes at 90^0 (Marchioni *et al.* 2005). SPSS is not able to label the factors but simply presents the variables that clump together (Pett *et al.* 2003). It is up to the researcher to interpret each of the factors based on the underlying theory and published literature. Within a factor, those with positive loadings have a direct association with dietary pattern, whereas those with negative loadings have an inverse association with dietary patterns. In cases where food items loaded on more than one factor, the factors with the highest loading will be considered for factor labelling (Helen-Ng *et al.* 2012). This procedure was advised by Pett *et al.* (2003) as an ideal factor rotation to construct a simple structure where each item that has high, or meaningful, loading on one factor only is highlighted.

There are a number of different methods that can be used for estimating factor scores from the data, and one of them is the regression approach besides Bartlett and Anderson-Rubin method (Hershberger 2014). Regression approach was selected as an estimation of factor scores in the SPSS analysis (Hershberger 2014). In this regression approach, factor loadings are adjusted to take account of the initial correlations between variables, which stabilized differences in units of measurement and variable variance (Field 2009):

$$\text{Factor score} = \text{loading}_1 {*} X_1 + \text{loading}_2 {*} X_2 + \ldots + \text{loading}_k {*} X_k$$

Factor scores were calculated from each of the remaining factors by summing up the frequency of consumption multiplied by factor loadings across all food items (Hu *et al.* 1999; Flood *et al.* 2008). These scores will have a mean equal to 0 (Pett *et al.* 2003).

7.1.2.1.4 Correlation between all dietary patterns derived by PCA and BMI in this sample of study

The factor scores on each of the factors or components were used to determine the relationship between dietary patterns and BMI. Pearson product-moment correlation was employed to measure the association between BMI and the estimated factor scores. This has been applied in other studies as well (Martinez-Ortiz *et al.* 2006). Before conducting Pearson product-moment correlation, the estimated factor scores for all respondents were examined for missing values and fit between distributions and assumptions (Dancey *et al.* 2012). Assumptions of normality and possible extreme scores were conducted separately for each factor score.

7.1.2.1.5 The ability of new predictors (dietary patterns derived from PCA) to predict BMI

Hierarchical multiple regression was conducted for each factor including all respondents' characteristics in order to determine independent association. This was to assess if the estimated factor scores were associated with BMI independent of other contributing factors (e.g. characteristics of respondents etc.). P values < 0.05 were considered statistically significant for all analyses. The full procedures of conducting the hierarchical multiple regressions are explained under the multivariate linear regression section.

7.1.2.1.6 The baseline characteristics of dietary patterns derived by PCA for all respondents

An independent samples t-test was conducted to evaluate any significance difference in age between the lowest and highest quintile for each derived dietary patterns. An independent t-test was also employed for determining significance difference in BMI between the lowest and highest quintiles of the derived dietary patterns. Effect size of each independent samples t-test was calculated to provide an indication of the magnitude of the differences (Pallant 2007). Effect size was calculated based on Eta squared.

$$\text{Eta squared} = \frac{t^2}{t^2 + (N1+N2-2)}$$

Cohen classifies 0.01 as a small effect, 0.06 as a medium effect and 0.14 as a large effect (Ibid). Meanwhile, a chi-square was performed to evaluate association between i) gender, ii) ethnicity, and iii) level of education, and the lowest and highest quintiles of the six dietary patterns.

7.1.3 Results – Part 1: Analysing SPSS output from implementing PCA

The 17 items of the FFQ were subjected to the PCA using SPSS version 21. The first table that SPSS produces is the descriptive table as shown in Table 7.1. The table reported the mean value for all 17 items based on g/day weightage.

Table 7.1: Initial summary of each of the variables (g/day)

Food items (g/day)	Mean	Std. Deviation
rice	334.4	160.4
cereals and cereals products	234.4	122.8
meat	39.6	41.7
processed meats	10.8	14.6
other meat	8.6	23.2
fish and seafoods	114.0	81.7
eggs	30.8	28.8
legumes and legumes product	26.3	30.1
milk	9.0	31.8
processed dairy products	29.4	37.9
vegetables	134.3	108.5
fruits	202.7	161.0
non-alcoholic drink	2064.0	907.0
alcoholic drink	3.0	25.3
confectionery	81.0	60.7
spreads	7.1	10.6
flavourings	37.6	32.5

Next is observing presence of multicollinearity through the correlation matrix table. The correlation matrix shows the pairwise correlations. The significant correlations at $p < 0.05$ can provide an indication of the relationships between the variables. If it is lower than 0.000001, this indicates presence of multicollinearity. The SPSS output shows that the determinant of the R-matrix is 0.546 which is greater than 0.000001. Therefore, no presence is multicollinearity was observed. The correlation matrix must have some correlations but it is important to make sure that they do not correlate highly (e.g. $r > 0.8$). It is apparent from the correlation matrix table that there are no variables that are highly correlated (can refer to Appendix D for the correlation matrix table).

Prior to performing PCA, the suitability of data for factor analysis was assessed. Several methods are applied in determining data suitability through sampling adequacy and sphericity. The KMO is a test to examine whether the variables are adequate for correlation (Hinton *et al.* 2004). A general rule of thumb is that the KMO value must be greater than 0.5 to proceed to PCA. The KMO value for the PCA in this group of 17 items was 0.60 as shown in Table 7.2. Therefore, the PCA could proceed. On the other hand, Bartlett's Test of Sphericity is a test to observe if there is a relationship between the variables. If the Bartlett's test is $p > 0.05$, it is not significant which means there is no relationship between variables. If there is no relationship, then there is no point in proceeding to PCA. The results in Table 7.2 show that the Bartlett's test result is 0.000 which means it is significant.

Table 7.2: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.600
	Approx. Chi-Square	1851.273
Bartlett's Test of Sphericity	df	136
	Sig.	.000

In factor analysis, variability in one variable common to other variables is essential. This indicates that they are linked by an underlying factor (Hinton *et al.* 2004). SPSS assumption is that 100 per cent of the variance of each variable is common variance. It gives each variable a communality of 1.000. However after the factors have been extracted, it works out how much of the variability of each variable can be explained. For example, rice is initially given a communality of 1.00, but after extracting the factors, rice has a communality of 0.570 as shown in Table 7.3. This indicates that 57% of its variability is explained by the factors.

Table 7.3: Communalities of variables

	Initial	Extraction
rice	1.000	0.570
cereals and cereals products	1.000	0.587
meat	1.000	0.553
meat products	1.000	0.543
other meat	1.000	0.468
fish and seafoods	1.000	0.397
eggs	1.000	0.417
legumes and legumes product	1.000	0.347
milk	1.000	0.306
processed dairy products	1.000	0.685
vegetables	1.000	0.526
fruits	1.000	0.462
non-alcoholic	1.000	0.420
alcoholic	1.000	0.340
confectionery	1.000	0.435
spreads	1.000	0.345
flavourings	1.000	0.411

Extraction method: Principal Component Analysis.

Using the Kaiser's criterion to use all eigenvalues of more than 1.0, there are six components (factors) that have eigenvalues greater than this amount, as shown in Figure 7.1. Factor 1 accounts for 9.862 per cent of the variance. Six factors have been retained which explain a cumulative 45.937 per cent of the variance. Next is the scree plot as shown in Figure 7.2. The factors are the X-axis and the eigenvalues are the Y-axis. The scree plot also indicates that all six components may be chosen.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.677	9.862	9.862	1.677	9.862	9.862	1.563	9.192	9.192
2	1.609	9.467	19.329	1.609	9.467	19.329	1.433	8.427	17.619
3	1.248	7.339	26.668	1.248	7.339	26.668	1.312	7.715	25.335
4	1.191	7.006	33.673	1.191	7.006	33.673	1.250	7.356	32.690
5	1.084	6.378	40.051	1.084	6.378	40.051	1.149	6.759	39.450
6	1.001	5.886	45.937	1.001	5.886	45.937	1.103	6.488	45.937
7	.991	5.829	51.766						
8	.972	5.721	57.487						
9	.934	5.495	62.982						
10	.900	5.294	68.276						
11	.861	5.065	73.341						
12	.858	5.048	78.389						
13	.829	4.876	83.265						
14	.758	4.456	87.721						
15	.743	4.371	92.092						
16	.725	4.263	96.355						
17	.620	3.645	100.000						

Extraction Method: Principal Component Analysis.

Figure 7.1: Total variance explained

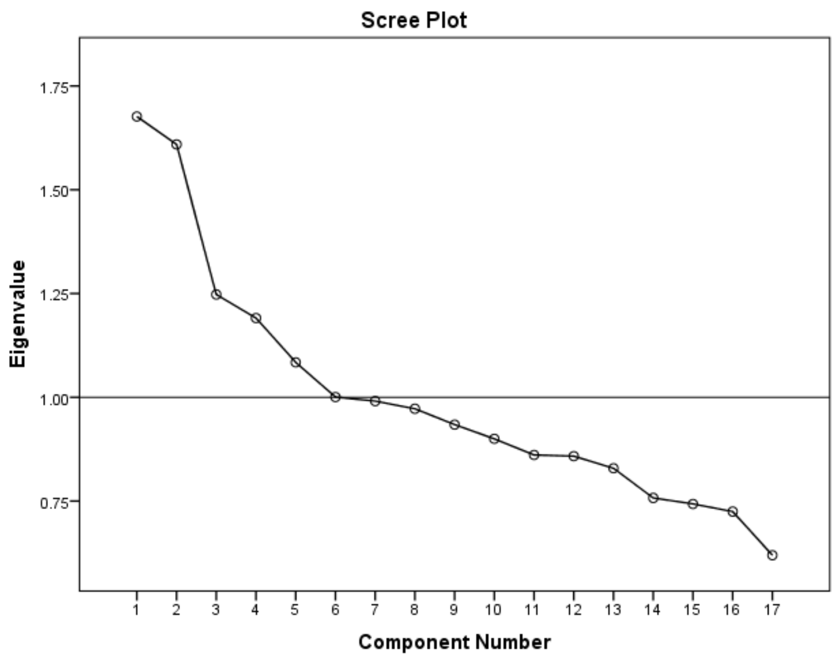


Figure 7.2: Scree plot showing eigenvalue for each component in factor extraction of data obtained from FFQ

The rotated component matrix details the factor loadings onto the six components. This table provides the loadings of the variables onto the factors. The rotated component matrix shows variables that are really important to Factor 1. Since PCA with a Varimax rotation has been selected, the rotated component matrix will provide a clearer picture of factor loadings onto the six components as shown in Table 7.4.

Variables with high loadings (≥ 0.2) have been selected for the rotated component matrix to ease the interpretation. Statisticians suggest some guidelines for selecting factor loadings. They propose that, in factor rotations, items that load < 0.2 should be excluded from a factor because less than 9% of that item's variable is shared with factor (Pett *et al.* 2003). Several studies on dietary pattern analysis using a factor analysis approach had considered absolute factor loadings > 0.2 as having significance as a contribution to dietary pattern analysis (Safari *et al.* 2013). It has been suggested that the higher the factor loadings, the greater is the degree of overlapping true variance between the item and the factor, and the more the factor is like the item in dietary patterns (Pett *et al.* 2003). Rotation has shown that different variables load onto different factors. Six components were chosen to best describe the dietary patterns of the respondents, explaining 45.9% of the variance.

Table 7.4: Rotated component matrix [a]

	Component					
	1	2	3	4	5	6
rice			-.702			
cereals and cereals products	-.222		.682		.230	
meat				.680		.201
processed meats				.674		
other meat	-.446				.431	-.208
fish and seafoods	.559		-.258			
eggs	.321			.306	.458	
legumes and legumes product		.533				
milk	-.232	.340				.248
processed dairy products						.799
vegetables		.635	-.252		.205	
fruits		.651				
non-alcoholic	.322		.235	-.292	.344	
alcoholic					.571	
confectionery	.552				-.244	
spreads		.205				.494
flavourings	.615					

Extraction method: Principal Component Analysis.
Rotation method: Varimax with Kaiser Normalization.
a. Rotation converged in 9 iterations.
Loadings ≥ 0.2 were only selected

7.1.4 Results – Part 2: Dietary Patterns Derived by PCA approach

After rotation took place, six dietary patterns were derived to best describe the dietary patterns of the respondents in this sample of study. The names addressed to each pattern are presented in Table 7.5 derived from Table 7.4. The names addressed were based on an understanding of the content of the variables (based on past research). Factor 1 was the most dominant food pattern within the population and explained 9.9% of the variance intake, whereas each of the remaining 5 factors explained between 9.5% (Factor 2) and 5.9% (Factor 3) of the variance.

Table 7.5: Principal components and corresponding scoring coefficients for dietary variables

Principal components	Positive scoring coefficients	Negative scoring coefficients	Variance explained (%)
Principal component 1 (PC 1)	Flavourings (0.62)	Other meat (- 0.45)	9.9
"Traditional"	Fish and seafood (0.56)	Milk (- 0.23)	
	Confectionery (0.55)	Cereals and cereal products (- 0.22)	
Principal component 2 (PC 2)	Fruits (0.65)		9.5
"Prudent"	Vegetables (0.64)		
	Legumes and legume products (0.53)		
	Milk (0.34)		
Principal component 3 (PC 3)	Cereals and cereal products (0.68)	Rice (- 0.70)	7.3
"Modern"		Fish and seafood (- 0.26)	
		Vegetables (- 0.25)	
Principal component 4 (PC 4)	Meats (0.68)	Non-alcoholic beverages (- 0.29)	7.0
"Western"	Processed meats (0.67)		
Principal component 5 (PC 5)	Alcoholic beverages (0.6)	Confectionery (- 0.24)	6.4
"Chinese-Malaysian"	Eggs (0.43)		
	Other meat (0.46)		
	Non-alcoholic beverages (0.34)		
Principal component 6 (PC 6)	Processed dairy products (0.8)		5.9
"Combination"	Spreads (0.5)		

Note: Each item has a high, or meaningful loading on one factor only even though factor loading $|r| \geq 0.2$ (Pett *et al.* 2003)

The first pattern, Factor 1, with high loadings for flavourings, fish and seafood, confectionery, eggs and non-alcoholic beverages was labelled "Traditional" dietary pattern. This "Traditional" dietary pattern was also associated with lower intakes of other meat, milk, cereals and cereal products. This was addressed as a "Traditional" dietary pattern because of the rich consumption of flavourings in Malaysian dishes which include sugar, honey, shrimp sauce, anchovy sauce, shrimp *cencalok*, thick soy sauce, light soy sauce, ketchup sauce, oyster sauce and fish sauce. These flavourings are added frequently during food preparation as part of the flavourings in most traditional Malaysian cuisines or served as an additional side dish. The most popular dish in Malaysia is '*nasi lemak*' (coconut rice). It is normally served during breakfast or even for dinner. *Nasi lemak* is a dish for which the rice is cooked along with a mixture of coconut and water. Meanwhile, the gravy is made with shrimp sauce along with chillies, sugar and anchovies. Even though the quantity of added shrimp sauce is small if it is consumed regularly, it does have an impact on dietary pattern. Other commonly consumed traditional dishes are fried rice and fried noodles. Preparation for these foods involves the use of thick soy sauce, light soy sauce and ketchup sauce. One more popular traditional dish is chicken rice which is mostly consumed by Malay and Chinese people. The chicken is prepared by marinating it with soy sauce and honey, along with other ingredients. Fish and seafood along with confectionery loaded moderately on Factor 1. Fish is the main sources of protein in Southeast Asia (Hajeb *et al.* 2009). It was highlighted that people in Malaysia consume a variety of fish and a study conducted in Malaysia shows that Chinese people consumed fish like Spanish mackerel, silver pomfret, anchovies, fish balls and fish cakes while the Malays consumed fish like Indian mackerel, black pomfret, hardtail pomfret, sardines and anchovies (Rahman *et al.* 2004). Sheng *et al.* (2008) showed that fish consumption in Malaysia was 56.39 kg/person/year in the year 2003 which accounted for 12.4 % of the total food intake per capita. Confectionery was added as one more important score on Factor 1. Confectionery included local delicacies, cake, biscuits and others, since a long time ago; confectionery was a tea-time dish for the Malaysian population. There are a wide range of choices of local delicacies. They may be home-prepared or can be bought in almost every food vendor's. All in all, this gives an overview of why Factor 1 is termed a "Traditional" dietary pattern.

The second pattern, Factor 2, which loaded heavily on fruits and vegetables, followed by legumes and legume products, and milk was named a "Prudent" dietary pattern. The term "Prudent" dietary pattern has been extensively applied in other studies to reflect vegetable and fruit intake (Marchioni *et al.* 2005; Crozier *et al.* 2006; Borland *et al.* 2008; Helen-Ng *et al.* 2012; Schoenaker *et al.* 2013). The "Prudent" dietary pattern does not have any coefficients with negative values.

The third pattern, Factor 3, has high loadings on cereals and cereal products, and a high negative loading was seen with rice, fish and seafood and vegetables and was therefore labelled a "Modern" dietary pattern. Since rice and fish were negatively loaded on factor 3 but cereals and cereal products loaded positively, it reflected the shift from a traditional dietary pattern to a modernized dietary pattern. This is a shift towards a greater supply of refined wheat and grain. This shift was extensively observed in many countries that are undergoing nutrition transition. The refined supply of wheat and grain is gradually increasing compared to the rice supply, but rice still dominates the dietary meal pattern in several transition countries (FAO 2006).

The fourth pattern, which was named a "Western" dietary pattern, was characterized by high intakes of meats and processed meats and low intakes of non-alcoholic beverages. The characteristics of a western diet are reflected by a high consumption of meats and processed meats. Thus, the fourth pattern is referred to as a "Western" dietary pattern.

The fifth pattern loaded highly on alcoholic beverages, eggs and other meat, followed by non-alcoholic beverages with negative loadings on confectionery and it was named a "Chinese-Malaysian" dietary pattern. This was labelled as a Chinese diet since it loaded highly on alcoholic beverages and other meat. These two foods are more commonly consumed by the Chinese population than the Indians. Malay respondents do not consume these two foods since they are prohibited by religion.

Finally, the sixth pattern, Factor 6, had high positive loadings on processed dairy products and spreads. The sixth pattern was referred to as a "Combination" dietary pattern. It is a combination between a traditional and modern dietary pattern (Helen-Ng *et al.* 2012). All in all, the pattern observed in this study provides an indication of the most common foods consumed amongst respondents.

7.1.4.1 Correlation between selected nutrient intake, BMI and composite factor scores

Once the dietary patterns were determined, scores for all respondents on each identified pattern were generated. The factor scores in SPSS are standardized, with mean = 0 and standard deviation

= 1. These computed scores were used in determining association between BMI and other nutritional profiles (i.e. fat, added sugar, saturated fat, salt and dietary fibre). No missing values were reported for the factor scores of all respondents. Preliminary analyses were implemented to avoid violation of the assumptions of normality, linearity and homoscedasticity. Table 7.6 presents the correlation between six dietary patterns and BMI, total energy intake and selected nutrients intake. It is apparent from the table that there were only a few variables that were not significantly correlated with one another at alpha 0.05 level. However, most variables had weak correlation whilst others had moderate association.

The "Traditional" dietary pattern showed a moderate, positive correlation with total protein and total sugar intake. The sample correlation coefficient was 0.298 and 0.370 indicating that approximately 9% of the variance in the "Traditional" dietary pattern can be explained by total protein and 14% of the variance in the "Traditional" dietary pattern can be explained by total sugar. The correlation between this dietary pattern and protein may be due to quite high loadings of fish and seafood in this dietary pattern. Fish provides a high quality of protein (Hajeb *et al.* 2009). High loadings on confectionery may be a plausible explanation for the moderate correlation between the "Traditional" dietary pattern and total sugar intake.

There was a significant moderate correlation between the "Prudent" dietary pattern and dietary fibre, $r = 0.482$, $p < 0.05$. The sample correlation coefficient was 0.23 indicating that approximately 5% of the variance in the "Prudent" diet can be explained by total dietary fibre intake. Meanwhile, the "Modern", "Western" and "Combination" dietary patterns failed to show any strong or moderate significant relationship between the selected variables.

There was a moderate positive association between the "Chinese" dietary pattern and total energy, $r = 0.296$, $p < 0.05$. The "Chinese" dietary pattern which is highly loaded on other meats (pork, ham, bacon, etc.) and alcoholic beverages may explain the increase in total protein and total energy respectively.

Table 7.6: Correlation coefficient between six food patterns and total energy intake, nutrient intake and BMI of respondents

Energy and nutrients	**Factor 1** ***"Traditional"***	**Factor 2** ***"Prudent"***	**Factor 3** ***"Modern"***	**Factor 4** ***"Western"***	**Factor 5** ***"Chinese"***	**Factor 6** ***"Combination"***
BMI	0.148*	0.121*	0.079*	-0.024	0.080*	-0.012
Total energy (kcal)	0.254*	0.187*	0.158*	0.183*	**0.296***	0.120*
Toal carbohydrate (g)	0.142*	0.145*	0.199*	0.031	0.167*	0.055*
Total protein (g)	**0.298***	0.275*	0.001	0.188*	0.259*	0.046*
Total fat (g)	0.145*	0.277*	0.092*	0.096*	0.087*	0.093*
Total dietary fibre (g)	0.081*	0.**482***	0.043	0.011	0.051*	-0.011
Total sugar (g)	**0.370***	0.249*	0.112*	0.066*	-0.036*	0.098*
Total saturated fat (g)	0.109*	0.247*	0.044*	0.213*	0.146*	0.270*
Total sodium (mg)	0.455	0.115*	-0.019	0.195*	0.149*	0.039*

* Correlation is significant at the 0.05 level (2-tailed)

7.1.5 Multivariate regression analysis subjected to all factor analysis

7.1.5.1 Introduction

Hierarchical multiple regression analysis was used to assess the ability of new predictors (all six-dietary patterns) to predict BMI as continuous variable , after controlling for the influence of gender, age, education, ethnicity, marital status and total energy intake. Hierarchical multiple regression was selected as it evaluates the relationship between the new predictors (all six-dietary patterns) and BMI, while taking into account the impact of a different IVs (gender, age, education, ethnicity, marital status and total energy intake) on the BMI.

7.1.5.2 Methodology

SPSS version 21 was used to implement the hierarchical multiple regression analysis. Several demographic variables were categorically recorded as dummy variables prior to the regression analysis. For example, marital status was four options: single, married, separated and widowed. Marital status was transformed to dummy coding. Single was coded as 0 for baseline. Other marital status was combined into two groups: married = 1, others = 0; separated = 1, others = 0 and widowed = 1, others = 0, as shown in Table 7.7.

Table 7.7: Dummy coding for marital status

Marital status	Dummy variable 1	Dummy variable 2	Dummy variable 3
Single	0	0	0
Married	1	0	0
Separated	0	1	0
Widowed	0	0	1

The same went for other categorical independent variables: gender, ethnicity, and education. The estimated regression equations took the following linear form

$$Y = B_o + B_1X_1 + B_2X_2 + B_3X_3 \ldots\ldots\ldots\ldots\ldots\ldots.. + B_kX_k + e \qquad (1)$$

where:

Y = BMI
B_o = Intercept
X_i = Independent variable
B_j = Partial regression coefficients, j = 1,………., k

The specific linear regression model used in this study is denoted below

$$Y = B_o + B_1X_1 + B_2X_2 + B_3X_3 + \ldots\ldots\ldots + B_{22}X_{22} + e \quad (2)$$

Y = BMI
B_o = Intercept
B_1 to B_{20} = Regression coefficient of each variable
X_1 = Gender
X_2 = Age
X_3 = less than high school vs. high school
X_4 = less than high school vs. college
X_5 = less than high school vs. degree
X_6 = less than high school vs. others
X_7 = Malay vs. Chinese
X_8 = Malay vs. Indian
X_9 = Malay vs. other
X_{10} = single vs. married
X_{11} = single vs. separated
X_{12} = single vs. widowed
X_{13} = single vs. others
X_{14} = Total energy intake
X_{15} = "Traditional" (F1)
X_{16} = "Prudent" (F2)
X_{17} = "Modern" (F3)
X_{18} = "Western" (F4)
X_{19} = "Chinese" (F5)
X_{20} = "Combination" (F6)
e = Error

The selected variables, namely: gender, age, education, ethnicity, total energy intake, "Traditional", "Prudent", "Modern", "Western", "Chinese" and "Combination" dietary patterns were regressed on the dependent variable, BMI. However, for hierarchical multiple regression analysis, the independent variables needs to be entered in steps/blocks in a predetermined order. Therefore, gender, age, education, ethnicity, and total energy intake were entered in Block 1 while new predictors (all six-dietary patterns) were entered in Block 2. By entering gender, age, education, ethnicity, and total energy intake into Block 1, the possible effects of Block 1 has been "removed" and we can see whether the new predictors (Block 2) is still able to explain some of the remaining variance in BMI.

As the samples of respondents were found to be distributed more or less normally over all the variables, multiple regression analysis was utilized in order to determine which of the selected independence variables would influence BMI.

7.1.5.3 Results – Analysing the SPSS output from the Hierarchical Multiple Regression analysis

The first task was to check the assumptions of the data. One of the assumptions was to observe absence of multicollinearity among the independent variables (not exceeding 0.9) (Pallant 2007). In this finding, none of the variables were highly correlated (see Table 7.8). One more procedure was to confirm the non-existence of multicollinearity among the variables through 'collinearity diagnostics' as shown in the coefficients table (see Table 7.9). Collinearity statistics provide two indicators: Tolerance and variance inflation factor (VIF), which can determine the absence of multicollinearity (Pallant 2007). Tolerance is an indicator of how much of the variability of the specified independent is not explained by the other independent variables in the model. If the value is less than 0.10, it indicates that the multiple correlations with other independent variables are high, proposing the existence of muliticollinearity. On the other hand, VIF acts inversely to Tolerance, with value > 10 indicating mulitcollinearity. In this case, the tolerance value for all respondents was greater than 0.10 and the VIF value was less than 10, which indicates the absence of multicollinearity (see Table 7.9).

Table 7.8: Correlation between selected independent variables (univariate comparisons of characteristics and scores)

	gender	age	Malay vs. Chinese	Malay vs. Indian	Malay vs. other	single vs. married	single vs. separated	single vs. widowed	less than high school vs. high school	less than high school vs. college	less than high school vs. degree	less than high school vs. others	Total energy	F1	F2	F3	F4	F5	F6
Pearson-correlation																			
gender	-	0.003	0.094	-0.033	-0.007	-0.194	-0.121	-0.182	0.224	0.471	0.057	0.176	0.035	-0.015	0.086	-0.054	-0.218	0.069	-0.014
age		-	-0.028	-0.014	-0.010	0.013	-0.050	0.048	-0.109	-0.114	-0.058	-0.109	0.409	0.102	-0.062	0.025	0.079	0.282	0.118
Malay vs. Chinese			-	-0.170	-0.239	-0.080	0.014	0.061	-0.067	-0.008	0.002	0.002	-0.009	-0.445	0.118	0.055	0.015	0.266	-0.127
Malay vs. Indian				-	-0.126	0.006	-0.018	-0.034	-0.002	-0.040	-0.011	0.030	-0.028	-0.109	-0.023	0.180	-0.125	-0.076	0.059
Malay vs. other					-	-0.070	-0.034	-0.086	0.171	0.050	0.013	0.004	-0.013	0.050	0.016	-0.184	-0.018	0.007	-0.122
single vs. married						-	-0.182	-0.300	-0.152	-0.053	-0.023	-0.075	0.023	0.033	-0.020	0.049	0.023	-0.064	0.065
single vs. separated							-	-0.101	-0.051	-0.073	-0.027	-0.023	-0.044	-0.029	0.012	-0.009	0.024	-0.023	-0.010
single vs. widowed								-	-0.084	-0.192	-0.018	-0.042	0.024	-0.088	0.042	0.059	0.120	-0.008	0.092
less than high school vs. high school									-	0.054	-0.007	0.132	-0.072	0.031	-0.052	-0.078	-0.095	-0.040	-0.086
less than high school vs. college										-	-0.158	-0.198	0.002	0.006	0.080	-0.046	-0.168	-0.017	-0.018
less than high school vs. degree											-	-0.015	-0.001	0.025	0.018	-0.040	0.005	0.004	-0.003
less than high school vs. others												-	-0.045	-0.022	0.010	-0.006	-0.053	0.000	-0.030
Total energy													-	0.254	0.187	0.158	0.183	0.296	0.120
F1														-	0.000	0.000	0.000	0.000	0.000
F2															-	0.000	0.000	0.000	0.000
F3																-	0.000	0.000	0.000
F4																	-	0.000	0.000
F5																		-	0.000
F6																			-
Sig. (1-tailed)																			
gender	.	0.425	0.000	0.032	0.340	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.027	0.210	0.000	0.001	0.000	0.000	0.213
age		.	0.058	0.222	0.283	0.235	0.003	0.004	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.086	0.000	0.000	0.000
Malay vs. Chinese			.	0.000	0.000	0.000	0.227	0.000	0.000	0.322	0.464	0.455	0.304	0.000	0.000	0.001	0.201	0.000	0.000
Malay vs. Indian				.	0.000	0.367	0.163	0.032	0.462	0.014	0.279	0.048	0.062	0.000	0.098	0.000	0.000	0.000	0.001
Malay vs. other					.	0.000	0.031	0.000	0.000	0.003	0.233	0.420	0.238	0.003	0.189	0.000	0.165	0.354	0.000
single vs. married						.	0.000	0.000	0.000	0.002	0.100	0.000	0.103	0.034	0.140	0.004	0.101	0.000	0.000
single vs. separated							.	0.000	0.002	0.000	0.068	0.099	0.007	0.057	0.257	0.315	0.095	0.097	0.296
single vs. widowed								.	0.000	0.000	0.154	0.011	0.088	0.000	0.010	0.001	0.000	0.338	0.000

less than high school vs. highschool	.	0.001	0.346	0.000	0.000	0.043	0.002	0.000	0.000	0.013	0.000
less than high school vs. college		.	0.000	0.000	0.458	0.368	0.000	0.006	0.000	0.168	0.157
less than high school vs. degree			.	0.205	0.488	0.087	0.165	0.013	0.387	0.403	0.441
less than high school vs. others				.	0.007	0.112	0.282	0.365	0.002	0.489	0.047
Total energy					.	0.000	0.000	0.000	0.000	0.000	0.000
F1						.	0.500	0.500	0.500	0.500	0.500
F2							.	0.500	0.500	0.500	0.500
F3								.	0.500	0.500	0.500
F4									.	0.500	0.500
F5										.	0.500
F6											.

Significant at p<0 .05

F1 = "Traditional"
F2 = "Prudent"
F3 = "Modern"
F4 = "Western"
F5 = "Chinese"
F6 = "Combination"

Table 7.9: Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	T	Sig.	Tolerance	VIF
1	(Constant)	12.129	0.464		26.124	0.000		
	age in yrs	0.065	0.008	0.168	8.145	0.000	0.591	1.691
	men vs. women	-1.427	0.153	-0.167	-9.323	0.000	0.778	1.286
	malay vs. chinese	-1.006	0.168	-0.101	-6.001	0.000	0.879	1.137
	malay vs. indians	-0.260	0.254	-0.017	-1.024	0.306	0.933	1.072
	malay vs. others	-0.410	0.202	-0.034	-2.030	0.042	0.868	1.152
	less than high school vs. high school	0.050	0.163	0.006	0.304	0.761	0.748	1.338
	less than high school vs. college	-0.127	0.309	-0.007	-0.411	0.681	0.880	1.136
	less than high school vs. degree	-0.110	0.220	-0.009	-0.499	0.618	0.769	1.300
	less than high school vs. others than all listed	-0.353	0.364	-0.016	-0.969	0.333	0.875	1.143
	single vs. married	1.605	0.185	0.176	8.697	0.000	0.611	1.638
	single vs. separated	0.845	0.651	0.021	1.298	0.194	0.925	1.082
	single vs. widowed	1.095	0.555	0.034	1.974	0.048	0.824	1.213
	Total energy	0.004	0.000	0.396	22.787	0.000	0.827	1.209
2	(Constant)	12.597	0.505		24.950	0.000		
	age in yrs	0.064	0.008	0.166	8.008	0.000	0.578	1.731
	men vs. women	-1.403	0.157	-0.164	-8.910	0.000	0.730	1.370
	Malay vs. Chinese	-1.150	0.205	-0.116	-5.606	0.000	0.583	1.715
	Malay vs. Indian	-0.333	0.267	-0.021	-1.247	0.213	0.839	1.191
	Malay vs. other	-0.450	0.208	-0.038	-2.164	0.031	0.815	1.227
	less than high school vs. high school	0.092	0.164	0.010	0.564	0.573	0.737	1.357
	less than high school vs. college	-0.091	0.309	-0.005	-0.296	0.767	0.876	1.141
	less than high school vs. degree	-0.027	0.223	-0.002	-0.119	0.905	0.743	1.346
	less than high school vs. others than all listed	-0.350	0.365	-0.016	-0.959	0.338	0.867	1.154
	single vs. married	1.600	0.185	0.175	8.658	0.000	0.605	1.652
	single vs. separated	0.888	0.649	0.022	1.367	0.172	0.923	1.084
	single vs. widowed	1.048	0.553	0.033	1.893	0.058	0.823	1.216
	Total energy	0.004	0.000	0.377	19.220	0.000	0.646	1.549
	F 1 (Traditional)	0.077	0.082	0.018	0.940	0.347	0.675	1.481
	F 2 (Prudent)	0.105	0.071	0.025	1.490	0.136	0.904	1.107
	F 3 (Modern)	0.185	0.071	0.043	2.607	0.009	0.896	1.116
	F 4 (Western)	-0.067	0.072	-0.016	-0.929	0.353	0.878	1.139
	F 5 (Chinese)	0.150	0.076	0.035	1.977	0.048	0.782	1.278
	F 6 (Combination)	-0.216	0.070	-0.051	-3.074	0.002	0.912	1.096

Next came the task of determining the outliers, normality, linearity, homoscedasticity and independence of residuals of the data. Residuals are the differences between the obtained and predicted dependent variables (Pallant 2007). One of the procedures for determining them is by looking at the Normal Probability Plot (P-P) of the Regression Standardised Residual and the scatterplot as presented in Figure 7.3 and Figure 7.4 respectively. In Figure 7.3, the normal P-P points lay in a sensibly oblique point. Meanwhile, in Figure 7.4 the scatterplot shows that the residuals were roughly of rectangular distribution with most of the score concentrated in the centre, at 0 point. The deviation from a centralised rectangle will suggest violation of assumptions. Hence, all these factors in this study meet the assumptions of normality and linearity.

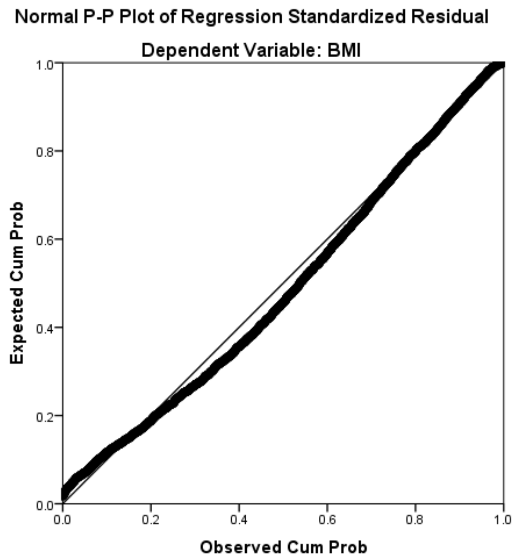


Figure 7.3: Normal P-P Plot of Regression Standardized Residual Dependent Variable: BMI

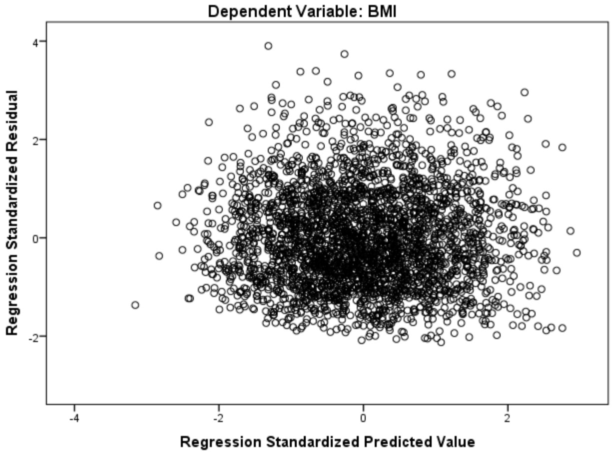


Figure 7.4: Scatter plot of standardised residuals which were roughly of rectangular distribution with most of the score concentrated in the centre, at 0 point

The existence of outliers can be detected through the scatterplot in Figure 7.4 as well. Tabachnick and Fidell (2013) suggest that outliers are those with more than 3.3.or less than -3.3 standardised residual. However, according to these researchers, it is normal to have a number of outlying residuals in a large sample size.

After a number of assumptions about the data has been checked and found not to be violated, the model for the data is evaluated. Table 7.10 shows the model summary. Age, gender, education, ethnicity, marital status and total energy intake were entered at step 1 (Block 1), explaining 23.7% of the variance in the BMI, with $R^2\Delta = 0.237$, $F\Delta\ (13, 3049) = 72.934$, p <0 .05. After entry of six dietary patterns at step 2 (Block 2), the total variance explained by the Block was 24.4%, indicating that the six dietary patterns explained an additional 0.7% of the variance in BMI, after controlling for the age, gender, education, ethnicity, marital status and total energy intake, $R^2\Delta = 0.006$, $F\Delta\ (6, 3043) = 4.223$, p <0 .05. Since the six dietary patterns only explained an additional 0.7% in BMI, we did not run the six dietary patterns in different steps (Blocks) as the R square change ($R^2\Delta$) was too small. We can only say that there is a low ability of the new predictors (six dietary patterns) to predict BMI. Even though the variance explained by these independent variables is small, yet it is statistically significant based on the calculations of Cohen *et al.* (2003).

Table 7.10: Model summary

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	0.487[a]	0.237	0.234	3.733	0.237	72.934	13	3049	0.000
2	0.493[b]	0.244	0.239	3.721	0.006	4.223	6	3043	0.000

a. Predictors: (Constant), Total energy, single vs. separated, Malay vs. Chinese, single vs. widowed, less than high school vs. college, less than high school vs. degree, Malay vs. Indian, less than high school vs. others than all listed, Malay vs. other, single vs. married, men vs. women, less than high school vs. high school, age in yrs
b. Predictors: (Constant), Total energy, single vs. separated, Malay vs. Chinese, single vs. widowed, less than high school vs. college, less than high school vs. degree, Malay vs. Indian, less than high school vs. others than all listed, Malay vs. other, single vs. married, men vs. women, less than high school vs. high school, age in yrs, REGR factor score 6 for analysis 1, REGR factor score 2 for analysis 1, REGR factor score 3 for analysis 1, REGR factor score 4 for analysis 1, REGR factor score 5 for analysis 1, REGR factor score 1 for analysis 1
c. Dependent variable: BMI

Next, it was important to determine the unique contribution of each variable included in the Block in the prediction of BMI. Thus, for determining the contribution of each variable, we refer to coefficient results as shown in Table 7.9. From the table, the Standardized Coefficients (Beta value) was referred. Standardised coefficient was selected than the Unstandardized (B value) for determination of contribution of each variable. This is because standardized coefficient (Beta value) has been converted to a scale that can be compared with other studies. Based on the table, the final model, age, gender (men vs. women), ethnicity (Malay vs. Chinese, and Malay vs. other), marital status (single vs. married), total energy intake, F3 ("Modern"), F5 ("Chinese") and F6 ("Combination") were statistically significant in explaining the BMI. Total energy intake recorded the highest beta value compared to the other significant predictors (beta =0 .377, $p < 0.05$). This indicates that the total energy intake provides the strongest unique contribution to explaining BMI, when the variance explained by all other variables in the model is controlled for. The Beta value for marital status (single vs. married) was the second largest contributor to BMI (beta = 0.175, $p < 0.05$). This was followed by age, gender (men vs. women), ethnicity (Malay vs. Chinese), F6 ("Combination"), F3 ("Modern"), ethnicity (Malay vs. Chinese) and F5 ("Chinese").

7.1.6 Baseline characteristics by quintile of dietary patterns for all respondents

Table 7.11 shows the distribution of respondents according to the lowest (Q1) and highest (Q5) quintile of each dietary pattern (based on factor scores). The baseline characteristics that were compared between the highest and lowest of the quintiles were as follow: age, BMI, gender, ethnicity and level of education.

An independent samples t-test was conducted to evaluate the hypothesis that there was no significance difference in age between the lowest and highest quintile for each dietary pattern. Age for the highest quintile of the "Prudent", "Western" and "Chinese" diets was substantially higher than those of the lowest quintile. The test was significant; Prudent: t (1165) = -3.99 at .05 alpha level two tails, Western: t (1185) = 2.0 at 0.05 alpha level two tails, and Chinese: t (1218) = -3.86 at 0.05 alpha level two tails. However, the magnitudes of the differences in the means for "Prudent", "Western", and "Chinese" dietary patterns were very small with eta squared = 0.013, 0.001, and 0.012 respectively. The 95% confidence interval of the difference was small for, "Prudent" ranging from -3.84 to -1.31, "Western" ranging from 6.49 to 8.90 and "Chinese" ranging from -1.8 to 2.18.

Table 7.11: Characteristics for the lowest and highest quintiles of 6-dietary patterns identified among the respondents [a] (n = 3,063)

	Factor 1: Traditional[b,c,d,e, f]		**Factor 2: Prudent**[b,c,d, f]		**Factor 3: Modern**[b,c,d, f]		**Factor 4: Western**[b,c,d,e, f]		**Factor 5: Chinese**[b,c,d]		**Factor 6: Combination**[c,d, f]	
	Q1	**Q5**	**Q1**	**Q5**	**Q1**	**Q5**	**Q1**	**Q5**	**Q1**	**Q5**	**Q1**	**Q5**
Age (years)	35.4 ± 11.1	34.4 ± 10.8	33.9 ± 11.3[a]	36.6 ± 10.8	35.8 ± 11.1	34.6 ± 10.9	39.1 ± 11.0[a]	31.4 ± 10.2	33.4 ±11.4[a]	36.0 ± 11.1	36.0 ± 11.2	35.0 ± 10.5
BMI (kg/m^2)	23.1 ± 4.1[a]	24.7 ± 4.5	23.0 ± 4.2[a]	24.4 ± 4.1	23.2 ± 4.3[a]	24.3 ± 4.3	24.0 ± 4.2[a]	23.5 ± 4.2	22.9 ± 4.2[a]	24.1 ± 4.2	23.9 ± 4.5	23.7 ± 4.2
Underweight [n (%)] [b]	70 (12)	41 (7)	82 (14)	37 (6)	76 (13)	55 (9)	44 (8)	72 (11)	88 (15)	46 (7)	66 (10)	63 (10)
Normal [n (%)]	333 (57)	277 (48)	329 (57)	300 (51)	327 (55)	283 (47)	297 (54)	359 (56)	322 (54)	336 (54)	361 (53)	319 (52)
Overweight [n (%)]	149 (26)	186 (32)	134 (23)	193 (33)	151 (26)	201 (34)	162 (29)	166 (26)	152 (25)	184 (30)	189 (28)	187 (30)
Obese [n (%)]	32 (5)	75 (13)	37 (6)	55 (9)	37 (6)	57 (10)	49 (9)	48 (7)	36 (6)	56 (9)	62 (9)	46 (8)
Gender [c]												
Men [n (%)]	255 (44)	338 (58)	342 (59)	268 (46)	314 (53)	348 (58)	277 (50)	357 (55)	166 (28)	458 (74)	296 (44)	372 (60)
Women [n (%)]	329 (56)	241 (42)	240 (41)	317 (54)	277 (47)	248 (42)	275 (50)	288 (45)	432 (72)	164 (26)	382 (56)	243 (40)
Ethnicity [d]												
Malay [n (%)]	83 (14)	437 (76)	376 (65)	263 (45)	314 (53)	279 (47)	251 (46)	355 (55)	356 (60)	223 (36)	273 (17)	384 (24)
Chinese [n (%)]	373 (64)	29 (5)	89 (15)	189 (32)	113 (19)	172 (29)	121 (22)	164 (25)	76 (13)	277 (45)	224 (30)	111 (15)
Indian [n (%)]	62 (11)	14 (2)	46 (8)	39 (7)	10 (2)	99 (17)	73 (13)	19 (3)	73 (12)	28 (4)	35 (14)	64 (25)
Others [n (%)]	66 (11)	99 (17)	71 (12)	94 (16)	154 (26)	46 (8)	107 (19)	107 (17)	93 (16)	94 (15)	146 (32)	56 (12)

Education [e]												
With degree [n (%)]	163 (28)	108 (19)	135 (23)	143 (24)	135 (23)	141 (24)	117 (21)	191 (30)	165 (22)	136 (22)	140 (21)	150 (24)
Without degree [n (%)]	421 (72)	470 (81)	447 (77)	442 (76)	456 (77)	455 (76)	435 (79)	454 (70)	433 (72)	486 (78)	538 (79)	465 (76)

[a] T-test for comparing difference for continuous variables and Chi-square test comparing percentile difference for categorical variables, Q5 as reference; significant at $p < 0.000$
[b.c.d. e.] There is significant difference between lowest (Q1) and highest quintiles (Q5); significant at $p < 0.000$

These results show that, even though the lowest and highest quintiles of "Prudent", "Western" and "Chinese" differ in age, the effect size is too small. Therefore, the null hypothesis could not be rejected as the difference in age between the lowest and highest quintiles appears to have been of little practical significance.

An independent samples t-test was also conducted to evaluate the hypothesis that there was no significance difference in BMI between the lowest and highest quintile for each dietary pattern. BMI was found to be significantly different between the lowest and highest quintile for all dietary patterns except for the "Combination" dietary pattern. The test was significant at 0.05 alpha level two tails. However, the magnitude of the differences in the means for the dietary patterns were very small with eta squared ranging from 0.004 to 0.02. These results suggest that, even though the dietary patterns appeared to differ in BMI between the lowest and highest quintiles, the effect size was too small. Therefore, the null hypothesis could not be rejected as the difference in BMI between the lowest and highest quintiles appears to have been of little practical significance.

A Chi-square test of independence was calculated comparing the lowest and highest quintiles of each dietary pattern in men and women. Gender (men and women) and the quintiles (lowest and highest quintiles) were found to be significantly related in:

"Traditional",	χ^2 (4, n = 3063)	= 48.6, $p < 0.05$, phi = 0.126;
"Prudent",	χ^2 (4, n = 3063)	= 31.0, $p < 0.05$, phi = 0.101;
"Modern",	χ^2 (4, n = 3063)	= 41.9, $p < 0.05$, phi = 0.117;
"Western",	χ^2 (4, n = 3063)	= 36.1, $p < 0.05$, phi = 0.109;
"Chinese",	χ^2 (4, n = 3063)	= 320.3, $p < 0.05$, phi = 0.123; and
"Combination",	χ^2 (4, n = 3063)	= 51.4, $p < 0.05$, phi = 0.13.

The phi coefficient indicates the correlation coefficient ranging from 0 to 1. The phi coefficient values for almost all dietary patterns were less than 0.3 which is considered a small effect using Cohen's criteria. This result shows that men and women do differ significantly in the lowest and highest quintiles of all dietary patterns but it was a very small effect size. We conclude that this was not of practical significance; therefore, we can say that there is no difference in the lowest and highest quintiles for each dietary pattern in men and women

A Chi-square test of independence was also calculated to compare the difference in the lowest and highest quintiles for each dietary pattern among Malay, Chinese, Indian and other groups. The Chi-square test for independence indicated that there were associations between ethnicity and quintile differences:

"Traditional",	χ^2 (12, n = 3063)	= 911.4, $p < 0.001$, Cramer's V = 0.545;
"Prudent",	χ2 (12, n = 3063)	= 73.5, $p < 0.001$, Cramer's V = 0.155;
"Modern",	χ^2 (12, n = 3063)	= 205.3, $p < 0.001$, Cramer's V = 0.259;
"Western",	χ^2 (12, n = 3063)	= 91.5, $p < 0.001$, Cramer's V = 0.173;
"Chinese",	χ^2 (12, n = 3063)	= 236.2, $p < 0.001$, Cramer's V = 0.278; and
"Combination",	χ^2 (12, n = 3063)	= 149.6, $p < 0.001$, Cramer's V = 0.221.

Cramer's V for almost all dietary patterns except for "Traditional", was less than 0.3 which is considered a small effect using Cohen's criteria. The "Traditional" dietary pattern had a large effect. Thus, there was a strong significant association between ethnicity and the quintiles for the "Traditional" dietary pattern (see Figure 7.5). Malay had the highest consumption of the "Traditional" dietary pattern while Chinese had the lowest consumption of the "Traditional" dietary pattern.

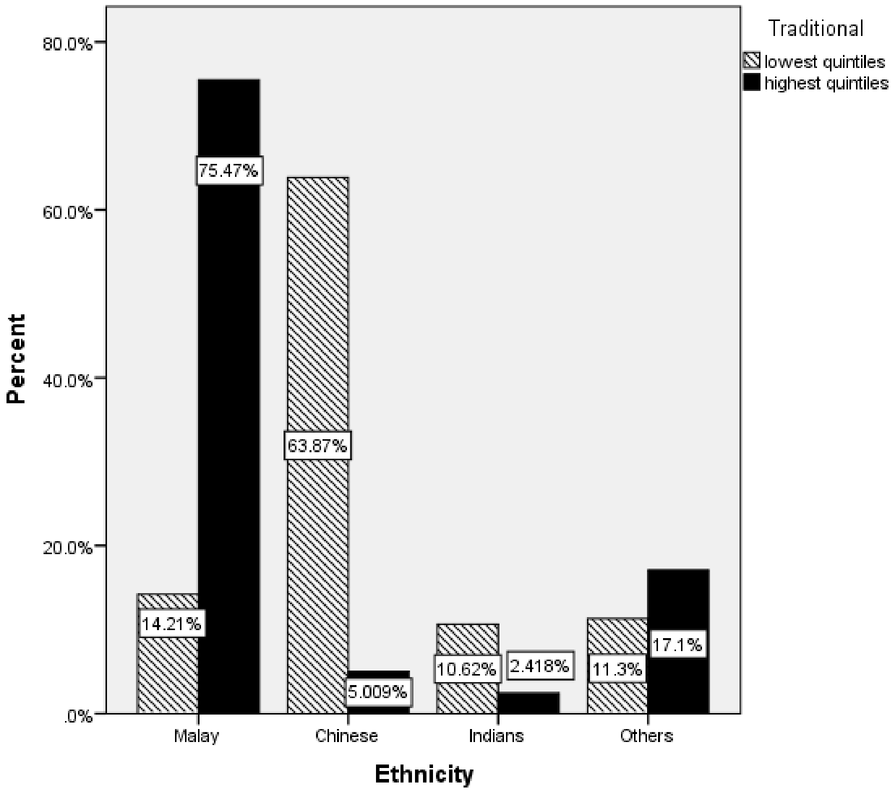


Figure 7.5: Distribution of Malay, Chinese, Indian and other according to the lowest and highest quintiles of a "Traditional" dietary pattern (n = 3,063)

A Chi-square test of independence was employed to compare the difference in the lowest and highest quintiles for each dietary pattern for different educational backgrounds. The result shows that there were associations between level of education and quintile differences for:

“Traditional”, χ^2 (4, n = 3063) = 16.7, $p < 0.001$, Cramer’s V = 0.074; and
“Western”, χ^2 (4, n = 3063) = 15.9, $p < 0.001$, Cramer’s V = 0.072.

The Cramer’s V values were 0.07, which is considered a very small effect. We conclude that this was not of practical significance; though it was statistically significant as for large numbers of sample size. Therefore, we can say that there is no difference in the lowest and highest quintiles for each dietary pattern in respondents with different educational backgrounds.

Table 7.12: Total energy intake and nutrient intake for the lowest (Q1) and highest (Q5) quintiles for six dietary patterns among the respondents [a] (n = 3,063)

Energy and nutrients	**Factor 1: Traditional**[a b c d]		**Factor 2: Prudent**[a c d e]		**Factor 3: Modern**[a b c]		**Factor 4: Western**[a b]		**Factor 5: Chinese**[a b c]		**Factor 6: Combination**[a d]	
	Q1	**Q5**	**Q1**	**Q5**	**Q1**	**Q5**	**Q1**	**Q5**	**Q1**	**Q5**	**Q1**	**Q5**
Energy (kcal/day) † [a]	2218 ± 17.5	2524 ± 17.9	2245 ± 17.4	2448 ± 18.1	2282 ± 17.5	2491 ± 18.2	2275 ± 16.6	2443 ± 17.8	2131 ± 16.2	2547 ± 17.5	2301 ± 16.6	2426 ± 16.9
Carbohydrate (g) [b]	18.9 ± 0.1	18.0 ± 0.1	18.7 ± 0.1	18.8 ± 0.1	18.39 ± 0.1	19.1 ± 0.1	19.0 ± 0.1	17.8 ± 0.1	19.1 ± 0.1	18.1 ± 0.1	18.6 ± 0.1	18.3 ± 0.1
Protein (g) [c]	4.2 ± 0.04	4.9 ± 0.06	4.1 ± 0.04	4.9 ± 0.08	4.7 ± 0.06	4.3 ± 0.05	4.6 ± 0.07	4.8 ± 0.04	4.2 ± 0.04	4.8 ± 0.05	4.4 ± 0.04	4.4 ± 1.1
Fat (g) [d]	2.2 ± 0.06	2.8 ± 0.09	1.9 ± 0.04	3.3 ± 0.12	2.3 ± 0.07	2.6 ± 0.08	2.5 ± 0.11	2.7 ± 0.06	2.5 ± 0.06	2.6 ± 0.08	2.2 ± 0.05	2.6 ± 0.06
Dietary fibre (g) [e]	0.40 ± 0.01	0.42 ± 0.02	0.21 ± 0.01	0.67 ± 0.02	0.39 ± 0.01	0.41 ± 0.01	0.44 ± 0.02	0.41 ± 0.01	0.42 ± 0.01	0.42 ± 0.01	0.41 ± 0.01	0.38 ± 0.01

[a b c d e f] T-test for comparing difference for continuous variables and Chi-square test comparing percentile difference for categorical variables, Q5 as reference; significant at $p < 0.000$
† reported in mean ± SE

Table 7.12 shows the total energy intake and nutrient intake for the lowest (Q1) and highest (Q5) quintiles for six dietary patterns among the respondents. An independent samples t-test was conducted to evaluate any significance difference in the total energy intake and nutrient intake for the lowest and highest quintile for each dietary pattern.

An independent samples t-test was employed to evaluate the hypothesis that there was a difference in total energy intake based on the lowest and highest quintiles for the six dietary patterns. The total energy intake for the lowest quintiles was substantially smaller than the highest quintiles in all six dietary patterns. The test was significant at 0.05 alpha level two tails. The magnitude of the difference in the means was small with eta squared (F2 = 0.05, F3 = 0.05, F4 = 0.038 and F6 = 0.02) except for the "Traditional" diet which had what would be considered a moderate effect size = 0.113. The 95% confidence interval of the difference for "Traditional" ranged from -354.75 to -256.52. Therefore, the null hypothesis for the "Traditional" diet was rejected as there was a moderate significance difference in total energy intake between the lowest and highest quintiles for the "Traditional" diet. Figure 7.6 shows the distribution for the lowest and highest quintiles for the "Traditional" diet.

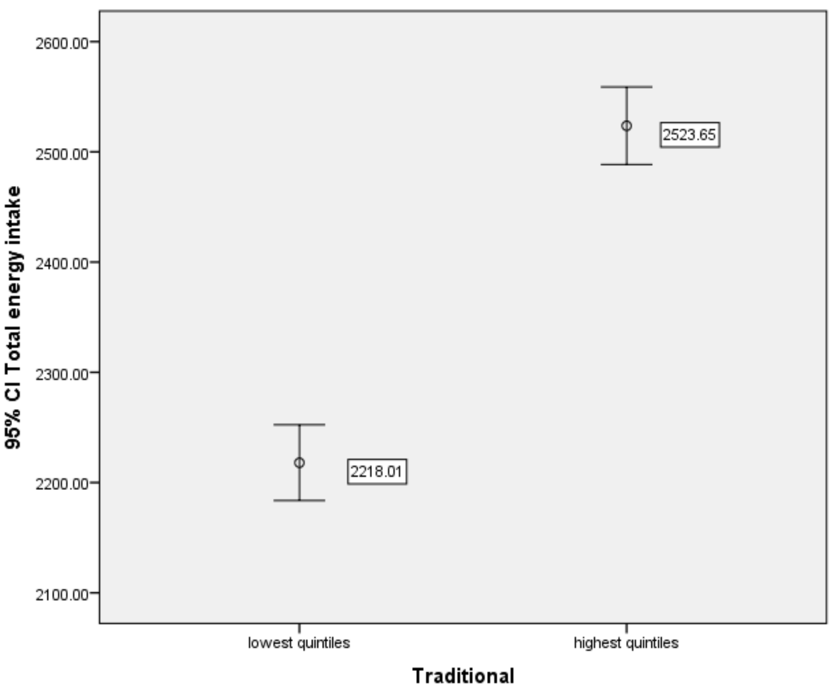


Figure 7.6: Distribution of total energy intake for the lowest and highest quintiles for the "Traditional" diet

There was only a significance difference in the total energy intake for the lowest and highest quintile of "Traditional" dietary pattern. Meanwhile, there was no significance difference in nutrient intake (carbohydrate, protein, fat and dietary fibre) for the lowest and highest quintile for each dietary pattern even though some had showed positive significance difference but the eta squared was very small, less than 0.01. Therefore, it indicates that the differences are of little health significance.

7.1.7 Discussions and summary of the PCA approach *(a posteriori)*

The present analysis explores dietary patterns amongst the Malaysian population using PCA. Six patterns were identified, "Traditional", "Prudent", "Modern", "Western", "Chinese" and "Combination" diets. All six patterns were able to explain 45.9% of the total variability. An earlier study conducted in Malaysia revealed four patterns within the Malaysian dietary pattern: modern, prudent, traditional and combination, explaining 69.4% of the total variance (Helen-Ng *et al.* 2012).

Age, gender, ethnicity, level of education and BMI were compared between the lowest and highest quintiles for all six dietary patterns. Results showed that there was only a significant association between ethnicity and the quintiles for the "Traditional" dietary pattern where Malay had the highest consumption of the "Traditional" dietary pattern while Chinese had the lowest consumption of the "Traditional" dietary pattern. Meanwhile, no significant practical difference was found between the lowest and highest quintiles for all six dietary patterns for age, BMI, gender and level of education. The aim was to observe differences between the quintile of the lowest and highest for each diet with regard to baseline characteristics. This is because some studies had shown a significance difference in terms of baseline characteristics. For example, for age, previous studies had shown that younger adults consume more of the "western" diet (Nielsen *et al.* 2002; Farzana *et al.* 2011; Larson *et al.* 2011), but less of the "prudent" diet compared to the older respondents (Grunbaum *et al.* 2004; Pearson and Biddle 2011). Another example relates to gender. Many studies had showed that women consume more fruit and vegetables than men (Dehghan *et al.* 2011; Lutfiyya *et al.* 2012) while men eat more meat and processed meats than women (Larsson and Wolk 2006; Ericson *et al.* 2013). However, this study failed to show any practical significance difference between the lowest and highest quintiles for all six dietary patterns for age, gender, level of education and BMI.

Total energy intake and nutrient intake (carbohydrate, protein, fat and dietary fibre) were compared between the lowest and highest quintiles for all six dietary patterns. Findings showed that only total energy intake in the "Traditional" diet gave practical significance difference between the lowest and highest quintiles. The total energy intake for the lowest quintiles was substantially smaller than for the highest quintiles in the "Traditional" diet.

Hierarchical multiple regression analysis was used to assess the ability of new predictors (all six-dietary patterns) to predict BMI, after controlling for the influence of gender, age, education, ethnicity, marital status and total energy intake. The results showed that all dietary patterns failed to show a significant association with BMI. Contrary to expectations, this study did not find a significant association between each dietary pattern and BMI. Therefore, factor analysis was unable to predict BMI. This result was different from those of other studies that merited association between dietary pattern and obesity through factor analysis (Sichieri 2002; Bamia *et al.* 2005; Okubo *et al.* 2008; Dugee *et al.* 2009; Kim *et al.* 2012). For instance, Dugee and colleagues (2009) identified three dietary patterns defined by PCA among Mongolians: (1) transitional high in processed meat and potato, (2) traditional rich in whole milk, fats and oils and (3) healthy with greater intake of whole grains, mixed vegetables and fruits. It was found that the higher quintile for the transitional pattern was linked with significantly greater risk of obesity in contrast to the higher quintile for the healthy pattern that was linked with significantly lower risk of obesity. Another study done in Korea found that the traditional dietary pattern here, which consists of white rice and kimchi, and also a diet pattern consisting of high-fat, sweets and coffee, both had a significant positive association with obesity after data were adjusted for socio-demographic and lifestyle factors (2012). A possible explanation for these results may be the heterogeneity of dietary intake patterns derived by factor analysis and lack of gold standards in applying the techniques might be a plausible explanation for the inconsistent results between dietary patterns and obesity (Togo *et al.* 2001). This was seconded by Newby and Tucker (2004) as they pointed out that some studies showed no association between dietary patterns defined by factor analysis and diet-related diseases, and inconsistencies were obvious. Inconsistencies may exist as a result of several methodological matters involved with factor analysis. Factor analysis went through several decision-making processes which may affect the number and type of patterns that are obtained, stated and evaluated (Newby and Tucker 2004). Referring to the previous method discussed in factor analysis, the initial step in making decisions is either to group food items into smaller numbers or simply to analyse all food items for entry analysis. If the researcher chooses to group the food items then, again, the researcher needs to make decisions on how to group them. The next decision relates to the number of patterns to retain in the final solution and then, finally, to naming them. All of these decisions were identified by Newby and Tucker (2004) and were stated to have an impact on the pattern analysis. Therefore, it is clear that more study of pattern analysis needs to be conducted among the Malaysian population to produce validity and reproducibility for this dietary approach considering all these methodological issues (Ibid). After having a clear set of definitions for the pattern analysis among the Malaysian population, then we can conduct association between pattern analysis and disease outcomes in the future.

7.2 Diet Quality Index Revised approach *(a priori)*

7.2.1 Introduction

In the previous section, it was explained that PCA was unable to show any associations between dietary pattern and obesity. Therefore, this part of the chapter presents *a priori* method, via DQI-R approach, for determining dietary pattern amongst the respondents. DQI-R consists of 10 components in which the total of those ten components will reflect the diet quality of the respondents. The next sub-section demonstrates the method used in analysing dietary pattern defined by DQI-R. After that, results are presented accordingly as below:

(i) Diet quality of respondents
(ii) Mean values of DQI-R components by score category
(iii) Relationship between BMI and DQI-R
(iv) Baseline characteristics of the respondents according to DQI-R score

7.2.2 Methodology

DQI-R, in this study, was measured by adapting the procedure used by Haines and colleagues (Haines *et al.* 1999). The semi-quantitative Food Frequency Questionnaire (FFQ) was used in performing DQI-R. This index consists of 10 components; 3 of them measure intake of food groups (grain group, vegetables group and fruit group), 5 of them assess nutrients (total fat, saturated fat, cholesterol, calcium and iron), and the remaining 2 components determine diet diversity and diet moderation (Kourlaba and Panagiotakos 2009) as shown in Table 7.13. The possible score for DQI-R ranged from 0 to 100 points where low scores reflect poor compliance with Malaysian dietary guidelines and vice versa. The first two components (total fat and saturated fat) were calculated as a percentage of total energy and contribute 0, 5, or 10 from each component depending on the achievement to fulfil the scoring criteria. Percentage of total fat and saturated fat should not exceed 30% and 10% of total energy intake respectively to obtain fullest marks (= 10 points). Then 5 points are given for total fat and saturated fat that were less than 40% but more than 30% and in between 10% and 13% respectively. Meanwhile, no scores were given for intake of more than 40% and 13% of total energy intake from total fat and saturated fat respectively. For dietary cholesterol, the daily recommended intake is less than 300 mg. Therefore, fulfilling the criteria would result in 10 points, while consuming more than 300 mg/day but less than 400 mg would result in 5 points. However, no points would be awarded if dietary cholesterol intake was more than 400 mg per day.

The next three components consist of food groups: fruit, vegetable and grain intake. The recommended servings for fruits, vegetables and grains (rice, noodle, bread, cereals, cereal products and tubers) were adjusted to Malaysian Dietary Guidelines (MDG). The score was presented as a continuous variable with a range of 0 to 10 points which was proportionate to the recommended range intake. Next, the component for calcium and iron were adjusted to Malaysian Recommended Nutrients Intake (RNI). The recommended calcium and iron were age dependent. The score given was delivered as a continuous score proportional to recommended range intake. The final two components in the DQI-R are the diversity and moderation scores.

Table 7.13: Components of DQI-R, the number of points available for each and the scoring criteria required to receive the highest and lowest scores

Component	**Score**	**Scoring criteria**
Total fat < 30% energy intake	0 -10 points	<30% = 10 ≥30, <40 = 5 >40 = 0
Saturated fat < 10% energy intake	0 -10 points	<10% = 10 >10, <13 = 5 >13% = 0
Dietary cholesterol < 300 mg/day	0 -10 points	<300mg = 10 >300, <400mg = 5 >400mg = 0
2 servings fruit per day [a e], % recommended servings	0 -10 points	>100% 99%-50% <50%

3 servings vegetables per day [a e], % recommended servings	0 -10 points	>100% 99%-50% <50%
4 - 8 serving grains per day [a e], % recommended servings	0 -10 points	>100% 99%-50% <50%
Calcium intake as % RNI for age [b c], % recommended servings	0 -10 points	>100% 99%-50% <50%
Iron intake as %RNI for age [c], % recommended servings	0 -10 points	>100% 99%-50% <50%
Dietary diversity score	0 -10 points	≥6 ≥3, <6 <3
Dietary moderation score	0 -10 points	≥7 ≥4, <7 <4

Adapted from Haines et al (1999)
[a]RNI = Recommended nutrient intake
[b]Iron bioavailability of 10% was used. It is recommended to used bioavailability of 10% for those in middle and lower income categories (NCCFN Malaysia, 2005)
[c]For the recommended servings, we had used the minimum size of servings recommended
[d]Based on 30g carbohydrate per serving
[e]Based on 1500, 2000 or 2500 kcal diet

The diversity component adapted 19 different broad food groups from the original 23 food groups in order to reflect Malaysian food consumption as shown in Table 7.14. The 19 food groups were listed under 4 main subgroups: grains, vegetables, fruits and meat/dairy components. A maximum score of 2.5 is to be given in each main subgroup giving a maximum total score of 10.0. A full score will be received only if respondents were to report consuming at least one and a half servings (Haines *et al.* 1999). The serving sizes were as suggested in the MDG. Hence, consumption of at least one serving of food out of each of the four main food groups daily in this study will receive the maximum overall variety score (max. = 10 points). If intake of any of these food groups is missing, the score is reduced.

Table 7.14: Elements of diet diversity score [a]

Food subgroups	Representative	Total score
Grains		**2.5**
Non whole grain breads/quick breads	White bread, biscuits, pancakes	
Pasta/all kind of noodles	Spaghetti, macaroni, wheat noodles, rice vermicelli	
Whole grain breads	Breads, pizza, tosai, capati, roti canai	
Whole grain cereals/non whole grain cereals	Cooked and ready to eat cereals	
Rice	All rice dishes	
Vegetable components		**2.5**
Green leafy vegetables	Mustard leaves, spinach, swamp cabbage	
Non-leafy vegetables	Ladies fingers, bean sprouts	
Root vegetables	Carrot, potatoes, sweet potato, yam and radish	
All types of cabbage	Cabbage, cauliflower, broccoli, Chinese cabbage	
Gourd vegetables	Cucumber, tomatoes, pumpkin, bitter gourd	
Ulam	Ulam	
Mushrooms	Fresh or dried mushrooms	
Fruit components		**2.5**
All other fruits and juices	Apples, bananas, grapes and etc	
Citrus fruit, melons	Oranges, citrus juices	
Meat/dairy components		**2.5**
Beef, mutton	Beef, mutton	
Milk	Milk, yogurt, cheese	
Poultry	Chicken, duck	
Eggs	Eggs	
Fish	All kind of fish	
	Total score	**10.0**

[a] Adapted from Haines *et al.* (1999)

On the other hand, dietary moderation scores consist of four elements; sugar, discretionary fat, sodium intake, and alcohol consumption as shown in Table 7.15. Each of the four components contributed to a maximum score of 2.5 which, in the end, will provide a total maximum score of 10.0. The breakdown of the 2.5 score includes 4 categories which are as follow: 2.5, 1.5, 1.0 and 0 points. The sugar included all sweeteners that were consumed separately or added as part of processed or prepared foods (Newby *et al.* 2003). Discretionary fat is defined as all additional fat in food beyond amounts found in the lowest fat forms, and included fats that were added to foods during preparation or at the table (Kantor 1998; Haines *et al.* 1999). Meanwhile, alcohol intake was converted to drinks per day. The recommended intake follows the US dietary guidelines as there is no clear cut guideline for alcohol consumption in Malaysia. The US dietary guidelines recommend alcohol intake of 1 drink per day for women and 2 drinks per day for men (Haines *et al.* 1999). These four elements: sugar, discretionary fat, sodium intake and alcohol consumption, were to reflect "discretionary" behaviour on the part of the respondents; more specifically, participants can control the quantity of sugar, alcohol, and salt intake (Popkin *et al.* 2003).

Table 7.15: Elements of diet moderation score

Component	**Score**	**Scoring criteria**
Sugar [a]	0 – 2.5 points	100% or less maximum = 2.5 points >100%, ≤150% = 1.5 points >150%, ≤200% = 1.0 points >200% = 0 points
Discretionary fat (g)	0 – 2.5 points	≤ 25 g/day = 2.5 points >25, ≤50 g/day = 1.5 points >50, ≤75 g/day = 1.0 points >75 g/day = 0 points
Sodium intake (mg)	0 – 2.5 points	≤2400 mg = 2.5 points >2400, ≤3400 mg = 1.5 points >3400 mg = 0 points
Alcohol intake	0 – 2.5 points	100% or less = 2.5 points >100%, ≤150% = 1.5 points >150%, ≤200% = 1.0 points >200% = 0 points

[a] Technical sub-committee on energy and macronutrients recommends sugar intake to be not more than 15% of total energy (NCCFN Malaysia, 2005) which will approximately be around 75g. This recommendation is higher than WHO/FAO (2003) which is not more than 10% (50g) of total energy as to be more realistic and appropriate advice for the local population (NCCFN Malaysia, 2005). Teaspoon measurement proposed by Haines *et al.* (1999) for measurement of sugar was changed to gram.

There are some of the components in DQI-R that followed the U.S. recommendation (saturated fat, dietary cholesterol intake, discretionary fat, and alcohol intake) as the recommendation was vague for Malaysian recommended nutrient intake. Other studies that had vague recommended nutrient intake, followed the original U.S. recommendation as well (Sundararajan *et al.* 2014). DQI-R consists of dietary adequacy (80 points), diversity (10 points) and moderation (points) (Sundararajan *et al.* 2014).

7.2.3 Results

7.2.3.1 Diet quality of respondents

Findings showed that the mean DQI-R scores of respondents was 64.6 (SD = 8.2) of a possible 100 points. There were six components from DQI-R that had scores of more than 8.0 points and four components with less than 3.5 points, as depicted in Table 7.16. The six components that achieved considerable good scores included energy intake from fat, energy intake from saturated fat, grain intake, calcium and iron intake and diet moderation. Meanwhile, four components that received poor scores were energy intake from dietary cholesterol, consumption of fruits and vegetables and diet diversity.

Table 7.16: Scores achieved in each DQI-R component (n = 3,063)

DQI-R component	Scores	Mean scores achieved
Component 1: Energy from fat	0 – 10 points	8.8 ± 2.8
Component 2: Energy from saturated fat	0 – 10 points	9.8 ± 1.2
Component 3: Dietary cholesterol	0 – 10 points	3.4 ± 4.2
Component 4: Servings of fruit per day	0 – 10 points	1.6 ± 3.2
Component 5: Servings of vegetables per day	0 – 10 points	3.1 ± 3.5
Component 6: Servings of grains per day	0 – 10 points	9.9 ± 0.1
Component 7: Calcium per day	0 – 10 points	8.1 ± 2.0
Component 8: Iron per day	0 – 10 points	8.0 ± 2.3
Component 9: Dietary diversity	0 – 10 points	2.1 ± 0.7
Component 10: Diet moderation	0 – 10 points	9.5 ± 0.8
Total	0 – 100 points	64.6 ± 8.2

7.2.3.2 Mean values of DQI-R components by DQI-R scores category

Mean values of DQI-R components and *r*-values for association between each component and DQI-R scores were determined and presented in Table 7.17. The relationship between each component and DQI-R scores was adjusted for age, gender and ethnicity. The mean percentage of energy from fat (M = 22.6, SD = 16.7) and saturated fat (M = 4.1, SD = 2.7) was less than 30% and 10% of energy intake respectively as recommended by dietary guidelines. There was a moderate, negative correlation between DQI-R scores and percentage of energy from fat, $r = -0.3$, n = 3063, $p < 0.001$ and saturated fat, $r = -0.29$, n = 3063, $p < 0.001$. Hence, as DQI-R scores increase, percentage of energy from fat and saturated fat will decrease.

Table 7.17: Mean values of DQI-R components by DQI-R score category (n = 3,063)

Variable	Mean ± SD	DQI-R score category										*r*-value
		0 - 40	**41 - 45**	**46 - 50**	**51 - 55**	**56 - 60**	**61 - 65**	**66 – 70**	**71 - 75**	**76 - 80**	**> 80**	
Number of subjects (%)	3063	3 (0.1)	16 (0.5)	83 (2.7)	252 (8.2)	555 (18.1)	786 (25.7)	629 (20.5)	415 (13.5)	206 (6.7)	118 (3.9)	
% of energy from fat	22.6 ± 16.7	92.4	97.9	50.1	28.7	22.3	21.6	19.9	19.5	18.8	19.0	- 0.30*
% of energy from saturated fat	4.1 ± 2.7	16.2	15.5	7.9	4.9	4.1	4.0	3.7	3.6	3.4	3.4	- 0.29*
Dietary cholesterol (mg)	523.3 ± 329.4	893.4	946.7	662.5	656.1	590.7	528.6	488.8	454.2	409.2	349.6	- 0.27*
% of recommended servings of fruit per day	19.7 ± 46.3	0.0	3.1	1.8	2.4	1.9	7.6	16.9	33.9	67.7	118.2	0.51*
% of recommended servings of vegetables per day	35.0 ± 48.4	0.0	6.3	2.8	6.6	11.1	21.9	44.0	66.6	74.8	94.6	0.52*
% of recommended servings of grains per day	178.4 ± 40.3	174.9	175.3	173.7	161.0	170.7	178.9	179.1	187.1	191.2	195.8	0.16*
% of RNI calcium per day	92.9 ± 38.2	127.9	116.3	85.0	75.4	80.7	90.8	97.2	104.5	107.4	114.7	0.24*
% of RNI iron per day	103.0 ± 55.4	222.0	193.8	98.3	80.0	88.5	99.3	104.7	118.5	126.5	128.7	0.12*
Dietary diversity (scale= 0 – 10)	2.1 ± 0.7	2.3	1.9	1.6	1.9	1.9	2.0	2.1	2.3	2.5	3.0	0.33*
Dietary moderation (scale= 0 – 10)	9.5 ± 0.8	7.5	9.6	9.5	9.5	9.5	9.5	9.4	9.5	9.5	9.6	0.02

* Correlation is significant at the 0.01 level (2-tailed), SD= standard deviation, RNI= recommended nutrients intake

Meanwhile dietary cholesterol had mean weight average of more than the upper threshold which was greater than 300 mg (M = 523.3 mg, SD = 329.4). There was a moderate, negative correlation between DQI-R scores and dietary cholesterol intake, $r = -0.27$, n = 3063, $p < 0.001$. Thus, as DQI-R scores increase, intake of dietary cholesterol decreases. Servings of fruit and vegetables had a mean average of 19.7 $\pm$ 46.3 and 35.0 $\pm$ 48.4 percent of recommended servings per day. There is a strong, positive correlation between DQI-R scores and fruit, $r = 0.51$, n = 3063, $p < 0.001$ and vegetables, $r = 0.52$, n = 3063, $p < 0.001$. On the other hand, grains had a mean average of 178.4 $\pm$ 40.3 percent of recommended servings per day. There was a weak positive correlation between grain consumption and DQI-R scores, $r = 0.16$, n = 3063, $p < 0.001$. Calcium and iron had achieved mean averages of 92.9 $\pm$ 38.2 and 103.0 $\pm$ 55.4 percent of recommended nutrient intake per day respectively. However, there was only a weak, positive correlation between DQI-R scores and intake of calcium, $r = 0.24$, n = 3063, $p < 0.001$ and iron, $r = 0.12$, n = 3063, $p < 0.001$. The last two components, dietary diversity and dietary moderation had mean scores of 2.1 $\pm$ 0.7 and 9.5 $\pm$ 0.8 points. There was a moderate association between diet diversity and DQI-R scores, $r = 0.33$, n = 3063, $p < 0.001$ but no association between dietary moderation and DQI-R scores, $r = 0.02$, n = 3063, $p > 0.001$. The breakdown of scores in dietary diversity and dietary moderation is as shown in Table 7.18 and Table 7.19 respectively.

Table 7.18: Scores achieved in dietary diversity among respondents (n = 3,063)

Food subgroups	Maximum score	Scores achievement (Mean $\pm$ SD)
Grains	2.5	0.8 $\pm$ 0.3
Non whole grain breads/quick breads		
Pasta/all kind of noodles		
Whole grain breads		
Whole grain cereals/non whole grain cereals		
Rice		
Vegetable components	2.5	0.1 $\pm$ 0.2
Green leafy vegetables		
Non-leafy vegetables		
Root vegetables		
All types of cabbage		
Gourd vegetables		
Ulam		
Mushrooms		
Fruit components	2.5	0.1 $\pm$ 0.3
All other fruits and juices		

Citrus fruit, melons		
Meat/dairy components	2.5	1.1 ± 0.5
Beef, mutton		
Milk		
Poultry		
Eggs		
Fish		
Total	**10.0**	**2.1**

Respondents had shown poor scores for dietary diversity. The scores obtained for dietary diversity were only 2.1 out of 10 points. The mean totals for diet diversity of grains, vegetables, fruit and meat/dairy components were 0.8 ± 0.3, 0.1 ± 0.2, 0.1 ± 0.3 and 1.1 ± 0.5 respectively. Despite high consumption of rice, the score for grain diversity was poor as Malaysian staple foods are concentrated only on rice consumption rather than other grains. Fruit and vegetables had the lowest scores for diet diversity compared to other components in diet diversity.

Meanwhile, respondents achieved 9.5 points out of 10 for dietary moderation as shown in Table 6.19. This means that each component was achieved within the advisable range of intake as suggested by Malaysian dietary guidelines.

Table 7.19: Scores achieved for dietary moderation among respondents (n = 3,063)

Component	**Score**	**Scores**
Added sugar	0 – 2.5 points	2.48
Discretionary fat (g)	0 – 2.5 points	2.49
Sodium intake (mg)	0 – 2.5 points	2.03
Alcohol intake	0 – 2.5 points	2.49
Total	0 – 10 points	9.5

7.2.3.3 Relationship between BMI and DQI-R

Partial correlation was used to explore the relationship between DQI-R and BMI, while controlling for age, gender, ethnicity, household income and total energy intake. A histogram of DQI-R was performed to ensure there was no violation of the assumption of normality (see Figure 7.7). There was no significant correlation between DQI-R and BMI when controlling for age, gender, ethnicity, household income and total energy intake, $p > 0.000$. An inspection of the zero order correlation found that there was a weak, positive correlation between DQI-R and BMI when not controlling for the other variables, $r = 0.08$, n = 3063, $p < 0.000$. This suggested that controlling for other variables had an effect on the significance of the relationship between these two variables.

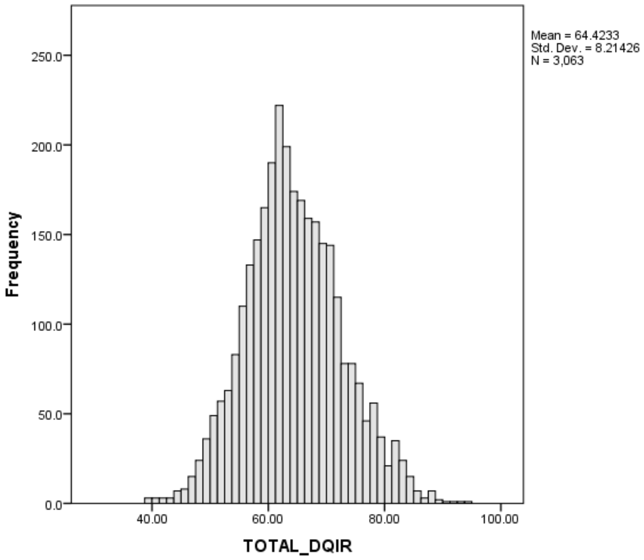


Figure 7.7: Distribution of DQI-R scores achieved by respondents (n = 3,063)

7.2.3.4 Baseline characteristics of the respondents according to DQI-R score

Continuous DQI-R scores were collapsed into five quintiles via 'visual binning' provided in SPSS. Visual binning is used to determine reasonable cut-off points to break the continuous variable DQI-R scores into five approximately equal groups.

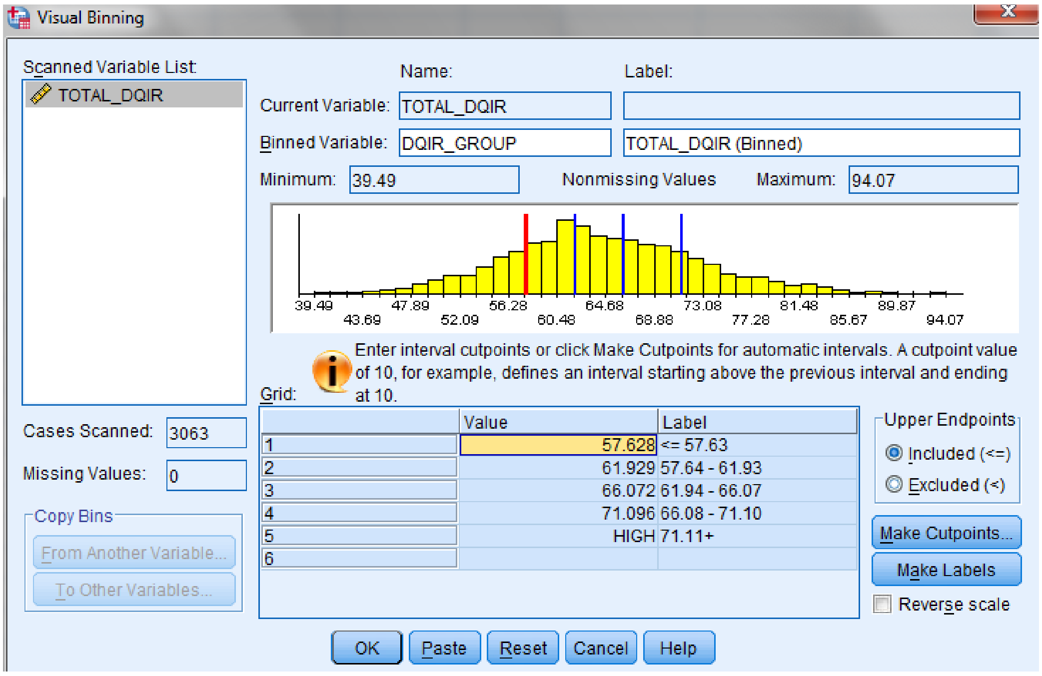


Figure 7.8: Grouping continuous DQI-R scores (TOTAL DQI-R) into quintiles of five (DQIR_GROUP)

The quintiles were then compared with the characteristics of the respondents. A one-way between-group analysis of variance was conducted to explore the differences in DQI-R scores in relation to the characteristics of the respondents. Respondents had been divided into five quintiles according to DQI-R scores: Q1: 57.63 or less, Q2: 57.64 to 61.93, Q3: 61.94 to 66.07, Q4: 66.08 to 71.10, and Q5: 71.11 and above (as shown in Figure 7.8). There was a statistically significant difference at $p < 0.05$ level between quintiles of DQI-R scores and *age*: F (4, 3057) = 8.4, $p < 0.001$, *household income*: F (4, 3058) = 5.0, $p < 0.001$, *BMI*: F (4, 3058) = 6.9, $p < 0.001$, and *total energy intake*: F (4, 3058) = 31.1, $p < 0.001$. Despite reaching statistical significance, the actual difference in mean scores between quintiles was quite small for all variables. The effect size, calculated using eta squared, was less than 0.04 for all variables indicating a small effect. The difference is of little practical importance but related to a significant difference as a result of the large sample size (n= 3063). Only household income had a medium effect since the eta squared calculated was 0.66. The effect size was calculated manually based on the proportionate sum of squares between groups and the total sum of squares provided in an ANOVA table.

$$\text{Eta squared} = \frac{\text{Sum of squares between groups}}{\text{Total sum of squares}}$$

Table 7.20: Characteristics of respondents according to quintiles of DQI-R scores †† (n = 3,063)

Characteristics	N	Q1	Q2	Q3	Q4	Q5
Gender						
Men, n (%)	1493	210 (14.1)	295 (19.8)	314 (21.0)	338 (22.6)	336 (22.5)
Women, n (%)	1570	403 (25.7)	317 (20.2)	299 (19.0)	274 (17.5)	277 (17.6)
Marital status						
Single, n (%)	894	169 (18.9)	208 (23.3)	187 (20.9)	170 (19.0)	160 (17.9)
Married, n (%)	2074	426 (20.5)	387 (18.7)	406 (19.6)	423 (20.4)	432 (20.8)
Divorced, n (%)	36	7 (19.4)	5 (13.9)	8 (22.2)	8 (22.2)	8 (22.2)
Widowed, n (%)	56	9 (16.1)	12 (21.4)	12 (21.4)	11 (19.6)	12 (21.4)
Ethnicity						
Malay, n (%)	1602	379 (23.7)	356 (22.2)	316 (19.7)	293 (18.3)	258 (16.1)
Chinese, n (%)	746	96 (12.9)	134 (18.0)	155 (20.8)	174 (23.3)	187 (25.1)
Indian, n (%)	252	21 (8.3)	47 (18.7)	56 (22.2)	50 (19.8)	78 (31.0)
Age (years)		34.2 ± 0.4	33.5 ± 0.4	34.5 ± 0.4	35.8 ± 0.4	36.7 ± 0.5 †
18 to 29 years, n (%)	1182	235 (19.9)	282 (23.9)	241 (20.4)	219 (18.5)	205 (17.3)
30 to 50 years, n (%)	1572	340 (21.6)	273 (17.4)	314 (20.0)	322 (20.5)	323 (20.5)
51 to 60 years, n (%)	308	38 (12.3)	56 (18.2)	58 (18.8)	71 (23.1)	85 (27.6)
Education						
With degree, n (%)	736	141 (19.1)	144 (19.5)	150 (20.4)	145 (19.7)	157 (21.3)
Without degree, n (%)	2325	471 (20.3)	468 (20.1)	463 (19.9)	467 (20.1)	456 (19.6)
Household income (MYR)		1631.2 ± 69.4	1844.4 ± 73.5	2140.1 ± 106.3 †	2237.3 ± 178.9 †	2110.3 ± 89.6 †
MYR 1500 or less, n (%)	1695	397 (23.4)	347 (20.5)	316 (18.6)	319 (18.8)	316 (18.6)
MYR 1500 – 3500, n (%)	953	156 (16.4)	197 (20.7)	203 (21.3)	201 (21.1)	196 (20.6)
MYR 3500 and above, n (%)	414	60 (14.5)	67 (16.2)	94 (22.7)	92 (22.2)	101 (24.4)
BMI (kg/m²)		23.0 ± 0.2	23.1 ± 0.2	23.5 ± 0.2	23.9 ± 0.2 †	24.0 ± 0.2 †
Underweight, n (%)	333	78 (23.4)	83 (24.9)	61 (18.3)	55 (16.5)	56 (16.8)
Normal, n (%)	1691	360 (21.3)	346 (20.5)	349 (20.6)	326 (19.3)	310 (18.3)
Overweight, n (%)	806	128 (15.9)	137 (17.0)	153 (19.0)	186 (23.1)	202 (25.1)
Obese, n (%)	233	47 (20.2)	46 (19.7)	50 (21.5)	45 (19.3)	45 (19.3)
Total energy intake (kcal/day)	3063	2151.6 ± 15.9 †	2267.7 ± 17.5 †	2300.9 ± 17.2 †	2344.9 ± 17.2 †	2404.1 ± 17.0 †

†† One-way Anova for comparing difference for continuous variables and Chi-square test comparing percentile difference for categorical variables, Q1 as reference
† There is significant difference at $p < 0.05$

Post-hoc comparisons for *age* using the Tukey HSD test showed that the mean score for Q1 (M = 34.2 years, SE = 0.4) was significantly different from Q5 (M = 36.7 years, SE = 0.5). It showed that the major difference was mean age between Q1 and Q5. Those with the highest score for diet quality were older than those with the lowest score for diet quality. Post-hoc comparisons for *household income* using the Tukey HSD test showed that the mean score for Q1 (M = 1631 MYR, SE = 69.4) was significantly different from Q3 (M = 2140 MYR, SE = 106.3), Q4 (M = 2237, SE = 178.9) and Q5 (M = 2110, SE = 89.6). Post-hoc comparisons for *BMI* using the Tukey HSD test showed that the mean score for Q1 (M = 23.0, SE = 0.2) was significantly different from Q4 (M = 23.9, SE = 0.2) and Q5 (M = 24.0, SE = 0.2). Post-hoc comparisons for *total energy intake* using the Tukey HSD test showed that the mean score for Q1 (M = 2152 kcal, SE = 15.9) was significantly different from Q2 (M = 2268 kcal, SE = 17.5), Q3 (M = 2301 kcal, SE = 17.2), Q4 (M = 2345 kcal, SE = 17.2) and Q5 (2404 kcal, SE =17.0). Despite reaching statistical significance, the actual difference in mean scores between quintiles was small for all variables.

A Chi-square test for independence indicated significant association between gender and DQI-R scores, χ^2 (4, n = 3063) = 72.4, $p < 0.001$, phi = 0.15. Results in Table 7.20 depict that most men were concentrated in quintile 4 (22.6%) and quintile 5 (22.5%) for DQI-R scores but women mainly had the lowest in DQI-R scores (25.7%).

7.2.4 Discussions and summary of DQI-R approach

Mean total DQI-R scores for respondents were approximately 65 points out of 100 with standard deviation of $\pm$ 8.2. Several studies had obtained DQI-R scores of approximately 60 to 70 points, similar to Malaysian diet quality scores (Haines *et al.* 1999; Clutter Snyder *et al.* 2007). A recent study in Canada showed 6325 adult men and 7211 non-pregnant adult women from the 2004 Canadian Community Health Survey had mean DQI-R scores of 67.4 (Sundararajan *et al.* 2014). The diet quality of Malaysian respondents was considered "in need of improvement" as it reflects relatively low compliance with the recommended intake in several DQI-R components. Despite achieving good scores in energy intake from fat, energy intake from saturated fat, grain intake, calcium and iron intake and diet moderation, Malaysian respondents obtained poor scores in dietary cholesterol, consumption of fruit and vegetables and diet diversity. This also accords with our earlier findings in UPP, which showed that consumption of fruit and vegetables is relatively small despite the existence of a "Prudent" diet which resulted from factor analysis. Many earlier studies showed that consumption of fruit and vegetables in Malaysia is low. The Food and Agriculture Organization estimated that from 1980 to 2003, total daily consumption of fruit and vegetables amongst the Malaysian population was 228 g (fruit = 150 g and vegetables = 78 g) which was lower than the WHO recommendation (Yen and Tan 2012). Low fruit and vegetable consumption was defined by WHO as having less than five servings of fruit and/or vegetables per day (or less than 400 g of fruits and vegetables daily) (WHO/FAO 2003). A cross-sectional study was carried out amongst the Malaysian population aged 20 to 24 years and it found that respondents who consumed fruits only 2 to 3 days in a week were in the majority whereas less than 29% of respondents reported having fruit every day (Al-Naggar *et al.* 2013). Findings from The World Health Survey (WHS), a large cross-sectional study, administered in 70 countries in 2002–2003, found that about 85% of Malaysian adults were in the 'low' category for consumption of vegetables as defined by WHO guidelines (Hall *et al.* 2009). In accordance with the present findings, another cross-sectional study conducted in several suburbs in Malaysia demonstrated that the vegetable intake was only three times a week and the intake of fruit only 2 times a week in households (Zainal Badari *et al.* 2012). Low consumption of fruit and vegetables was shown to have an adverse effect on health status (Oyebode *et al.* 2014) and higher consumption as recommended may promote better health and reduce health risks (Hartley *et al.* 2013; Rekhy and McConchie 2014). A possible explanation for low intake of fruit and vegetables in Malaysia is the high price of the goods compared to other foods. This was supported by a study carried out by Shamsul and colleagues (2012) which showed that lower consumption of fruit and vegetables among 285 adults in Klang Valley, Malaysia was the result of higher prices. This was seconded by the findings of Kearney and colleagues (2008) and other studies (Giskes *et al.* 2009; Bihan *et al.* 2010; Jack *et al.* 2013) which depicted that lower socioeconomic status respondents had a lower intake of fruit and vegetables than those with a higher socioeconomic status. Other socioeconomic status too may link to an association with DQI-R in other studies conducted, for instance, age, marital status and other factors. All in all, Malaysian consumption of fruit and vegetables is lower than the WHO recommendation.

The diet diversity score among the respondents in this study was found to be very low. The mean totals for diet diversity of grains, vegetables, fruit and meat/dairy components were 0.8 $\pm$ 0.3, 0.1 $\pm$ 0.2, 0.1 $\pm$ 0.3, and 1.1 $\pm$ 0.5 respectively. The score for grain diversity is poor as Malaysian staple foods are more concentrated on rice consumption than other grains. Fruit and vegetables had the poorest score in diet diversity while meat/dairy components had better scores. A recent cross-sectional study in Malaysia also showed low scores in diet diversity. The foods were found to be less varied in the food groups and respondents were focused only on palatable foods that were cheaper and affordable (Zainal Badari *et al.* 2012). A study done in Malaysia showed that respondents with higher scores in diet diversity and higher intake of meat/fish/poultry/legumes were more likely to have fewer health risks (Mohamadpour *et al.* 2012) and better child growth (Ey Chua *et al.* 2012) while poorer scores were linked with a higher risk of food insecurity (Ihab *et al.* 2012). These results seem to be consistent with other research which found that low diet diversity is significantly related to food insecurity (Labadarios *et al.* 2011; Belachew *et al.* 2013), and higher risk of poor health status (Kant and Graubard 2005; Azadbakht *et al.* 2006; Flores *et al.* 2010; Azadbakht and Esmaillzadeh 2011). Azadbakht (2005) has proposed to mainly increase variety of fruits and vegetables as to increase diet diversity scores. This is, perhaps, a crucial recommendation for Malaysians as well, since the consumption of fruit and vegetables itself is low.

DQI-R scores had an inverse association with fat, saturated fat and dietary cholesterol in this study. On the other hand, DQI-R scores had a positive association with fruit, vegetables and dietary diversity. The present findings seem to be consistent with other studies which shared similar results (Fung *et al.* 2005). Hence, it could conceivably be hypothesised that respondents with higher DQI-R scores may have better intake of fruit, vegetables and better dietary diversity but at the same time is having low intake of fat, saturated fat and dietary cholesterol.

Results from the significant differences across the quintiles showed that respondents with the highest scores for diet quality were older, had higher household incomes, higher BMIs and higher energy intakes than those with the lowest scores. However, it was only household income that had a medium effect while others had a small effect. Fisberg and colleagues (2006) found results similar to those in this study where age, household income and energy intake had a positive association with diet quality among 3454 adults aged 20 years and above living in regions of the State of São Paulo, Brazil. Another study taken from the US Continuing Survey of Food Intake by Individuals 1994-96 showed that household income had a positive association with diet quality (Forshee and Storey 2006). There seems to be an interrelation between being older and having higher household income in this sample of study. People buy more foods including fruit and vegetables when they have access to more money (Kearney *et al.* 2008; Zainal Badari *et al.* 2012; Kant and Graubard 2013). This may explain why DQI-R scores improve as respondents grow older and have a higher household income. The cons of having a higher household income are the tendency to buy more energy-dense foods which may lead to an imbalance of energy balance (Caballero 2007). In essence, there is a connection which exists between DQI-R and age, household income, BMI and energy intake in this sample study.

This study set out with the main aim of assessing the association between dietary patterns and obesity. The Revised diet quality index (DQI-R) is the third approach used in this study after adopting the UPP and PCA approaches. The results of this study were unable to show that DQI-R and BMI are correlated after being adjusted for age, gender, ethnicity, household income and total energy intake. This finding is consistent with the UPP and PCA analysis in earlier chapters for which all findings had shown no significant correlation between dietary patterns and BMI among this sample study. This finding also accords with several previous studies, which showed that BMI were uncorrelated with dietary pattern (Kant *et al.* 1991; Slattery *et al.* 1997; Kant 2000; Kant *et al.* 2000). However, this finding was unable to support previous research which links dietary patterns and BMI as discussed in the literature review previously (Sichieri 2002; Okubo *et al.* 2008; Dugee *et al.* 2009; Sherafat-Kazemzadeh *et al.* 2010; Kim *et al.* 2012; Tavares *et al.* 2012). There are several possible explanations for this result.

The explanation for this will be discussed in length in the conclusion chapter along with other dietary approaches as well.

7.3 Conclusion

This chapter, Chapter Six, had set out to explore dietary pattern approaches by *a posteriori* (PCA approach) and *a priori* methods (DQI-R) and their relationship with nutrient intake (*diet quality*) and body mass index (BMI). Meanwhile, in previous Chapter Five, UPP approach had been used to explore dietary pattern and its relationship with nutrient intake and BMI. Therefore, for the next upcoming chapter, Chapter Seven, a comparison between these three approaches will be explained and further discussion on the judgement on the mixing of methods will be discussed. Chapter Seven will also discuss on the absence of association between the three dietary approaches and BMI.

Chapter 8: Discussion and Conclusion

This chapter presents the discussion of the main findings of the study, reviews these findings in the light of previously published work and finally draws conclusions and recommendations for future research.

8.1 Main findings

Before presenting the main findings of results obtained from this study, a reminder of the introduction will be given. The study aim was to **explore dietary patterns [1]** **using different approaches [2]** and to determine the relationship between **each dietary pattern and obesity [3]** among the **Malaysian population [4]**. The purpose of conducting this study has been explained in earlier chapters (Chapter 1 to Chapter 3). However, a recap of all justifications is given below in a summary point.

1 - The reasons for **exploring dietary pattern** rather than exploring single nutrients were:

(i) epidemiological studies were unable to yield consistent results on the association between single nutrients and obesity (Lissner and Heitmann 1995; Seidell 1998);

(ii) intakes of certain foods are highly correlated, thus it becomes difficult to examine their effect separately as people do not eat only certain nutrients or foods, but rather a complex mixture of foods;

(iii) the effect of a single nutrient may be too small to detect, but the cumulative effects of multiple nutrients included in a dietary pattern may be sufficiently large to be detectable (Hu 2002b).

2 - The reasons for **using different dietary approaches** were:

(i) A number of approaches in classifying dietary patterns have been developed and used in developed and developing countries, but they have not yet been widely used in Malaysia. Our main focus was the Ultra-Processed Products/Foods (UPP) approach, a recent approach towards a new food classification based on the nature, extent and purpose of food processing. Why was UPP the main focus?

a. lack of summary or critical appraisal of the body of literature over the past decade on the study of processed foods in Malaysia;
b. increased consumption of processed foods nowadays in Malaysia due to 'less-time for food preparation', global food industry, cheaper prices and aggressive marketing;
c. increasing consumption of processed foods was associated in ecological studies with the increase of NCDs (Cutler *et al.* 2003; Monteiro *et al.* 2011; Moubarac *et al.* 2012);
d. the impact of processed foods on BMI has not been well studied

(ii) By exploring different dietary approaches, we can compare the differences of the UPP approach in classifying dietary pattern with other established dietary pattern approaches (i.e. Principal Component Analysis, *a posteriori* approach and Diet Quality Index-Revised approach, *a priori* approach)

3 - The reasons in determining the relationship between **each dietary pattern and obesity** were:

(i) studies examining the association between dietary patterns and obesity are vague, doubtful and controversial (Togo *et al.* 2001)
(ii) studies have shown positive/adverse association between dietary pattern and obesity
   a. low scores in the Healthy Eating Index (*a priori* approach) were significantly related to overweight and obesity (Guo *et al.* 2004)
   b. higher dietary index scores (*a priori* approach) showed a consistent negative association with BMI and obesity (Togo *et al.* 2001)
   c. Principal component analysis (PCA -*a posteriori* approach) was applied to generate Mongolian dietary intake and revealed three dietary patterns. Findings showed that respondents in the higher quintile of the transitional pattern (which is high in processed meat and potato) had significantly greater risk of obesity, while respondents in the higher quintile of healthy pattern (which had high intake of whole grains, mixed vegetables and fruits) had significantly lower risk of obesity (Dugee *et al.* 2009)
   d. PCA was performed for Korean dietary intake and resulted in four dietary patterns. The Western dietary pattern, consisting of high-fat, sweets and coffee, had a significant positive association with obesity after adjustments for socio-demographic and lifestyle factors (Kim *et al.* 2012)
   e. high consumption of highly processed foods (Group 3 of the UPP approach) and the metabolic syndrome are significantly associated (Tavares *et al.* 2012)

Therefore, this study was conducted to determine the association of each dietary pattern and BMI among the Malaysian population as there are very few studies examining dietary patterns and obesity in Malaysia

(iii) by characterising the dietary pattern that best predicts overweight and obesity, Malaysia will at least have a tool to monitor the nutritional status of the population, dietary pattern, and associated NCD risk;

(iv) whether different ways of characterising dietary patterns will be better able to predict obesity via nutrient intake;

(v) and that even if no link presence with obesity there are important links with dietary risk factors associated with increased risk of hypertension and other NCDs

4 - The reasons for conducting the study on the **Malaysian population** were:

(i) Malaysia is experiencing transition in dietary patterns, mainly because of rapid changes in globalisation and urbanisation, which leads towards more variety and includes more processed food, more food of animal origin, with more added sugar and fat (Popkin *et al.* 2001a). This transition may bring some benefits i.e. for stunting and nutrition deficiencies.

(ii) Nutrition transition in Malaysia is associated with an increase of overweight and obesity alongside the co-existing problem of under-nutrition, leading to a "double burden of malnutrition" (Schmidhuber and Shetty 2005).

(iii) Performing such a study among the Malaysian population would be of great interest, as Malaysian is multiracial country consists of different ethnicities, namely Malays, Chinese and Indians.

(iv) It is more challenging to investigate the association between dietary patterns and obesity among such a multi-ethnic population.

(v) There are very few studies examining dietary patterns and obesity in Malaysia.

General findings of each dietary approach

The findings of each approach have been fully described in Chapter 6 (findings of the UPP approach) and Chapter 7 (findings of the PCA and DQI-R approach). Here, we summarise the findings from the analysis of the 3,063 Malaysian adult populations, aged 18 to 59 years, drawn from the Malaysia Adult Nutrition Survey (MANS). Table 8.1 shows the summary of the three dietary approaches. The UPP approach showed that 45.5%, 19.7%, 5.8% and 29.8% of total energy intake came from Group 1 (unprocessed or minimally processed foods), Group 2 (processed culinary ingredients), Group 1&2 (traditional prepared foods) and Group 3 (ultra-processed products/foods), respectively. PCA analysis derived a six-pattern analysis of dietary patterns addressed as “Traditional”, “Prudent”, “Modern”, “Western”, “Chinese” and “Combination”. About 46% of the total variability of total energy intake was explained by these six dietary patterns. The DQI-R approach produced a mean score of 64.6 (SD = 8.2) out of 100 points (quality increases with the score) reflecting the diet quality of the respondents. The current score of DQI-R indicates that the diet quality could be improved.

Table 8.1: Main findings from the three dietary approaches (UPP, PCA and DQI-R)

	UPP APPROACH	**PCA APPROACH**	**DQI-R APPROACH**
General findings of each approach	Relative contribution of each group to total energy intake: 1. Group 1 (unprocessed or minimally processed foods) – 45.5% 2. Group 2 (processed culinary ingredients) – 19.7% 3. Group 1&2 (traditional prepared foods) – 5.8% 4. Group 3 (ultra-processed products/foods) – 29.8%	Six patterns were identified: 1. "Traditional" diet 2. "Prudent" diet 3. "Modern" diet 4. "Western" diet 5. "Chinese" diet and 6. "Combination" diet All six patterns were able to explain 45.9% of the total variability.	Mean DQI-R score of respondents was 64.6 $\pm$ 8.2 of a possible 100 points. Mean values of ten DQI-R components: 1. % energy from fat = 22.6 $\pm$ 16.7 (Mean + SD) 2. % energy from saturated fat = 4.1 $\pm$ 2.7 3. Dietary cholesterol = 523.3 mg $\pm$ 329.4 4. % Recommended servings of fruit per day = 19.7 $\pm$ 46.3 5. % Recommended servings of vegetables per day = 35.0 $\pm$ 48.4 6. % Recommended servings of grains per day = 178.4 $\pm$ 40.3 7. % RNI calcium per day = 92.9 $\pm$ 38.2 8. %RNI iron per day = 103.0 $\pm$ 55.4 9. Dietary diversity (scale=0 – 10) = 2.1 $\pm$ 0.7 10. Dietary moderation (scale= 0 – 10) = 9.5 $\pm$ 0.8
The dietary approach selected - from the perspective of socioeconomic status (SES)	Group 1 consumption was higher among those living in rural counterpart, other ethnicities, divorced/separated, less than high school education, household income less than MYR 1500 and normal weight. Group 2 consumption was the highest among the obese respondents	Age, gender, ethnicity, level of education and BMI were compared between the lowest and highest quintiles for all six dietary patterns. Results showed that there was only a significant association between ethnicity and the quintiles for the "Traditional" dietary pattern, where Malay had the highest consumption of the "Traditional"	There was a statistically significant difference between quintiles of DQI-R scores and age, gender, BMI, and total energy intake. Despite reaching statistical significance, the actual difference in mean scores between quintiles was small for all variables.

	Group 1&2 consumption was the highest among Indians, followed by Malay and Chinese. Group 3 consumption was higher among women, living in urban areas, Indian, single, had a Bachelor's degree, and household income more than MYR 3500	dietary pattern while Chinese had the lowest.	
The dietary approach selected - from the perspective of contribution to nutrient intake	Group 1 is positively associated with carbohydrate, protein, fat and dietary fibre intake, but has no association with added sugar, saturated fats and sodium. Group 2 is positively associated with carbohydrate Group 3 is positively associated with added sugar, sodium and saturated fat. Group 1&2 has no association with all the selected nutrient markers	"Traditional" dietary pattern showed a moderate, positive correlation with total protein and total sugar intake There was a significant moderate correlation between the "Prudent" dietary pattern and dietary fibre There was a moderate positive association between the "Chinese" dietary pattern and total energy	Inverse association: 1. As DQI-R scores increase, percentage of energy from fat and saturated fat will decrease 2. As DQI-R scores increase, intake of dietary cholesterol decreases. Positive association: 1. There is a strong, positive correlation between DQI-R scores and fruit and vegetables 2. There was a weak positive correlation between grain consumption and DQI-R scores 3. There was a weak positive correlation between DQI-R scores and intake of calcium There was a moderate association between diet diversity and DQI-R scores
Contribution of SES and a dietary approach	Total energy intake was the most influential predictor variable for the BMI of the respondents. This was followed by marital status (married vs.	Hierarchical multiple regression analysis was used to assess the ability of new predictors (all six-dietary patterns) to predict BMI, after controlling	There was no significant correlation between DQI-R and BMI when controlling for age, gender,

to BMI	single), gender, age and ethnicity (Chinese vs. Malay). However, UPP groups were unable to predict BMI in the multivariate model. UPP may not be a suitable approach in predicting obesity. However, UPP may have more advantages in estimating nutrient value or nutrient density in an individual dietary intake	for the influence of gender, age, education, ethnicity, marital status and total energy intake. All dietary patterns failed to show a significant association with BMI. After entry of the six dietary patterns at step 2 (Model 2), the total variance explained by the model was 24.4%, indicating that the six dietary patterns explained an additional 0.7% of the variance in BMI, after controlling for age, gender, education, ethnicity, marital status and total energy intake Hence, the new predictors (six dietary patterns) have low ability to predict BMI. In the final model, age, gender (men vs. women), ethnicity (Malay vs. Chinese, and Malay vs. Other), marital status (single vs. married), total energy intake, F3 (“Modern”), and F6 (“Combination”) were statistically significant in explaining the BMI. However, we conclude that all six dietary patterns from the PCA approach are of little practical significance in predicting BMI, since they only explain 0.7% of the variance in BMI.	ethnicity, and total energy intake, $p > 0.000$.

UPP, PCA and DQI-R approach - from the perspective of socioeconomic status (SES)

The Malaysian population is still generally consuming a traditional diet, as the percentage of ultra-processed foods was less than 30% in Group 3 and factor loadings loaded highly on "Traditional" diets. This "Traditional" diet was highly consumed by the Malays, the majority population. The Malaysian population is still consuming a low amount of processed foods, but there is a trend of increasing intake that is appearing among the population living in the urban counterparts with monthly household income of more than MYR3500 (USD977). This shows that urban people from the middle- and high-income classes are consuming the highest proportion of more of the ultra-or highly- processed foods/products (UPP). This socio-economic pattern of eating UPP foods is different to the UK and other high income countries (HICs). In UK, highly processed foods were more consumed by the less wealthy (Zainal Badari *et al.* 2012; Schneider and Gruber 2013), whilst, in Malaysia and other low- and middle income countries (LMICs), the wealthy are the ones consuming most of the highly processed foods (Heng and Guan 2007; Aloia *et al.* 2013; Zhang *et al.* 2014).

These LMICs are undergoing a nutrition transition and more people are eating more processed foods especially those in higher SES. As discussed in earlier chapters, the emergence of the massive global food industries in Malaysia and changes in the lifestyle of the Malaysian population have paved the way for Malaysians to consume more highly processed foods. This is part of the effect of nutrition transition in Malaysia. In terms of diet quality, the respondents scored 64.6 points out of a total of 100 points. In essence, the respondents were having more of traditional, unprocessed diet compared to highly processed foods and reflected a diet quality of 64.6 points, indicating the diet quality could be improved. It will be interesting to see if there are any changes in the dietary pattern and diet quality of Malaysian population in a few years. What will happen to diet quality in the next few years if the percentage of highly processed foods increases? This has thrown up few questions in need of further investigation for the Malaysian population; i) will diet quality of Malaysian population improved or decreased? ii) will UPP consumption increase in lower socio-economic groups? iii) are the UPP foods fall in price?, and iv) are the UPP foods become more accessible?

UPP, PCA and DQI-R approach - from the perspective of contribution to nutrient intake

Next, we view these dietary approaches and their contribution to nutrient intake. The unprocessed or minimally processed foods in the UPP approach were positively and significantly related to protein, fat and dietary fibre. This was in line with the "Traditional" and "Prudent" dietary pattern that positively correlated with total protein. These two dietary patterns are diets that loaded highly on unprocessed foods (i.e. fish and seafood, and fruits, vegetables, legumes and milk). On the other hand, the ultra-processed foods/products were positively associated with added sugar, sodium and saturated fat. This can be reflected by the DQI-R inverse association with fat, saturated fat and cholesterol. As diet quality was improved, intake of fat, saturated fat and dietary cholesterol reduced, while intake of fruits, vegetables and calcium increased. In short, we may say that, as the levels of fat and saturated fat increase, the lower is the diet quality of the respondents, and the higher the consumption of processed foods.

Contribution of SES and dietary approach (UPP, PCA and DQI-R) to BMI

The final important part is the association of each of the three dietary approaches with BMI. All three dietary approaches were unable to show any significant association with BMI. However, characterising dietary intake according to a specific pattern is helpful in unpacking the total energy to determine the key food supplying the total energy intake. This is because, for the same amount of total energy, one can obtain either a 'healthy energy' or 'unhealthy energy'. When looking at UPP, it shows that Group 1, which represents the unprocessed/minimally foods, had a positive association with carbohydrate, protein and dietary fibre. Group 2, the processed culinary ingredients, on the other hand, had a positive association with the carbohydrate intake. Meanwhile, Group 1&2, the traditional prepared foods, had no association with any nutrient markers. Finally, Group 3, the ultra-processed foods, revealed a positive association with carbohydrate, sugar, sodium and saturated fat intake. This shows that Group 3 is the main contributor to increases in sugar, sodium and saturated fat intake. Comparing with traditional dietary assessment, the capability of indicating the key food supplier for unhealthy energy through UPP is relatively high. For example, two different people may get the same amount of excess energy; one gets it from high unprocessed foods (rice, vegetables, fruits, etc.), whereas the other gets it from highly processed foods (breads, soft drinks, burgers, etc.). They may have the same BMI, but their NCD risk profile is very different (metabolic syndrome, serum cholesterol level, salt intake and blood pressure, etc.). Another finding derived from the UPP dietary approach is that we know that, when people are having more Group 3 foods, they are getting more of their energy from these empty calories. That has been confusing in the past; we have been feeding starving children with energy and not thinking whether it is a good or bad energy. All in all, it is almost like healthy energy versus unhealthy energy projected by this UPP characterisation.

Characterising dietary intake via principal component analysis (PCA) failed to show any associations with BMI. This result is likely to be related to the heterogeneity of dietary intake patterns derived by factor analysis and may be explained by the lack of gold standards in applying the PCA (Togo *et al.* 2001). This was supported by Newby and Tucker (2004), as some studies had no association between dietary patterns defined by factor analysis and diet-related diseases, and inconsistencies were apparent. These may exist due to methodological issues involved with factor analysis. Factor analysis has gone through several decision-making processes, which may affect the number and type of patterns that are obtained, stated and evaluated (Newby and Tucker 2004). Despite the non-association of dietary patterns defined by factor analysis and BMI, some components derived from the factor loadings showed positive association with several nutrient markers, as shown in Table 7.1, namely:

(i) "Traditional" dietary pattern showed a moderate, positive correlation with total protein and total sugar intake;
(ii) There was a significant moderate correlation between the "Prudent" dietary pattern and dietary fibre;
(iii) There was a moderate positive association between the "Chinese" dietary pattern and total energy.

However, it is less capable in unpacking the total energy into distinguishable key suppliers. This is because each factor loads on a variance of foods, for example, food pattern 1, the "traditional" diet, loaded highly on fish and seafood and confectionery. These two aspects were respectively high in protein and sugar intake. However, it fails to deliver a message to the public about what is healthy energy.

Meanwhile, one of the most commonly used dietary indexes in dietary quality assessment, DQI-R, also failed to show any association with BMI in this sample of respondents even though DQI-R was adopted and modified according to the Malaysian Dietary Guidelines. In addition, DQI-R contains no components that really gauge the intake of processed foods as it assesses compliance with prevailing dietary guidelines that have not put an emphasis on processed foods. Although some studies managed to show an association between diet quality index and obesity (Togo *et al.* 2001; Guo *et al.* 2004; Dugee *et al.* 2009), this study had contrasting findings. This study supports the findings from a cross-sectional analysis by Asghari *et al.* (2012) on 708 respondents from the Tehran Lipid and Glucose Study (TLGS) which used the Mediterranean Diet Scale (MDS), Healthy Eating Index-2005 (HEI-2005), and Diet Quality Index-International (DQI-I), and found that the diet quality indices did not show any significant relation with BMI. Another cross-sectional Survey in Europe on Nutrition and the Elderly (SENECA) baseline study and Framingham Heart Study were used to explore relationship between Mediterranean Diet Score (MDS) and BMI. Findings of the study showed no association between MDS and BMI of the 828 US elderly (Haveman-Nies *et al.* 2001).

Returning to the main objective posed at the beginning of this chapter, it is now possible to conclude that all three dietary approaches were unable to show any relationship between dietary pattern and obesity in my study. However the study did partially substantiate that the UPP approach may differentiate between 'healthy' and 'unhealthy' energy by unpacking the total energy to nutrient value.

8.2 Agreement between the derived dietary patterns

Pearson Correlation Coefficients were used to further explore the agreement between these three dietary approaches through selected nutrient intakes (i.e. carbohydrate, protein, fat, saturated fat, sodium, sugar and dietary fibre). However, since different approaches to dietary patterns identify different axes of variation in diet, agreement between these three dietary patterns was decided to be observed on a designated 'poor' dietary pattern of each approach. Our question was "do people in the 'poor' category of UPP fall into the 'poor' category as well when using the PCA and DQI-R approaches?" The designated 'poor' dietary pattern for each dietary approach is as follows:

1. <u>Designated 'poor' dietary pattern for UPP approach</u>

   'Poor' for the UPP approach refers to the Group 3 consumption. The proportion of respondents consuming Group 3 was divided into quintiles based on total energy intake. The proportion of respondents consuming the highest quintiles in Group 3 was selected to define the 'poor' dietary pattern in UPP.

2. <u>Designated 'poor' dietary pattern for PCA approach</u>

   For the PCA approach, the lowest quintile of composite score in PCA 1 (referring to "traditional" dietary pattern) was selected. The lowest quintile in PCAs was to represent the 'poor' dietary pattern. Only PCA 1 was chosen, as it was the main principal component for PCA since it is the first factor extracted, which accounts for the maximum possible variance in the dataset (Newby and Tucker 2004).

3. Designated 'poor' dietary pattern for DQI-R approach

Meanwhile, for the DQI-R approach, the lowest quintile of scores in DQI-R was designated as the 'poor' dietary pattern.

Assessing agreement between 'poor' dietary intakes of each dietary pattern and nutrient intakes

Pearson Correlation Coefficient was conducted to evaluate the relationship between the 'poor' dietary intakes of each dietary pattern and all the selected nutrient intakes (i.e. carbohydrate, protein, fat, sugar, saturated fat, sodium and dietary fibre). This means that we want to see whether there is a relationship between the selected nutrient intake from the 'poor' pattern of UPP with the 'poor' pattern of PCA1, and 'poor' for DQI-R.

Table 8.2: Pearson Correlation Coefficient (*r*) in assessing agreement between the three dietary approaches via selected nutrient intakes

		UPP	PCA1	DQI_R
UPP	Pearson Correlation	1	.982**	.995**
	Sig. (2-tailed)		.000	.000
PCA1	Pearson Correlation	.982**	1	.980**
	Sig. (2-tailed)	.000		.000
DQI_R	Pearson Correlation	.995**	.980**	1
	Sig. (2-tailed)	.000	.000	

**. Correlation is significant at the 0.01 level (2-tailed).

The results indicated that there was positive strong agreement between these designated 'poor' dietary patterns via nutrient intakes, as correlation coefficients were all significant at the $p = 0.05$ level (see Table 8.2). It shows that the correlations are all high, which reinforces similarity of spread. What is more interesting is that these dietary approaches highlight internal differences within each dietary approach that do pick up nutrient difference, but may be saying slightly different things when viewed across each dietary approach. Meanwhile, Figure 8.1 shows the mean nutrient intake for each of the designated 'poor' dietary patterns for each dietary approach. One of the striking results is that respondents in the lowest quintile of scores in DQI-R showed the highest mean of saturated fat (M= 13.46, SD = 12.02) and total fat (M = 79.27, SD = 79.34) than the other approaches for the designated 'poor' dietary pattern. However, at the same time, DQI-R showed the highest mean of dietary fibre (M = 11.55, SD = 13.35) and protein (M = 114.88, SD = 53.12) compared to the other approaches for the designated 'poor' dietary pattern.

Meanwhile, high proportion in Group 3 consumption, designated as the 'poor' dietary pattern for the UPP approach, showed a higher mean value for sugar (M = 76.49, SD = 39.8) and sodium intake (M = 2,360 mg, SD = 1169.8) than the other dietary approaches.

What we can conclude from this is that the 'poor' dietary pattern for DQI-R showed high intake of fat and saturated fat, and was also higher in dietary fibre and protein, while 'poor' dietary pattern for UPP showed higher intake of sodium and sugar. Even though there was no big difference between the designated 'poor' dietary pattern of these approaches, it already gives an insight that UPP classification may be more prone to capture sodium and sugar in this study while DQI-R is more prone to capturing intake of fat and saturated fat. Perhaps, for future study, UPP and DQI-R can both be applied in assessing dietary patterns in Malaysia.

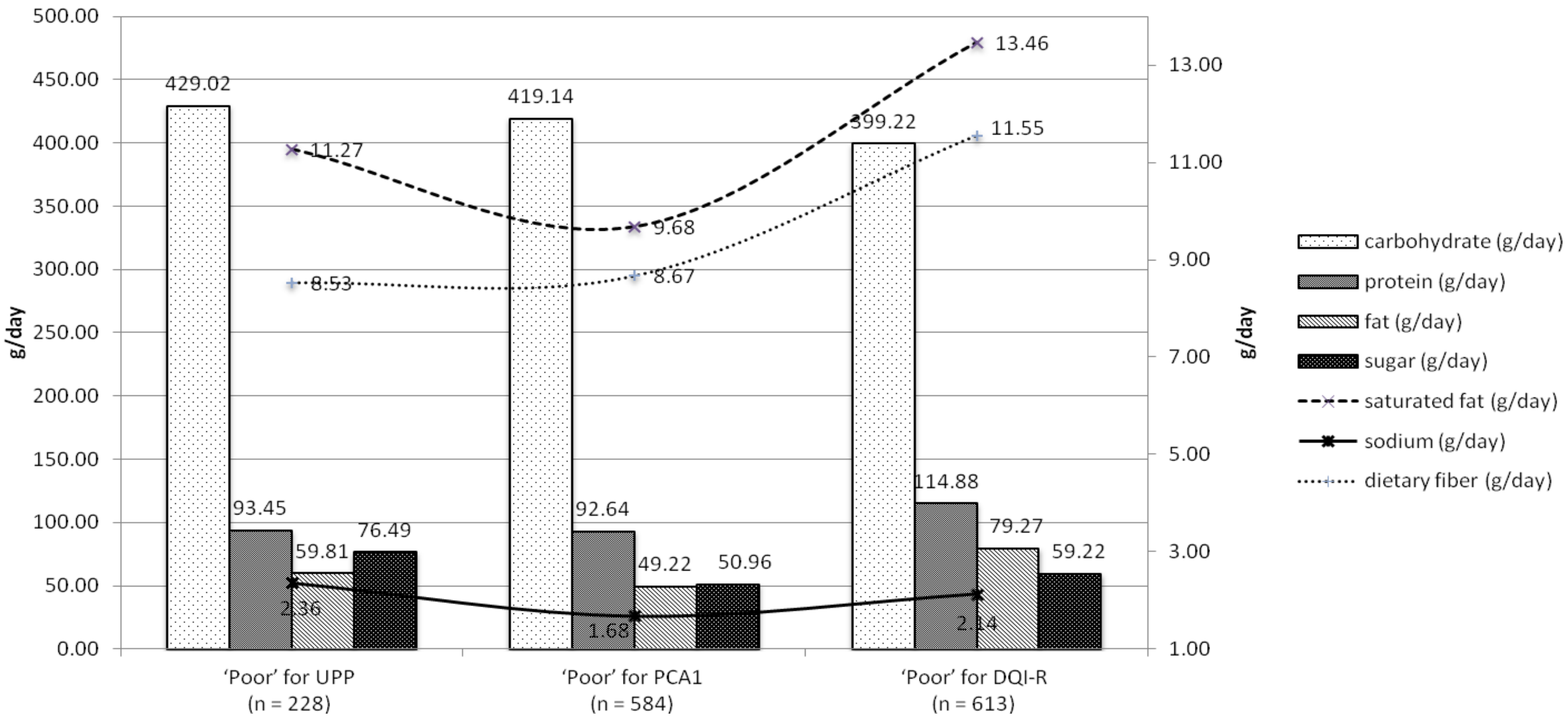


Figure 8.1: Mean nutrients intake of the 'poor' dietary pattern for each dietary approach

8.3 Contribution to body of knowledge

By having Malaysian dietary intake grouped according to the nature of processing proposed by Monteiro *et al.* (2011), this study has interesting findings regarding the contribution of Group 3 foods to the total energy intake in Malaysia.

Second, this study has attempted to analyse in detail individual dietary patterns and obesity through individual dietary intake. It is considered that individual dietary intake may bring more evidence of association between highly processed foods and obesity. Monteiro *et al.* (2011) did not study the nutritional status of the population at an individual level. His studies, along with several other countries that have applied the same approach, were all ecological associations and not individual-based measures of dietary patterns. Monteiro had used Brazilian food budget survey to applied UPP classification. The ecological study is a weak study design for assessing causation as it studies risk-modifying factors on health or other outcomes based on populations defined, either geographically or temporally, rather than individuals (Morgenstern 1995; Wakefield 2008). There is the problem of the ecological fallacy as well as uncontrolled confounders. Just because consumption of processed food goes up, then obesity goes up, it does not mean that processed food consumption was the sole causal for obesity. Ecological fallacy would say you can't assume individuals with high UPP are the ones who are obese. The ecological association may be confounded by other factors (e.g. physical activity).

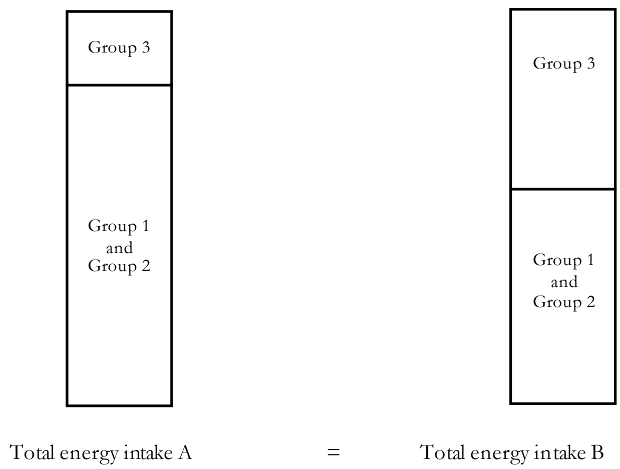


Figure 8.2: Distribution of total energy intake of plate A and plate B

Higher ultra- or highly processed food (Group 3) intake is positively associated with sodium, saturated fat and sugar level in Malaysia. This is consistent with what Monteiro showed at an ecological level. Although the ultra- or highly processed foods were not significantly associated with BMI, the intermediate risk factors/factors (sodium, saturated fat, sugar, etc.) that have been linked independently of BMI are clearly important links to healthiness and future disease health risk.

This is not just about energy in total, but can be about the quality of fat, the amount of added sugar and much more. For example, an individual's dietary intake may have more rice and perhaps added some processed foods, but dietary intake is still dominated by rice, which means that most energy is currently coming from the rice (see Figure 8.2: Total energy intake of plate A). However, that is probably changing over time and rice consumption will go down and processed foods consumption will grow (see Figure 8.2: Total energy intake of plate B). If that is the situation, the amount of total energy might be the same, but the level of sugar, salt and saturated fat will be higher. This study hasn't looked at the impact of this increase, but there is considerable evidence that shows association between these nutrient markers and its metabolic consequences (increased serum cholesterol, type 2 diabetes, high blood pressure, CVD risk factor and many more). Therefore, BMI might be rather a crude sort of sum of outcome, which obviously has an inherent value, but somehow hides some subtlety beneath it that is worth flagging.

8.4 Strengths and Limitations of the Work

This study is considered novel, as this is the first time that a study has taken a dietary survey to this degree of attention to detail (i.e. eliminating people who are poorly reporting their energy etc., proper nutritional dietary survey) and was robustly done. This is the first time a study has tried to characterise dietary pattern to march of epidemiological from ecological associations to generate hypothesis to test in individual-based studies on this number of respondents. This is also a robust and large contemporary national survey enabling dietary pattern and BMI.

The study is limited by the lack of information on food items listed in the Malaysian Adult Nutrition Survey (MANS) FFQ. MANS FFQ was validated through two-day, 24-hour, dietary recall (a weekday and weekend dietary recall) at two-week intervals during the validation phase. The development of the MANS FFQ resulted in a list of 126 food items, all commonly consumed throughout the year among the Malaysian population (Ministry of Health Malaysia 2008). Despite the MANS FFQ validation, the number of foods listed in MANS appears to have been insufficient to capture the common Malaysian dietary intake. Foods that are highly processed are increasing, but only few were listed in the MANS

FFQ. A variety of ready-to-eat foods (franchise doughnuts, crepes, waffles, instant spaghetti sauce, etc.) and international fast-foods (kebabs, sushi, etc.) are also widely available in Malaysia, but were not listed. Even the local food needs attention in the FFQ as there are local foods that were commonly consumed, but were not included, for example, mung bean (green gram). In addition, some of the food items were put together, which made it difficult to gauge the real food consumed. For instance, instant noodles were placed together with other noodles. For future studies, it is likely to be necessary to develop and validate a new FFQ.

This study is also limited by the lack of information on the level of lipids, blood pressure, and other nutritional status assessments. Therefore, this study had constraints in assessing the relationship between the derived dietary patterns and other nutritional status assessments.

This study used data that were collected in 2002/2003 and may not reflect the current situation of Malaysian dietary intake. The most recent national dietary survey for Malaysia was collected in 2009/2010. However, during the period in which this study was conducted, the most recent national dietary survey had not been released by the Malaysian Institute of Public Health (IPH) for research usage. Therefore, this study used the second most recent national dietary survey for Malaysia, which was the Malaysian Adult Nutrition Survey (MANS).

Another limitation is in the analysis of data from only half the MANS population. After consideration, the under- and over- reporting were excluded, as studies have shown that dietary trends, or the magnitude of the estimates of intake, were affected by the exclusion of under-reporting (de Castro 2006; Warwick 2006). If not, this may result in spuriously low estimates of respondents' nutrient intake (de Castro 2006). One Australian study, from 1988 to 2003, involving female university students, showed an increase in the trend for total energy, protein and carbohydrate intake when under-reporting was excluded from the analysis. It was suggested that this was probably due to a disproportionate skewing of the results by the very low energy intake in under-reporting (Warwick and Reid 2004). After excluding the under- and over- reporting of energy intake, the mean of total energy intake increased from 1,955 kcal $\pm$ 657 SD to 2,293 kcal $\pm$ 657 SD. Even though half of the respondents were left out, the socio-demographic difference between the actual MANS data and this current data showed similar percentage.

Another limitation is the use of cross-sectional design to study complex changes in nutrient patterns over time. In the context of this study, obesity is developing over time in Malaysia and it is influenced by many factors. Cross-sectional data on dietary pattern and obesity only capture a snapshot with the exposure (dietary pattern) and outcome (obesity) being measured at the same time. It has no temporality, so we can't say exposure led to outcome and not vice versa. There are restrictions in having to know what other things happened before, for example, physical activity, lifestyle, etc., which may be part of the life course influence. As for the consumption of highly processed foods among the Malaysian population, this may be developed over time. In a changing population like Malaysia, different ages are starting to introduce changes in their dietary pattern. These changes are a fluid thing and, therefore, what happened before is changing as well as the influence. It is complicated, as the instability and other things affecting successive generations are rapidly changing. This may probably entail the fact that ultra- or highly processed foods are not that common, which may lead to less variance. Variance in processed foods is needed to be able to show a relationship between processed foods and obesity, or any other outcomes. Of the total energy intake reported in this study, only 29% (SE = 0.21) comes from highly processed foods. In Malaysia, the consumption of highly processed foods is less spread and less dominant, whereby most people's energy is not coming from highly processed foods, but from rice.

8.5 Conclusion of the three dietary approaches

The three dietary approaches were not associated with BMI and could not be used to predict obesity. Why were these approaches not related to BMI? It is clear that rice still dominates the energy supply, but, increasingly, the quality of the diet is shifting, which is reflected in the sodium, sugar and fat changes, so it may take time to see the shift in source of energy to these more UPP foods, or, for Malaysia, rice may still dominate, so the interpretation may be more complex than in Brazil or the UK.

However, of all the dietary approaches, UPP intake may be a more translatable message for the public. This is because most people know about highly processed foods and information can be easily taken in and understood. The UPP can straightforwardly exemplify, for instance, that ultra-processed foods consist of bread, snacks, biscuits, burgers and others. However the UPP is not just fast-food or junk food, it includes the all the processed food industries (Hawkes 2010). The proportion of unadulterated ingredients in UPP is very small; 30% of most processed foods are added sugar for the same plate if compared to other groups (Monteiro 2011). Some manufacturers try to obfuscate by reformulating the products, for example, by adding micronutrient substances such as vitamin C in snacks. Unfortunately, the basic ingredients of ultra-processed/highly processed foods usually still contain high sugar, salt and other ingredients to make them taste better, last longer and much more. Therefore, reformulation of product does not solve the problem of gaining high sugar and salt intake.

Highly- or ultra- processed foods are made from taking Group 1 (unprocessed/minimally processed foods) and Group 2 (culinary ingredients) and adding unknown ingredients. The worst part in producing highly processed foods is that Group 1 foods are disaggregated and reconstituted in a way that is not recognisable from their original form. For example, potatoes are reconstituted into all sorts of things (instant mash potatoes, wedges and many more). Another example is the commercial breakfast cereal. Breakfast cereals are actually mainly sugar. For example a Weetabix is a 100% whole grain with nothing else added; for the same 100g, you make it into cornflakes, except now you have about 30% of whole grains and the rest of it is added sugars or other things that are there to enable prolonged shelf life, and colouring. You get the same 100 gram with either Weetabix, which is 100% cereals, or cornflakes, but you're losing at least half the amount of cereals.

Therefore, an edible and healthy meal is based on cooking a combination of Group 1 and Group 2 foods without adding unknown or chemical ingredients. Therefore, indirectly, the UPP approach presents a strong message to people to home-cook foods, which involves preparing foods from Group 1 and Group 2 only. This study has included a combination of Group 1 and 2, labelled as Group1&2, in order to address the traditional prepared foods. This traditional prepared meal is usually consumed daily by the Malaysian population, either being self-cooked or brought from hawker stalls/restaurants. The PCA results showed no association between traditional meal and BMI or other adverse nutrient markers. That is to say that preparation of food that only involves Group 1 and Group 2 is healthier than consuming food from Group 3.

As mentioned earlier, rice still dominates total energy intake in Malaysia and drives any relationship between dietary patterns to total energy intake. However, rice consumption (a staple of traditional diet) is decreasing among the Malaysian population, as discussed previously, and processed foods are increasing. Therefore, Malaysia may be at a junction where it is not too late to stop, or at least slow, this transition. A major public health intervention is needed to prevent total energy intake being dominated by processed foods, otherwise Malaysia may end up like Canada, the US and other HICs where 60 to 70% of total energy consumption now comes from highly processed foods.

Another important thing is that UPP may need support from a diet index score that will reflect the overall diet quality of a population. This is because a diet index score handles both foods and nutrients requirement for an individual, which UPP doesn't have.

8.6 Implications for policy

One of the prominent implications is addressing UPP classification as part of dietary guidelines for the public. This is because UPP classification is capable of addressing dietary patterns, being practical and being easily understood by the public. Furthermore, the Malaysian dietary guidelines (MDG) that existed were unable to help in picking out the processed foods, as it is a mix of highly processed and unprocessed foods. As discussed in Chapter 2, the terminology "serving size" in MDG was commonly mistaken by the consumer. Consumers took a misleading message about consuming a lot of the base level group (cereals, tubers and grains group), since it is at the bottom of the pyramid (Monteiro 2011). Furthermore, there is a debatable argument about the clear-cut definition of 'unhealthy'/'less healthy' and 'healthy'/'healthier' food, and other nutrients as well (Arambepola *et al.* 2008). It becomes more confusing for the consumer when this is used by food retailers, food manufacturers and others in labelling food products as, for example, 'low-fat' or 'healthy' (Scarborough *et al.* 2007a; Arambepola *et al.* 2009). There is, therefore, a definite need in the future for this kind of approach to be further studied and subsequently implemented for the Malaysian population as guidance for healthy food choice.

Additionally, the UPP approach is an initial stage to address the importance for the Malaysian government in monitoring the emergence of the global food industries. Despite the relatively low (but increasing) consumption of highly processed foods among the Malaysian population, it is not something for Malaysia to take for granted. High consumption of UPP restricted to more in higher SEs but this will change Greater efforts are needed to ensure Malaysia does not follow the pattern intake of other HICs. One reasonable approach would be to highlight the importance of cooking more real food at home and reduce buying processed food from outside. Real food here is defined as foods categorised under Group 1 and Group 2 in the UPP approach, which are minimally processed and consist of culinary ingredients. Malaysia's Ministry of Health previously launched a 'healthy kitchen' campaign, but it was a one-off approach. This campaign needs to be run continuously alongside teaching children in schools to cook. Continued efforts are needed to alert the population to the adverse effects of a high consumption of highly processed foods. The real challenge is to control the percentage of highly processed food consumption among the Malaysian population. At this point of time, the percentage is still low, but we do not know what will happen in the next 10 years if no action is taken by the government, the Malaysian health authorities and related bodies. One of the key policy priorities should, therefore, be to plan for the long-term care of the emergence of the food industries. We do not want them taking over our traditional dishes and serving our plates with food containing unknown ingredients.

Lastly, the findings could be used as a guideline to improve intervention programmes in the future (e.g. constructing a simple labelling of food stuffs in supermarkets as UPP or not). This information can be used to alert people and guide them in making healthy food choice. However, more studies need to be done to understand more on the UPP message and its implication towards the individual, population, and country. In addition, it could be used as a reference for researchers who share the same research interest.

8.7 Recommendations for further research

In this study, none of the dietary approaches had an association with BMI. Further studies need to be carried out by repeating periodic dietary surveys with robust methods. For the UPP approach, large randomised controlled trials could provide more definitive evidence. Besides, a case-control study would be interesting to compare diet pattern over last period of years including from the UPP perspective between obese and non-obese people. In addition, further research, including longitudinal studies, assessing dietary pattern (including a UPP approach) and the relationships with other metabolic consequences (i.e. type 2 diabetes, CVD risk, high blood pressure, increased serum cholesterol) is warranted. This is more practical, as we could see changes in nutrient values and its association with other metabolic consequences. For example, if a UPP approach is applied in a longitudinal study, we may, perhaps, observe a difference in the percentage of processed food consumption and changes in blood pressure, plasma glucose, serum triglycerides and high-density lipoprotein (HDL) levels.

Meanwhile, for dietary indices, we found that diet quality, which was assessed using DQI-R index, was improved, with intake of fat, saturated fat and dietary cholesterol reduced, while intake of fruits, vegetables and calcium increased. Therefore, diet quality indices were found to aid in capturing the overall diet quality, rather than depending only on a single nutrient or food group. It is proposed that, for future research, a standard index for assessing diet quality in Malaysia should be developed, as has been done by other countries. Therefore, Malaysia will have its own diet quality index without having to modify diet indices from other countries.

Additionally, we proposed that, for future studies, dietary pattern is derived from both UPP and DQI-R (or any suitable dietary index). This is because UPP can gauge what type of foods people are eating, while dietary index can grasp the quality of what they are eating. Both seem to complement each other. Meanwhile, for PCA, more study of pattern analysis needs to be conducted among the Malaysian population to produce validity and reproducibility for this dietary approach, considering all methodological issues (Newby & Tucker 2004). After having a clear set of definitions for the pattern analysis among the Malaysian population, we can then conduct an association between pattern analysis and disease outcomes in the future.

8.8 Final remarks

In this study, the aim was to explore dietary approach and its impact on obesity. The results of this study show that dietary approaches were not associated with BMI and could not be used to predict obesity. However, a key strength of this study was that one of the dietary approaches, UPP, has the capability of indicating the key food supplier for unhealthy energy. The findings of this study suggest that further work needs to be done related to the UPP approach to strengthen the idea of this dietary approach for the Malaysian population.

This study extends our knowledge of the consumption of highly- and ultra- processed foods among the Malaysian population. This can subsequently serve as a base for future studies on highly- and ultra-processed foods in Malaysia.

Appendices

Appendix A: MANS Data Agreement between researcher and IPH (Malaysian Institute of Public Health)

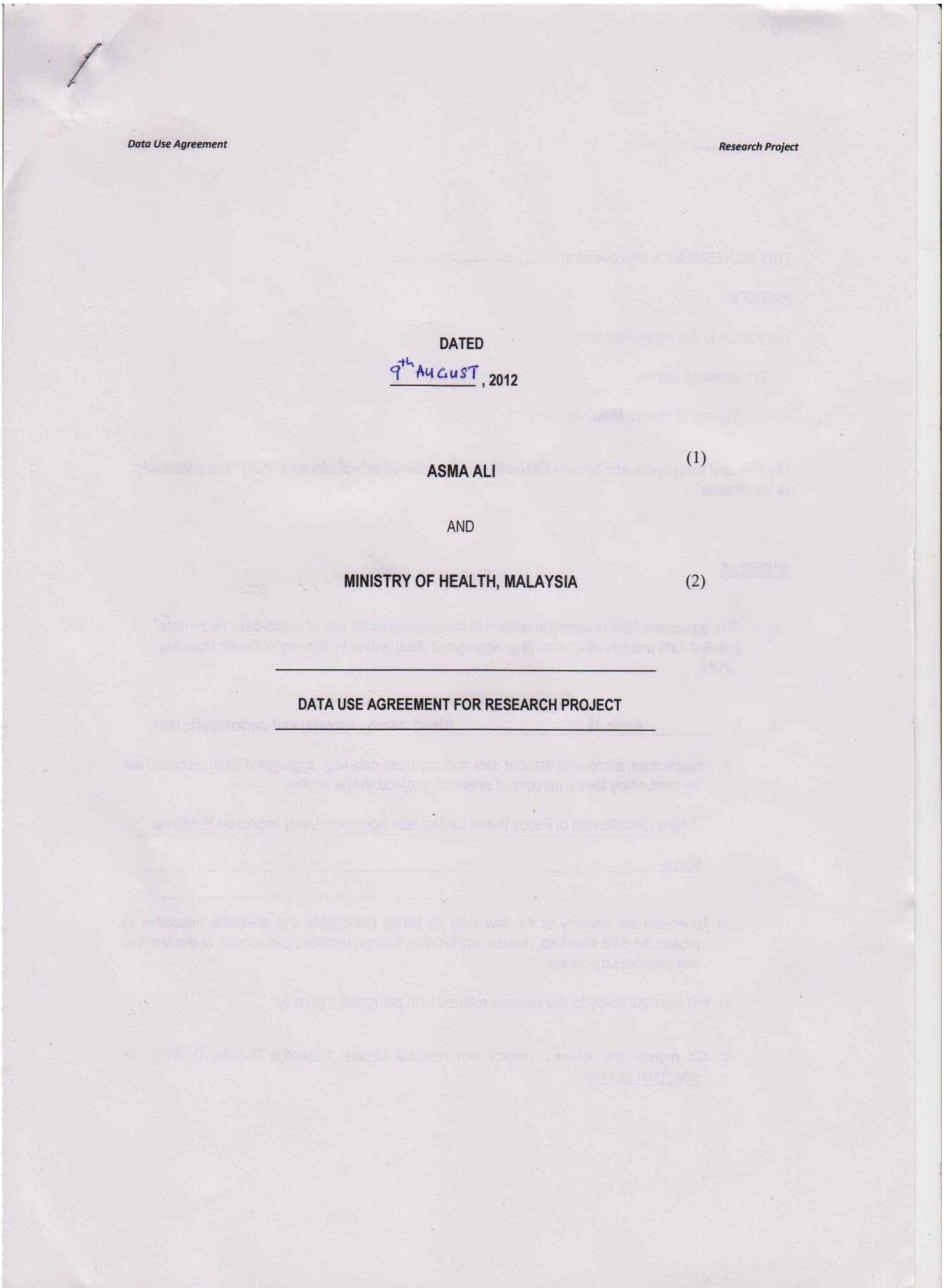
Appendix B: MANS FFQ

Appendix C: Food Groupings for dietary pattern analysis (via PCA)

Appendix D: Correlation Matrix Table (derived from PCA)

Appendix A Data Agreement

MANS Data Agreement between researcher and IPH (Malaysian Institute of Public Health)



Data Use Agreement *Research Project*

DATED

9th AUGUST, 2012

ASMA ALI (1)

AND

MINISTRY OF HEALTH, MALAYSIA (2)

DATA USE AGREEMENT FOR RESEARCH PROJECT

Appendix A

THIS AGREEMENT is effective as of ____________________

PARTIES

The Parties to this Agreement are:

(1) Asma Ali and

(2) Ministry of Health, Malaysia

The Principal Investigator and Ministry Of Health shall be referred individually as a "Party" and collectively, as the "Parties".

WHEREAS

I. This agreement form is signed in relation to the approval of the use of macro data, micro data, detailed data and any other data (e.g. aggregated data) issued by Ministry of Health Malaysia (MOH).

II. I, Asma Ali **(User) hereby agree(s) and undertake(s) that:**

a) Macro data, micro data detailed data and any other data (e.g. aggregated data) obtained will be used solely for the purpose of **research project/ thesis** entitled

A New Classification of Foods Based on Monteiro Approach: Likely Impact on Nutritional Status

b) To ensure the security of the raw data by taking reasonable and adequate measures to protect the data from loss, misuse, exploitation, ravage, unauthorized access, or disclosed to any unnecessary parties.

c) Will use data solely for the purpose referred to in paragraph II (a) only.

d) Will register the research project with National Medical Research Register (NMRR) at http://nmrr.gov.my

e) Will obtain approval from the Director-General of Health, Malaysia for any publication(s) resulted from the use of the data according to the appointed procedure before the article sent for publish.

f) Will acknowledge Director General of Health, Malaysia for his permission to use the data and to publish the article.
e.g. *The authors would like to thank the Director General of Health, Malaysia for his permission to use the data from the National Health and Morbidity Survey III and to publish this paper.*

g) Will submit a copy of the final manuscript of scientific publication to

Secretariat National Institutes of Health (NIH),
Ministry of Health Malaysia,
c/o Institut Pengurusan Kesihatan
Jalan Rumah Sakit Bangsar
59000 Kuala Lumpur

through

Pengarah ,
Institut Kesihatan Umum,
Jalan Bangsar
59000 Kuala Lumpur

III. I am aware that the breach of this contract will lead to blacklist from obtaining and/or using any form of data from Ministry of Health, Malaysia.

IV. I have read and understood all of the above clauses and agree to abide with all the terms mentioned.

Data Use Agreement *Research Project*

IN WITNESS WHEREOF the Parties have caused this Agreement to be executed by their duly authorized representatives on the day and year first stated above.

For and On Behalf of:

Investigator

Signature ....

Name of Principal Investigator ASMA' ALI

Designation PHD STUDENT

Date 9/8/2012

In the presence of:-

Signature ....

Name of Supervisor/Head of Department PROF B. M. MARGETTS

Designation PROFESSOR

Date 9/8/12

For and On Behalf of:

Ministry Of Health

DR. MUHAMMAD FADHLI BIN MOHD YUSOFF
Head of Method & Statistic
Institute for Public Health
Ministry of Health, Malaysia

In the presence of:-

DR. HJ.TAHIR B. ARIS
Director,
Institute for Public Health
Ministry of Health, Malaysia

Appendix B MANS FFQ

MANS Food Frequency Questionnaire

FORM E

DIETARY INTAKE SURVEY MALAYSIA 2002 / 2003

ID Respondent	Region	Daerah Banci	BP	TK	Household No.

SECTION 1: FOOD FREQUENCY QUESTIONNAIRE

Code	Type of foods	Frequency intake					Serving size (Just choose one)	How many serving size for each of consumption
		By day	By week	By monthly	By yearly	Never eat		
	A. Cereal & cereal products							
A1	Rice						Plate Chinese bowl Cup Ladle	
A2	Porridge						Medium bowl Cup Ladle	
A3	Glutinous rice						Chinese bowl Cup Ladle	
A4	Noodles/insant noodles						Oval bowl Plate Chinese bowl Ladle	
A5	Vermicelli noodles/*kueh teow/laksa/ laksam*						Oval bowl Plat Chinese bowl Ladle	
A6	*Loh shi fun*						Chinese bowl	
A7	Pasta						Plate Ladle	
A8	*Sago						Cut pieces Cup Spoon	
A9	Bread						Piece	
A10	Bun						Item	
A11	*Roti canai*						Piece	
A12	*Capati*						Piece	
A13	*Tosai*						Piece	
A14	Breakfast cereals						Cup Chinese bowl	
A15	Instant cereals						Chinese bowl Cup	
A16	Pizza						Slice	
A17	Corn						Item Cup	

[E-1]

Kajian Pengambilan Makanan Malaysia 2002/2003

BORANG E

Code	Type of foods	Frequency intake					Serving Size (Just choose one)	How many serving size for each consumption
	B. Meat and meat products	By day	By week	By month	By year	Never eat		
B1	Chicken						Piece	
B2	Beef						cup	
B3	Mutton						cup	
B4	Burger patty						piece	
B5	Sausage / hotdog / frankfurter						piece	
B6	Nugget						piece	
B7	Fishball						piece	
B8	Duck						piece	
B9	*Ham						piece	
B10	*Bacon						piece	
B11	*Luncheon meat						piece	
B12	*Pork						cup	

Code	Type of foods	Frequency intake					Serving Size (Just choose one)	How many Serving size for each consumption
	C. Fish and seafoods	By day	By week	By month	By year	Never eat		
C1	Marine fish						Piece	
							Item	
C2	Fresh fish						Piece	
							Item	
C3	Anchovies						Table spoon	
C4	Canned fish						Piece	
C5	Cockles						Table spoon	
C6	Prawns						Cup	
C7	Cuttle fish						Cup	
C8	Dried cuttle fish						Piece	
							Item	
C9	Ketam						Piece	
C10	Salted fish						Piece	
							Item	
C11	Fish balls						Ball	
							Item	
C12	Lekor						Piece	

Code	Type of foods	Frequency intake					Serving Size (Just choose one)	How many Serving size for each consumption
	D. Egg	By day	By week	By month	By year	Never eat		
D1	Chicken egg						Egg	
D2	Duck egg						Egg	
D3	Quail egg						Egg	
D4	Salted egg						Biji	

Code	Type of foods	Frequency intake					Serving Size (Just choose one)	How many Serving size for each consumption
	E. Legumes	By day	By week	By month	By year	Never eat		
E1	Pulses						Table spoon	
E2	Soybean						Piece	
E3	Fermented soybean						Piece	
							Table spoon	
E4	Groundnut						Table spoon	

Code	Type of foods	Frequency intake					Serving Size (Just choose one)	How many serving size for each consumption
	F. Dairy products	By day	By week	By month	By year	Never eat		
F1	Fresh milk / UHT						Cup	
							Glass	
F2	Powder milk						Table spoon	
F3	Condensed milk						Table spoon	
F4	Evaporated milk						Table spoon	
F5	Yogurt / lassi / tairu						Cup	
							Table spoon	
F6	Cheese						Piece	

Code	Type of foods	Frequency intake					Serving Size (Just choose one)	How many serving size for each consumption
	G. Vegetables	By day	By week	By month	By year	Never eat		
G1	Leafy vegetables						Cup	
G2	Non-leafy vegetables						Cup	
G3	Root						Cup	
G4	Cabbage						Cup	
G5	Pumpkin						Cup	
G6	Salted vegetables						Cup	
G7	Ulam						Cup	
G8	Baby corn						Table spoon	
G9	Mushrooms						Cup	
G10	Sprouts						Cup	

Code	Type of foods	Frequency intake					Serving Size (Just choose one)	How many Serving size For each consumption
	H. Fruits	By day	By week	By month	By year	Never eat		
H1	Papaya						Slice	
H2	Guava						Piece	
H3	Mandarin orange						Item	
H4	Mango						Slice	
H5	Pineapple						Slice	
H6	Banana						Item	
H7	watermelon						Slice	
H8	Star fruit						Item	
H9	Jack fruit						Item	
H10	Apple						Item	
H11	Orange						Item	
H12	Pear						Item	
H13	Grape						Piece	
H14	Durian						Item	
H15	Rambutan						Item	
H16	Fresh Longan						Item	
H17	Fresh Laychee						Item	
H18	Honeydew						Slice	
H19	Dried fruits						Slice	
H20	Tinned fruits						Slice	

Code	Type of foods I. Beverages	Frequency intake					Serving Size (Just choose one)	How many serving size for each consumption
		By day	By week	By month	By year	Never eat		
I1	Plain water						Glass	
I2	Tea						Cup	
I3	Coffee						Cup	
I4	Chocolate drink						Cup	
I5	Malted drink						Cup	
I6	Rose syrup						Glass	
I7	Fruit juice						Cup	
I8	Carbonated drink						Glass/can	
I9	Soy bean drink						Glass	
							Packet	
I10	Botanical herbs drink						Glass	
							Packet	
I11	Energy drink						Glass	
							Packet	

Code	Type of foods J. Alcohol drinks	Frequency intake					Serving Size (just choose one)	How many serving size for each consumption
		By day	By week	By month	By year	Never eat		
J1	Syandi						Can	
J2	Beer						Glass	
							Can	
							Bottle	
J3	Wine						Wine glass	
J4	*Spirit						Glass	
J5	*Liqueur						Glass	

Code	Type of foods K. Confectionery	Frequency intake: By day	By week	By month	By year	Never eat	Serving size (Just choose one)	How many serving size for each consumption
K1	Local delicates						Item	
K2	Cake						Slice	
K3	Biscuits						Piece	
K4	Sweets						Item	
							Slice	
K5	Ice cream (milk						Cup	
							Scoop	
K6	*ABC (*air batu campur*) / ice / lollipop						Bowl	
							Piece	
K7	Agar-agar / jelly / custard						Cup	
							Slice	
K9	Snacks						Piece	

Code	Type of foods L. Spread	Frequency intake: By day	By week	By month	By year	Never eat	Serving size (Just choose one)	How many serving size for each consumption
L1	Jam						Tea spoon	
L2	Sri kaya						Tea spoon	
L3	Butter						Tea spoon	
L4	Margarine						Tea spoon	
L5	Peanut butter						Tea spoon	
L6	Cream cheese						Tea spoon	

Code	Type of foods M. Flavours	Frequency intake: By day	By week	By month	By year	Never eat	Serving size (Just choose one)	How many serving size for each consumption
M1	Sugar						Tea spoon	
M2	Honey						Tea spoon	
M3	Shrimp sauce						Table spoon	
M4	Anchovies sauce						Tea spoon	
M5	Shrimp cencalok						Tea spoon	
M6	Thick soy sauce						Tea spoon	
M7	Light soy sauce						Table spoon	
M8	Ketchup sauce						Table spoon	
M9	Oyster sauce						Tea spoon	
M10	Fish sauce						Tea spoon	
M11	Prawn paste						Tea spoon	

Appendix C Food Groupings for Dietary Pattern Analysis (via PCA)

No.	Original food items	Food of food groups
1	Rice	Rice
2	Rice Porridge	Rice
3	Glutinous Rice	Cereals and cereals products
4	Noodles	Cereals and cereals products
5	Vermicelli	Cereals and cereals products
6	Lohshifun	Cereals and cereals products
7	Pasta	Cereals and cereals products
8	Sagu	Cereals and cereals products
9	Bread	Cereals and cereals products
10	Bun	Cereals and cereals products
11	Roti Canai	Cereals and cereals products
12	Capati	Cereals and cereals products
13	Dosai	Cereals and cereals products
14	Cereals	Cereals and cereals products
15	Ready To Eat Cereals	Cereals and cereals products
16	Pizza	Cereals and cereals products
17	Corn	Cereals and cereals products
18	Chicken	Meat
19	Meat	Meat
20	Goat	Meat
21	Duck	Meat

No.	Original food items	Food of food groups
22	Meat burger	Processed meats
23	Hot Dog	Processed meats
24	Nugget	Processed meats
25	Chicken Ball	Processed meats
26	Ham	Other meat
27	Bacon	Other meat
28	Luncheon	Other meat
29	Pork	Other meat
30	Fish	Fish and seafood
31	Fresh Fish	Fish and seafood
32	Anchovy	Fish and seafood
33	Canned Fish	Fish and seafood
34	Cockles	Fish and seafood
35	Prawn	Fish and seafood
36	Cuttle Fish	Fish and seafood
37	Dried Cuttle Fish	Fish and seafood
38	Crab	Fish and seafood
39	Salted Fish	Fish and seafood
40	Fish Balls	Fish and seafood
41	Lekor	Fish and seafood
42	Chicken Egg	Eggs

No.	Original food items	Food of food groups
43	Duck Egg	Eggs
44	Quail Egg	Eggs
45	Salted Egg	Eggs
46	Pulses	Legumes and legume products
47	Soy Bean	Legumes and legume products
48	Fermented Soy	Legumes and legume products
49	Groundnut	Legumes and legume products
50	Milk	Milk
51	Powder Milk	Milk
52	Condensed Milk	Processed dairy products
53	Evaporated Milk	Processed dairy products
54	Flavoured Yogurt	Processed dairy products
55	Cheese	Processed dairy products
56	Leafy Vegetable	Vegetables
57	Non-Leafy Vegetable	Vegetables
58	Root	Vegetables
59	Cabbage	Vegetables
60	Pumpkin	Vegetables
61	Salted Vegetables	Vegetables
62	Ulam	Vegetables
63	Baby Corn	Vegetables

Appendix C

No.	Original food items	Food of food groups
64	Mushrooms	Vegetables
65	Sprouts	Vegetables
66	Papaya	Fruits
67	Guava	Fruits
68	Mandarin Orange	Fruits
69	Mango	Fruits
70	Pineapple	Fruits
71	Banana	Fruits
72	Watermelon	Fruits
73	Star Fruit	Fruits
74	Jack Fruit	Fruits
75	Orange	Fruits
76	Apple	Fruits
77	Pear	Fruits
78	Grape	Fruits
79	Durian	Fruits
80	Rambutan	Fruits
81	Longan Segar	Fruits
82	Laici Segar	Fruits
83	Honey Dew	Fruits
84	Tinned fruits	Fruits

No.	Original food items	Food of food groups
85	Dried fruits	Fruits
86	Plain water	Non-alcoholic beverages
87	Tea	Non-alcoholic beverages
88	Coffee	Non-alcoholic beverages
89	Chocolate Drink	Non-alcoholic beverages
90	Malted Drink	Non-alcoholic beverages
91	Rose Syrup	Non-alcoholic beverages
92	Fruit Juice	Non-alcoholic beverages
93	Carbonated Drink	Non-alcoholic beverages
94	Botanical Herbs	Non-alcoholic beverages
95	Energy Drink	Non-alcoholic beverages
96	Soya bean Drink	Non-alcoholic beverages
97	Syandi	Alcoholic beverages
98	Beer	Alcoholic beverages
99	Wine	Alcoholic beverages
100	Spirit	Alcoholic beverages
101	Liquor	Alcoholic beverages
102	Local delicates	Confections
103	Cake	Confections
104	Biscuits	Confections
105	Sweets	Confections

No.	Original food items	Food of food groups
106	Ice cream	Confections
107	ABC	Confections
108	Jelly/custard	Confections
109	Snacks	Confections
110	Jam	Spreads
111	Seri kaya	Spreads
112	Butter	Spreads
113	Margarine	Spreads
114	Peanut	Spreads
115	Cream cheese	Spreads
116	Sugar	Flavourings
117	Honey	Flavourings
118	Shrimp sauce	Flavourings
119	Anchovies sauce	Flavourings
120	Shrimp cencalok	Flavourings
121	Thick soy sauce	Flavourings
122	Light soy sauce	Flavourings
123	Ketchup sauce	Flavourings
124	Oyster sauce	Flavourings
125	Fish sauce	Flavourings
126	Prawn paste	Flavourings

Appendix D Correlation Matrix Table (derived from PCA analysis)

Correlation Matrix[a]

		rice	cereals and cereals products	meat	meat products	other meat	fish and seafoods	eggs	legumes and legumes product	milk	processed dairy products	vegetables	fruits	non-alcoholic	alcoholic	confections	spreads	flavourings
Correlation	rice	1.000	-.247	-.047	-.079	-.031	.111	-.006	-.114	-.047	-.060	-.018	-.125	-.017	-.009	-.071	-.135	.041
	cereals and cereals products	-.247	1.000	.035	.019	.107	-.141	-.007	.044	-.024	-.027	-.039	-.037	.047	.048	-.155	.025	-.112
	meat	-.047	.035	1.000	.176	.078	-.021	.082	.000	-.013	.067	.068	.012	.005	.012	.011	.048	.022
	meat products	-.079	.019	.176	1.000	-.034	-.013	.092	.057	-.020	.040	.018	.075	-.005	-.012	.131	.056	.020
	other meat	-.031	.107	.078	-.034	1.000	-.145	.026	.004	-.007	-.089	.077	-.014	-.027	.097	-.119	.014	-.129
	fish and seafoods	.111	-.141	-.021	-.013	-.145	1.000	.080	.029	-.042	.019	.039	.007	.035	-.054	.110	-.060	.208
	eggs	-.006	-.007	.082	.092	.026	.080	1.000	.043	-.035	.027	.073	.026	.048	.034	.064	-.012	.107
	legumes and legumes product	-.114	.044	.000	.057	.004	.029	.043	1.000	.025	.029	.150	.152	.059	.013	.028	.071	-.047
	milk	-.047	-.024	-.013	-.020	-.007	-.042	-.035	.025	1.000	-.026	.078	.042	.026	-.017	-.019	.043	-.050
	processed dairy products	-.060	-.027	.067	.040	-.089	.019	.027	.029	-.026	1.000	-.017	-.032	.029	-.021	.026	.066	.034
	vegetables	-.018	-.039	.068	.018	.077	.039	.073	.150	.078	-.017	1.000	.176	.030	.006	.039	.022	-.001
	fruits	-.125	-.037	.012	.075	-.014	.007	.026	.152	.042	-.032	.176	1.000	.062	.002	.065	.093	-.045
	non-alcoholic	-.017	.047	.005	-.005	-.027	.035	.048	.059	.026	.029	.030	.062	1.000	.024	.090	.019	.037
	alcoholic	-.009	.048	.012	-.012	.097	-.054	.034	.013	-.017	-.021	.006	.002	.024	1.000	-.045	.011	-.023
	confections	-.071	-.155	.011	.131	-.119	.110	.064	.028	-.019	.026	.039	.065	.090	-.045	1.000	.030	.177
	spreads	-.135	.025	.048	.056	.014	-.060	-.012	.071	.043	.066	.022	.093	.019	.011	.030	1.000	-.009
	flavourings	.041	-.112	.022	.020	-.129	.208	.107	-.047	-.050	.034	-.001	-.045	.037	-.023	.177	-.009	1.000
Sig. (1-tailed)	rice		.000	.005	.000	.045	.000	.374	.000	.005	.000	.158	.000	.174	.307	.000	.000	.011
	cereals and cereals products	.000		.027	.151	.000	.000	.350	.007	.094	.068	.015	.019	.004	.004	.000	.082	.000
	meat	.005	.027		.000	.000	.121	.000	.496	.236	.000	.000	.255	.398	.245	.271	.004	.107
	meat products	.000	.151	.000		.031	.233	.000	.001	.139	.014	.158	.000	.399	.248	.000	.001	.134
	other meat	.045	.000	.000	.031		.000	.073	.421	.348	.000	.000	.223	.065	.000	.000	.225	.000
	fish and seafoods	.000	.000	.121	.233	.000		.000	.057	.010	.151	.015	.343	.028	.002	.000	.000	.000
	eggs	.374	.350	.000	.000	.073	.000		.009	.027	.071	.000	.071	.004	.030	.000	.262	.000
	legumes and legumes product	.000	.007	.496	.001	.421	.057	.009		.083	.055	.000	.000	.001	.233	.059	.000	.005
	milk	.005	.094	.236	.139	.348	.010	.027	.083		.075	.000	.011	.074	.176	.146	.009	.003
	processed dairy products	.000	.068	.000	.014	.000	.151	.071	.055	.075		.174	.037	.055	.118	.077	.000	.030
	vegetables	.158	.015	.000	.158	.000	.015	.000	.000	.000	.174		.000	.048	.377	.015	.113	.480
	fruits	.000	.019	.255	.000	.223	.343	.071	.000	.011	.037	.000		.000	.451	.000	.000	.007
	non-alcoholic	.174	.004	.398	.399	.065	.028	.004	.001	.074	.055	.048	.000		.089	.000	.148	.019
	alcoholic	.307	.004	.245	.248	.000	.002	.030	.233	.176	.118	.377	.451	.089		.007	.272	.100
	confections	.000	.000	.271	.000	.000	.000	.000	.059	.146	.077	.015	.000	.000	.007		.049	.000
	spreads	.000	.082	.004	.001	.225	.000	.262	.000	.009	.000	.113	.000	.148	.272	.049		.303
	flavourings	.011	.000	.107	.134	.000	.000	.000	.005	.003	.030	.480	.007	.019	.100	.000	.303	

a. Determinant = .546

Glossary of Terms

a posteriori	a data-driven method that applies factor or cluster analysis to derive dietary patterns (Kant 2004)
a priori	a dietary method to derive dietary patterns through diet indexes or scores that assess compliance with prevailing dietary guidelines
adequate intake level (AI)	Estimation of observed mean nutrient intakes by groups of healthy people who are maintaining a defined criterion of adequacy (National Coordinating Committee on Food and Nutrition 2005)
BMR	Basic metabolic rate; minimal rate of energy exchange in the body, but yet contributes the largest component of energy expenditure (National Coordinating Committee on Food and Nutrition 2005)
dietary pattern	a combination of different foods or food groups
DQI-R	Diet Quality Index Revised, a dietary index to assess diet quality based on scores
double burden of disease	Facing burden of undernutrition, and on the same time are experiencing a rapid increase in non-communicable diseases (NCDs) risk factors such as obesity and overweight
EAR	sets an estimate of the average requirement for a nutrient in a population defined by age and gender – if average intake for a population is close to the EAR, it is possible that everyone in the population is meeting their nutrient needs
FAFH	Food away from home; is food that are bought outside home
FAH	Food at home; is foods that are prepared at home
fast food	as specialised food that can be prepared in a short time for immediate consumption, either on the premises or elsewhere, and which is relatively inexpensively (Farzana *et al.* 2011)
Glocalization	the global marketing strategies of global fast food and soft drinks companies to local consumers
HICs	High income countries
LMICs	Lower- and middle-income countries
metabolic syndrome	a cluster of the most dangerous heart attack risk factors: diabetes and raised fasting plasma glucose, abdominal obesity, high cholesterol and high blood pressure (Alberti *et al.* 2005)
NCDs	Non-communicable diseases (NCDs) are a group of conditions of long duration, generally slow progression and not passed from one person to another. The main types of NCDs are cardiovascular diseases (such as heart attacks and stroke), diabetes and cancer.
night market	a food retailing style in East Asia among societies strongly collectivist in nature (Wu and Luan 2007)
Nutritionist Pro	a computerised dietary analysis program, is a nutrient database that consists of data from the Continuing Survey of Food Intake of Individuals (Spencer *et al.* 2005) and other sources, including Asian countries
obesity	is the result of excess energy intake (high energy input) and less energy expenditure (low energy output)

PCA	Principal Component Analysis (PCA) is *a posteriori* approach that has been applied in determining dietary patterns among a population. PCA deducts dietary variables through aggregation and produces a unique factor solution (Kant 2004)
positive energy balance	as a result of less energy output, but more energy input
transnational corporations (TNC)	Companies that operate in several countries
trade liberalisation	reduced barriers to imports and exports, foreign direct investment and trade in services, other measures facilitating business activity, and the process of harmonizing national regulations (Hawkes 2010)
UL	the tolerable upper intake level (UL) is the maximum level of continuing daily nutrient intake that is likely to present no risk of adverse health effects in almost all individuals in the specified life stage group (National Coordinating Committee on Food and Nutrition 2005)
Under-reporting	Under-reporting of energy intake is a well-documented phenomenon in self-dietary assessment (Rennie *et al.* 2007). This occurs when energy intakes were underestimated compared to measured energy expenditure
UPP	Ultra-processed foods/products; is a classification of foods according to the nature, extend and purpose of food processing (Monteiro 2012)
westernisation diet	It is characterized by high intakes of red meat, sugary desserts, high-fat foods, and refined grains (Gandey and Vega 2009)

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Supporting Publications

Asma A, Margetts BM and Roderick P. "Comparison between UK, Brazil & Malaysia and consideration of value of current food based dietary guidelines (FBDGs)". World Nutrition Rio2012, 27 – 30 Apr, 2012, Rio de Janeiro, Brazil. – Oral Presenter

Asma A, Margetts BM and Roderick P. "Consumption of ultra-processed foods and likely impact on human health: evidence from Malaysia". Faculty of Medicine Research Conference, 13 – 14 June, 2012. Southampton, UK. – Poster Presenter

Asma A, Margetts BM and Roderick P. "Developing a new approach of food classification for Malaysian population". Primary Care and Population Science (PCPs) PhD Research Presentation, 15 January, 2013. Southampton, UK. – Short oral communication

Asma A, Margetts BM and Roderick P. "Consumption of Ultra-Processed Foods in Malaysia". Summer Conference 'Tackling Population Health Challenges', 12 June, 2014. Southampton, UK. – Poster Presenter