THE FAMILY DIET STUDY:

Dietary and lifestyle factors associated with weight status of Malay primary school children and their main carers in urban areas of Klang Valley, Malaysia

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A thesis submitted for the degree of PhD (Nutrition and Dietetics)

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Statement of Originality

The thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent to the final version of my thesis being made available worldwide when deposited in the University's Digital Repository**, subject to the provisions of the Copyright Act 1968.

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Wai Yew Yang

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Publications and Presentations arising from this thesis

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2. Yang WY, Burrows T, MacDonald-Wicks, Williams LT, Chee WSS & Collins CE. Quality of dietary intake methodology and reporting in epidemiology studies examining relationship between dietary patterns and childhood obesity in Asian developing countries: a systematic review. Nutrition and Dietetics. 2014; 71: 201-209
3. Yang WY, Burrows T, Collins CE, MacDonald-Wicks L, Williams LT & Chee WSS. Prevalence of energy intake mis-reporting in Malay children varies based on application of different cut-points. Journal of Tropical Pediatrics. 2014;60(6):472-475.
4. Yang WY, Burrows T, Collins CE, MacDonald-Wicks L, Williams LT & Chee WSS. Studying the Family Diet: An investigation into association between diet, lifestyle and weight status in Malaysian families. Malaysian Journal of Nutrition. 2015; 21(2): 139-154
5. Yang WY, Burrows T, MacDonald-Wicks L, Williams LT, Collins CE & Chee WSS. The Family Diet Study: A cross-sectional study into the associations between diet, food habits and weight status in Malay families. Journal of Human Nutrition and Dietetics. doi: 10.1111/jhn.12356

Manuscripts in peer-reviewed journals: Under review

1. Yang WY, Burrows T, MacDonald-Wicks L, Williams LT, Collins CE & Chee WSS. Dietary energy intake is associated with body mass index amongst plausible energy reporters in urban Malay children: evidence from The Family Diet Study. Under review. Asia Pacific Journal of Public Health (Submitted on 27th March 2016)

Conference abstracts: Published in peer-review journals

1. Yang WY, Burrows T, MacDonald-Wicks, Williams LT, Chee WSS & Collins CE. Quality of dietary intake methodology and reporting in epidemiology studies examining relationship between dietary patterns and childhood obesity in Asian developing countries: a systematic review. Obesity Review. 2014; Vol 15 (S2), 234

Conference abstracts: Published in conference proceedings

2. Yang WY, Burrows T, MacDonald-Wicks L, Williams LT, Collins CE & Chee WSS. Prevalence of energy intake mis-reporting in Malay children and their parents – findings from The Family Diet Study. 9th International Conference on Diet and Activity Methods. Australia. 2015 (Oral presentation)
3. Yang WY, Williams LT, Collins CE & Chee WSS. The relationship between dietary patterns and overweight and obesity in children of Asian developing countries: A Systematic Review. 30th Nutrition Society of Malaysia Scientific Conference. 2015 (Oral presentation)
4. Yang WY, Burrows T, MacDonald-Wicks L, Williams LT, Collins CE & Chee WSS. Dietary intake and body weight status of urban Malay primary school children. 21st Malaysian Dietitians' Association National Conference. 2015 (Poster presentation)
5. Yang WY, Burrows T, Collins CE, MacDonald-Wicks L, Chee WSS & Williams LT. Prevalence of energy intake mis-reporting in Malay children varies based on application of different cut-points. 29th Nutrition Society of Malaysia Scientific Conference. 2014 (Poster presentation)
6. Yang WY, Burrows T, MacDonald-Wicks L, Williams LT, Chee WSS & Collins CE. Quality of dietary intake methodology and reporting in epidemiology studies examining relationship between dietary patterns and childhood obesity in Asian developing countries: a systematic review. 12th International Congress of Obesity. Malaysia. 2014 (Poster presentation)

Other awards

1. Nestle Nutrition Institute Young Researcher Award, 2014

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List of Abbreviations

ACAORN	Australian Child and Adolescent Obesity Research Network
AMPM	Automated Multiple Pass Method
ANOVA	Analysis of Variance
B	Baseline
BF	Body fat
BIA	Bio impedance analysis
BMI	Body mass index
BMR	Basal metabolic rate
CCO	Concerns about child overweight
CDC	Centers of Disease Control and Prevention
CFQ	Child feeding questionnaire
CHO	Carbohydrate
CI	Confidence interval
CL	Confidence limit
cm	centimetre
CVD	Cardiovascular disease
DLW	Doubly labelled water
DR	Dietary Recall
EE	Energy expenditure
EI	Energy intake
EMBASE	Excerpta Medica Database
EURReca	European Micronutrients Recommendation Aligned
F	Female
FAO	Food and Agriculture Organisation
FFQ	Food frequency questionnaire
FHQ	Food habits questionnaire
FR	Food record

g	gram
HDL-C	High-density lipoprotein cholesterol
HEBAT	Healthy Eating and Be Active Trends Program
IOTF	International Obesity Task Force
IQR	Interquartile range
IPAQ - M	International Physical Activity Questionnaire - Long Form (Malay)
IPAQ - SF	International Physical Activity Questionnaire – Short Form
JBI	Joanna Briggs Institute
JBI-MAStARI	Joanna Briggs Institute Meta-Analysis of Statistics Assessment and Review Instruments
kcal	kilocalorie
kg	kilogram
kJ	kilojoule
LDL-C	Low-density lipoprotein cholesterol
m	metre
M	Male
MANS	Malaysian Adult Nutrition Survey
MASCOT	Malaysian Childhood Obesity Treatment Trial
MDG	Malaysian Dietary Guidelines
MetS	Metabolic syndrome
mg	milligram
ml	millilitre
mmol	millimole
MONI	Monitoring
MYR	Malaysian Ringgit
n	Numbers (sample)
NA	Not applicable
NCHS	National Centre of Health Sciences of United States

NHMS	National Health and Morbidity Survey of Malaysia
NR	Not reported
NW	Normal weight
N/A	Not available
OB	Obese
OR	Odds ratio
OW	Overweight
PAL	Physical activity level
PAQ-C	Physical Activity Questionnaire for Children
PCO	Perceived child overweight
PFR	Perceived feeding responsibility
PPO	Perceived parent overweight
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PTE	Pressure to eat
QoL	Quality of life
RCT	Randomised controlled trial
REST	Restriction
RNI	Recommended Nutrient Intake
RR	Relative risk
RSS	Recommended Serving Size
SD	Standard deviation
SDS	Standard deviation score
SE	Standard error
SEANUTS	South East Asian Nutrition Survey
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
TEF	Thermic effect of food
UK	United Kingdom
UL	Upper tolerable nutrient intake level

US	United States of America
USD	United States Dollar
USDA	United States Department of Agriculture
vs.	versus
WC	Waist circumference
WHO	World Health Organization
%E	Percentage energy
µg	microgram
χ^2	chi-square
β	standardized regression coefficient
r	correlation coefficient

Abstract

Childhood obesity is becoming more prevalent as Malaysia, a developing Asian country experiences a rapid nutrition and lifestyle transition. Given the detrimental short-term and long-term consequences of childhood obesity, effective and well-targeted obesity treatment interventions are the priorities for implementation. Yet, current evidence related to major environmental determinants of childhood obesity in Malaysia is limited and warrants an observational study as the most appropriate first step to inform a weight management intervention programme. The primary aim of this thesis is to evaluate and describe the dietary intakes and body weight status within Malay families, and the secondary aim is to examine association within Malay families for parent-child dyads related to body weight status and dietary intake. Two systematic reviews, one pilot study, and one cross-sectional studies were undertaken to meet the aims of the research.

Two systematic reviews assembled the available literature from developing countries in Asia to provide a clear background and justification for this thesis. The first review summarised the prevalence of childhood overweight and obesity, and synthesised the associations between children's dietary patterns and their body weight status. Results indicated that there was a wide range of prevalence rates of overweight and obesity with no specific trend in age or gender. As meta-analysis was not possible due to heterogeneity of the studies, several significant yet inconsistent statistical associations between dietary patterns and childhood overweight/ obesity were found. The second review appraised the quality of dietary assessment methodology and reporting in studies included in the first systematic review. The analyses provided evidence that the majority of the included studies had 'poor' ratings and the quality rating was influenced by the dietary assessment method chosen.

A pilot study tested the study protocol in terms of flow, timeline, recruitment and feasibility of the main cross-sectional study (known as the Family Diet Study) in the Malaysian setting. Eleven families completed pilot data collection by answering study questionnaires (inclusive of socio-demographic, food habits, parental child feeding practices and physical activity), diet intakes were reported using 24-hour dietary recalls and participant anthropometric measures (body weight, height, body fat and waist circumference) were measured. Results showed overall feasibility of the study protocol

and directed some modifications in recruitment and measurements. The pilot sample also allowed the investigation of the prevalence of energy intake mis-reporting amongst the children. A high prevalence of energy mis-reporting was found and varied according to the cut-points used (Goldberg equations, Torun cut-point and Black & Cole method).

A cross-sectional study, the Family Diet Study (n=236) evaluated the body weight status and dietary intakes of Malay families (child aged 8-12 years and their parents), in comparison to current obesity standards and food and nutrient recommendations. Body mass index was calculated and categorised using World Health Organisation BMI-for-age growth reference (5 to 19 years old) and using BMI Asian classification for ≥ 18 years for the adults. Approximately a third of the children and three-quarter of the parents were classified as overweight or obese. The children's BMI was positively associated with parental BMI. Mean nutrient intakes and food group servings were compared to the Malaysian Recommended Nutrient Intakes and the national dietary guidelines for adults and children. The majority of participants had sub-optimal intakes of nutrients and food groups were below the recommended targets. The obese children had the lowest energy intakes adjusted for body weight compared to children of other weight status categories. Moderate-to-strong and weak-to-moderate correlations were found between mother-father and child-parent dyads, respectively, with child-mother dietary intakes more closely related than that of child-father intakes. Multiple regression analyses demonstrated that maternal percentage energy from fat largely explained the variation in child fat intakes. Using the Black & Cole method, a large proportion of energy intake mis-reporters were identified within all family members. Amongst children reporting plausible energy intake (n=141), results suggested that higher energy intake was associated with higher BMI z-score.

In conclusion, the study findings presented in this thesis support the evidence that developing Asian countries undergoing nutrition transition are at risk of childhood obesity epidemic. High quality dietary studies are limited in this region due to usage of non-validated tools and a lack of standardised reporting. Despite a significant proportion of Malay families being overweight or obese, the majority reported dietary intakes below national recommended levels which was distorted by energy intake mis-reporting. Children's body weight status may be modifiable through optimising total energy intake and by conducting nutritional interventions that target the mother. The results have

important implications for obesity-related research targeting Malaysian families, emphasizing the need for higher quality research and specific nutrition programmes to improve overall family dietary patterns.

Chapter 1 Introduction

1.1 Background and context

This introductory chapter provides an overview of the prevalence of childhood obesity in developing countries and its consequences (Section 1.1.1), identifies nutrition transition as the underlying driver of childhood obesity in developing countries (Section 1.1.2) and highlights the need for a dietary study on Malaysian families (Section 1.1.3).

1.1.1 Childhood obesity in developing countries

Childhood obesity is a global health challenge of the 21st century especially in developing countries. In 2010, 80% of overweight children under the age of five years were from developing countries[1] while a review of childhood overweight in developing countries published in 2007 revealed the highest prevalence to be found in the Middle East (89.6%) and Eastern Europe (48.4%).[2] Within Asia, despite a relatively low prevalence of childhood obesity in older studies published prior to the millennium,[3, 4] the magnitude of the problem is now likely to be understated given the large population density and the rate of economic development in this region.[1, 3, 5-7] Malaysia is a developing Asian country demonstrating an exponential increase in the prevalence of childhood obesity, from 9.8% in 1991[8] to 34.5% in 2013.[9] This nearly four-fold increase is alarming as it follows the worldwide trend of a more steep rise in developing countries (+65%) than in developed countries (+48%) over the last two decades.[1] Of the three main ethnicities in Malaysia, the impact of childhood obesity could be greater for Malay children being the main ethnic group based on the proportion of Malaysian population (67.4% Malay and 32.6% others).[10]

The consequences of childhood obesity are detrimental; physically, psychosocially and economically.[5, 11-13] The disease burden is significant as overweight and obesity have been estimated to cause 3.4 million deaths, 4% of years of life lost and 4% of disability-adjusted life-years worldwide.[14] Epidemiological data showed that alongside with rising childhood obesity, the prevalence of type 2 diabetes is also increasing globally, with children from specific ethnic groups specifically South Asians at increased risk than white children.[15-17]

The body of evidence from developed countries provided comprehensive information on the long-term impact of childhood obesity. Obese children are predisposed to a higher risk of developing chronic conditions such as type 2 diabetes, hypertension, hypercholesterolaemia and hypertriglyceridaemia [clustered together with abdominal obesity and then known as metabolic syndrome (MetS)] and premature mortality in adulthood.[13, 18] The Malaysian schoolchildren aged 7 to 12 years who are obese have recently shown a dramatic rise from 1.3% to 5.3% in the prevalence of MetS, increasing their risk of chronic disease.[19, 20]

The greatest health problems may yet emerge when this generation reaches adulthood as the children currently overweight or obese are at risk of shortened life expectancy, estimated as seven years less than their parents.[12] Two longitudinal studies included in a systematic review on health consequences of obesity concluded that adolescent obesity has adverse effects on social and economic outcomes in adulthood.[11] The economic impact is thought to be greater in developing countries such as Malaysia due to the increasing triple burden of malnutrition, inclusive of under-nutrition, micronutrient deficiencies and over-nutrition.

1.1.2 Nutrition transition – the underlying driver to childhood obesity in developing countries

Developing countries undergoing epidemiological transition experience a reduction in mortality from communicable diseases, but are being faced with significant increases in nutrition-related non-communicable diseases like Type 2 diabetes and cardiovascular diseases (CVD), related to the increasing prevalence of obesity.[15, 21-23] Based on World Bank Classification of Countries 2015, developing countries (economies) include both low- and middle-income economies with gross national income per capita of ≤ United States Dollar (USD)1,045 and between USD1,045 and USD12,736, respectively.[24] The epidemiological transition as originally hypothesized by Omran (2005), is characterized by mortality patterns over time in three stages: (i) the age of pestilence and famine (where mortality is high and fluctuating), (ii) the age of receding pandemics (where mortality progressively declines), and (iii) the age of degenerative and man-made diseases (where mortality continues to decline and eventually approaches stability at a relatively low level).[25] Occurring parallel with the epidemiologic transition were major shifts in dietary

intake and physical activity habits in five patterns resulting in changes in body composition, nutritional status and disease outcome (known as nutrition transition).[26]

The causes of overweight and obesity in children in developing countries is less studied than developed countries.[5, 23] Genetics is a non-modifiable risk factor in the aetiology of childhood obesity. Obesity is predominantly driven by environmental factors especially as the rapid changes in prevalence of obese children is within a relatively stable population within a short time frame.[5] A review of worldwide trends by Wang and Lobstein suggested that children in developing countries, especially those growing up in urban environments, experiencing socio-economic development and adopting a Western lifestyle, face a major risk of becoming obese, given the increased prevalence of various obesogenic environment, such as energy-dense foods and television ownership.[6]

With economic globalisation, developing countries in Asia have experienced significant environmental change including improved motor vehicle transportation and rapid growth of the fast food industry.[5] These changes have resulted in nutritional and lifestyle transition characterised by a shift away from high energy activities of daily living to a sedentary lifestyle and from a traditional grain-based diet to one higher in animal products, oils and fats, and lower in fibre.[5, 22, 23, 27-29] The change towards a diet high in energy-dense, and nutrient-poor processed foods is prevalent in Malaysia, demonstrated by a doubling of imported food in the decade from 1985 to 1995.[27, 29] This epidemiological shift adversely influence the behaviour, the social and cultural drivers within the obesogenic environment, hence is likely to contribute to the onset and rapidly growing childhood obesity in the developing countries.[6, 30]

1.1.3 The need for a dietary study on Malaysian families

While current data demonstrates that prevalence of over-nutrition is rising steadily in the developing countries, pockets of under-nutrition as well as micronutrient deficiencies remain a significant problem within the communities.[22] The coexistence of under-nutrition and over-nutrition in developing countries makes it difficult for public health policymakers to strategize and manage when resources are generally constrained in these countries.[29] Considering the adverse implications of obesity specifically on the paediatric population, this research focuses on childhood obesity in Malaysia.

With no existing national standard for classification of childhood obesity, the interpretations and comparisons of the Malaysian data on prevalence of childhood obesity are limited. The use of various growth standards with different cut-offs by different researchers could either underestimate or overestimate the actual prevalence because the body of evidence demonstrated that children from different populations vary in their rate of proportional growth and in fat patterning.[31-33] Similarly, the true consequences of childhood obesity on health and well-being could be understated with the lack of studies published from developing countries like Malaysia.[14]

1.1.3.1 Dietary intake studies by body weight status

Diet is an important contributor to energy imbalance and specific foods including increased consumption of sugar-sweetened beverages and processed meats, and snacking on energy dense processed foods are associated with overweight status amongst children in developed countries.[34-39] Within developing countries in Asia, the systematic review conducted for this research (see Chapter 3), found inconclusive associations between diet and childhood obesity, primarily due to a general lack of studies (with one study from Malaysia);[7] and methodological issues regarding the use of non-validated dietary assessment tools.[40]

Malaysia had no national nutrition and dietary intake data for children aged below 12 years from the early 1980's until a recent publication in 2013.[9] The earlier published dietary studies used cross-sectional designs and mainly reported on either nutrient intakes;[9, 41-45] food habits,[42, 44, 46, 47] or individual dietary practices.[46, 48, 49] The national nutrition survey [South East Asian Nutrition Survey (SEANUTS) Malaysia] collected data from May 2010 till October 2011 on anthropometry (weight, height, mid-upper arm circumference, and waist and hip circumference), blood biochemistry (haemoglobin, serum ferritin, vitamin A and D); and dietary intake using a semi-quantitative food frequency questionnaire (FFQ).[9] This study revealed that over-nutrition to be more prevalent than under-nutrition in children aged 6 months to 12 years. The researchers also found a high prevalence of vitamin D insufficiency and inadequate intakes of calcium and vitamin D.

Despite the lack of comprehensive data on dietary intakes of Malaysian children and the increased obesity prevalence, there are fewer detailed studies of dietary intake data studies

according to body weight status in Malaysia.[41, 45, 50, 51] This limits the ability to determine the aetiological dietary factors linked to positive energy balance and weight gain over time amongst Malaysian children.

1.1.3.2 Family environment: an important setting to address childhood obesity

Obesity is found to be more prevalent within families, suggesting an intergenerational transmission of obesity.[5, 52-55] Given the rising prevalence of childhood obesity in Malaysia, investigation into the family environment, beyond individual levels, is needed, however, current research into this aspect is lacking. As the first and predominant social context, the family environment is unarguably the most important setting in relation to influencing young children's eating patterns and impacting on the child body weight status.[56] Therefore, in this research, parents and other family-related carer(s) playing the role as primary provider of food for the child were invited to participate.

Systematic and narrative reviews of predominantly Western families have suggested that the dietary intakes of parents could affect their children through increasing availability and accessibility of foods in the home and the role of parental modelling.[57-59] While there is growing evidence in developed countries of the associations of dietary intake between children and their parents, [60-62] less is known about child-parent dietary correlations in developing countries. Previous studies amongst families in developed countries found considerable variations in the correlations between dietary intakes within family members across nutrients and food groups.[58, 60-62] Exploring how various dietary intakes correlate within families in developing countries could provide important insights to guide the development and implementation of family-based interventions.[59]

1.1.3.3 Childhood obesity intervention programme

Research to develop effective weight management interventions to treat children affected by overweight and obesity has been ongoing.[63, 64] Several key systematic reviews on interventions for treating obesity in children have been published over the last two decades, parallel with the increased prevalence of childhood obesity.[63-68] To date, childhood obesity interventions conducted in developed countries have reported successful usage of a parent-centred approach and focused on specific dietary guidelines and strategies.[69-73] Yet, direct extrapolation of effective intervention programmes from

the developed countries to the developing countries could be inappropriate due to different causative factors associated with childhood obesity besides the limited resources and budget in the developing countries.

However, only a few randomised controlled trials (RCT) of interventions for treatment of childhood obesity have been carried out in developing Asian countries,[74-78] including two from Malaysia.[79, 80] The Malaysian Childhood Obesity Treatment Trial (MASCOT) was the first intervention conducted in Malaysia, targeting 107 primary school children and their parents, focusing on key behaviours related to obesity treatment.[80] The second RCT, known as Healthy Eating and Be Active Trends Program (HEBAT) aimed to improve weight status and self-esteem, and increase physical activity level of 11 year old overweight children.[79] These Asian studies omitted detailed reporting of dietary assessment tools used and dietary data, despite the fact that diet is a key contributory factor for the development of obesity and a cornerstone of a successful intervention in weight management.[74-76, 78-80] Two related systematic reviews published six years apart [2006[65] and 2012[64]] measuring effectiveness of dietetic interventions in child obesity came to similar conclusions regarding the lack of high quality dietary interventions internationally, limiting the ability to develop effective strategies for future intervention studies and highlights the need for in-depth analysis of dietary intakes.

Several significant research gaps exist in relation to the understanding of the role of diet in childhood obesity aetiology in Malaysia. Therefore, an observational study on Malaysian families with detailed assessment of diet, anthropometry and related causative factors is warranted. This is the most appropriate first step towards a family-based weight management intervention programme.

1.2 Research aims and hypotheses

The primary aim of this thesis was to evaluate and describe the dietary intakes and body weight status of Malay school children aged 8 to 12 years and their main carer(s) in urbanized areas at central of Peninsular Malaysia *(Klang Valley)*. The secondary aim was to examine association within Malay families for parent-child dyads related to body weight status and dietary intake. This study is formally known as the Family Diet Study.

More specifically, the aims (and *hypotheses*) of this thesis are:

A. Systematic Review

1. To systematically review and summarize the best available evidence on the prevalence of childhood overweight and obesity in developing Asian countries and to synthesise the evidence on the epidemiological association between dietary patterns of children and childhood obesity in developing Asian countries.

    - *The prevalence of childhood overweight and obesity in developing Asian countries will be similar to that of developed countries.*
    - *The dietary patterns of children from developing Asian countries are associated with increased risks of overweight and obesity.*

2. To systematically review and evaluate the quality and reporting of dietary assessment methods used in studies examining the relationship between dietary outcome and childhood obesity in developing Asian countries.

    - *The quality and reporting of dietary assessment methods used in studies examining the relationship between dietary outcome and childhood obesity in developing Asian countries will be similar to that of developed countries.*

B. Pilot Study

3. To develop and test the feasibility of the Family Diet Study conducted in urbanized areas at central of Peninsular Malaysia *(Klang Valley)* amongst a sample of Malay primary school children and their main carer(s).

    - *The protocol of the pilot study for the Family Diet Study will be feasible for main trial implementation.*

4. To identify the percentage of energy intake (EI) mis-reporting using a range of commonly used cut-points amongst a pilot sample of Malay children.

    - *The prevalence of EI mis-reporting amongst the pilot sample of Malay children will be similar to that of developed countries.*

C. Cross-Sectional Study

5. To describe the dietary intakes and body weight status of primary school-aged Malay children and their main carer(s) enrolled in the Family Diet Study.
6. To determine whether Malay children and their main carer(s) in the Family Diet Study, consume nutrients and foods in accordance with national recommendations for nutrients and food groups.

    - *The dietary intakes of the Malay children and their main carer(s) will not match national food group recommendations or provide sufficient intake of key nutrients, compared to the national recommendations for nutrient intakes.*
    - *The prevalence of overweight and obesity amongst participants will be similar to the developed countries.*

7. To analyse the dietary intakes of Malay children in the Family Diet Study according to body weight status.

    - *There will be an association between dietary intakes and body weight status of the children.*

8. To identify the prevalence of EI mis-reporting of primary school-aged Malay children and their main carer(s) who enrolled in the Family Diet Study.

    - *The prevalence of EI mis-reporting amongst Malay children and their main carer(s) will be similar to that of developed countries.*

9. To determine any associations between dietary intakes of the children and their main carer(s) in the Family Diet Study.

    - *There will be an association between dietary intakes of the children and their main carer(s).*
    - *There will be stronger dietary associations for child-mother dyads than child-father dyads.*

10. To determine any associations between body weight status of the children and their main carer(s) in the Family Diet Study.

- *There will be an association between body weight status of the children and their main carer(s).*
- *There will be stronger associations for body weight status of child-mother dyads than child-father dyads.*

1.3 Thesis structure and study design

1.3.1 Overview

The thesis begins with a comprehensive review of literature supporting this work (Chapter 2). The background, methods, results and discussion of findings and implications of the research conducted for this thesis are then presented as a series of six research papers (Chapter 3 to 8)[7, 40, 81-84]. The papers present the work from a body of research made up of three key components: two systematic reviews (Section 1.3.2), a pilot study (Section 1.3.3) and a cross-sectional study (Section 1.3.4). A brief overview of each component is provided below, including its relationship with the included research papers. An overall discussion of the findings from the body of research, the implications for research and practice, and concluding remarks are provided as the final chapter of the thesis (Chapter 9). Figure 1-1 illustrates the flow and links between the subsequent chapters in this thesis and the corresponding research papers.

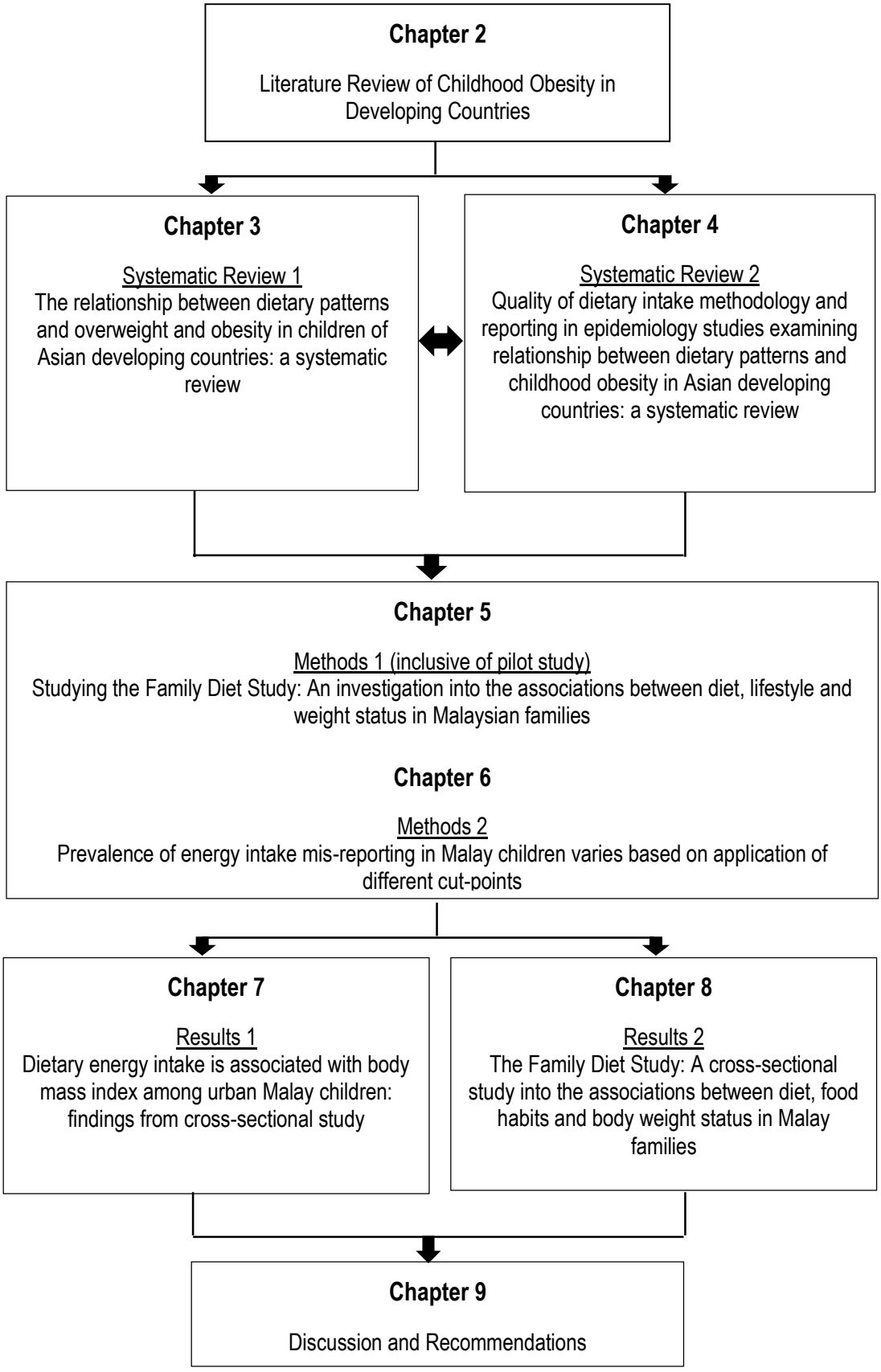

Figure 1-1: Flow diagram of the thesis chapters and corresponding research papers that form this thesis

1.3.2 Systematic reviews

Two systematic reviews were undertaken to assemble the current body of knowledge to date in order to inform this research and to provide a clear justification for the observational study.

Systematic Review 1

The first systematic review aimed to: (i) summarize the best available evidence on the prevalence of childhood overweight and obesity in developing Asian countries, and (ii) synthesise the evidence on the epidemiological association between dietary patterns of children and childhood obesity in developing Asian countries (Research Aim No.1).[7]

A pre-defined protocol for this systematic review was developed under the University of Newcastle Evidence Based Health Care Group, a Joanna Briggs Institute (JBI) Evidence Synthesis Group; peer-reviewed and published by the JBI Library of Systematic Reviews (can be accessed at: http://connect.jbiconnectplus.org/ViewSourceFile.aspx?0=5489; 11th July 2012). This review included any analytical observational studies reporting dietary pattern and obesity, limited to children under 18 years of age residing in developing Asian countries (based on World Bank Classification of Countries, 2011). Electronic databases searched were MEDLINE, CINAHL, EMBASE (Excerpta Medica Database), ProQuest, Web of Science and Scopus from inception to September 2011 with an English language restriction. All studies were assessed for relevance based on title, abstract and description/MESH heading independently. The papers were subsequently appraised using JBI standardised critical appraisal instruments from the JBI Meta-Analysis of Statistics Assessment and Review Instruments (JBI-MAStARI). Comprehensive data extraction was conducted using an adapted version of the JBI standardised data extraction form and included specific details on study design, sample characteristics, classification of overweight and obesity, measurement of dietary pattern exposure and outcomes. The detailed methods and results pertaining to the objectives of this review have been published in the JBI Database of Systematic Reviews and Implementation Reports (Chapter 3).

Systematic Review 2

The second systematic review focused on evaluating the quality of reporting of dietary intake methods within these epidemiological studies looking at the relationship between dietary outcomes and childhood overweight and obesity in developing Asian countries (Research Aim No.2).

Papers included in the first systematic review were audited for quality of dietary assessment methods and dietary intake methods reporting using a specific checklist developed by the Australian Child and Adolescent Obesity Research Network (ACAORN).[85] The checklist was adapted based on two toolkits i.e. the dietary assessment methods checklist of Nelson and colleagues[86] and the European Micronutrients Recommendation Aligned (EURReca) scoring system.[87] It consisted of six components: methodology validated in similar population, appropriate validation statistics used, data collection quality, reporting of scoring or details of food composition database, and two specific parameters related to the dietary assessment method used. Data extraction was undertaken using a standardised data extraction tool and cross-checked for completeness and accuracy. The detailed methods and results pertaining to the objectives of this review have been published in Nutrition and Dietetics journal (Chapter 4).[40]

Findings from both systematic reviews were used to develop the aims and methods of the observational study, The Family Diet Study.

1.3.3 Pilot study

A pilot study was undertaken: (i) to test the study protocol in terms of flow, timeline, recruitment and feasibility of the main study (the Family Diet Study) in the Malaysian setting (Research Aim No.3), and (ii) to investigate the prevalence of EI mis-reporting using a range of commonly used cut-points amongst the pilot sample (Research Aim No.4).

Approval was obtained from the Human Research Ethics Committees of the University of Newcastle, Australia (H-2013-0065) and International Medical University, Malaysia (IMU 275/2013). Five percent of the targeted sample size for the main study (n=311) was recruited between August and September 2013 from a national primary school in central

of Peninsular Malaysia (*Klang Valley*). Inclusion criteria were family of Malay ethnicity with main carer(s) living full time with their child who had no concurrent medical conditions. Data collection followed a standardised procedure and was carried out by trained data collectors. The study measures included family socio-demographics, dietary intake, parental attitudes, beliefs and practices about child feeding and obesity proneness, physical activity and body weight status.

Eleven of the sixteen families recruited to the pilot study completed data collection. The main carer(s) completed all study measures at school, in their home or at their workplace, while children underwent anthropometric measurements and interviews on dietary intake and physical activity at school. Three commonly used cut-points [Goldberg equations,[88, 89] Torun cut-point[90] and Black & Cole method[91]] were applied to the children's dietary data to identify EI mis-reporting.

The detailed methods and results pertaining to the objectives of the pilot study have been published in two papers in the Malaysian Journal of Nutrition (Chapter 5)[81] and the Journal of Tropical Pediatrics (Chapter 6).[82]

1.3.4 Cross-sectional study

The Family Diet Study, a cross-sectional study, was conducted at five national primary schools in urbanized areas in one state and one Federal Territory located at central of Peninsular Malaysia (*Klang Valley*). Approval was obtained from the Human Research Ethics Committees of University of Newcastle, Australia (H-2013-0065) and International Medical University, Malaysia (IMU 275/2013). Participants were recruited using multi-stage sampling methods and each family consisted of a Malay child aged 8 to 12 years and at least one main carer(s). Using the pilot study data on prevalence of skipping breakfast, the targeted minimum sample size was reduced to 220 participants from the initially estimated number of 311.

Invitations were sent to 1372 children. After eligibility screening, 315 participants were enrolled into the study and 236 participants completed all measures. The study measures for children and their main carer(s) included family socio-demographics, dietary intake, parental attitudes, beliefs and practices about child feeding and obesity proneness, physical activity and body weight status are listed in Table 1-1. Data collection started

from August 2013 to October 2014 with assessments conducted either at school or the participant's home based on the family preference and suitability. To obtain the main carer(s) follow-up 24-hour dietary recalls (DR), a phone call was conducted within 1 to 2 months of recruitment.

The Family Diet Study was undertaken to address six research aims (Research Aims No.5 to No.10). The detailed methods and results pertaining to the objectives of the cross-sectional study have been submitted for publication in two manuscripts.[83, 84] The paper presented in Chapter 7 has been submitted to Asia Pacific Journal of Public Health and is currently under review while the paper presented in Chapter 8 is published in the Journal of Human Nutrition and Dietetics.

The paper presented in Chapter 7 describes the dietary intakes and body weight status of primary school-aged Malay children in comparison to national recommendations and by body weight status (Research Aims No.5 and No.6), identifies the prevalence of EI mis-reporting amongst the children (Research Aim No.8) and reports whether the dietary intakes of the children in the Family Diet Study are associated with their body weight status (Research Aim No.7). The aim of the paper presented in Chapter 8 was to describe the dietary intakes and body weight status of the main carer(s) enrolled in the Family Diet Study in comparison to national recommendations (Research Aims No.5 and No.6), to identify the prevalence of EI mis-reporting amongst the participants (Research Aim No.8) and to determine any associations between dietary intakes and body weight status of the children and their main carer(s) (Research Aims No.9 and No.10).

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Table 1-1: Overview of measures for The Family Diet Study

Study Participants	Location of Study Measure	Type of Study Measures				
		Socio-Demographic	**Dietary Intake**	**Physical Activity**	**Child Feeding Practices**	**Anthropometry (Body Weight Status)**
Children	School/ Home	NA	• Repeated 24-hour Dietary Recalls • Food Habits Questionnaire	• Physical Activity Questionnaire for Children	NA	• Body weight • Height • Waist Circumference • Percentage of Body Fat
Main Carers	School/ Home/ Workplace	• Parents' employment status, education level & total monthly income • Family living conditions related to food and dietary habits	• Repeated 24-hour Dietary Recalls • Food Habits Questionnaire	• International Physical Activity Questionnaire-Short Form	• Child Feeding Questionnaire[a]	• Body weight • Height • Waist Circumference • Percentage of Body Fat

NA: Not Applicable; [a] Only filled by mother (if not applicable, other main carer identified)

Chapter 2 Literature Review

2.1 Overview

Chapter 2 provides a definition of obesity in childhood along with a review of the current state of childhood obesity in developing countries (Section 2.2). Contributors to the development of childhood obesity is discussed in Section 2.3 followed by a review of dietary intake assessment methods in children (Section 2.4). Lastly, a summary of current strategies used to address childhood obesity is presented (Section 2.5).

Section 2.2 begins with an overview of childhood obesity including the prevalence, (Section 2.2.1), definition (Section 2.2.2), and consequences of obesity in children (Section 2.2.3). The main contributors to childhood obesity are examined in Section 2.3 including the role of energy balance in regulating body weight (Section 2.3.1), a summary of EI and energy expenditure (EE) in children (Section 2.3.2 and Section 2.3.3) and the role of the family environment (Section 2.3.4) in the development of childhood obesity. Section 2.4 outlines the evidence for the measurement of dietary intake in children (Section 2.4.1), issues in measuring a child's dietary intake (Section 2.4.2) with a summary of dietary intake validation studies also provided (Section 2.4.3). The final section of the literature review presents current evidence on strategies to address childhood obesity (Section 2.5), including intervention trials for the treatment and prevention of childhood obesity (Section 2.5.1) and appropriate settings for effective interventions (Section 2.5.2). The framework of the literature review is shown in Figure 2-1.

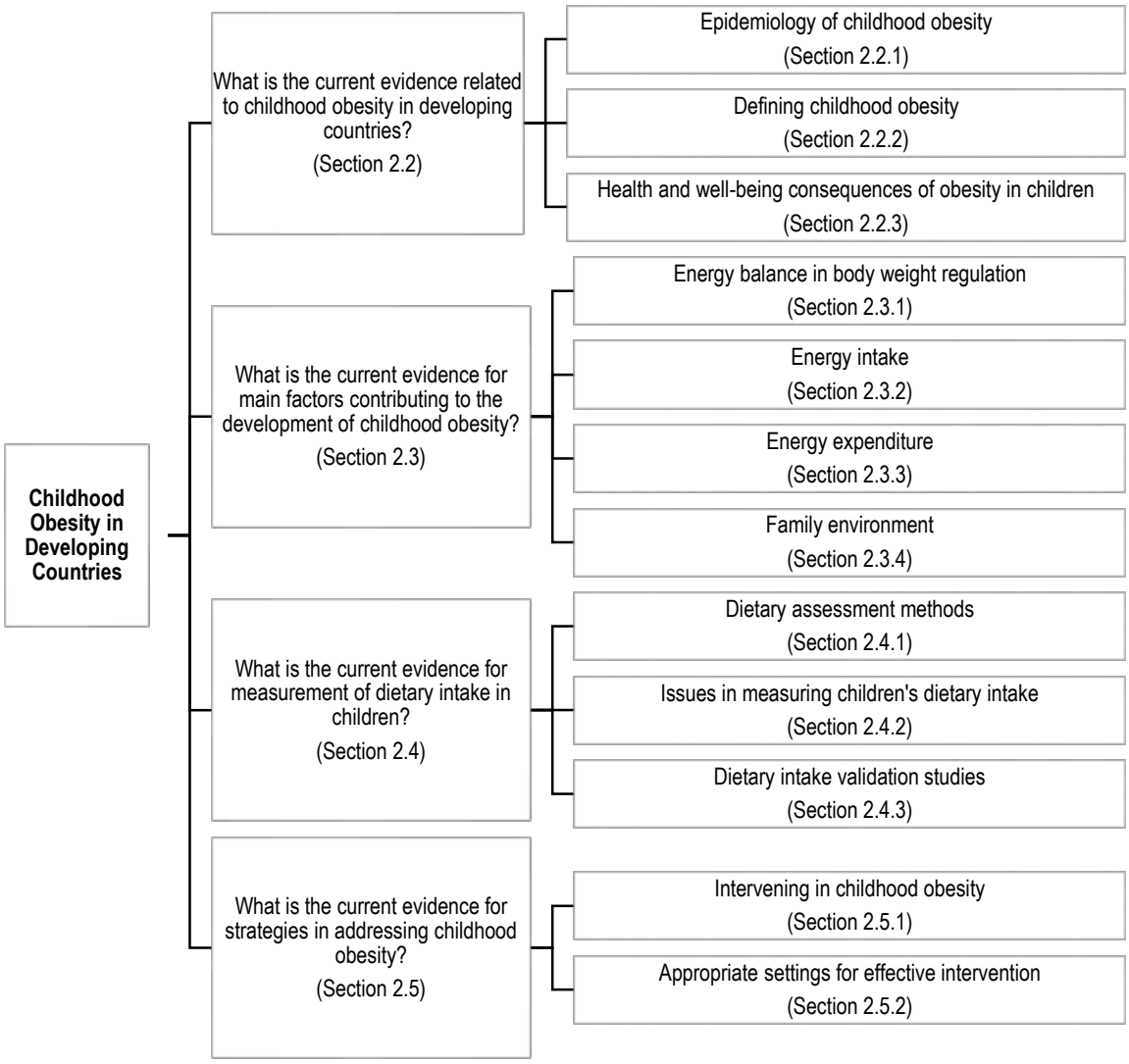

Figure 2-1 Framework of the literature review

2.2 Childhood obesity in developing countries

2.2.1 Epidemiology of childhood obesity

The global prevalence of childhood overweight and obesity has risen by nearly 50% over the last three decades, posing a major health challenge of the 21st century.[92] Although the prevalence has been reported to be higher in children and adolescents in developed countries, there has also been large increases amongst those residing in developing countries, with an increase from 8.1% to 12.9% in boys and 8.4% to 13.4% in girls between 1980 and 2013.[92] In 2010, 80% of children under the age of five were overweight in developing countries.[1] A systematic review on childhood overweight in developing countries (2007) outlined that the highest prevalence was found in Eastern Europe (48.4%) and the Middle East (89.6%) while developing Asian countries such as Sri Lanka (2.2%) had the lowest prevalence.[2] Such distinct geographical patterns for childhood obesity exist in developing countries with small sex differences in the prevalence and trends of overweight and obesity.[92]

The prevalence of overweight and obesity in children residing in developing Asian countries ranges from 5.1%[93] to 19.9%[94] using the International Obesity Task Force (IOTF) classification standards (refer to Chapter 3 for more details). The highest prevalence rates are consistent with figures reported in developed countries[1, 5, 92] and likely to be associated with socioeconomic status and geographical location.

Malaysia is a developing Asian country currently experiencing a significant increase in the prevalence of childhood obesity amongst the urban population, increasing from 9.8% in 1991[8] to 34.5% in 2013.[9] Findings from local studies have consistently shown that urban children were heavier than their rural counterparts throughout the country, regardless of age group.[8, 9, 41, 95, 96] Due to the varying definitions of childhood obesity used in the review (Chapter 3), no specific secular trend for a higher prevalence of childhood obesity with increasing age was found.[7] However, in Malaysia, existing data demonstrated that in certain paediatric population, trends in obesity were found. In children under five years of age, it was found that less than 10% of children were defined as overweight[96, 97] while the rate was higher (up to 22%) for those children around the age of puberty (9 to 10 years).[95] In a study of adolescents, lower prevalence rates were

reported (18%).[41] Table 2-1 summarises the studies that reported the prevalence of childhood obesity in Malaysia since mid-1990s.

There could be a possible ethnicity and gender difference in the prevalence of childhood obesity in Asia as demonstrated by studies from China[98, 99] and India.[100] Malaysia is a multi-ethnic country of Malay, Chinese and Indian making up the majority of ethnicities. Hence, the impact of childhood obesity may be greater for Malay children as this is the predominant ethnic group in Malaysia contrary to China and India.[10] However, at present there is insufficient data to draw any conclusion for comparison by ethnicity given the similar exposure to the same environment.

In terms of gender, a Malaysian study in 2008 showed the prevalence for boys and girls under five was similar at around 6%.[96] However, in the recent SEANUTS survey (2013), the strata comparison showed a significantly higher prevalence of obesity in urban boys than girls in both 4 to 6.9 years [boys 12.8% versus (vs.) girls 5.8%, $P<0.05$] and 7 to 12 years (boys 23.5% vs. girls 16.7%, $P<0.05$).[9] For Malaysian adolescents, despite an earlier study showing that males were also heavier than females (19.5% vs. 16.7%, $P<0.05$),[41] the baseline data from a cohort study on adolescents aged 13 years found no significant gender differences in body weight status.[101] This may be an effect of growth stage in boys.

2.2.2 Defining childhood obesity

An important aspect that should be considered when defining the prevalence of childhood obesity is the lack of consensus on optimum methods to define childhood obesity. International standards such as the IOTF 2000 classification[31], the World Health Organisation (WHO) Child Growth Standards,[102-104] or the 2000 Centers of Disease Control and Prevention (CDC) Growth Charts [105] are the most widely used in conjunction with respective national population reference standards. However, the actual prevalence and trend comparisons could be underestimated or overestimated since criteria for assessing childhood obesity varies and this has been the subject of debate and research.[31, 32]

It is essential to differentiate between a ‘reference’ and a ‘standard’ when using growth charts. Based on the WHO working group, a ‘reference’ is defined as a device used to

group and analyse data for purposes of comparison, and a 'standard' embodies the concept of a norm or target, or a value judgement.[106] The key distinction between a growth reference and a growth standard is the development and application of growth charts.[105] Hence, in certain populations with insignificant ethnic effect on children's growth, the reference and standard could refer to the same growth charts. In this research, the WHO Child Growth Standards were applied due to the absence of national growth charts in Malaysia.

Table 2-1: Studies on prevalence of childhood overweight/obesity in Malaysia (1996 – 2014)

Author	Year	Age (Years)	Sample Size	Main Findings	Growth Reference for Overweight and Obesity
Bong & Safurah[8]	1996	7 & 12	2706	• Overweight - 7.8%	Weight-for-Height, NCHS 1975
Kasmini *et al.*[107]	1997	7-16	6239	• Overweight - 6% • Obese 3.5%	Weight-for-Height, NCHS 1975
Norimah & Lau[97]	2000	4-6	91	• Overweight - 3%	Weight-for-Height, NCHS/CDC, 1983
Zalilah *et al.*[108]	2000	6-10	8005	• Overweight - 5.8%	Weight-for-Height, NCHS/CDC, 1983
Moy, Gan & Kassim[109]	2004	11-16	3556	• Overweight - 7.3%	BMI-for-Age, WHO, 1995
Anuar *et al.*.[95]	2005	9-10	1405	• Overweight - 16.3% • Obese - 6.3%	BMI-for-Age, IOTF, 2000
Zalilah *et al.* [41]	2006	11-15	618	• Overweight – 18.3%	BMI-for-Age, WHO, 1995
Rampal *et al.*[110]	2007	13-17	16127	• At risk of overweight - 11.4% • Overweight - 8.2%	BMI-for-Age, Goran, 2001
Khor *et al.*[96]	2008	≤18	22032	• Overweight - 5.4%	BMI-for-Age, WHO 2006 BMI-for-Age, WHO 2007
Khor *et al.*[111]	2009	≤5	5344	• Overweight - 6.4%	BMI-for-Age, WHO, 2006
Quah *et al.*[20]	2010	7-12	932	• Overweight - 13.5% • Obese - 17.9%	BMI-for-Age, WHO, 2007
Khor *et al.*[112]	2011	7-12	402	• Overweight – 17.9% • Obese – 16.4%	BMI-for-Age, WHO, 2007
Soo *et al.*[45]	2011	10-12	278	• Overweight – 1.4% • Obese – 23.4%	BMI-for-Age, WHO, 2007
Poh *et al.*[9]	2013	0.5-12	16203	• Overweight – 9.8% • Obese – 11.8%	BMI-for-Age, WHO, 2007
Hazreen *et al.*[101]	2014	13	1361	• Overweight – 15.4% • Obese – 8.5%	BMI-for-Age, IOTF, 2000

BMI: Body Mass Index; CDC: Centers of Disease Control; IOTF: International Obesity Task Force; NCHS: National Centre of Health Services; WHO: World Health Organization

2.2.2.1 Body Mass Index

Body Mass Index (BMI), an anthropometric method, is the ratio of weight (kg) divided by recumbent length or standing height (m^2).[103] BMI is commonly used in epidemiological studies and clinical practice as proxy measures of adiposity because of its simplicity. Although BMI does not measure body fat (BF) directly, research has shown that BMI correlates to direct measures of BF, such as underwater weighing and dual energy x-ray absorptiometry.[113, 114] BMI in childhood changes substantially with age as the child grows, hence age specific reference centiles or z-score are required.[31]

A. Body Mass Index cut-off points

The centile indicates the relative position of the child's BMI compared to children of the same sex and age.[105] The IOTF 2000 classification is compiled from six large nationally representative [Brazil, Great Britain, Hong Kong, Netherlands, Singapore and United States of America (US)] cross-sectional studies from birth to 25 years of age. The age- and sex-specific centile curves correspond to the BMI cut-off points of 25kg/m^2 and 30kg/m^2 to define overweight and obesity, respectively.[31] In the CDC Growth Charts, which are based on a population from the US, the 85th and 95th centiles of BMI-for-age are cut-offs for overweight and obesity, respectively.[105]

B. Body Mass Index z-score

A z-score is the individuals deviation from the reference population mean divided by the standard deviation (SD) for the reference population.[103] The BMI z-score measures a child's relative weight adjusted for age and sex. Z-scores or standard deviation scores (SDS) are increasingly being used to present child nutritional status.[103] In children, the z-score allows for more sensitive measures than BMI and is optimal for assessing adiposity on a single occasion.[115] Example of standards using a BMI z-score to classify overweight and obesity is the WHO Child Growth Standards[116] as shown in Table 2-2. The WHO Child Growth Standards were developed based on data of 8500 children from a diverse set of countries (Brazil, Ghana, India, Norway, Oman and US) to increase its representation as an internationally applicable standard.[103]

Table 2-2: WHO BMI-for-age z-scores and body weight status classifications (Birth-19 years)

z-score	Birth to 5 years	5 to 19 years
Below -3SD	Severe thinness	Severe thinness
-3SD < z < -2SD	Thinness	Thinness
-2SD < z < +1SD	Normal	Normal
+1SD < z < +2SD	At risk of overweight	Overweight
Above +2SD	Overweight	Obese

Source: WHO (World Health Organization)[103, 104]

2.2.2.2 Percentage Body Fat

Percentage BF refers to the amount of fat in reference to total body weight. A higher percentage of BF predisposes a person to greater metabolic risk, especially those with excess fatness distributed around the central region of the torso.[117] Percentage BF, although an ideal measure for overweight and obesity, is relatively impractical in epidemiological studies.[31] Sex-specific centile curves for BF were developed using the Lambda, Mu and Sigma method based on Caucasian children aged 5-18 years in the United Kingdom (UK), in which cut-offs to define 'underfat', 'normal', 'overfat' and 'obese' were set at the 2nd, 85th and 95th centiles.[118] Williams and colleagues (1992) proposed applying the absolute percentage BF value of above 25% for boys and 30% for girls as the diagnosis of obesity.[119] These cut-offs were adopted as reference standards in a multi-centre study on BF in Asian pre-pubertal children.[120]

It is known that in growing children, there are dynamic changes in body composition with some degree of gender difference. However, the body composition measurement used for body weight does not differentiate between BF and lean tissues, and therefore, measurement of body weight alone may not reflect the true picture.[121] Among the adult population, it has been established that at a similar level of BMI, BF level is higher in Asians especially in South Asians compared to the white Caucasians.[122] The lack of comprehensive assessment of ethnic differences in body composition and its relationship with BMI of Asian children presents additional challenges to monitor childhood obesity trends in this region. A multi-centre study in children aged 8 to 10 years from different Asian backgrounds revealed significant ethnic differences in body composition with Thai girls having higher percentage BF than their Chinese, Lebanese, Malay and Filipino

counterparts. Results also showed that compared with Caucasians of the same age and percentage BF, Asian children had 3 to 6 units lower BMI.[120]

2.2.2.3 Waist Circumference

It is recognised that waist circumference (WC) is a highly sensitive and yet subjective measure of abdominal obesity and visceral adipose tissue in children.[123, 124] A recent systematic review by de Moraes *et al*. (2011) on the prevalence of abdominal obesity using WC in adolescents worldwide reported that those living in developing countries had a higher prevalence of abdominal obesity (3.8% to 51.7%) compared to developed countries (8.7% to 33.2%).[125] As children from different populations vary in their rate of proportional growth and in fat patterning, [123] there was no clear consensus about cut-off points for WC in children.[125]

A team of Malaysian researchers subsequently developed the population-specific WC centile curves for those aged 6.0 to 16.9 years.[126] In the development process, results revealed that while Malaysian boys had higher WC values than girls at every age and percentile, the Chinese children had the highest WC measures compared to other ethnicities.[126] The gender and ethnicity differences of BF distribution are congruent with findings from other studies highlighting the impact of geopolitical and cultural factors on varying populations.[5, 125] This is particularly true for Asian pre-pubertal children from different origins who were found to have different fat distribution patterns which were significantly higher than Caucasians.[33] Therefore, this highlights the importance of applying local and recent references as the comparison tool[106] such as in this research, to reflect the actual magnitude of childhood obesity in Malaysia.

2.2.2.4 Defining childhood obesity in developing Asian countries

The reference standards used to classify weight status outcomes for developing Asian countries is addressed as part of the systematic review presented in Chapter 3. With no existing national standard for classification of childhood overweight and obesity, the interpretations and comparisons of the Malaysian data on prevalence of childhood obesity with other countries has limitations due to inconsistent measurements and interpretations by different researchers. All Malaysian studies except for one[101] were of cross-sectional design (Level IV Evidence National Health and Medical Research Council of

Australia)[127] and a few of the earlier studies were conducted on small sample sizes in selected geographical areas (refer Table 2-1). For example, the weight-for-height reference from the National Centre of Health Services was used in one study[8] whereas two population-based studies utilised the WHO Child Growth Standards: i) the Third National Health and Morbidity Survey (NHMS III) was the first local study to include all ages ≤18 years for assessment of nutritional status[96];and ii) the SEANUTS Malaysia investigated nutritional status and dietary intake of children aged 6 months to 12 years.[9] Using the same reference standard, results showed higher prevalence of overweight children in the SEANUTS Malaysia (5.4% vs. 9.8%) indicating a cause for concern.

2.2.3 Health and well-being consequences of obesity in children

In 2010, overweight and obesity were estimated to be attributed to 3.4 million deaths, 4% of years of life lost and 4% of disability-adjusted life-years worldwide.[14] Since childhood obesity has been shown to track into adulthood, the consequences of obesity in children are summarised in Table 2-3.[5, 11-13]

Table 2-3: Physical and psychosocial consequences of childhood obesity

Physical	Psychosocial
Pulmonary • Sleep apnoea • Asthma Gastroenterological • Cholelithiasis • Liver steatosis/ non-alcoholic fatty liver • Gastro-oesophageal reflux Cardiovascular • Hypertension • Dyslipidaemia • Atherosclerosis • Left ventricular hypertrophy Metabolic • Insulin resistance/ impaired glucose tolerance • Type 2 diabetes • Metabolic syndrome Orthopaedic • Slipped capital epiphyses • Blount's disease • Tibial torsion • Flat feet • Ankle sprain • Increased risk of fractures Other • Polycystic ovary syndrome • Systemic inflammation/ raised C-reactive protein • Idiopathic intracranial hypertension (e.g. pseudotumour cerebri)	• Social bias, prejudice and discrimination • Poor self-esteem • Anxiety • Depression • Body shape dissatisfaction • Eating disorders

Adapted from Lobstein, Baur & Uauy (2004)[5]

2.2.3.1 Physical

A. Pulmonary

The relationship between obesity and asthma risk and the impact of obesity on clinical asthma outcomes in children is not well understood. However, recent evidence consistently points toward positive associations by linking both to inflammatory conditions.[128-130] A meta-analysis on the relationship between BMI and the development of asthma concluded that overweight and obese children were at 40-50% increased risk of physician-diagnosed asthma compared to normal weight children [Odds Ratio (OR), boys: 1.40, 95% confidence interval (CI) 1.01, 1.93; girls: 1.53, 95% CI 1.09, 2.14].[128] Results from a recent longitudinal cohort study of children aged 6-19 years suggested that a higher BMI contributed to asthma development (OR, overweight: 1.16, 95% CI 1.13, 1.20; moderately obese: 1.23, 95% CI 1.19, 1.28; obese: 1.37, 95% CI 1.32, 1.42) and may also lead to more severe asthma.[129]

A recent review on childhood obesity and obstructive sleep apnoea reported that the prevalence of obstructive sleep apnoea amongst overweight and obese children could be as high as 60%.[131] Similarly, the few studies on Asian children with sleep problems found a significantly higher risk of developing obstructive sleep apnoea.[50, 132] Kang *et al*. found that the risk of having obstructive sleep apnoea was significantly higher in severely obese Taiwanese children than that of normal weight children.[132] In addition, a Malaysian sleep study revealed that school children with the shortest sleep duration had 4.5 times higher odds of being overweight/obese (OR: 4.54, 95% CI: 1.91, 8.90) compared to children with normal sleep duration.[50]

B. Gastroenterological

A major concern in obese children is the development of non-alcoholic fatty liver disease.[5] Non-alcoholic fatty liver disease can differ in severity, from fatty infiltration of the liver alone (steatosis) which is relatively benign to fatty infiltration with inflammation known as non-alcoholic steatohepatitis, which can progress to fibrosis, cirrhosis and end-stage liver disease.[5] The diagnosis of non-alcoholic steatohepatitis is based on the histologic findings of steatosis, hepatocellular injury and the pattern of fibrosis.[133] In a study of 742 paediatric autopsies, Schwimmer *et al.* estimated that non-

alcoholic fatty liver disease was present in approximately 1 of every 10 children after adjusting for age, gender, race and ethnicity. The highest prevalence of non-alcoholic fatty liver disease was found in obese children (38%) and of the children with the condition, 23% had progressed to steatosis.[134] While another histology-based study showed that one-third met the criteria for MetS, the risk of MetS was highest in children with grade 3 compared to grade 1 steatosis (OR: 2.58, $P<0.001$).[135] Central obesity was significantly associated with steatosis ($r=2.08$), fibrosis ($r=1.74$) and hepatocellular ballooning ($r=2.15$). It is likely that the common causative pathway originates from insulin resistance as lipogenesis and lipolysis in the liver are strongly influenced by insulin.[135]

C. Cardiovascular

Obesity is also directly linked to CVD risk factors.[125, 136] The well-established Bogalusa Heart Study in the US has provided comprehensive information on cardiovascular risk factors in childhood and their persistence into adulthood through the cross-sectional and longitudinal analyses. In the paper published in 2007, 39% of the obese children with BMI $\geq 95^{th}$ centile and 59% with BMI $\geq 99^{th}$ centile were found to have at least two risk factors for CVD. The risk factors include elevated triglycerides and low-density lipoprotein cholesterol (LDL-C), reduced high-density lipoprotein cholesterol (HDL-C), elevated fasting insulin, and elevated systolic blood pressure and diastolic blood pressure.[18] More alarmingly, Cote and colleagues (2013) in their review highlighted that childhood obesity not only increases CVD risk in adulthood, but it is also associated with progressive CVD damage during childhood.[137]

Data from a nationwide surveillance study in the Netherlands reported that nearly two-thirds of severely obese children aged ≤12 years already had one or more CVD risk factor with the most frequently reported risk factor being hypertension (50%).[138] In a recent systematic review investigating the association between abdominal obesity and cardio-metabolic risk factors in children and adolescents from developed and developing countries, central adiposity predisposed the paediatric population to higher risk of CVD irrespective of definitions for abdominal obesity and types of anthropometric methods used. Blood pressure was the most common measurement among the studies with the majority reporting significant associations of abdominal obesity and elevated blood

pressure.[139] Although the mechanisms of obesity-related hypertension remain unclear, it has been suggested that blood pressure is mediated by the secretion of factors such as leptin and angiotensinogen from fat tissues that is likely to be disrupted in obese individuals.[140]

D. Metabolic

It was found that not only was insulin resistance present in obese type 2 diabetic children, but there was also deterioration in β-cell function and consequent reduction in insulin secretion, implying a serious underlying pathology.[136] Epidemiological data showed that the prevalence of type 2 diabetes is increasing globally, with children from specific ethnic groups at increased risk compared to white children.[15-17] While there was an overall increase in the incidence of type 2 diabetes in British children, the incidence among the ethnic minorities was far higher amongst those with increased adiposity (95% overweight and 83% obese) and family history of type 2 diabetes (84%).[17] Similarly, in a multisite case-control study in India, presence of three risk factors (central obesity along with hypertriglyceridemia and family history of type 2 diabetes) increases the odds of type 2 diabetes by 112.1 (95% CI 10.8, 1164.7) in young Asian Indians. The high risk could be linked to the genetic predisposition of individuals such as South Asians due to underlying insulin resistance.[12]

Despite limited data, the prevalence of the MetS in children is increasing in most developing countries.[15] Two cross-sectional studies from Malaysia published about a year apart involving urban school children aged 7 to 12 years, revealed a much higher prevalence of MetS amongst overweight/obese children than previously reported. In Quah *et al.* (2010), about 1.3% of the obese children were diagnosed with MetS[20] and the figure quadrupled to 5.3%.[19] Indian children had higher odds (OR: 5.5, 95%, CI 1.5, 20.5) of developing MetS compared to Malay children; with the Chinese having the lowest odds (0.3, 95% CI 0.0, 2.7). Overweight/obese children had poorer metabolic risk factor profiles (high WC, OR: 189.0, 95% CI 70.8, 504.8; low HDL-C, OR: 5.0; 95%CI 2.4, 11.1), high blood pressure, OR: 4.2, 95% CI 1.3, 18.7) and higher odds of developing MetS compared to normal-weight children (OR:16.3, 95% CI 2.2, 461.1).[19]

E. Orthopaedic

All overweight/obese children to some extent experience poorer balance and musculoskeletal discomfort as a result of excessive weight.[136] The most common orthopaedic problems in children with excess weight include Blount's disease and slipped capital femoral epiphysis resulting from the impact of increased weight on the developing skeletal system.[141] A recent systematic review concluded that overweight and obesity are associated with various musculoskeletal complaints in childhood. A positive association was found between being overweight and low back pain (RR: 1.42, 95% CI 1.03, 1.97) and between being overweight and injuries and fractures (RR: 1.08, 95% CI 1.03, 1.14).[142]

2.2.3.2 Psychosocial

Obesity in children and adolescents may have its most immediate consequences in the psychosocial aspects.[5] The evidence regarding the psychological consequences of child and adolescent obesity is conflicting and is largely based on studies of children in Western populations.[11, 143-145] The inconsistent data can be partly explained by how self-esteem, an important realm of psychosocial assessment, is measured which includes a wide range of parameters.[5] An older meta-analysis of combined child and adult literature on obesity and self-esteem has shown a modest negative relationship between self-esteem and obesity (r=-0.18, 95% CI -0.33, -0.40). The researchers found that the correlation between self-esteem and weight was higher for studies of self-perceived weight than for studies of actual weight, implying the stigmatization was related to personal and social identity.[144] By systematically reviewing published evidence from studies of different designs [(n=17 self-esteem; n=25 quality of life (QoL)], Griffiths and colleagues (2011) concluded that there was significant reductions in global self-esteem and QoL in obese youth than healthy weight children and adolescents. Among the sub-domains of self-esteem, physical competence, appearance and social functioning were particularly affected.[143]

Mixed results were observed for the associations between weight loss and self-esteem improvements from the included intervention studies in the above systematic review. The likely explanation could be linked to the variation in measures for self-esteem or timing of the assessment conducted.[143] Conversely, psychological benefits beyond weight loss in child weight management programmes were previously reported, and suggested that a

positive environment or support network featured in the intervention structure could play a pivotal role in promoting the overall welfare of the obese child.[145] Age and gender could also be mediating reasons affecting the psychosocial well-being of the children. Newer findings from longitudinal analyses on British pre-schoolers showed that obesity could affect boys more than girls psychologically (OR: 1.11, 95% CI 0.20, 2.01 vs. 0.12, 95% CI -0.60, 0.83).[146]

Being one of the few studies from developing countries, the MASCOT trial found low health-related QoL with no significant change after participating in the 6-month intervention programme. The total health summary scores for QoL measured by the Paediatric QoL Inventory (UK) were significantly lower for obese children than normal weight children [median 60.9, Interquartile range (IQR) 50.8, 73.9 vs. median 76.1, IQR 64.1, 84.8].[147] This finding is consistent with results from a meta-analysis on the effect of childhood BMI on quality of life mainly from developed nations. Using the same measurement tool for QoL, the overall score was reduced by 10.6 points (95% CI, 14.0, 7.2; $P<0.001$) in obese children and adolescents.[148] Aside from the significant physical consequences of childhood obesity, the impaired QoL can further impact upon on the psychological morbidity of this high-risk population.

2.2.3.3 Economic

A large proportion of the evidence on the economic impact of obesity came from developed countries which stated that obesity-related costs contributed to 2% to 6% of total health care costs.[149, 150] Two longitudinal studies included in Reilly *et al.*'s (2003) systematic review on health consequences of obesity found that adolescent obesity has adverse effects on social and economic outcomes in adulthood.[11] Furthermore, it was projected that in the US, a 1% point reduction in overweight and obese adolescents could reduce lifetime medical care costs after age 40 by USD586 million.[151] Closer to Malaysia, the direct cost of obesity in Indonesia was estimated at around 2% of the total health expenditure (equivalent to USD18 million).[152] Given no prior research that enumerated specifically the economic costs of overweight and obesity in Malaysia, the Ministry of Health estimated the cost for the treatment of obesity and its primary comorbidities at approximately USD162 million yearly.[153] If left unchecked, the demand

that childhood obesity will place on any health care systems is huge,[5] especially in developing countries who deal with the triple burden of malnutrition concurrently.

In this section, a detailed discussion on the extent of the epidemiology of childhood obesity globally, nationally and regionally were presented while various methods to define childhood obesity were also examined. The body of evidence on the health and well-being consequences of childhood obesity was discussed. This comprehensive background provided essential knowledge to inform and establish the true costs of the problem in developing countries like Malaysia and reinforce the need for urgent action according to priority areas.

2.3 Main factors contributing to the development of childhood obesity

Malaysia experienced a rapid nutrition and lifestyle transition in the early stages of economic and social development, with increasing mortality due to CVD and cancers, while mortality due to communicable diseases decreased.[27-29] Literature to date on the aetiology of childhood obesity suggests that obesity results from a multitude of reasons (genetics and environment) as illustrated in Figure 2-2.[5, 15, 154] While the underlying environmental determinants (dietary factors, energy expenditure and family determinants) of childhood obesity in developing countries are largely the same as developed countries, it emphasizes the pressing need for more research in developing countries.[5, 23] Factors that promote positive energy balance and increase obesity incidence over time include:[15, 22]

1. Changes in dietary intake contributing to higher energy density;
2. Reduced physical activity and increased sedentary behaviour; and
3. Socio-cultural influences such as high socioeconomic status, urbanization, and demographic characteristics

A. Genetics

It has been suggested that the mismatch between human biology and modern society favours the expression of genes for fat storage resulting in major changes in body composition.[5, 23] The self-regulation of human metabolism within the sparse food supply and the physical demands of survival have become maladaptive in the current obesogenic environment which minimizes opportunities for EE and maximizes opportunities for EI.[12, 23] Specific genetic conditions (e.g. single gene mutations or genetic syndromes), and endocrine disorders (e.g. hypothyroidism and Cushing's syndrome) have been closely linked to the development of obesity in some children[154, 155] In addition, genetic similarities among twins reared apart explained up to 70% of the phenotypic variation in adiposity.[156, 157] Recently, a large representative twins study in the UK estimated the heritability of BMI as 0.60 at age 7 and 0.74 at age 10.[158]

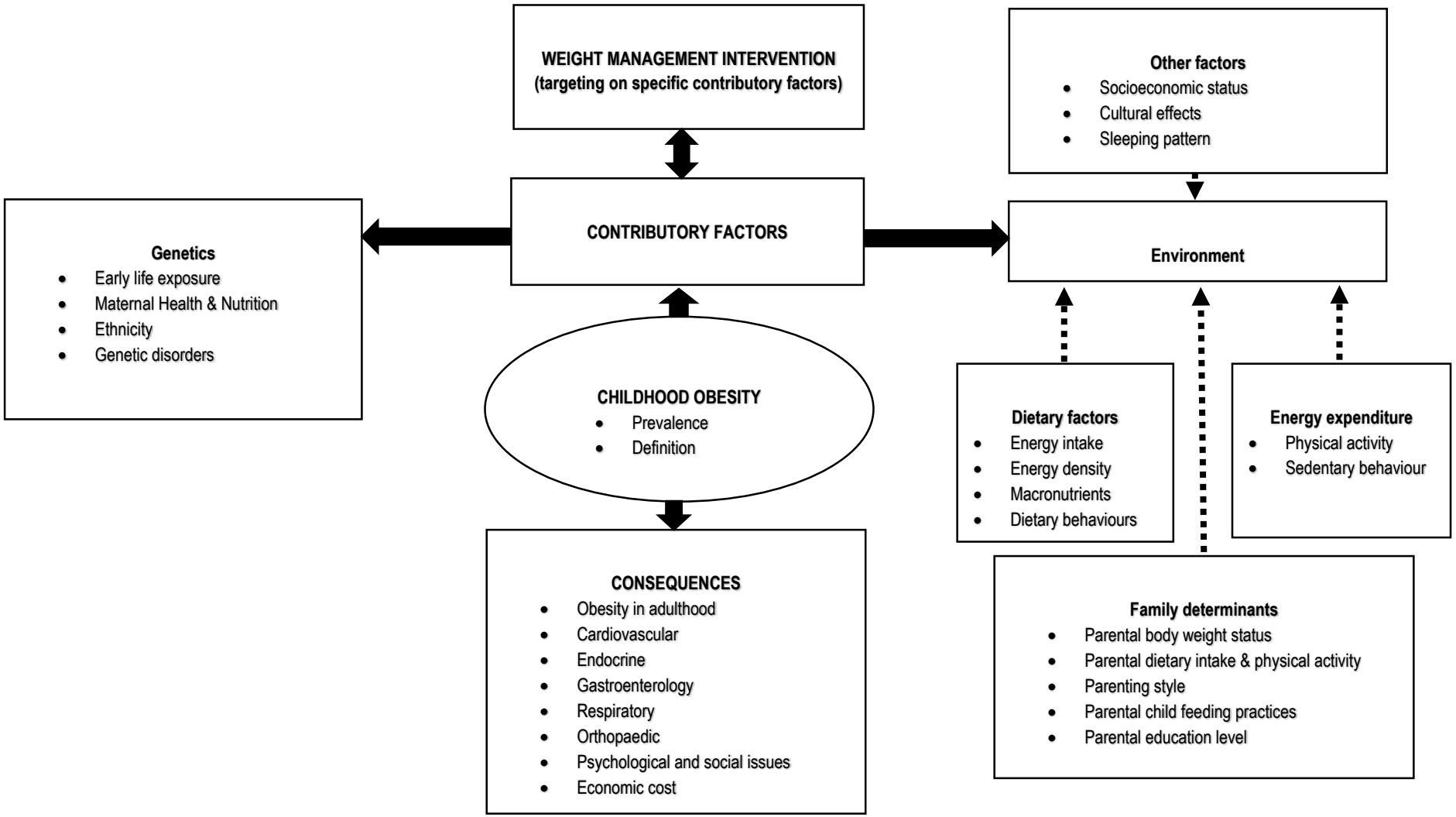

Figure 2-2: Conceptual framework of childhood obesity, its main contributory factors and potential consequences
(▬ ▬▶ Plausible link; ▬▶ Direct ink; ↕ Inter-related)

Data illustrating the important contribution of genetics to the obese phenotype are mainly from Caucasian populations, however, studies indicate that environmental factors are the predominant factors that predispose a child to obesity. The role of genetic variation lies in determining the individual differences in susceptibility or resistance to gaining fat when subsequently exposed to an obesogenic environment. Older reviews and studies on twins, adoption and family studies reported that inheritance accounted for 25% to 40% of inter-individual difference in development of obesity,[154, 159] recent data from a Caucasian cohort of twins reported similar findings.[160] Environmental risk factors accounted for up to 50% of the variance in BMI fluctuation for the twins and their relatives, and was associated with risks for non-communicable diseases and depression.[160]

B. Environmental

The revolutions of agriculture and technology in the late 20th century have greatly influenced the energy balance equation, making the environment more obesogenic.[161] This transformation in developing countries is characterised by widespread increases in domestic farming and plantation resulting in increased food intake from animal-sources and usage of caloric sweeteners; coupled with increased use of technology in all aspects of movement/exertion.[23] The impact of environment on obesity was well recognised in an earlier WHO/Food and Agriculture Organization (FAO) expert consultation, emphasising that treatment for childhood obesity is unlikely to succeed if the focus is only on the children without including their environment.[162] This was reinforced in the 2010 WHO Forum and Technical Meeting on Population-based Prevention Strategies for Childhood Obesity.[163] Within the younger children's obesogenic environment, it is important to consider the impact of families and family environment in influencing their obesity risk.[5]

The following sub-sections discuss the environmental factors based on the concept of energy balance as the fundamental mechanism of body weight regulation. This is followed by a review of the literature related to EI and EE within the context of childhood obesity and lastly, an examination of the family environment as a major influential factor in the aetiology of childhood obesity.

2.3.1 Energy balance in body weight regulation

The relative contribution of changes in EI versus total EE within the energy balance context has been vigorously debated.[164-167] Earlier, Prentice and Jebb (1995) published a narrative review of epidemiologic data on physical activity and lifestyle, and demonstrated that modern trends towards inactivity are at least as important as changes in diet in precipitating the obesity epidemic.[168] However, it has been shown that EI is the key determinant for higher mean population weight for children in a study modelling body weight response to changes in total EI using data from doubly labelled water (DLW) studies.[169] While the specific details on exact mechanisms affecting energy imbalance remains in part hypothetical, it is unclear at what age point obesity will most likely develop, specifically in children.[170]

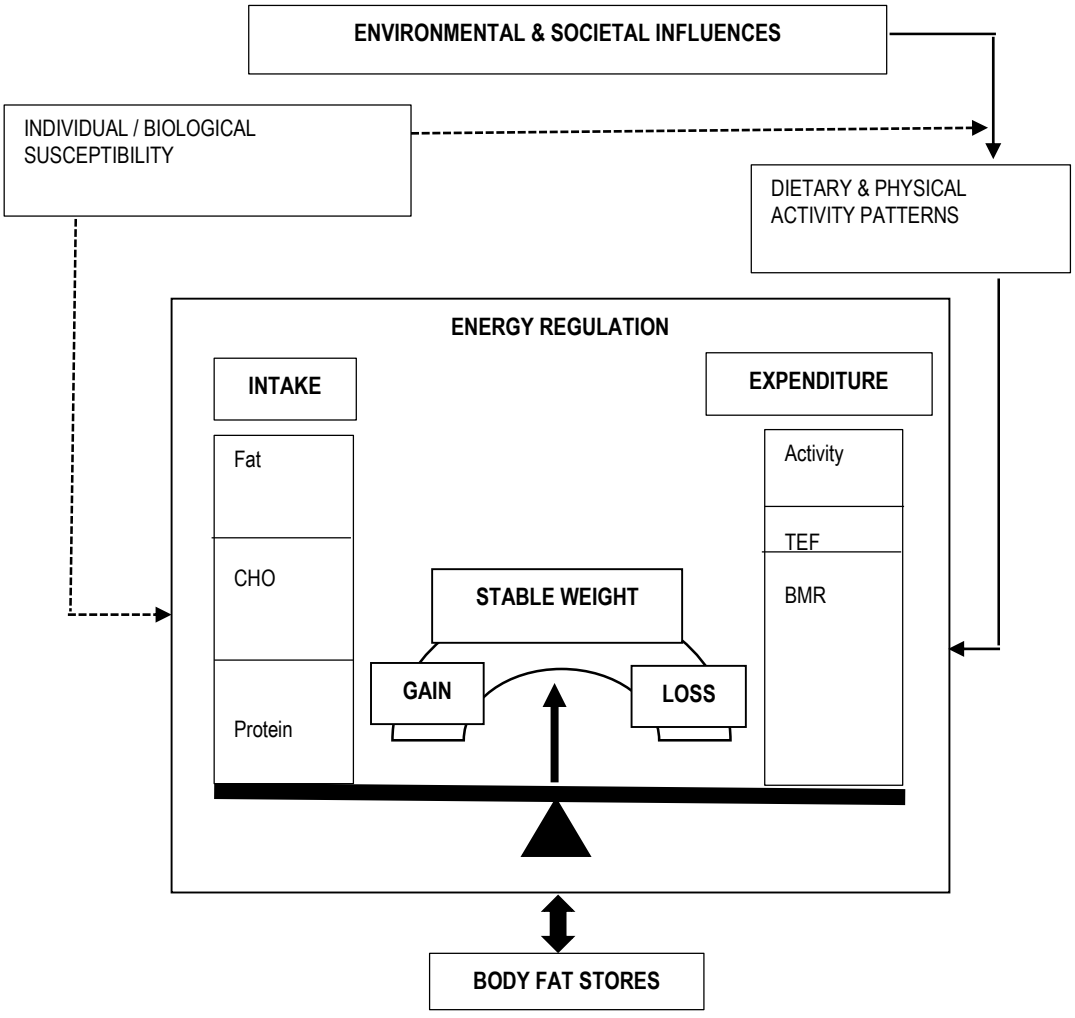

Figure 2-3: Fundamental principles of energy balance and regulation of body weight.

TEF: Thermic effect of food; BMR: basal metabolic rate; CHO: carbohydrate.

Reprinted from the World Health Organization. Obesity, preventing and managing the global epidemic: a report of a WHO Consultation on Obesity, p.109, Figure 7.2, 1998, with permission WHO, Geneva

Energy balance is defined as the difference between EI and total EE. The energy balance system is interactive and complex where a change in one component can affect one or more other components.[166] When the total energy consumed equals the total energy required to meet different needs for basal metabolism, growth, thermogenesis, the thermic effect of food and physical activity, a child is in energy balance with a relatively stable body weight and growth trajectory. During childhood, energy requirements vary widely, depending on stage of growth, gender and physical activity.[171, 172] Figure 2-3 depicts schematically the two main components of energy balance.

As illustrated, human physiology conforms to the first law of thermodynamics which states that energy can be transformed from one form to another but cannot be created or destroyed.[166] Within energy regulation, when the changes within the components of EI and total EE act synergistically in the direction of facilitating weight gain, the biological response to these external changes will likely result in overweight/obesity.[161, 164] Past experiments in small animals and observations in wild animals showed that a 'set-point' for body weight is accurately defended under most conditions and this also applies to humans.[161] Although the exact details of 'set-point' regulation remain controversial, human physiology demonstrates the vulnerability in energy balance homeostasis when exposed to changing external conditions.[161, 166]

2.3.2 Energy intake

Energy for metabolic and physiological functions of humans is derived from the chemical energy bound in food as carbohydrates, fats, proteins and alcohol which act as substrates or fuels. Food and beverages represent the 'energy in' side of the energy balance equation.[166] The next subsection will firstly look at the national dietary recommendations for Malaysian children and adolescents. This is followed by a comprehensive review of the literature related to EI, to ascertain a better understanding on the role of EI within energy imbalance, body weight regulation and childhood obesity.

2.3.2.1 National dietary recommendations

The Malaysian dietary recommendations for children and adolescents are based on the Recommended Nutrient Intakes (RNI) for Malaysia[173] and the Malaysian Dietary Guidelines (MDG) for Children and Adolescents.[174]

A. Recommended Nutrient Intake for Malaysia

The RNI is the daily intake corresponding to Recommended Daily Allowance, which meets the nutrient requirements of healthy individuals.[173] Upper tolerable nutrient intake levels (ULs) have been defined as the maximum intake from food that is unlikely to pose risk of adverse health effects from excess in almost all apparently healthy individuals in an age and sex-specific population. The range of intakes encompassed by the RNI and UL should be considered sufficient to prevent deficiency while avoiding toxicity.[173] The Malaysian RNI recommends that total carbohydrate should contribute 55% to 70%, total fat 20% to 30%, and protein 10% to 15% of total caloric intake per day for adults.[173] Appendix 2.0 summarises the RNI for Malaysia.

B. Malaysian Dietary Guidelines for Children and Adolescents

The MDG for Children and Adolescents (2013) is the first dietary guidelines developed for children and adolescents in Malaysia. The guidelines comprise 15 key messages based on the latest science-based nutrition and physical activity recommendations as listed in Table 2-4. The MDG is for healthy populations from birth to 18 years of age, therefore, it is not for those with conditions requiring specific nutritional needs.[174] The Malaysian Food Pyramid is a tool used to provide guidance on choosing a variety of foods to consume while meeting recommended nutrient intake targets (Figure 2-4). The size of each food group becomes smaller to indicate foods are consumed in greater quantities at the base of the pyramid and less foods at the top.[175] This recommendation is based on the daily caloric needs of individuals and the distribution of the daily caloric intake consisting of target percentage ranges from carbohydrate, protein and fat.[174]

Table 2-4 Key messages in Malaysian Dietary Guidelines for Children and Adolescents 2013

No.	Key Message
1.	Practise exclusive breastfeeding from birth until 6 months and continue to breastfeed until 2 years of age
2.	Give appropriate complimentary foods to children between the age of 6 months to 2 years
3.	Eat a variety of foods within your recommended intake
4.	Attain healthy weight for optimum growth
5.	Be physically active everyday
6.	Eat adequate amount of rice, cereals or tubers
7.	Eat fruit and vegetables everyday
8.	Consume moderate amounts of fish, meat, poultry, egg, legumes and nuts
9.	Consume milk and milk products everyday
10.	Include appropriate amounts and types of fats in the diets
11.	Limit intake of salt and sauce
12.	Consume foods and beverages low in sugar
13.	Drink plenty of water daily
14.	Consume safe and clean foods and beverages
15.	Educate children on the use of nutrition information on food labels

Modified and adapted from the National Coordinating Committee on Food and Nutrition, 2013[174]

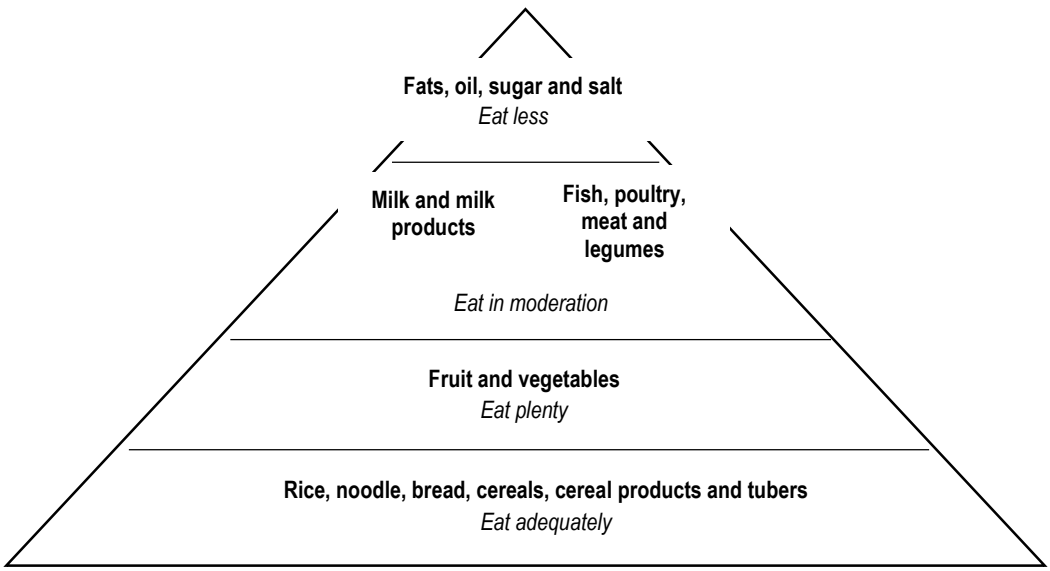

Figure 2-4: Malaysian Food Pyramid

Modified and adapted from National Coordinating Committee on Food and Nutrition, 2010[176]

The recommended number of servings reflects an average amount that an individual requires at different life stages and genders.[176] Table 2-5 summarises the daily servings recommended for children aged 7-12 years.

Table 2-5: Recommended daily serving sizes for children aged 7-12 years

Main Food Groups		Boys (7 - 9 years) (1800kcal)	Girls (7 - 9 years) (1600kcal)	Boys (10 - 12 years) (2200kcal)	Girls (10 - 12 years) (2000kcal)
Rice, noodle, bread, cereals, cereal products and tubers	Cereals/ grains	5	5	7	6
Fruits & Vegetables	Fruits	2	2	2	2
	Vegetables	3	3	3	3
Poultry, meat, fish and legumes	Meat/ poultry	1	1	1 1/2	1
	Fish	1	1	1	1
	Legumes	1	1/2	1	1
Milk and dairy products	Milk and dairy products	2	2	2	2

Modified and adapted from the National Coordinating Committee on Food and Nutrition, 2013[174]

2.3.2.2 Dietary intake of Malaysians

Prior to national dietary intake surveys for Malaysia in 2003 for adults and 2013 for children below 12 years, the Food Balance Sheets from FAO provided a comprehensive picture of the country's food supply.[27, 29] The nutrition transition in Malaysia has increased food availability with at least two substantial changes in the dietary patterns from 1967 to 2007. In the past four decades, a significant increase was noted in calories from animal products (per capita per day), and sugar and sweeteners (kg per capita per year) of 82% and almost 70%, respectively. The availability of sugar and sweeteners in Malaysia is similar to other developed countries like the US and Australia.[29]

The rapid growth of the fast food industry has added another dimension to the transformation in food consumption patterns of Malaysians[28]. Throughout the world, the aggressive marketing of energy-dense snacks, sugar-sweetened foods and beverages, and fried foods often targets children using various techniques as they are the highly vulnerable group.[177] The increase in portion sizes, especially relative to children's energy needs,[178] and the rapid growth of convenience stores and vending machines have expanded the availability of energy-dense, inexpensive, and highly palatable foods in the

majority of developing countries including Malaysia.[23] These further increase the risk of obesity in children. A list of commonly reported food and beverages amongst the Malay population is listed in Appendix 1.

A. Malaysian Children

Over the last thirty years in Malaysia, only one national nutrition survey (SEANUTS Malaysia) has been conducted in children aged 6 months to 12 years, and was recently published (2013) as explained earlier in Chapter 1.[9] Despite dietary intake studies amongst pre-pubertal children not being well studied earlier, this age group has gained much attention with an increase in publication rates over the last five years compared to adolescents and pre-schoolers. From the literature search conducted, the focus of these studies were on nutrients, food groups or dietary habits to address specific nutritional issues such as childhood obesity,[45, 50] and aspects related to the home environment[179, 180] and cognition.[181]

In one of the few narrative reviews consisting of three local studies on dietary patterns between 2001 and 2006, the majority of children aged 10 to 12 years (n=6000) ate breakfast daily, while only slightly more than half of the adolescents did. Common breakfast foods were bread, fried rice and '*nasi lemak'*. Almost all primary school children reported they frequently snacked on energy-dense foods such as '*keropok*', biscuit, bread, ice-cream, fruits and fried potatoes.[46] Skipping meals was common,[45, 46, 109] especially among overweight female adolescents and increased with age (primary 5 aged 11-12 years, 13% and secondary 4 aged 15-16, 26.7%). For eating out, outlets frequently visited included hawker stalls and fast food restaurants and this was considered by adolescents to be a social activity with friends, before and after school.[46, 48, 109] Sugar-sweetened beverages were mainly consumed at home during main meals and afternoon teatime with Malay children having the highest intakes amongst the three ethnicities.[47] Other sweetened beverages included chocolate malted drink (21.3%), carbonated drinks (13.7%) and fruit juice (12.7%).

Using a food habits questionnaire (FHQ) and a 3-day food record (FR) as the dietary intake assessment tools, Norimah *et al.* (2007) found that, irrespective of body weight status, older adolescents (n=977) did not meet the RNI targets for their age group except for protein and vitamin C, only boys fulfilled the dietary iron requirement and girls

achieved half the recommended calcium and iron requirements.[46] A small survey using a purpose-built unvalidated FHQ (n=24 items) reported that Chinese pre-schoolers (n=91) usually ate three main meals and one snack, with preferences for milk, fruit, fish and high fat foods and that they disliked vegetables.[97] The same dietary assessment tool developed by Norimah and Lau (2000) was used in a recent nationwide dietary study in Peninsular Malaysia (n=1933), with findings similar to the earlier study. Therefore, indicate consistent dietary patterns across different ethnicities despite the gap of more than a decade.[51]

Zalilah and colleagues performed a comprehensive dietary profile assessment of 749 urban children aged 1-10 years by household income status using the combination of a two-day food recall and record method. Results showed that low income pre-schoolers had the lowest mean intake of fruits (0.07 serving), meat/poultry (0.78 serving) and milk/dairy products (1.14 serving), and irrespective of household income status, all age groups had a mean intake below the recommended servings.[179] Similarly, significant associations were found between household income and frequency of fruits (χ^2=12.00, *P*=0.02) and vegetables consumed (χ^2=10.53, *P*=0.03) in a study conducted among pre-schoolers.[51]

B. Malaysian Adults

Dietary studies in Malaysian population are uniformly lacking in terms of looking at the impact of parental dietary intake on the child's intake and body weight status. Hence, a brief description of the Malaysian adults' dietary intake pattern is discussed here. Prior to the Malaysian Adult Nutrition Survey (MANS) in 2003, data from FAO's Food Balance Sheets for Malaysia showed an increase in available calorie intake from 2430 kcal/person/day in 1961 to 2990 kcal/person/day in 1997;protein increased from 49 g/person/day to 61 g/person/day; and fat from 49 g/person/day to 87 g/person/day.[27, 28] The changes in the sources of available calories between 1967-2007 was further reflected by a substantial increase in calories from animal products (from 267 calories to 485 calories per capita per day), sugar and sweeteners (from 28.8kg to 48.7kg per capita per year) and vegetable oils (from 9.5kg to 14.0kg per capita per year).[29]

A large scale study assessing adults' food intake using 3-day estimated FRs reported a significant difference in mean EI between urban (2275 kcal/day) and rural men (2024 kcal/day), with fats contributing 30% and 19% of the total calories, respectively. Although mean EIs of urban and rural women were similar, fats also contributed a higher percentage in the urban subjects compared to rural counterparts.[182] The MANS study which used an adapted semi-quantitative FFQ (n=126 items in 15 food groups) found Malaysian adults were generally eating in line with the MDG (1999) and conformed to the variety element in the Malaysian Food Pyramid.[183] In most of the demographic and socioeconomic groups, adult males had higher mean EI than females (1776 kcal vs. 1447 kcal), but lower than national recommendations.[184] The reported EI was largely confounded by energy mis-reporting defined using the Goldberg equation (1991).[184]

2.3.2.3 Dietary factors associated with childhood obesity

A. Developed countries

Although certain dietary factors play a significant role in promoting energy imbalance, the overall evidence on the effect of dietary energy and macronutrient composition and its association with weight gain and obesity in children from developed countries remains equivocal.[37, 170, 185-188] In addition, specific foods including increased consumption of sugar-sweetened beverages,[34-37] processed meats[35] and snacking on energy dense processed foods[38, 39] may or may not be associated with overweight status amongst children in Western countries. Since there are diverse methods for measuring dietary intake, this is one factor in the complexity of investigating food and eating behaviour and relating it to the development of childhood obesity.

Energy intake

Previous reviews[185, 188] and well-designed prospective studies[189-191] examining associations between EI and risk of overweight/obesity in children and adolescents showed inconclusive findings. Despite three of the five included prospective studies in a recent systematic review reporting positive associations between energy balance behaviours in preschool children and overweight/obesity, results were impacted by two studies with low methodological quality.[185] Newby's earlier review on dietary intakes and eating behaviours related to childhood obesity concurred and similarly concluded

with equivocal findings.[188] In addition, a birth cohort followed over 15 years found that instead of total energy and macronutrient intake (using estimated 3-4 day food diary), the child's current level of body fatness (defined by BMI, triceps and subscapular skinfolds) was a more important predictor of risk of children becoming or remaining overweight as they grow.[190]

Two longitudinal studies have reported positive associations between EI and adiposity in children. In a large sample of Australian children aged 5-17 years investigating the relationship between body weight status with EI and percentage EI from macronutrients (measured by 24-hour FR), the researchers found statistically significant, yet weak correlations between BMI z-score and WC with total EI among those classified as acceptable EI reporters.[192] The Growing Up Today Study in the US followed a sample of more than 10,000 preadolescents and adolescents, and demonstrated promising results in this light. The initial results revealed that the increment of EI during a period of 1 year was positively related to an increase in BMI.[193] In a subsequent publication, this study found that milk intake was associated with small BMI increases during the year for both genders [β ± Standard Error (SE), boys: 0.019 serving/day ± 0.009, P=0.03; girls: 0.015 serving/day ± 0.007, P=0.04], suggesting that high intakes of milk may contribute to excess EI which lead to weight gain.[194]

Inverse associations between EI and obesity have also been reported, contrary to the popular hypothesis. Three studies observed lower EIs among overweight compared to normal weight children across differing age groups.[195-197] Gazzaniga and Burns (1993) examined the relationship between diet composition (using 3-day, 24-hour DRs) and body fatness in 48 children, and found that percentage BF correlated negatively with total EI adjusted for body weight (P<0.001).[195] Similarly, in a Spanish study involving 331 adolescents, the overweight boys and girls had significantly lower EI and under-reported more often.[197] Results from a dietary study in Northern Greece concurred and found overweight preadolescents and adolescents reported lower EIs compared with their non-overweight counterparts when expressed as kilocalories per kg of body weight (means ± SD, boys: 33.4 ± 14.8 vs. 52 ± 20.8, P<0.001; girls: 28 ± 10.7 vs. 43.9 ± 16.3, P<0.001).[196]

The lack of evidence for association between EI and being overweight does not imply that no relationship exists. The area of investigation is extremely difficult coupled with the independent effects of free-living populations in epidemiology studies and to a lesser extent in controlled laboratory conditions. Moreover, the use of inaccurate measures to assess dietary intakes and potential confounders such as EI mis-reporting are additional challenges to the validity of dietary data obtained.[170, 185, 188] A detailed discussion on dietary assessment methods and issues related to measurement of children's dietary intake is presented in Section 2.4.

Energy density

Compared to adults, fewer studies have been conducted to determine the effects of energy density on EI among children and adolescents. However, the evidence is growing that supports the relationship between energy density and body weight in the paediatric population. Energy density is defined as the amount of energy in a particular weight of food.[198] Amongst the macronutrients, carbohydrates and fats present in foods are now highly refined which increase their energy density, decrease their satiety index, and reduce the amount of physiologic work required in digestion and absorption. This is in contrast to nutrient-rich and low-energy foods such as fruits and vegetables, pulses and wholegrain products.[198, 199]

The evidence suggests that intake of energy-dense foods readily leads to passive overconsumption of energy,[198, 200, 201] as part of the human appetite regulation. Children responded similarly to adults in their reaction to energy density changes. When lower energy density meals are served, children do not compensate at the next meal leading to reductions in EI.[198, 200, 201] In a systematic review of six longitudinal studies on the relationships between dietary energy density and body weight in children from Western countries, results suggest that there was a moderate-to-strong positive association between higher dietary energy density and increased adiposity.[186] These findings demonstrate that lowering the energy density of food is an effective strategy and should be considered in both prevention and treatment of overweight and obesity.

Macronutrients

With the change in dietary composition contributing to total dietary EI over the years, attention has now focused on the potential role of dietary macronutrient composition in the aetiology of obesity. Fat is the major determinant of the energy density of diets, providing the highest energy value of 38kJ/g (9kcal/g) followed by carbohydrate and protein [17kJ/g (4kcal/g)].[173] Comparatively, dietary carbohydrate and protein balance are more efficiently self-regulated than fat. Fat balance is affected by and dependent on the balance of the other two macronutrients.[154, 166] In fact, dietary fat might not have an effect on satiety compared to carbohydrate as demonstrated by Cotton and colleagues (2007) in their test breakfasts supplemented either with fat or carbohydrate.[202] Their results suggested that dietary fat could lead to passive overconsumption of energy after a high-fat meal.[202] Findings from earlier longitudinal studies have revealed that higher intakes of dietary fat are associated with greater increases in relative weight among children.[187, 203] In a sample of pre-schoolers followed for 4 years, it was found that total energy and total grams of fat, albeit assessed by observation, were significantly different between cases and controls. This indicates that children with high adiposity consumed higher intakes of fat and energy-dense foods over time.[203] In addition, using repeated 24-hour DRs, a study on pre-school girls which reassessed at 7 years (n=197) reported that the participants' percentage intake of energy from fat was one of the variables predicting change in BMI.[187]

The hypothesis that high protein intake in early life linked to obesity later in adulthood was first proposed in 1995 by Rolland-Cachera and colleagues.[204] Based on a follow-up study in a sample of 112 French children from 10 months to 8 years of age, high intakes of protein (% energy) at 2 years pre-disposed to the later development of obesity via an early adiposity rebound.[204] This finding was subsequently replicated in other longitudinal studies.[37, 205] Children in the Bogalusa Heart Study who were consuming more meats (including mixed meats, poultry, seafood, eggs, pork, and beef) were more likely to be overweight.[35] Similarly, a systematic review assessing the health effects of different levels of protein intake in infancy and childhood revealed that the children's intake of protein was high (>15% energy) and this may contribute to increased risk of developing obesity later.[206] As with many developed countries, the consumption of protein, particularly of animal origin, is increasing in developing countries and is likely

to be more than sufficient to meet physiological requirements.[23] The excessive protein intake hence stimulates insulin-like growth factor-1 and insulin secretion, which promotes both fat storage and the proliferation of mature adipocytes.[206]

Dietary behaviours

Consumption of sugar-sweetened beverages has been widely associated with the development of overweight in a number of studies of Western children. Ludwig *et al.* (2001) found that in children aged 11-12 years, the odds of becoming overweight increased by 60% for each serving of sweetened drink consumed daily.[34] A similar positive finding was reported from an Australian study on schoolchildren (n=2184). Children consuming more than 4 servings of fruit juice/drinks the previous day were twice as likely to be overweight/obese compared to those who had no servings.[207] Similar results from a longitudinal study of Dutch infants also demonstrated that high intakes of beverages with sugar may increase the risk of overweight at the age of 8 years [(OR: 1.13, 95% CI 1.03, 1.24).[37] Two meta-analyses demonstrated equivocal findings on the associations between sugar-sweetened beverages and BMI in children and adolescents. By including 11 studies, Forshee and colleagues (2008) found the random-effects estimate was near zero [0.017 (95% CI -0.009, 0.044)].[36] However, results from Malik *et al.* (2009) showed a non-significant inverse trend among those with adjusted energy estimates [-0.03 (95% CI -0.11, 0.04)], and suggested a clear positive association for unadjusted estimates [0.08 (95% CI 0.03, 0.13)].[208] Despite the inconsistencies, this dietary behaviour is highly prevalent across different age groups within the paediatric population. The suggested mechanism is that higher sugar-sweetened beverage intake contributes to increased EI and low satiety, which is not compensated for by lowering EI from other food sources.[209] There is a clear need for more studies in developing countries where sugar consumption through intake of sugar-sweetened beverages is rapidly increasing due to nutrition transition in these countries.

A common dietary behaviour linked to reduced risk of overweight/obesity is intake of fruit and vegetable. The WHO population goals for fruit and vegetable intake is a minimum of 400g per day for prevention of chronic diseases including obesity.[210] Fruits and vegetables are promoted for their satiating properties (bulk and fibre) and low energy density which could displace energy-dense foods from the diet,[198, 199] hence reducing total EI. A narrative review of fourteen epidemiologic studies discussed on the role of

plant foods and plant-based diets in the prevention of childhood obesity.[211] This review suggested that the available data does not support a protective effect of fruit and vegetable consumption on the risk of childhood obesity.[211] Five out of the total 23 included studies (excluding cross-sectional studies) in a review by Ledoux and colleagues,[212] indicated that the relationship between fruit and vegetables intake and adiposity in children was unclear.[212] Non-significant changes in body weight secondary to higher fruit and vegetable intake among normal weight children was similarly reported in an experimental study.[213] A recent systematic review[214] which aimed to synthesize the best available evidence on the effectiveness of prescribing more fruit and vegetables for weight loss or the prevention of weight gain, the researchers found no intervention studies in children that met the review's inclusion and exclusion criteria.[214] The current evidence is limited, mainly due to methodology issues, which highlights the gap in literature examining the specific impact of modulating fruit and vegetable intake with the view to impact on the risk and management of childhood obesity.

B. Developing Asian countries

To date, little has been reported on the relationship between dietary intake and obesity relationship in Asia and the few cross-sectional studies have demonstrated inconsistent findings. Therefore, it would be beneficial for a systematic review of the associations between dietary patterns and overweight and obesity in children of developing Asian countries to be conducted. The review should appraise the existing evidence on the epidemiological association between dietary patterns of children and childhood obesity. Therefore, this gap in the research literature is addressed through a systematic review conducted as part of this research which is discussed comprehensively in Chapter 3.

C. Malaysia

A literature search found that there is no direct dietary association between childhood obesity and non-communicable disease trends. Only four dietary studies investigated dietary intake according to body weight categories.[41, 45, 50, 51] An earlier study by Zalilah *et al.* in 2006 (n=618) was conducted amongst adolescents to determine differences in EI, diet composition, physical activity and EE by body weight status. Overweight adolescents had the highest crude EI and EE, however, after adjustment for body weight, their EIs and total EE were the lowest compared to underweight and normal weight adolescents.[41]

Soo and colleagues (2011) found that macronutrients intakes were significantly higher amongst the overweight children than those with normal weight [protein (87g ± 42 vs. 62g ± 21), fat (85g ± 41 vs. 67g ± 24) and total calorie intakes (2153kcal ± 772 vs. 1880kcal ± 516)].[45] In another study of 164 children aged 6-12 years, carbohydrate intake was significantly correlated with weight (r=0.191, P<0.05), BMI (r=0.188, P<0.05) and WC (r=0.227, P<0.05). However, the total EI was not significantly different between overweight/obese and normal weight groups, partly due to under-reporting in obese subjects.[50] Similarly, a nationwide pre-school study revealed that there was no significant association between body weight status and frequency of main meals, fruit and vegetable intake, milk and dairy products and fast food intake.[51] Given the evidence of rapidly rising childhood obesity in Malaysia and the limited data on children's EI, this gap in the evidence base requires high quality research to determine the aetiological dietary factors.

2.3.3 Energy expenditure

The rapid changes to modern lifestyles have been associated with significantly-reduced demands for physical activity and increased sedentary behaviour over the last few decades in both developed and developing countries.[23, 161] Although a definite relationship between EE and obesity is yet to be fully understood, EE, like EI is an important factor in the development of, or protection against obesity in children and adolescents.[5] Reviews on physical activity, sedentary behaviour and obesity in children and adolescents prior to 2010 found inconclusive evidence linking physical activity and risk of overweight,[159, 170, 215-218] while sedentary behaviour may or may not be obesogenic.[215, 218-220]

The measurement of total EE includes information about metabolic rate, thermic effect of food and physical activity.[173] Studying EE involves a range of methodologies which includes: measuring direct energy output using calorimetric methods; evaluating the incidence or prevalence of specific physical activities as indicators of raised EE; and determining levels of inactivity, or sedentary behaviour, as indicators of low EE.[5] Similar to EI, the difficulties in obtaining EE data and the lack of validity in data related to physical activity levels among paediatric populations is well acknowledged.[170, 221] However, the caution when comparing results on EE from the literature,[170] may be

reduced by the usage of newer objective methods such as accelerometry over more traditional methods in measuring both physical activity and sedentary behaviour.[221]

2.3.3.1 Physical activity

Physical activity has been shown to decline dramatically from childhood to adolescence.[222, 223] In comparison to sedentary behaviour, physical activity is a complex component of EE often expressed in terms of frequency, intensity, time and type. Most public health physical activity guidelines [224-226] (including Malaysia)[174] for children and adolescents generally recommend that those aged 5 years and above should participate in at least 60 minutes of moderate- to vigorous-intensity physical activity daily. Past studies found that the majority of children do not meet this recommendation,[218, 227] while globally, WHO in 2010 reported that 81% of school going adolescents aged 11–17 years were insufficiently physically active.[228] These elements have been questioned for their appropriateness, especially for pre-schoolers in view of the nature of children's activity which is highly sporadic and spontaneous.[229] Such limitations indicate that a newer approach for example, step-counting could be more relevant for this population to reflect their physical activity level.[222]

Clear and direct evidence to suggest that lack of physical activity is the dominant factor in the aetiology of childhood obesity is lacking. The earlier systematic review by Parson and colleagues (1999) on childhood predictors of adult obesity identified a number of longitudinal studies from industrialised countries estimating the effect of physical activity in childhood on subsequent fatness.[159] The authors found either no effect in the infant group or inconsistent effect of activity on adiposity mainly attributed to the small sample sizes, different methods for the analysis of physical activity and a variety of methods used to measure actual physical activity.[159] Two systematic reviews examining associations between physical activity and BMI found similar findings in the pre-schoolers[217] and children and adolescents.[216]

Nevertheless, significantly more obese subjects were being less active than non-obese in a global survey involving more than 100,000 children and adolescents.[215] Results from recent reviews were promising. In Reilly's comprehensive review on physical activity, sedentary behaviour and energy balance (2008), levels of habitual physical activity were typically much lower than recommendations as measured using objective methods.[218]

Furthermore, data from the epidemiological studies using accelerometers was supportive of the hypothesis that higher levels of physical activity may potentially reduce the risk of overweight for pre-schoolers in developed countries.[218] A systematic review with thirteen prospective studies (six studies used objective measures), arrived at the same conclusion with strong evidence of an inverse association between total physical activity and overweight.[185] The evidence is further supported by a prospective study by Telford *et al.* (2012) on an Australian cohort of children aged 7-8 years followed up to age 11-12 years with results demonstrating that children who reduced their physical activity over the four years increased their percentage BF (P=0.04).[230]

2.3.3.2 Sedentary behaviour

Sedentary behaviour has emerged as an essential focus in energy balance-related research as it is likely to lower habitual physical-activity EE, displacing physically-active behaviour and may also be associated with higher dietary EIs.[231] Common forms of sedentary behaviours includes television watching, computer use or sitting which involve low levels of EE.[229] It appears that all sedentary activities, particularly television watching, promote overconsumption of unhealthy foods,[232] which may explain its association with overweight. Television may also provide confusing messages about lifestyle from the advertisements or programmes.[233]

As reported by Dietz and Gortmaker (1985), there has been a longstanding assumption that television watching in children and adolescents is highly and significantly associated with overweight and obesity, even after controlling for various confounders.[233] Similarly, in a cohort study, a 1-year increase in BMI was larger in those who reported more time spent with television/videos/games between the two BMI measurements taken ($\beta \pm$ SE, boys: 0.038kg/m^2/hour/day $\pm$ 0.010; girls: 0.037kg/m^2/hour/day $\pm$ 0.011).[193] Physical activity and television watching were the only significant predictors of BMI in a prospective study followed for 3 years among a cohort of 3-4 year old children (P<0.05).[191]

Several systematic reviews have suggested positive associations between sedentary behaviour and body weight status. Pearson and Biddle (2011) investigated the relationship between sedentary behaviour in young people [children (n=19 studies) and adolescents (n=26 studies)] and revealed that sedentary behaviour is associated with

consuming a less healthy diet.[232] However, as the associations drawn were mainly from cross-sectional studies, the strength of the relationships was small-to-moderate.[232] In addition, moderate evidence for a positive association between television/video/computer time and overweight was shown in a systematic review of energy balance behaviours in pre-school children.[185] Moreover, a meta-analysis involving 983,840 participants suggests that decreasing any type of sedentary time is associated with lower health risk in youth aged 5-17 years [-0.81 (95% CI -1.44, -0.17, *P*=0.01)] indicating an overall decrease in mean BMI associated with the interventions.[234]

2.3.3.3 Evidence from developing countries

The generalizability of much of the evidence base for EE and its association with obesity is limited to Western children and adolescents. Despite a lack of definite data on the influence of physical activity and sedentary behaviour in the aetiology of childhood obesity in the developing countries, the research interest is fast growing. The latest WHO data compiled based on a population-based survey in school-going adolescents' physical activity showed those residing in the South East Asia region had the lowest prevalence of insufficient physical activity (74%), followed regionally by the Americas (81%), Europe (83%), Western Pacific (85%), Africa (85%) and Eastern Mediterranean (88%). The large variation in economic and income status within countries in the Asia region may explain the comparatively low prevalence observed.

Specifically, the prevalence reported from Malaysia is 86%, with more girls aged between 11- 17 years being inactive than boys (92% vs. 80%), a figure similar to those reported in other regions.[228] The high prevalence of inactivity concurs with findings from a review on physical activity, fitness and energy cost of activities for children and adolescents in the tropics.[235] Based on data from the Global School-based Student Health Survey collected using questionnaires for adolescents aged 13-15 years in developing countries, the researchers estimated that only 23.9% boys and 16.4% girls in the tropics had met the physical activity recommendation while more than a quarter of the adolescents spent 3 or more hours a day on sedentary activities.[235]

The few cross-sectional studies from developing countries found that television watching was closely associated with increased levels of obesity.[236, 237] In the Thai nationwide study (aged 6-14 years), playing computer games for more than 1 hour a day was found

to be associated with an increased risk of overweight (adjusted OR: 1.4, 95% CI 1.02, 1.93), and the effect was significantly pronounced among girls who spent ≤3 days per week in 60 minutes of moderate-intensity physical activity than those who spent more days (adjusted OR:1.99 95% CI 1.15, 3.47 vs. 0.77 95% CI 0.33, 1.80).[236] In fact, a population-based study on Iranian students indicated that the time spent watching television was associated with an increased risk of overweight and obesity (OR: 1.27, *P*=0.001).[237] In the only obesity intervention study from SEA, Sharifah and colleagues (2014) reported that although obese children spent significantly more time in sedentary behaviours than healthy weight children (90% vs. 89%, *P*=0.001), moderate- to vigorous-intensity physical activity levels were exceptionally low across body weight categories (1.2% vs. 0.7%, *P*<0.001).[238]

Based on the available evidence, it appears that physical activity and sedentary behaviour are significant environmental factors associated with the development of overweight and obesity among children and adolescents. However, data from developing countries remains unclear, indicating the need for more robust and high quality studies to be carried out.

2.3.4 Family environment

During early and middle childhood, family environments are key determinants for development of food preferences, EI, eating behaviours, and activity preferences and patterns which may subsequently influence the onset of obesity.[56] The construction and experience of a child's environment can be carried forward to the next generation via the impact of parental diet and lifestyle behaviours, parenting styles and feeding practices.[239] Yet, it should be acknowledged that parent-child interactions are bidirectional. Parenting influences children and children also influence parenting within the shared environment.[56]

Intergenerational relations between family members and other care-givers are considered to contribute to the constitution of particular obesogenic environments. Terms such as "intergenerational" and "familial influences" refer to a range of processes and practices surrounding an overweight and obese child that are conceptualised according to different disciplinary definitions and applications.[52] With increasing numbers of mothers having

full-time employment in Asian countries, the involvement of caregivers such as grandparents and domestic helpers are likely a powerful determinant of children's eating habits and food intake patterns.[240] The investigation of an intergenerational approach would require recognition of multiple directions of the relationship of influence that exist between family members and caregivers.[52] Little is known about the impact of this shift on children's nutrition, hence in our research, other family-related carer(s) playing the role as primary provider of food for the child were invited to participate.

The areas of study that the family environment may impact on, is discussed in this section: body weight status, dietary intake and physical activity, parenting styles and parent-child feeding practices, and other factors such as socio-economic and cultural effects.

2.3.4.1 Body weight status

Parental obesity is well-established as an important predictor of childhood obesity in the developed countries.[53, 159, 187, 241-244] With more recent published literature from the developing countries on familial weight resemblance (one study from Malaysia),[54, 55, 93, 245-248] this relatively large body of evidence strengthens the hypothesis of an intergenerational transmission of obesity universally. The association between overweight parents especially the mothers,[93, 159, 187, 243, 244, 247, 249] and overweight children suggests both genetic factors and cumulative environmental influences including learnt lifestyle behaviours are impacting on child weight status. Stronger maternal contributions to child obesity would implicate a greater dominance of maternal-child interaction related to eating and physical activities and include factors such as role modelling, the home environment and maternal feeding practices. Nevertheless, with the changing roles of mothers in the Asian countries including full-time employment,[240, 250] the impact on child weight status should be further examined and monitored.

Although parent-child body weight status is closely related, current evidence is mixed on parental recognition of obesity in children from both developed and developing countries.[99, 251] This indicates parents may or may not be able to recognize weight problems in their own children. It is acknowledged that parental recognition of obesity is the critical first point in effecting change in their child's weight status. Parents' failure to recognise the negative consequences of obesity needs to be addressed to effectively identify those at risk and subsequently, to deliver intervention programmes.[251]

2.3.4.2 Dietary intake and physical activity

Previous studies found the strength of the dietary relationships between parent-child was weak-to-moderate[60-62] with considerable variations in the correlations across nutrients and food groups.[58, 60-62] While some studies demonstrated that child-mother's dietary intakes were more related than that of child-father intakes,[60, 62, 252] others had identified fathers as key influencers of non-core food intakes in children.[61, 253] The weak-to-moderate correlations suggest that it is likely that parental dietary intake is one of the many contributing factors affecting a child's diet. Other factors are likely to be the community and school environments, peer influence or the media.[62, 254]

The literature regarding familial aggregation of physical activity levels is limited compared to those available for dietary intake with varying degrees of associations of parent-child physical activity levels. In an earlier review by Sallis *et al*.(2000) on correlates of physical activity in children and adolescents, the evidence was inconsistent across studies for parental influences, mainly due to measurement error and variation in the population examined.[255] Two recent systematic reviews of similar scope in pre-schoolers[217] and children aged 4-12 years[216] showed that parental physical activity was positively associated with both of the age group's physical activity. This finding concurred with a specific review on parental correlates of children's and adolescents' physical activity which unanimously supported the importance of parents' physical activity as a modifiable factor for intervention efforts.[256]

Current research found that children learn about food and physical activity either by direct experience of eating or playing, or observing their parents.[58, 180, 257, 258] It has also been suggested that parents could affect their children through aspects of the home environment, for example, role modelling[57-59, 258, 259] and increasing availability and accessibility of energy-dense, nutrient poor foods[57-59, 258] and physical activity equipment at home.[258, 259] Using the 'Home Environment Survey' developed based on the socio-ecological framework, Gattshall and colleagues[259] found that the concepts of availability, accessibility, parental role modelling and parental policies correlated well between parent and their overweight child's nutrition and physical activity.[259] In a Malaysian study utilising the same assessment tools to determine the association between home environment, dietary practice and physical activity among primary school children,

similar results were observed.[180] These findings highlight the importance of parental roles within the home environment in promoting healthy eating and an active lifestyle among children, and ultimately impact on the regulation of children's weight status.

It is believed that a young child's eating habits are more likely to be influenced by their parents than the adolescent child who often exhibit more independence in their food selection. In Pearson *et al.*'s systematic review of family correlates of fruit and vegetable consumption, the researchers found that parental intake was the only common correlate positively associated with children's and adolescent's intake,[58] which indicates clear parental roles in dietary behaviours of their offspring, irrespective of age. Contrary, no association was observed between parental physical activity and the adolescents' physical activity as reported by Van Der Horst and colleagues (2008).[216] The conflicting results between dietary intake and physical activity for the older age group suggest a complex interaction of multidimensional factors associated with adolescents' behaviours, which are yet to be ascertained.

2.3.4.3 Parenting style

Parenting style may play a role in the development of childhood overweight and obesity. The commonly used typological approach in parenting research is based on the work of Maccoby and Martin (1983) that originated from Baumrind (1971), who described parenting style as a function of two dimensions of parental behaviour: the extent to which parents are responsive to their children's needs (responsiveness), and controlling their children's behaviours (demandingness). Parenting style is classified into one of four categories based on the variations in the dimensions of responsiveness and demandingness that parents express:[260]

1. Authoritative parents who are both responsive and demanding;
2. Authoritarian parents who are less responsive but highly demanding;
3. Indulgent /permissive parents who provide a high level of responsiveness but are less demanding; and
4. Neglectful/uninvolved parents who show relatively low levels of both dimensions

Although past research has shown positive associations between an authoritarian parenting style and risk of overweight in children predominantly from developed countries, current evidence is equivocal.[239, 261] With up to 97% of the included studies from developed countries, results from Sledden *et al.*'s systematic review on the influence of general parenting on children's diet and activity behaviours and weight status suggest that children raised in authoritative homes ate more healthily, were more physically active and had lower BMI levels than children raised with other parenting styles.[239] However, a study examining the relationships between parental perceptions, feeding practices and feeding styles of Chinese Americans, and their school-aged child revealed that children of parents who used an indulgent feeding style were more likely to be overweight or obese than children of parents using other styles. The researchers also found that the less the parents restricted their children's eating of unhealthy food the more the children weighed.[261]

It has become increasingly evident that the influence of parenting style varies depending on the social milieu in which the family is embedded.[52] Previous studies found that the prevalence of different styles of parenting varies markedly among ethnic groups in the US. Such variability could be related to the different parenting style operating in the particular cultural context that may differentially affect children's development.[260] The traditional Asian parenting style within the obesogenic environment in developing Asian countries may or may not be impacting on children's body weight status. In addition, the current younger generation of mothers in Asia are shifting away from traditional parenting styles to adopt Western styles, a transformation that may have an adverse impact on the development of overweight and obesity in children given that developed nations are battling with higher childhood obesity prevalence. The lack of understanding of ethnic differences in parenting style on children's development highlights the need for further research in Asian populations.

2.3.4.4 Parental child-feeding practices

Parental child-feeding practices are an important factor influencing children's eating patterns; this can be a positive influence[262-265] or negative influence.[263-265] Parental feeding practices are embedded in their feeding styles and may vary based on parental concerns and perceptions of the child's risk for developing a problem in the domain of

food.[260] Much work by Birch and colleagues in the 1990s revealed that child-feeding practices had clear effects on the child's emerging food preferences, intake patterns, and development of self-regulations of food intake. Child-feeding practices, specifically restriction and pressure, can promote children's overeating in response to the readily available palatable food in today's obesogenic environment.[56] Despite limited evidence from the developing countries, these child-feeding practices can be especially problematic in developing countries experiencing nutrition transition.

Parental feeding practices are specific practices that parents usually use during eating such as pressure to eat healthy food, restriction of less healthful food, monitoring of the child's food intake, or the use of rewards for food consumption. One commonly used instrument is the Child Feeding Questionnaire (CFQ), validated in the US amongst Western children, assessed parental beliefs, attitudes, and practices regarding child feeding, with a focus on obesity proneness in children.[266] The CFQ focuses on broadly defined behaviours that are linked to control over feeding during a child's development as suggested by Costanzo and Woody (1985).[267] Deviating from the parenting styles approach,[260] the concept of domain-specific model for parenting was proposed, where parents are most likely to exert control in child feeding when they are highly interested in child feeding and/or perceive there to be child weight issues. It was hypothesised that high levels of parental involvement in feeding could produce unintended and counterproductive effects in children's self-control.[267]

Existing reviews concentrated on specific types of parental control to eating behaviour that affect children's weight-related health outcomes.[262, 264, 265, 268] Results from Faith and colleagues reported positive associations between restrictive feeding practices and eating and weight status of children as opposed to other general feeding control or domain.[262] However, the Wardle and Carnell (2007) review covered a range of research designs on Western families and had conflicting findings that parental control could either lead to lower or higher adiposity, or have minimal impact on eating and the weight status of the children.[265] Hurley *et al.*'s subsequent systematic review of responsive feeding and child obesity in high-income countries concurred the equivocal results.[264] Such unclear evidence on the impact of parental child-feeding practices on children's weight, which largely arises from studies conducted in developed countries must be interpreted cautiously. It has been suggested that parental feeding practices vary widely with ethnicity

and socio-economic status[264, 265] which are evident characteristics of populations in the developing countries.

All of the research in the field of parental child-feeding practices in Malaysia uses cross-sectional designs. It is recognised that although cause and effect cannot be established, these studies provide important data on associations within large and diverse community samples with limited resources. To date, there were only three published studies using CFQ that reported associations between parental child-feeding practices and child body weight status.[248, 269, 270] A survey of 1430 primary school children found positive associations between concern about a child's weight (r=0.125, P<0.01) and restriction of unhealthy foods (r=0.057, P<0.05), and negative relationships between a child's BMI and pressure to eat (r=-0.135, P<0.01).[248] In two smaller studies, similar results were observed between two specific feeding practice domains and BMI; food restriction[269, 270] and pressure to eat.[269, 270] As a whole, the impact of parental child-feeding practices on child weight status in Malaysia remains unclear.

2.3.4.5 Other factors

Other familial factors such as socio-economic status, parental education level and cultural effects have also been identified as predictors of childhood obesity in the developing Asian countries. Unlike developed countries where obesity is closely related to lower socioeconomic groups, Chinese children from high-income households recorded the greatest proportion of excessive weight gain between year 1991 and 2004.[271, 272] A similar observation of childhood obesity associated with increased family affluence was reported in other main cities of Asia: Bangkok, Thailand;[273] New Delhi, India;[15] Ho Chi Minh, Vietnam;[246] and Jakarta, Yogyakarta and Kuta, Indonesia.[274] Ghosh (2011) has highlighted the potential negative impact of parental education level towards children's excessive weight status given children with more educated parents were more prone to become overweight or obese. These parents were likely to be working away from home with less attention to their child's eating, allowing their child to eat fast foods and processed foods more often.[250] When considering the Asian culture and beliefs, obesity-prone practices such as overfeeding, forced feeding and feeding oils and fats to children are still in existence. Although well-intended in the traditional perspective, these may inadvertently contribute to excessive weight gain in the child over a period of time.[15]

The discussion around parental effects on child weight status, dietary intake, physical activity and feeding practices does not imply that these are the only aspects of the family environment that are important within the context of childhood obesity. These findings are currently reported predominantly in Western families and collectively highlight the importance of parents' practices and how they can affect many aspects of the children's nutritional intake and lifestyle. It illustrates efforts to delineate environmental factors associated with the development of childhood overweight and obesity, and to point to areas where additional research is needed, especially in developing countries.

2.4 Measurement of dietary intake in children

2.4.1 Dietary assessment methods

Reporting what children eat and drink, examining the factors that influence their dietary choices and how these change in response to a dietary intervention are crucial to understanding the link between diet and disease.[275] There is no consensus regarding the best method of assessing dietary intake in children.[172, 276] A variety of methods exist for collecting dietary intake data and each method is associated with a certain degree of error, advantages and disadvantages.[172]

Table 2-6 summarises the dietary assessment methods used in dietary studies amongst Malaysian children and adolescents with some methods more widely used than others. The choice of methods was likely to be influenced by research budget, burden associated with both respondents and researchers, and the study design. The common methods used between year 2000 until to date in descending order are briefly described in Table 2-7; food habits/ dietary habits questionnaires (8 studies),[42, 46, 48, 49, 51, 97, 277, 278] 24-hour DRs,[42-44, 47, 179, 180] and the less common being the FFQs (5 studies)[9, 44, 47, 50, 181] and estimated diet records (4 studies).[41, 45, 46, 179] While the only one cohort study reported using the diet history method,[101] no published local study has reported administering weighed FRs as their dietary assessment methodology.

The ultimate goal in choosing the best dietary assessment method to measure dietary intake in children is to select a method most suitable for the study design and outcome of interest with maximum validity.[279, 280] When evaluating which dietary assessment

method is most appropriate for a research study, factors to be considered include the type of information required about foods, nutrients, other food constituents or specific dietary behaviours; the average intake of a group or individual; absolute or relative intake; level of accuracy, time period of interest and constraints of money, time, personnel and respondent characteristics.[172, 275, 281]

In a systematic review on the validity of dietary assessment methods in children which includes the gold standard measure of EE using DLW as the reference standard, the researchers reported that 24-hour multi-pass records over a 3-day period inclusive of weekdays and weekends was a valid method to estimate total EI in children aged between 4 to 11 years with parents as proxy reporters. Diet history method has been recommended as the method of choice for those children aged 16 and above, while the weighed FRs were reported to provide the best estimates for younger children aged 0.5 to 4 years.[282] Livingstone *et al.* (2004) concurred, stating that by 8 to 10 years children can reliably report food intake with their parents, where the parents' role is a supplementary role to provide details about types and quantities of food consumed.[276] However, the involvement of parents as proxy reporters for children especially for those aged between 8 and 12 years is increasingly being questioned[283, 284] as discussed in the following sub-section.

Table 2-6: Types of dietary assessment methods

	Dietary Assessment Methods	Description	Strengths	Limitations	Use in children
METHODS COMMONLY USED IN MALAYSIAN CHILDREN DIETARY STUDIES					
Retrospective	Questionnaire	• Specific surveys to measure food related behaviours and activities to complement actual food intake information collected from the common dietary assessment methods	• Simpler to administer • Much lower participant burden • Useful for population surveys	• Relies on participant's memory[285] • Self-report nature likely promotes reporting bias • Development process of a food/dietary questionnaire is much less stringent than that of a food frequency questionnaire	• Can be used on older primary school-aged children[286]
	24-hour Dietary Recall	• Involves a trained interviewer to ask respondents to recall the exact detail of all food and drink consumed during the previous 24-hour period, assisted by food models or household measures for quantification. [287] • Better quality 24-hour dietary recall instrument is the United States Department of Agriculture's Automated Multiple Pass Method, consists of 5 steps, or passes, that involve an initial quick list, a forgotten foods list, stating time and occasion, a detailed pass and final review[281]	• Less respondent burden so can be used when cooperation or literacy of respondents is limited[288] • Less expensive and does not alter the usual diet of the respondent	• Relies on respondent's memory • Requires trained interviewers, hence expensive • Contains larger random error, which can be overcome by increasing the numbers of days of recall (depending on the nutrient(s) of interest)[289] and use of statistical modelling method[290] • Minimum two administrations on a subsample are required to estimate distributions of group usual intakes[285]	• Improves with child's age and adult assistance • Parents can proxy for children under 8 years[291]
	Food frequency questionnaire	• Respondents are provided with a list of foods with instructions to report their food intake for a period greater than 24 hours (e.g. week/s, month/s, year/s)[292] • Determine respondent's energy and nutrients intake based on their frequency of consuming a list of foods that contributed to particular nutrients in that population and subsequently, to set the relevant food guidelines and standard[287]	• Suitable for large-scale surveys • Can be self-administered, posted or online • Does not alter the usual diet of the respondent • Allows ranking of individuals by food or nutrient intakes so characteristics of those with high and low intake may be compared	• Biases caused by errors in memory, perception, conceptualization of food portion sizes • Daily variation in diet not usually assessed • Does not allow quantification of absolute intake of individuals	• May not be suitable for those under 10 years of age due to considerations around the child's cognitive ability[276]

	Dietary Assessment Methods	Description	Strengths	Limitations	Use in children
Prospective	Estimated food record	• Simpler version of weighed food record to provide detailed data on food and beverages intake without the burden of weighing • Requires respondents or their proxies to be both motivated and literate to record their dietary intake prospectively[281]	• Does not rely on respondent's memory • Widely used to reflect current diet	• Considerable respondent burden and may be completed after food is consumed from memory instead of at the time of intake • Requires literacy and numerical skills • Expensive and alters habitual dietary habits	• Reporting bias may be more severe compared to dietary recall and food frequency questionnaire for children and adolescents[293] • Parental involvement for younger child
METHODS NOT COMMONLY USED IN MALAYSIAN CHILDREN DIETARY STUDIES					
Retrospective	Diet History	• Original diet history usually begins with a face-to-face interview to describe usual food intake followed by second phase to complete a food frequency questionnaire/ checklist and the third phase, a 3-day food record[294]	• Obtained comprehensive qualitative and quantitative data as well as information about portion size and cooking method • Useful in clinical practice	• Expensive and tiring for interviewers • Expensive and unsuitable for population studies • Relies on respondent's memory and foods may be forgotten • Requires high cooperation from participants • Requires quality checking/ training of interviewers on data collection	• Very complex for children although with involvement of trained interviewer
Prospective	Weighed food record	• Record actual intake of foods and beverages consumed at the time of consumption for a specified period • Foods and beverages are measured using weighing scale[295]	• Assess the current diet of what is consumed as it does not rely on individual memory • Detailed descriptions of the foods consumed including exact portion sizes and all eating occasions • Used as standard in dietary validation studies	• A time- and labour-intensive method for researcher and respondent • Requires literacy and numeracy skills • Under-reporting of energy intake may increase with age or weight status • Requires more days of recording to improve validity of records • Multiple records can introduce compliance issues due to high respondent burden	• Greatest bias towards under-reporting in older children and adolescents[276, 288, 293] • Parental involvement for younger child

Table 2-7: Summary table for dietary assessment methods used in dietary studies among Malaysian children and adolescents

Author & Year	Age (Years)	Sample Size	Setting	Dietary intake reporting approach
• **Food habits/ dietary habits questionnaire**				
Norimah & Lau 2000[97]	4 to 6	M: 48, F: 43 (Chinese)	• Kindergartens, *Subang Jaya, Selangor*	• Dietary behaviours (main meals, snacks & fast foods) • Food preference and dislikes
Pon *et al.* 2004[42]	14 & 16	M & F: 100	• School, *Teluk Intan, Perak*	• Eating behaviours (daily meal patters, meal skipping habits, snacking, fast foods & intake related to emotional distress)
Lew & Barlow 2005[48]	11 to 21	M & F: 200	• Schools and colleges, Singapore & Malaysia	• Dietary behaviours (main meals, snacks, eating out & selected food & beverages)
Moy *et al.* 2006[49]	11, 14 & 16	M & F: 3620	• Schools, *Kuala Lumpur*	• Dietary behaviours (main meals, snacks, eating out, fast foods & nutritional supplement)
Norimah *et al.* 2007[46]	10 to 17	M & F: 6977	• Peninsular Malaysia	• Dietary behaviours (skipping breakfast, snacking and fast foods)
Poh *et al.* 2012[277]	5 to 6	M: 484, F: 508	• Kindergartens, *Klang Valley*	• Nutrition knowledge, attitudes and food preferences
Norimah *et al.* 2014[51]	4 to 6	M: 929, F: 1004	• Kindergartens, Peninsular Malaysia	• Dietary behaviours (main meals, snacks & fast foods) • Food preference and dislikes
Koo *et al.* 2015[278]	10 & 11	M: 196, F: 188	• Schools, *Kuala Lumpur*	• Knowledge, attitudes and practice regarding wholegrain consumption
• **24-hour Dietary Recall**				
Pon *et al.* 2004[42]	14 & 16	M & F: 100	• Schools, *Teluk Intan, Perak*	• Energy & nutrients intake
Zalilah *et al.* 2005[43]	7 to 9	M: 158, F: 174	• Schools, *Hulu Langat, Selangor*	• Energy & nutrients intake • Dietary diversity score
Elias *et al.* 2007[44]	6 to 10	M: 113, F: 112 (Malay)	• Schools, *Kuala Lumpur*	• Energy & nutrients intake
Norimah & Toh 2009[47]	7 to 12	M: 100, F: 98	• Schools, *Klang Valley*	• Sugar and sweetened beverage intake
Woon *et al.* 2014[180]	9 to 12	M & F: 293	• Schools, *Selangor*	• Energy & macronutrients intake • Home environment survey
Zalilah *et al.* 2015[179]	1 to 10	M: 366 F: 383	• Child care centres, kindergartens and schools at urban areas, *Klang Valley*	• Energy & macronutrients intake • Food groups consumption

M: Male; F: Female

Author & Year	Age (Years)	Sample Size	Setting	Dietary intake reporting approach
• **Food frequency questionnaire**				
Elias *et al.* 2007[44]	6 to 10	M: 113, F: 112 (Malay)	• Schools, *Kuala Lumpur*	• Dietary intake pattern
Norimah & Toh 2009[47]	7 to 12	M: 100, F: 98	• Schools, *Klang Valley*	• Sweetened beverage drinking habits
Poh *et al.* 2013[9]	0.5 to 12	M & F: 3542	• Child care centres, kindergartens and schools, nationwide	• Energy & nutrients intake
Firouzi *et al.* 2014[50]	6 to 12	M: 90, F: 74	• Schools	• Energy & macronutrients intake
Nurliyana *et al.* 2015[181]	12 to 13	M: 161, F: 255	• Schools, *Gombak, Selangor*	• Dietary patterns (refined-grain/ snack-food/plant-based food/high-energy food)
• **Estimated diet records**				
Zalilah *et al.* 2006[41]	11 to 15	M: 301, F: 317	• Schools, Peninsular Malaysia	• Energy & macronutrients intake
Norimah *et al.* 2007[46]	10 to 17	M & F: 6977	• Peninsular Malaysia	• Energy & nutrients intake
Soo *et al.* 2011[45]	10 to 12	M: 144, F: 134 (Chinese)	• Schools, *Kota Bharu, Kelantan*	• Energy & macronutrients intake • Dietary behaviours (skipping breakfast)
Zalilah *et al.* 2015[179]	1 to 10	M: 366 F: 383	• Child care centres, kindergartens and schools at urban areas, *Klang Valley*	• Energy & macronutrients intake • Food groups consumption
• **Diet history**				
Hazreen *et al.* 2014[101]	13	M & F: 1361	• Schools, *Klang Valley & Perak*	• Energy & nutrients intake

M: Male; F: Female

2.4.2 Issues when measuring children's dietary intake

It is particularly difficult to assess children and adolescent's diet accurately.[172, 275, 276, 280] Hence, dietary intake data obtained from the paediatric group must be interpreted in the context of these limitations.[287] While most methodological issues of gathering dietary data from children are similar to adults, there are additional concerns closely linked to the age-related abilities of the children to report on diet. There is also a growing recognition of the need to engage children themselves in healthcare-related research.[296] These factors associated with measuring children's dietary intake are briefly discussed below.

2.4.2.1 Age

Age determines whether reliable self-report data can be obtained directly from the child or whether parents might be the reasonable or accurate proxies.[85] Although individual variation in ability exists, in general, children aged ≥ 9 years are capable of accurately self-reporting their dietary intake where the children's novelty and curiosity of assisting in or self-reporting of food intakes may help to sustain enthusiasm for, and compliance in dietary monitoring.[276] Adolescent despite being more capable than younger children might be less compliant in reporting due to the additional demands on recording imposed by unstructured eating patterns, significant degree of out-of-home eating, concerns with self-image, dieting behaviour and peer pressure.[172, 276] For children below 8 years, they are unable to conceptualise frequency correctly in addition to their dependency on adults for food provision, timing and frequency of eating occasions.[276, 280] Nevertheless, it should be acknowledged that age is an approximation of what a child's aptitudes are and could be a barrier to engage with the child, especially when eliciting detailed information such as dietary intake.[296]

2.4.2.2 Cognitive ability

By understanding the underlying mechanism of the child's cognition, researchers can consider how to involve children in research with practical strategies to obtain valid data.[296] An old review that sets the theoretical basis for children's participation in qualitative interviews comprehensively explored how children process, store and retrieve experiences.[297] This theory was reiterated by Irwin and Johnson (2005) that reported that both closed-ended and open-ended questions should be used in combination when

conducting qualitative interviews with children to produce a good outcome.[298] Reporting dietary intake involves a series of cognitive processes that requires a child to reach the appropriate developmental stage. These complex processes include understanding what information is being asked by the researchers, searching for the information and evaluating the retrieved information for the most appropriate answer before providing a response.[276]

A model of cognitive processing on how children report dietary intake was originally proposed by Baranowski and Domel (1994).[299] The model as shown in Figure 2-5 consists of three structural elements: a sensory register, short-term memory and long-term memory.[299] Briefly, to obtain a reasonably accurate report of intake, the child must fulfil the following aspects: attend an eating event; form an initial short-term memory of the event; the memory must be in terms, units, and sufficient detail to be interpretable by the investigators; perform some elaboration of the event to be stored in long-term memory; accurately introspect and recall all aspects of the memory; avoid overlap across days in such memories; and face no internal or perceived external constraints on the reporting of the memory. Errors can occur throughout the reporting processes including attention, perception, organization, retention, retrieval and response.[289]

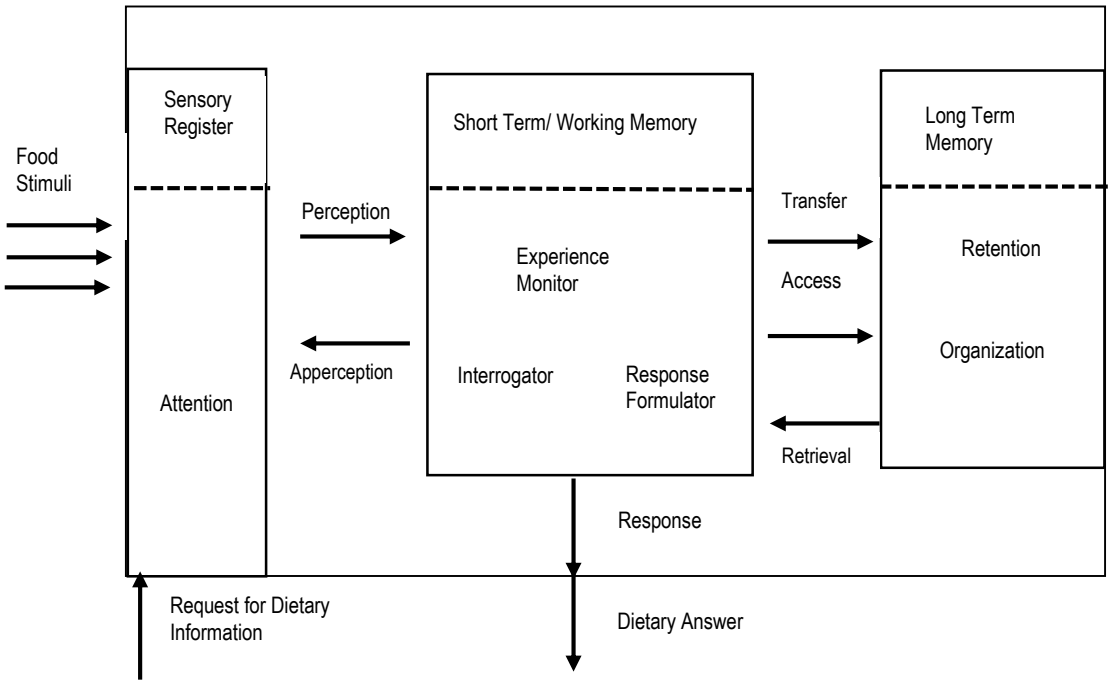

Figure 2-5: A model of child's cognitive processing of food information

Reprinted from the American Journal of Clinical Nutrition 59 (Suppl), Baranowski T & Domel SB. A cognitive model of children's reporting of food intake. p.213S, Figure 1, 1994, with permission from the American Society for Nutrition

2.4.2.3 Portion size estimation

The ability to estimate portion size is not age-dependent as both children and adolescents reported difficulty in estimating portion size.[280] The estimation of food portion size is compatible with the perpetual and conceptual capacities of the children and unlikely to be achieved until they have reached the stage of abstract reasoning (approximately around 10 to 11 years).[276] In an earlier study on British children, there were large error margins in the reporting of portion sizes estimations when compared to the actual portion sizes. Both under-estimation (up to 52%) and over-estimation (up to 100%) were prevalent.[300] In addition, Collins *et al.* (2015) demonstrated that self-selected portion sizes of common foods varied from the standard serving sizes by both parents and children with the highest overestimation up to 155% for pasta.[301]

The current evidence around using quantification tools such as photos, food models and household measures to improve the validity of portion size estimation is equivocal[276, 300, 302] because this skill involves a complex process of perception, conceptualization and memory. Perception involves a subject's ability to relate an amount of food while conceptualization refers to the subject's ability to make a mental construct of an amount of food which is complicated by memory which affects the precision of the conceptualization.[303] In a study of children aged 4-16 years investigating various tools to estimate food portion size found that children had results closer to actual portion sizes using an interactive computerized system and food photographs rather than food models.[302] This highlights the need for more methodological studies to evaluate the use of estimation methods on portion size in children.

2.4.2.4 Weight status

It has been established that in dietary studies involving children and adolescents of different body weight status, positive associations were found between low energy reporting and increased body fatness, particularly in adolescents.[275, 304-307] In younger children where parents act as proxy reporters of their children's food intake, reporting accuracy may likewise be compromised by parental obesity status and/or parental perception on such information as a reflection of their child's weight. This bias towards underestimation of food intake by obese parent(s) for their children has been observed in some studies.[305, 308] Given the increasing prevalence of childhood obesity worldwide, it

is essential to consider the effect of body weight status as a confounder of reported intake in all dietary studies.[172, 280] Hence, it is recommended that researchers include an assessment of weight status when assessing dietary intake to adjust for this potential confounding factor.[172]

2.4.2.5 Parental reporting

Parental involvement in reporting children's dietary intake is inevitable especially for children below 8 years who have limited cognitive development, reading skills and vocabulary.[275, 276, 280] In two reviews of validation studies for the assessment of dietary intake in children, parents were the most commonly used proxies in the majority of the included studies.[280, 282] However, each adult-representative is providing their interpretation of what they think the child ate and drank, and what is best for them which could have been filtered from actual intake. Parents may be less accurate reporters than the child themselves,[284, 309] especially for foods consumed outside the home.[283] The assumption that parents are good reporters of their child's food intake therefore can be challenged.[172, 276] Mothers were traditionally viewed as the main person involved in meal planning, food preparation and influencing the child's intake in the family environment, yet recently fathers were found to be more accurate reporters of their child's intake.[283] As such, it has been suggested that researchers clearly indicate who is the source of dietary intake reporting as it remains unclear whose report is more valid.[284]

2.4.3 Validation studies of dietary intakes

Ideally, all dietary studies should include independent measures of validity and reproducibility, especially in the population for which their use is intended.[172, 280] However, validation usually involves only one aspect of the whole diet and dietary intake is a complicated behaviour which is difficult to validate. The validity of a dietary tool refers to its ability to measure what it is intended to measure while the reproducibility/reliability of a tool is its ability to produce very similar results when used on repeated occasions.[287] While it is near impossible to capture a person's true usual intake, the best that can be achieved is to perform relative validation by comparing results from one dietary assessment method with findings from another assessment tool designed for the same purpose.[172] However, good agreement between two dietary assessment

methods may not necessarily indicate validity and the failure of one instrument to compare favourably with another may result from the inappropriateness of the reference method chosen.[287] In McPherson's review on validity and reliability of dietary assessment methods among school-aged children, it was evident that many dietary assessment tools used as validation standards were imperfect, especially for children.[280]

The diverse food culture and demographic uniqueness associated with diet of the developing Asian countries could potentially affect the validity and reproducibility of the dietary assessment method chosen and hence, the reporting quality. Furthermore, the lack of Asian population-specific dietary assessment tools, and specifically the availability of validated methods compared to developed countries raises additional challenges to obtain accurate dietary intake data. The limited understanding of the reporting of dietary intake methods in this region calls for a high quality and up-to-date systematic review. Therefore, epidemiological studies from developing Asian countries looking at the relationship between dietary outcomes and childhood overweight and obesity were appraised using a quality checklist and the gap in research has been addressed in Chapter 4.

Recognising this constraint, biomarkers offer the advantage to be an objective assessment of the reported intake to assist with assessing the validity of the dietary method.[280] Biomarkers are components of body fluids or tissues that are directly related to the dietary intake component of interest, independently of the measurement of food intake and therefore, avoid the biases associated with common dietary assessment methods.[172] To date, no validation study has been conducted in Malaysia that has utilised nutritional biomarkers in a population of children. The main constraint for the use of biomarkers as validation methods in developing countries is the high cost and technical assistance required. Additionally, a single biomarker is unable to provide information on all nutrients of interest at the same time.[279, 287] The common validation methods using biomarkers are listed in Table 2-8.

Table 2-8: Common validation methods using biomarkers for dietary intake

Method	Biomarker	Description	Limitation
Doubly labelled water (DLW)	Energy intake	• Gold standard of measuring total energy expenditure • Based on the fundamental principle of energy metabolism that energy expenditure and energy intake are equal under conditions of stable body weight and composition • Involves dosing individuals with a measured quantity of DLW at baseline and collecting urine samples over a designated period of time, usually 7 to 15 days • Dose of DLW given to each individual is calculated by multiplying a certain quantity of DLW by an individual's body weight or total body water	• Seldom carried out due to the expense, analysis and limited facilities
Plasma carotenoids	Fruit and vegetable intake	• Dose-response relationship between intake of fruit and vegetable and appearance of carotenoid in plasma • Commonly measured carotenoids include provitamin A compounds: α-carotene, ß-carotene, ß-cryptoxanthin and also lycopene, lutein and zeaxanthin	• Individual variability in absorption, availability and metabolism
Plasma fatty acids	Dietary fat intake	• Specific fatty acids reflect dietary intake of individual and classes of fatty acids • Most commonly measured from plasma/ red blood cell membranes/ subcutaneous fat	• Individual variability in absorption, availability and metabolism
24-hr urine nitrogen excretion	Dietary protein intake	• Collect urine sample from an individual over 24-hour for a period of 7 to 10 days • Nitrogen, derived from amino acids and released through protein catabolism in the body is excreted in the urine	• Use of this method based on assumption that individuals are in nitrogen balance and no accumulation due to growth/ repair/loss of muscle tissue/ loss due to starvation and dieting • Difficulty to complete 24-hour urine sample collection
Urinary sodium	Dietary sodium intake	• Collect urine sample from an individual over 24-hour for a period of 7 to 10 days	• Difficulty to complete 24-hour urine sample collection

Adapted from Lee & Nieman 2010,[287] and Collins *et al.,* 2010[172]

2.4.3.1 Dietary mis-reporting

The development of DLW method as a gold standard for measuring total EE from early 1980s to 1990 has led to the understanding and identification of mis-reporting in dietary assessment,[310] however, it is beyond the scope of most dietary intake studies. Dietary mis-reporting reflects poor validity of reporting and introduces severe measurement error. A comprehensive review of studies which compared reported EI to total EE measured by DLW showed high prevalence of under-reporting.[304] Comparisons between EI and total

EE estimated by DLW show a tendency of under-reporting to increase with age but that the magnitude of age-related under-reporting is also dependent on the dietary assessment method.[172] Although under-reporting is commonly reported in both adults and children,[91, 304] over-reporting could actually be more widespread amongst younger children.[293]

EI is usually used as a proxy for dietary intake despite being only one aspect of the diet and also likely to be mis-reported. This is because if EI is underestimated, it is probable that the intakes of other nutrients are also underestimated.[304] In the absence of direct measures of total EE such as DLW, cut-points can be used to identify mis-reporters.[283] While there are no standardised recommendations internationally and particularly in children, the common methods include Goldberg equations,[88, 89] Torun cut-point[90] and the Black & Cole method[91] as summarised in Table 2-9. When applying the cut-offs, the total EE can be calculated based on population, age and sex-specific basal metabolic rate (measured or estimated) and the relevant physical activity level factor.

Despite the difficulty of accurately measuring usual dietary intake and lack of agreement on the best methods to be used in developing countries, the ability to quantify the degree of mis-reporting and to identify some of the characteristics of subjects related to mis-reporting indicates overall progress towards obtaining accurate dietary data. However, the extent of energy mis-reporting among Malaysian children has rarely been investigated when compared to this assessment of children in developed countries.[304-307] Therefore, a brief research project was undertaken to identify the prevalence of energy mis-reporting amongst the pilot sample of Malay children using a range of commonly used cut-points as presented in Chapter 6.

In summary, much remains to be learned about measuring dietary intake in children, and even more limited in Malaysian children. This is a growing area of research, and besides the two studies related to dietary methodology for Malay and Asian children as part of this research, it calls for more studies in this region.

Table 2-9: Cut-points used to determine energy intake mis-reporting

Goldberg equation 1991[89]	Torun cut-point[90]	Goldberg equation 2000[88]	Black & Cole method[91]
• Identify under-reporters based on EI: BMR ratio (<1.35)	• Classifies under, acceptable and over-reporters based on an EI : BMR ratio	• Classifies under, acceptable and over-reporters • Cut offs values are the CL of agreement between EI:BMR and PAL	• Cut-points based on 95% CL of agreement between EI and total EE measured by DLW • Classifies under, acceptable and over-reporters based on EI: estimated EE ratio

BMR: Basal Metabolic Rate, CL: Confidence limit, DLW: Doubly labelled water; EE: Energy expenditure, EI: Energy intake, PAL: Physical Activity Level

2.5 Strategies in addressing childhood obesity

Obesity is a chronic disease requiring short- and long-term strategies for its effective treatment and prevention.[5] Contrary to adult obesity that focuses on weight loss, strategies in addressing childhood obesity are targeted at weight maintenance or appropriate weight loss depending on the degree of excess weight, age and stage of growth.[163, 311] The primary goal of intervening in childhood obesity is to ensure regulation of the child's body weight while achieving adequate nutrition for growth and development.[311, 312] Hence, concerted intervention efforts are needed to optimise fat-free mass while the child grows and to reduce or maintain fat mass constant to normalize the body weight and body composition.[311, 312] Interventions aimed at managing obesity in the paediatric population should caution against the risks of developing disordered eating patterns, malnutrition and social isolation which requires careful monitoring from healthcare professionals.[311-313]

It is acknowledged that obesity management strategies need to address all interdependent intervention approaches through a variety of settings.[163] While the effectiveness of some approaches have been shown in the adult population, evidence is equivocal but rapidly increasing in children to provide some guidance on management approaches to produce more favourable outcomes.[311, 312] It is essential that factors implicated in the development of childhood obesity are considered when intervening in order to ensure the problem is being tackled comprehensively and effectively. Most evidence-based guidelines and expert group recommendations support that interventions should be multicomponent approaches including diet, physical activity/ sedentary behaviour and behavioural therapy.[311, 312, 314] Table 2-10 summarises these approaches and includes pharmacotherapy and surgical intervention in child and adolescent weight management.

Table 2-10: Summary of approaches in childhood obesity intervention programme

Components of Intervention			Examples of Approaches	Description	Remarks
Lifestyle	Dietary management	• To reduce or stabilise energy intake & improve eating behaviour & quality of the diet	*Traffic Light/ Stoplight diet*	• Calorie-controlled approach • Categorizes food into different coloured groups: red (very limited), yellow (limited) & green (eat freely)	• Effective relative weight loss across different age groups, settings, & countries[64] • Stoplight/ Traffic Light diet originally by Epstein and Squires & frequently used as dietary prescription mainly in studies in US[315] • Evolved over the years in number of foods for each coloured group, less focus on calorie restriction, alignment with food pyramid & integration of behavioural therapy[65]
			Hypocaloric diet	• Low calorie or very low calorie diet based on restriction of 500 to 1000 kcal/day by limiting fat intake	• Effective relative weight loss across different age groups, settings, & countries[64] • No evidence on long-term maintenance of weight loss after 1 year[64]
			Protein-sparing modified fast[315]	• Intended to maximise fat loss & minimise loss of lean body mass • Consists of 600 to 900 kcal/day, 1.5g to 2.5g of high biological protein per kg body weight & minimum 1500ml water daily • Supplemented by multivitamin	• Previously used for adolescents with severe obesity under close medical supervision for short duration • Weight loss associated with potential medical risks
			Food pyramid/ Dietary guidelines	• Follow the age-appropriate dietary recommendations as suggested by national guidelines[64]	• Focus on specific food groups could be more effective
	Physical activity	• To promote physical activity & reduce inactivity & sedentary behaviour	*Aerobic/ resistance activity*	• Structured exercise sessions for 60 minutes of moderate-to-vigorous intensity physical activity over 1 session or several sessions lasting ≥ 10 minutes[311]	• Effective relative weight loss across different age groups, settings, & countries[64] • Limited evidence on best exercise approach - strategies, intensity, & duration of intervention[64]
			Lifestyle exercise	• Increase energy expenditure in regular daily activity (walking, cycling, using stairs & active play)[311]	• Less structured & flexible nature could be more favourable
			Inactive behaviours	• Reduce sitting & watching television, using of computer or playing video games[311]	• Might be more measurable and more modifiable than changes in physical activity

Components of Intervention		Examples of Approaches	Description	Remarks
Behavioural therapy	• To assist in lifestyle changes in weight management[311, 316]	*Problem-solving*	• Identify barriers preventing behaviour change & explore ways to overcome the identified barriers	
		Self-monitoring	• Record lifestyle (diet & physical activity/ sedentary behaviour) by child/ family for progress monitoring	• Regarded as key component of behavioural change by increasing self-awareness
		Goal-setting	• Involve the child to take responsibility to identify lifestyle changes required and set goals towards making changes • Changes should be small and progressive to enhance confidence and promote success	• Should follow SMART principles (small, measurable, achievable, recorded & timed)
		Rewards	• Allow child to choose a reward for achieving the agreed lifestyle change goals as positive reinforcement	• Should be non-food related
		Stimulus control	• Control stimuli or cues that encourage or sustain unhealthy behaviour & provide cues to support/ promote new healthy behaviour	
Pharmacotherapy	• To promote weight loss	*Medications (Orlistat)[311]*	• Decrease absorption of about 30% of the fat consumed during digestion (via inhibition of intestinal lipase) • Might require micronutrients supplementation	• For children ≥ 12 years with moderate & severe obesity under close medical supervision • Associated with gastrointestinal side effects besides weight loss
		Medications (Metformin)[317]	• Inhibits hepatic gluconeogenesis, diminishes insulin resistance & hyperinsulinaemia	• For patients ≥ 10 years with type 2 diabetes • Associated with abdominal discomfort with no long-term improvement in body weight or complications evaluated
Surgery	• To promote weight loss	*Bariatric surgery[311]*	• Surgical procedure to reduce the capacity of stomach by inserting a band or re-route the digestive system past stomach or remove part of the stomach	• Generally not recommended in children, except for exceptional circumstances for adolescents • Associated with substantial complications post-surgery besides weight loss

2.5.1 Intervening in childhood obesity

It is important to note that interventions to manage obesity may vary in effectiveness depending on the age of the child, since children are metabolically, developmentally, emotionally and nutritionally different in each of the three childhood phases (i.e. infancy, childhood and adolescence). Interventions for childhood obesity are mainly divided into two components; treating children with established overweight/ obesity, and prevention of overweight/ obesity amongst children and adolescents. The research on treatment and prevention are discussed in the following sub-sections with a segment focusing on current evidence from the developing Asian countries.

2.5.2.1 Treatment for overweight and obese children

Research to develop effective weight management interventions to treat children affected by overweight and obesity has been ongoing. However, it remains unclear which intervention is the most effective in assisting overweight/obese children to improve body composition without adversely affecting growth rates.[63, 64] Several key systematic reviews on interventions for treating obesity in children have been published over the last two decades, parallel with the increased prevalence of childhood obesity.[63-68] Results as summarised in Table 2-11 highlight that the body of evidence is rapidly growing with improvements in the quality and quantity of studies, and increasingly included data from developing countries. The outcome measures have extended beyond body weight status to cardiometabolic risk assessment. While the evidence-based intervention approaches for childhood obesity still focus on lifestyle modifications, newer reviews have examined the impact of pharmacologic trials. The risks of pharmacology treatment should be weighed against the lack of evidence on persistence of weight reduction after active treatment ends.[63, 68]

An earlier review on obesity that covered a range of treatment approaches for childhood obesity revealed that evidence supporting the use of most treatment modalities is equivocal due to study methodological issues. However, the results of studies aimed at reducing sedentary behaviour appear promising in treating obese children.[66] In two subsequent Cochrane systematic reviews [2003[67] & 2009[63]], adding behavioural therapy may be beneficial to improve the effectiveness of treatment for childhood obesity,

this is especially when parents were given the primary responsibility for behaviour change.[67] Furthermore, combined behavioural lifestyle interventions of diet, physical activity and behavioural component compared with standard care or self-help can produce a meaningful reduction in overweight in children [mean difference in BMI-SDS: 6-month follow-up -0.06, 95% CI -0.12,-0.01; 12-month follow-up -0.04, 95% CI -0.12, 0.04] and adolescents (mean difference in BMI-SDS: 6-month follow-up -0.14, 95% CI -0.17, -0.12; 12-month follow-up -0.14, 95% CI -0.18, -0.10).[63]

The meta-analysis for eight of the thirty-seven included studies in a systematic review assessing the effectiveness of dietetic treatment for obese children suggests that interventions that contain a dietary component are effective in achieving relative weight loss in overweight/obese children and adolescents (pooled standardized mean difference: −1.82, 95% CI −2.40, −1.23).[65] Although a dietitian was reported to be involved in the formulation and/or delivery of the dietary intervention in 13 primary studies, detailed reporting of dietary intake was variable in most studies.[65] Ho and colleagues (2012) updated this systematic review by including cardio-metabolic risks and studies up to 2010. In addition to favourable results on body weight changes, lifestyle interventions with a dietetic component produced significant improvements in LDL-C (-0.30 mmol/L, 95% CI -0.45, -0.15), triglycerides (-0.09 mmol/L, 95% CI -0.11, -0.07) and fasting insulin (-55.1pmol/L, 95% CI -71.2, -39.1) up to 1 year from baseline.[64]

2.5.2.1 Prevention of childhood obesity

Evidence from reviews indicated that prevention of obesity is the most realistic and cost effective approach for dealing with childhood obesity, similar to adult obesity. The WHO meeting on population-based prevention strategies for childhood obesity (2010) stated that comprehensive and coordinated interventions which support and facilitate physical activity and a healthy diet, represent the best way forward for obesity prevention in childhood.[163] Compared to systematic reviews on treatment of childhood obesity, fewer reviews were available in the literature for prevention, however, the number of studies in this area is increasing over the years (Table 2-11). The only one study by Flodmark *et al.* included in Glenny's (1997) systematic review on prevention of childhood obesity suggested that family therapy may be more effective as compared to conventional treatment of dietary counselling by dietitian and regular paediatrician visits.[66] The

subsequent systematic review published in 2005 concluded that many diet and exercise interventions to prevent obesity in children appeared to be ineffective in preventing weight gain, but could be effective in promoting a healthy diet and increased levels of physical activity.[318] Of the twenty-two included studies, studies that focused on combining diet and physical activity approaches did not significantly improve BMI, but those focusing on diet or physical activity approaches alone showed a small but positive impact on BMI status. Similar conclusions were reported in an earlier review of reviews by Miccuci and colleagues (2002).[319]

The meta-analysis in the latest Cochrane systematic review by Waters *et al*.(2011) of 37 studies on prevention of childhood obesity, included 27,946 children and provided strong evidence that child obesity prevention programmes were effective at reducing BMI if the study duration was a minimum of three months.[320] Overall, children in the intervention group had a standardised mean difference in adiposity of -0.15kg/m^2 (95% CI -0.21, -0.09). Other significant outcome from this review was no evidence of adverse outcomes such as unhealthy dieting practices, increased prevalence of underweight or body image sensitivities.[320]

Table 2-11: Systematic reviews on intervention studies for treatment and prevention of childhood obesity

Author & Year	Age (Years)	Search Period	No. Included Studies	Length of Study	Countries Included	Intervention approach	Outcome measure(s)
TREATMENT							
	Lifestyle						
Glenny *et al.* 1997[66]	≤18	NR	11 (RCTs)	≥ 1 year	Developed countries: • US & Canada	• Family therapy (Parental involvement) • Diet (Traffic Light diet/ Protein Sparing Modified Fast/hypocaloric diet) • Exercise or sedentary behaviour • Behavioural (Mastery criteria)	• Body weight • Fat content (BMI, ponderal index/ skin folds/ fat free mass/ fat loss) • Fat distribution (waist hip ratio/ waist size)
Summerbell *et al.* 2003[67]	≤18	1985 to July 2001	18 (RCTs)	≥ 6 months	Developed countries: • US, Australia, Sweden, Israel, Germany & Austria	• Family/ parent therapy • Diet (Traffic Light diet/ hypocaloric diet/ nutrition education) • Physical activity/ exercise (aerobic or lifestyle or callisthenics/ sedentary behaviour • Behavioural (Mastery criteria/ problem-solving/ cognitive behavioural therapy/ contingency reinforcement)	Primary • Measured height & weight for BMI • Estimates of overweight (in %) Secondary • Behaviour change • Participant's views • Self-esteem, health status & well-being, QoL • Harm associated with process or outcomes • Cost effectiveness
Collins *et al.* 2006[65]	≤18	1975 to 2003	37 (RCTs)	≥ 6 weeks	Developed countries: • US, Austria, Italy, Israel, Sweden, Belgium, Australia Developing countries: • Hong Kong (China)	• Family/ parent therapy • Dietary intervention (Stoplight or Traffic Light diet/ hypocaloric diet/ food exchange programs/ low fat vs low carbohydrate/ nutrition education) • Physical activity/ sedentary behaviour • Behavioural therapy/ cognitive behavioural therapy (problem-solving)	• Percentile of BMI • BMI z-score • Percentage of children overweight for age • Waist circumference • Skinfolds • Percentage of BF • Percentage of lean body mass
Ho *et al.* 2012[64]	≤18	1975 to 2010	38 (RCTs)	≥ 2 months	Developed countries: • US, UK, Belgium, Australia, Israel, Germany, Finland & Korea Developing countries: • China, Mexico, Iran, Taiwan & Tunisia	• Dietary intervention (Traffic Light or modified Traffic Light diet/ hypocaloric diet/ restrictions snacks & beverages/ healthy eating advice) • Exercise Intervention (supervised physical activity sessions or exercise training/ pedometer)	• BMI • BMI z-score • Body composition by percentage of BF • Serum lipids • Fasting insulin/glucose & insulin resistance • Blood pressure

BF: Body Fat; BMI: Body Mass Index; CCT: Controlled clinical trials; NR: Not Reported; QoL: Quality of Life; RCT: Randomized controlled trials; SDS: Standard deviation score; UK: United Kingdom; US: United States of America

Author & Year	Age (Years)	Search Period	No. Included Studies	Length of Study	Countries Included	Intervention approach	Outcome measure(s)
Oude Luttikhuis *et al.* 2009[63]	***Lifestyle***						
	≤18	1975 to 2003	54 (RCTs)	≥ 1 month	Developed countries: • US, UK, Belgium, Australia, Sweden, Israel, Germany, Finland, France, Switzerland, Italy, Austria, Japan & Canada Developing countries: • China & Brazil	Lifestyle intervention • Dietary intervention (Stoplight or Traffic Light diet/ hypocaloric diet/ calorie exchange/ modified macronutrient/ nutrition education/ portion control) • Physical activity/ sedentary behaviour (exercise education/ therapy) • Behavioural therapy/ cognitive behavioural therapy (problem-solving/ stress management/ self-image/ Family therapy)	Primary • Measured height & weight (BMI-SDS/ BMI z-score) • Body fatness Secondary • BF distribution • Metabolic changes • Behaviour change • Participant's views • Self-esteem, health status & well-being, QoL • Harm associated with process or outcomes • Cost effectiveness
	Drug						
	12-19	1975 to 2003	10 (RCTs)	≥ 3 months	Developed countries: • US, Australia, Netherlands & Canada Developing countries: • Mexico & Turkey	• Drug (sibutramine/ orlistat/metformin)	
Whitlock *et al.* 2010[68]	***Lifestyle***						
	≤18	2005 to 2008	15 (RCTs and CCTs)	≥ 6 months	Developed countries: • US, Germany, Israel, Australia & Sweden	• Weight-loss or healthy diet counselling • Physical activity counselling or physical activity programme participation • Behaviour management technique • Family involvement • Mental health treatment beyond behaviour therapy	• Change in BMI • BMI-SDS • Percentage overweight • Adiposity • Adverse effects (decreased morbidity/ improved functioning/ reduced mortality)
	Drug						
	12-18	2003 to 2008	10 (RCTs)	≥ 6 months	Developed countries: • US, Netherlands & Canada Developing countries: • Mexico & Brazil	• Pharmacologic (sibutramine/ orlistat)	

BF: Body Fat; BMI: Body Mass Index; CCT: Controlled clinical trials; NR: Not Reported; QoL: Quality of Life; RCT: Randomized controlled trials; SDS: Standard deviation score; UK: United Kingdom; US: United States of America

Author & Year	Age (Years)	Search Period	No. Included Studies	Length of Study	Countries Included	Intervention approach	Outcome measure(s)
PREVENTION							
Glenny *et al.* 1997[66]	≤18	NA	1 (RCTs)	≥ 1 year	Developed countries: • Sweden	• Family therapy (Parental involvement) • Diet counselling • Paediatrician visit	• BMI
Campbell *et al.* 2001[321]	≤18	Jan 1985 to Oct 1999	7 (RCTs & non RCTs with concurrent control)	≥ 3 months	Developed countries: • US & Italy Developing countries: • Thailand	Lifestyle intervention • Diet (diet education/ modification of dietary intake/ changes to food supply/ decrease high fat foods/ increase fruits and vegetables/ hypocaloric diet) • Physical activity (promotion of physical activity/ reduction of sedentary behaviour/ aerobic dance/ reducing screen time)	• Estimates of percent BF • BMI • Ponderal index • Skinfold thickness
Micucci *et al*. 2002[319]	School-age youth/ adoles-cents	1990 to Jan 2002	23 (reviews)	≥ Several days	NR	• School-setting • Nutrition/ diet education • Physical education classes • Elements of behavioural theory	• Percent BF/ metabolic indices • Increase/ decrease in physical activity/ healthy eating/ nutrition
Summerbell *et al*. 2005[318]	≤18	1990 to Feb 2005	22 (RCTs & CCTs)	≥ 3 months	Developed countries: • US, UK & Germany Developing countries: • Thailand & Chile	• Diet and nutrition (educational/ health promotion) • Exercise and physical activity (educational/ health promotion) • Lifestyle and social support (psychological/ family/ behavioural therapy/ counselling/ management strategies)	Primary • Measured height & weight for BMI • Percent fat content • Ponderal index • Skinfold thickness Secondary • Activity level • Dietary intake • Change in knowledge • Environment change • Stakeholders' views • Self-esteem, health status & well-being, QoL • Harm associated with process or outcomes • Cost effectiveness

BF: Body Fat; BMI: Body Mass Index; CCT: Controlled clinical trials; NR: Not Reported; QoL: Quality of Life; RCT: Randomized controlled trials; SDS: Standard deviation score; UK: United Kingdom; US: United States of America

Author & Year	Age (Years)	Search Period	No. Included Studies	Length of Study	Countries Included	Intervention approach	Outcome measure(s)
Waters *et al*. 2011[320]	≤18	1990 to Mac 2010	55 (with or without randomisation)	≥ 3 months	Developed countries: • US, Canada, UK, France, Germany, Netherlands, Belgium, Sweden, Italy, Spain, Australia/ New Zealand Developing countries: • Brazil, Mexico, Thailand & Chile	• Diet and nutrition (educational/ health promotion) • Exercise and physical activity (educational/ health promotion) • Lifestyle and social support (psychological/ family/ behavioural therapy/ counselling/ management strategies)	Primary • Measured height & weight • Percent fat content • BMI • Ponderal index • Skinfold thickness • Prevalence of overweight & obesity Secondary • Activity level • Dietary intake (using validated measures) • Change in knowledge • Environment change • Stakeholders' views • Self-esteem, health status & well-being, QoL • Harm associated with process or outcomes • Cost effectiveness

BF: Body Fat; BMI: Body Mass Index; CCT: Controlled clinical trials; NR: Not Reported; QoL: Quality of Life; RCT: Randomized controlled trials; SDS: Standard deviation score; UK: United Kingdom; US: United States of America

2.5.2.1 Intervention trials in developing Asian countries

There have only been a few RCTs for the treatment of childhood obesity conducted in the developing Asian countries over the past three decades: China (n=4),[74, 75, 77, 78] Taiwan (n=1)[76] and two from Malaysia.[79, 80] There are fewer prevention trials in the published literature, with the oldest being from Thailand (n=1),[322] followed by China (n=2)[323, 324] and one study from India.[325] This lack of high quality intervention studies indicates a paucity of good evidence to effectively curb the childhood obesity epidemic within the region. These studies are summarised in Table 2-12 and are briefly discussed below:

A. Treatment

Recognising the increasing prevalence of childhood obesity in Malaysia, two trials were recently implemented. The MASCOT was the first RCT for obese primary school children and their parents (n=107), focusing on key behaviours related to obesity treatment.[80] Although changes were relatively small, researchers reported a significant reduction in weight gain in the intervention group compared to control (+1.5kg vs. +3.5kg, $P<0.01$). In another trial called 'HEBAT',[79] the two primary schools with the highest rate of childhood obesity in a state participated. With the aim to improve weight status, eating habits and physical activity, the preliminary results showed improvements in BMI, EE and self-esteem in overweight children in the intervention group.[79]

In an outpatient clinic study in Hong Kong by Woo *et al.*,[75] eighty-two children aged 9 to 12 years and their parents participated in either the diet education programme only or diet and exercise programme for 6 weeks and were followed-up for one year. Despite no significant difference found for BMI at 12 months between groups, beneficial effects were observed on vascular health associated with the addition of an individualised exercise training programme continued beyond the initial 6 weeks intervention. A subsequent intervention programme trial for 165 overweight and obese school-aged children found that students in the intervention arm significantly reduced their BMI z-score (−0.21, 95% CI −0.34, −0.07) and BF (−2.67%, 95% CI −5.12, −0.22) compared to the wait-list control group, and successfully maintained reduction in BMI z-score at 8-month follow-up from baseline.[77]

A family-based lifestyle intervention in 75 obese Chinese adolescents was conducted with the involvement of paediatricians and home visits.[74] The children's food diaries, kept as part of monitoring measures, were checked and suggestions were made after each evaluation. This trial achieved a high retention rate of more than 90% in both arms and produced a significant reduction in the treatment group for BMI after two years (2.6kg/m^2, 95% CI 2.06, 3.18). Although findings from a recent large and long-term school-based study are yet to be published, the baseline data found a high prevalence of childhood obesity in both intervention and control groups (27.4% vs. 26.1%, *P*=0.61), with no difference in physical activity time between groups (257 minutes/week ± 341 vs. 218 minutes/week ± 324, *P*=0.13).[78] The trial comprises a classroom curriculum, school environment support, family involvement and fun programmes. The only Taiwanese trial that focused on physical activity demonstrated the greatest improvements in cardiometabolic outcome measures, in terms of lipid profiles, blood glucose and insulin resistance after the 12-week intensive lifestyle programme ended.[76] The mean BMI and BF percentage differences between the intervention and control group was -1.5 kg/m^2 (*P*=0.024) and -1.2% (*P*=0.008), respectively.

B. Prevention

An obesity prevention trial focusing on a preschool-based exercise programme was first published from Thailand.[322] At 7.5 months post intervention, Mo-Suwan and colleagues (1998) found a reduction in the prevalence of obesity in the intervention arm that approached statistical significance (*P*=0.058). In addition, girls in the exercise group had a lower likelihood of having an increased BMI slope than control girls (OR: 0.32, 95%CI 0.18, 0.56). In India, under the large-scale school-based intervention programmes known as "Medical education for children/adolescents for realistic prevention of obesity and diabetes and for healthy ageing", a sub-study found significant improvements in nutrition and physical activity based on Dietary Guidelines for Indians.[325] The positive effects were seen in the intervention group receiving intensive and comprehensive nutrition and lifestyle education compared with the control group at 6-months follow-up. As shown in Table 2-12, the anthropometric and biochemical profiles also demonstrated favourable changes among the Indian adolescents.

In a 3-year intervention programme for Chinese primary schoolchildren, the prevalence of overweight and obesity was significantly reduced in the intervention schools compared to the control schools (overweight: 9.8% vs. 14.4%, $P<0.01$; obesity: 7.9% vs. 13.3%, $P<0.01$).[324] With the objective to determine whether a large-scale physical activity intervention could impact on body composition among school-age children in Beijing, a one-year cluster RCT concluded that a brief 20-minutes of daily moderate-to-vigorous physical activity within the school hours, is a feasible and effective way to prevent childhood obesity.[323] Significant mean differences in BMI and BMI z-score were reported post-intervention in the intervention group compared to control (0.15 kg/m^2 95% CI -0.28, -0.02; -0.07 95% CI -0.13, -0.01, respectively).

The growing body of evidence for treatment and prevention trials in the developing Asian countries demonstrates that study numbers are increasing. However, it also highlighted the need for ongoing research in this area, especially from other developing countries undergoing nutrition transition towards effective effort in managing childhood obesity within the region.

Table 2-12: Randomized controlled trials for treatment and prevention of overweight/ obesity in developing Asian countries

Study (Author & Year)	Setting	Age (Years)	Sample Size (Gender)		Intervention Period	Follow-Up	Intervention Approach		Outcomes	Effectiveness in treating childhood overweight/ obesity
			Intervention	Control			Intervention	Control		
TREATMENT										
Malaysia										
Sharifah *et al*., 2011[326]	Primary schools, *Kuala Lumpur*, Malaysia	7-11	B: 52 F/Up: 34	B: 55 F/Up: 46	6-month	NA	Children & parents: • 8 sessions of an 8-hour family-centred group treatment programme of nutrition and physical activity sessions conducted by dietitian and exercise physiologist • Nutrition education involves traffic light diet, food label reading, energy balance & portion sizes	• No treatment	• BMI z-score • Health related quality of life • Objectively measured habitual physical activity • Sedentary behaviour	*Post 6-month from baseline:* *(Intervention vs. control)* • Reduction in weight gain (+1.5kg vs +3.5kg, p<0.01) • Increase in percentage of time spent on moderate to vigorous physical activity (P=0.01)
Siti Sabariah *et al*., 2015[79]	Two primary schools, *Negeri Sembilan*, Malaysia	10-11	21	22	3-month	6-month	• Two series of 3-day camps • Regular school-based fun activities in healthy eating and active lifestyle • Healthy weight competition • Parents attended a half-day workshop	NR	• BMI z-score • BF percentage • Waist circumference • Sleep habit • Dietary habit • Self-esteem • Pedometer step counts	*Post 6-month from baseline:* *(Intervention vs. control)* • Lower BMI (-1.12 vs. 0.49) *Post 6-month from baseline:* *(Intervention group)* • Increase in step count (from 8348 to 10206, P=0.015) • Improve in self-esteem (from 29.33 to 32.81, P=0.009)

B: Baseline; BF: Body Fat; BMI: Body Mass Index; F/Up: Follow-Up; M: Male; F: Female; HDL-C: High-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein cholesterol; NA: Not Applicable; NR: Not reported; OR: Odds ratio

Study (Author & Year)	Setting	Age at baseline (Years)	Sample Size (Gender)		Intervention Period	Follow-Up	Intervention Approach		Outcome Measures	Effectiveness in preventing childhood overweight/ obesity
			Intervention	Control			Intervention	Control		
China										
Woo *et al*., 2004[75]	Outpatient clinic, Hong Kong, China	9-12	B: 41 (22 children continue weekly exercise programme after 6 weeks)	B: 41	6 weeks	1 year	• Diet education & exercise programme • Prescribed hypocaloric diet (900-1200 kcal daily; low fat, high complex carbohydrate & adequate protein) • Customized training of circuit style with 18 workout stations (9 stations for each session, twice a week for 6 weeks & weekly for 1 year)	• Diet education programme	• BMI • BF • Serum cholesterol (LDL-C & HDL-C) & triglycerides • Ultrasound-derived arterial endothelial function • Intima-media thickness of common carotid artery	*Post 6-week from baseline:* *(Both groups)* • Decreased waist-hip ratio (P<0.02) & total cholesterol level (P<0.05) • Improved endothelial function • No significant difference for BMI, BF and fat-free mass between groups *Post 1-year follow-up from intervention:* *(Intervention group)* • Less carotid wall thickening (P<0.001) • Improved in BF (P<0.01)
Jiang *et al*., 2005[74]	Family-based, single middle-school, Beijing, China	12-15	B: 33	B: 35	2 years	NA	• Monthly paediatricians home visit • Increase exercise for 20 to 30 minutes daily for four days per week & reduce sedentary time • Modified traffic light diet to decrease energy intake & promote balanced diet	• No special intervention	• Weight and height • Blood pressure • Blood cholesterol • Triglycerides	*Post 6-week from baseline:* *(Intervention group)* • Decrease in BMI (2.6, P<0.001), total cholesterol (-0.26, P<0.001), triglycerides (-0.08, P<0.001), systolic blood pressure (-1.5, P=0.001) & diastolic blood pressure (-0.8, P=0.003)

B: Baseline; BF: Body Fat; BMI: Body Mass Index; F/Up: Follow-Up; M: Male; F: Female; HDL-C: High-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein cholesterol; NA: Not Applicable; NR: Not reported; OR: Odds ratio

Study (Author & Year)	Setting	Age at baseline (Years)	Sample Size (Gender)		Intervention Period	Follow-Up	Intervention Approach		Outcome Measures	Effectiveness in preventing childhood overweight/ obesity
			Intervention	Control			Intervention	Control		
China										
Lee *et al*., 2014[77]	4 primary schools, Hong Kong, China	8-12	B: 57	B: 49	4-month	4-month	Children: • Ten 75 minutes after-school sessions & one 3-hour week-end session of practical interactive & fun activities on healthy eating & exercise • Provided meal plan & printed tailor-made management advices. Parents • Received introductory seminar with specially designed exercise for their overweight children	• General school based health promotion activities and awaiting second phase	• BMI z-score • BF percentage • Self-reported attitude & behavioural variables	*Post 4-month from baseline:* *(Intervention group)* • Reduced BMI z-score (−0.21, 95% CI −0.34, −0.07, P=0.003) & BF (−2.67%, 95% CI −5.12, −0.22, P=0.033) *Post 8-month from baseline:* *(Intervention group)* • Reduction in BMI z-score (−0.11, 95% CI −0.17, −0.005) & BF (-1.71%, 95% CI −3.44, 0.02, P=0.052)
Xu *et al*., 2014[78]	8 urban primary schools, Nanjing, China	9-10	B: 638	B: 544	3.5 years	NR	• Classroom curriculum (including physical education & healthy diet education) • School environment support • Family involvement • Fun programmes/ events	• Usual health education curriculum	• BMI • Waist circumference • Dietary intake • Physical activity	NR

B: Baseline; BF: Body Fat; BMI: Body Mass Index; F/Up: Follow-Up; M: Male; F: Female; HDL-C: High-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein cholesterol; NA: Not Applicable; NR: Not reported; OR: Odds ratio

Study (Author & Year)	Setting	Age at baseline (Years)	Sample Size (Gender)		Intervention Period	Follow-Up	Intervention Approach		Outcome Measures	Effectiveness in preventing childhood overweight/ obesity
			Intervention	Control			Intervention	Control		
Taiwan										
Huang *et al*., 2007[76]	School	10-13	B:60	B: 60	12-week	12-week	Lifestyle programme: • 30-minutes of nutrition instruction twice per week at school • 40-minutes of classroom-based non-competitive aerobic activity 3 times per week	• No treatment	• BMI • Percent BF • Blood pressure • Physical fitness • Heart health knowledge	*Post 12-week from baseline:* *(Intervention vs. control)* • Mean BMI difference (-1.5 kg/m^2, P=0.047) • Mean BF percentage difference (-1.2%, P=0.008)
PREVENTION										
Thailand										
Mo-Suwan *et al.,* 1998[322]	2 Kindergartens, Hat Yai municipality, Songkhla province, southern Thailand	Mean age: 4.5	B: 158 (56% boys) F/Up: 147	B:152 (61% boys) F/Up: 145	29.6 weeks	6 months	• Superkids/ superfit physical activity programme by specially trained staff including a 15-minute walk before morning class & a 20-minute aerobic dance session after afternoon nap 3-times a week	• Not reported, presumably usual school curriculum	• BMI • Triceps skinfold • Ratio of weight in kg divided by height cubed in meters	*Post 6-month from baseline:* *(Intervention vs. control)* • No statistical significant change between groups • Prevalence of obesity decreased at baseline & post-intervention: Intervention 12.2% to 8.8% (P=0.058); Control 11.7% to 9.7% (P=0.179) • Girls in exercise group lower odds of increasing BMI slope than control girls (OR: 0.32; 95% CI 0.18, 0.56)

B: Baseline; BF: Body Fat; BMI: Body Mass Index; F/Up: Follow-Up; M: Male; F: Female; HDL-C: High-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein cholesterol; NA: Not Applicable; NR: Not reported; OR: Odds ratio

Study (Author & Year)	Setting	Age at baseline (Years)	Sample Size (Gender)		Intervention Period	Follow-Up	Intervention Approach		Outcome Measures	Effectiveness in preventing childhood overweight/ obesity
			Intervention	Control			Intervention	Control		
China										
Jiang *et al*., 2007[324]	5 primary schools, Beijing, China		B: 1029	B: 1396	3 years	NA	Children & parents: • Nutrition lecture per semester at parents' meetings, distribution of education materials, classroom lesson • Additional running for 20 minutes after class if fail routine school physical education tests	• Usual health and physical education curriculum with no extra intervention	• Weight & height	*Post 3-year from baseline: (Intervention vs. control)* • Lower prevalence of overweight (9.8% vs. 14.4%, P<0.01) & obesity (7.9% vs. 13.3%, P<0.01) • Lower BMI (18.2 vs. 20.3, P<0.01) • Less non-obese became obese (2.4% vs. 7%, P<0.01) • Less obese remain obese (49.2% vs. 61.9%, P<0.01)
Li *et al.,* 2010[323]	20 Primary schools, DongCheng & ChongWen districts, Beijing, China	8-11	B: 2329 (M: 1264, F: 1065) F/Up: 2028	B: 2371 (M: 1194, F: 1177) F/Up: 2092	1 year	1 year	• Happy 10 programme twice daily during break between classes for 10 minutes incorporated into school curriculum using activity cards, video demonstration, tracking posters & stickers	• No intervention	• BMI • BMI z-score • Body composition (Fat free mass, fat mass & percentage BF)	*Post 1-year from baseline: (Intervention vs. control)* • Increased BMI, 0.56 kg/m^2 (SD 1.15) vs. 0.72 kg/m^2 (SD 1.20) • BMI z-score [-0.05 (SD 0.44) vs. +0.01 (SD 0.46)] *Post 1-year follow-up from intervention (Intervention group)* • BMI (-0.13, -0.25, -0.01) • BMI z-score (-0.05, -0.10, -0.01) • Fat mass (-0.27 kg, -0.53, -0.02) • Percentage BF (-0.53, -1.00, -0.05)

B: Baseline; BF: Body Fat; BMI: Body Mass Index; F/Up: Follow-Up; M: Male; F: Female; HDL-C: High-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein cholesterol; NA: Not Applicable; NR: Not reported; OR: Odds ratio

Study (Author & Year)	Setting	Age at baseline (Years)	Sample Size (Gender)		Intervention Period	Follow-Up	Intervention Approach		Outcome Measures	Effectiveness in preventing childhood overweight/ obesity
			Intervention	Control			Intervention	Control		
India										
Singhal *et al.,* 2010[325]	Two secondary schools, Metropolitan city, North India	15-17	B: 99 (M: 60, F: 39)	B: 102 (M: 61, F: 41)	6 months	NR	• Seven multi-component intervention model of nutrition & lifestyle education based on Dietary Guidelines for Indians	• No intervention	• BMI • Body composition • Circumference measurement (mid-thigh, mid-upper arm, sagittal abdomen) • Biochemical (fasting blood glucose, triglyceride & HDL-C) • Nutrition-related knowledge, attitude, lifestyle practices • Food frequency • Body image	*Post-intervention (Intervention group)* • Decrease in mean waist circumference (P=0.02, 95% CI,-2.43,-0.17), sagittal abdominal diameter (P<0.001, 95% CI=-0.82,-0.09), waist-to-hip ratio (P=0.02, 95% CI=-0.03,-0.004) & fasting blood glucose (P=0.05, 95% CI=-0.09, 5.00) • Less intake of aerated drinks (15.1%; P<0.001) & energy-dense unhealthy foods (8.9%; P=0.03) • Increased tiffin (packed lunch) to school (14.9%; P=0.004) & brought a fruit together (30.7%; P<0.001)

B: Baseline; BF: Body Fat; BMI: Body Mass Index; F/Up: Follow-Up; M: Male; F: Female; HDL-C: High-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein cholesterol; NA: Not Applicable; NR: Not reported; OR: Odds ratio

2.5.2 Appropriate settings for effective interventions

Current evidence from the literature supports the important role of family,[63, 64, 69, 327, 328] school[320, 327, 329] and healthcare settings[311, 312] in contributing to effective interventions for management of childhood obesity.

2.5.2.1 Family involvement

Family involvement as the main driver in the management of childhood obesity and has been widely discussed and recognised in the literature, particularly in developed countries.[5, 315] The value of family support was clearly demonstrated in the long-term findings of four RCTs by Epstein and colleagues where significantly less weight gain was observed in overweight children when parents participated in the intervention, and up to ten-year period post-intervention.[330] Recent evidence concurred with these earlier studies and suggests that treatment of pre-adolescent obesity along with parent(s) involvement is superior to a child-centred approach.[63, 64, 69, 328] Golan in a 2006 review stated that the consensus for intervention programmes to prevent and treat childhood obesity indicates that they should involve the family. The program should include both the overweight/obese child and at least one parent participating in various levels of behavioural modification, behavioural therapy and problem solving.[69]

Despite variations in effect sizes reported by two meta-analyses on interventions targeting childhood obesity, outcomes were favourable after participating in a family-based intervention.[63, 328] For children under twelve years of age, the results showed that family-targeted behavioural lifestyle interventions were associated with a greater decrease in BMI-SDS than in standard care (-0.06, 95% CI -0.12, -0.01).[63] Furthermore, the meta-analysis in the systematic review by Berge and Everts (2011) found the majority of included studies had a moderate-to-large effect size for change in the target child's BMI (BMI percentile, BMI z-score, and percent overweight). Long-term change varied by study, but the majority of studies produced sustainable change in child BMI, although with smaller effect sizes.[328]

As discussed in Section 2.3.4, the family environment is one of the strongest influence on a child's risk of obesity, hence, a sensible setting for childhood obesity treatment and

prevention efforts would appear to be within the families of susceptible children. Ho *et al*.'s systematic review on lifestyle interventions in child obesity suggested specific features of family involvement are required for effective interventions.[64] These include separate education sessions for the parent and child, targeting parents as the sole agent of change of the child environment, encouraging parents to lose weight if they were overweight, and/or provision of opportunities for physical activity, e.g. a free family swim pass to participants. In addition, strategies such as engaging parents to support home activities that encourage children to be more active, eat more nutritious foods and spend less time in screen-based activities were aspects of beneficial programmes that targeted prevention of obesity in children.[320]

The added bonus of family participation is that all members of the family are likely to benefit, hence reducing the feelings of social isolation and increasing social support for behavioural change. Further evaluation of the family role in addressing childhood obesity needs to be undertaken given that the main limitation of family-based studies is the high dropout rate, partly attributed by low parental confidence, with studies also potentially confounded by selection bias of motivated families for intervention.[327]

2.5.2.1 School approach

Schools are listed as one of WHO's target for "Health Promoting School" programme[163] and in principle, provide an excellent setting for prevention of childhood obesity.[5] The majority of children and adolescents attend school, although this percentage varies from country to country, and children spend a considerable amount of time at school including time spent on eating and exercising. Furthermore, the commencement of schooling is associated with a period of increased risk of excessive weight gain as children begin to increase their independence and have more varied diet and activity patterns.[163, 313] Interestingly, a recent review on the effect of different seasonal patterns on adiposity, physical activity and sleep for children in US suggests that child's weight gain during the summer break, which was attributed to lower EE and shorter sleep duration compared to during the school year.[331] While schools offer the ability to reach a large proportion of children in the general population, and provide a linkage with the family and the wider community, they can also assist in identifying those who may be at risk of obesity through health screening and visits by healthcare professional at key developmental stages.[313]

The evidence on effectiveness of school-based intervention in childhood obesity from a review published in 2009 found inconsistent results.[329] Yet, findings from the Cochrane systematic review of RCTs on the prevention of obesity in children concluded that several policies and strategies within school setting were promising, which include:[320]

1. School curriculum that includes components related to healthy eating, physical activity and body image,
2. Increased sessions for physical activity and the development of fundamental movement skills throughout the school week,
3. Improvements in nutritional quality of the food supply in schools, environments and cultural practices that support children eating healthier foods and being active throughout each day,
4. Support for teachers and other staff to implement health promotion strategies and activities (e.g. professional development, capacity building activities)

Similarly, Kelishadi and Soleiman in their systematic review on ameliorating childhood obesity found that school-based programmes resulted in positive impacts, mainly on nutrition and physical activity, in a large target group and could be sustained for several years after the intervention period.[327] As discussed, consistent beneficial results of school based interventions to prevent childhood obesity are emerging. However, the maintenance of these programmes within the school curricula in the long-term could be challenging in view of competition for school time, involvement of school staff and financial limitations, as well as concerns of stigmatization based on body weight status.[163]

2.5.2.1 Healthcare settings

Despite evidence-based guidelines highlighting the fundamental role of healthcare professionals in managing overweight and obese children,[311, 312] the potential of the healthcare setting for delivery of childhood obesity management programme has yet to be fully utilised. Frequent contact with health professionals has been identified as one of the most important strategies and opportunities to create awareness of and to educate the family on obesity and the lifestyle changes required, to support families in making and sustaining lifestyle changes, and to facilitate positive behaviour changes.[313, 316]

The management of childhood obesity involves physicians and the allied healthcare professionals, for example, dietitians, clinical psychologists, nurses and physiotherapists/exercise therapists. Ideally, all healthcare professionals should offer regular, non-discriminatory long-term follow-up and ensure continuity of care within the multidisciplinary team.[311] The healthcare professional's understanding of the child family's values and circumstances, may be most helpful in tailoring recommendations in managing childhood obesity.[311, 312]

Currently, there is a lack of evidence on the most effective healthcare setting (e.g. community, primary care, secondary care) and delivery mode (e.g. group, or individual), or dose to treat obese children.[311, 312] It is suggested that an integrated pathway of care should incorporate both group and individual-based programmes for the child and family to choose. As for prevention, community interventions that can be provided closer to home and hence may be more accessible and hence a greater proportion of target groups being reached.[163, 316]

2.6 Summary of literature review

To summarise, this chapter provides a comprehensive review of childhood obesity in developing countries, the major factors contributing to the development of obesity in children, measurement of dietary intake in children and strategies in addressing childhood obesity. The major factors associated with childhood obesity development are not yet fully elucidated, particularly in developing countries. A high quality systematic review of the literature is therefore required. The current chapter also highlights that despite there being strong link between dietary intake and overweight/obesity in children, further research is required to ascertain this relationship in the developing Asian countries using validated tools. More specifically, we require a greater understanding of the family environment that can influence the development of childhood obesity and whether specific factors are implicated. There is a need to understand the measurement of dietary intake in children and to determine how it affects the validity of data in dietary studies which currently lacking in developing countries. The knowledge on evidence-based strategies in addressing childhood obesity would be useful to inform future intervention. Together this research will assist to identify the environmental factors that may promote the development of childhood obesity in Malaysia.

Chapter 3 Systematic Review Paper 1: Associations of dietary patterns and childhood obesity of developing Asian countries

This chapter was published in 2012.

Yang WY, Williams LT, Collins CE, & Chee WSS. The relationship between dietary patterns and overweight and obesity in children of Asian developing countries: A Systematic Review. The JBI Database of Systematic Reviews and Implementation Reports. 2012;10(58): 4568 - 4599

The work presented in the manuscript was completed in collaboration with the co-authors (Appendix 3.0). Permission to reproduce the published manuscript has been granted by the publishers (Appendix 3.1).

3.1 Introduction

3.1.1 Background

Developing countries in the epidemiological transition are undergoing a reduction in mortality from communicable diseases, but have concomitant increases in nutrition-related non-communicable diseases, thereby experiencing the double burden of malnutrition and obesity.[5, 22] There is a growing concern about the rapid rise in prevalence of obesity amongst children globally and particularly in developing countries. A review of nationally representative cross-sectional surveys on prevalence of overweight among preschool in developing countries published in 2000, reported that there were 17.6 million overweight children under five years of age residing in developing countries and 61% of them in Asia.[332] A systematic review of childhood overweight in developing countries published in 2007 revealed that the highest prevalence was found in Eastern Europe (48.4%) and the Middle East (89.6%), while developing countries in Asia such as Sri Lanka (2.2%) had the lowest prevalence comparatively.[2]

In 1995, the WHO estimated that 2.9% of pre-schoolers in Asia were overweight, with a higher prevalence in Eastern Asia and SEA.[3] Within Asia, Popkin and Gordon-Larsen noted an increased prevalence of overweight in children in China of 0.2% annually between 1991 and 1997.[4] Despite the relatively low prevalence in the older studies,[3, 4] this region is facing potential risk for exponential increase in childhood overweight and obesity considering the IOTF's report in 2004 that one in four children in SEA will become either overweight or obese.[5] The magnitude of the problem could be understated yet significant in view of high population density within the region.[3, 5, 6]

The consequences of childhood obesity are serious. Obese children have a higher risk of developing adult-type conditions such as type II diabetes, hypertension and high cholesterol, which can lead to CVD and other weight-related health consequences, increasing the risk of premature death.[11, 333] Psychological morbidity is the most widespread adverse health cost among overweight and obese children.[11, 334] Childhood obesity is also likely to persist into adulthood.[11]

Childhood obesity is considered to have a multi-factorial causation with contributing factors categorised as being either genetic or environmental. The contribution of genetics is relatively minor in comparison to the environment, specifically energy intake in excess of energy output.[21, 22] With economic globalisation, Asian countries have experienced significant environmental change including improved motor vehicle transportation, higher television ownership, and rapid expansion of the fast food industry.[5] These changes have resulted in nutrition transition involving an increased intake of energy dense foods, high in fats and sugars, decreased fibre consumption[21] and a shift away from high energy activities of daily living to a more sedentary lifestyle.[5] Children are particularly susceptible to these changes, as energy-dense, nutrient-poor foods and beverages are heavily marketed to this group.[21, 335] However the extent to which these changes impact on obesity prevalence in Asian developing countries is unknown.

In order to tackle the problem of childhood obesity in Asia, it is important to explore the main factors contributing to the emerging obesity epidemic. The systematic reviews published to date examining weight status and its association with dietary factors, have focused on children and adolescents from developed countries.[63, 336] To date, no systematic reviews or randomised controlled trials investigating the association between dietary patterns and obesity in children of Asian developing countries have been published.

The systematic review protocol for this systematic review has been peer reviewed and published by the Joanna Briggs Institute (JBI) Library of Systematic reviews and can be accessed at: http://connect.jbiconnectplus.org/ViewSourceFile.aspx?0=5489 (Accessed, 11th July 2012).

3.1.2 Objectives

Given the lack of existing reviews specifically focusing on developing countries in the Asian region, our objectives were to summarize the best available evidence on the prevalence of childhood overweight and obesity in Asia and to synthesise the evidence on the epidemiological association between dietary patterns of children and childhood obesity. During the conduct of this systematic review, we decided to include prevalence

data that were available as it became apparent this data is useful for interpreting data on the epidemiological association between dietary patterns and obesity.

3.1.3 Inclusion criteria

3.1.3.1 Types of participants

This review considered any studies that included children under 18 years of age who live in developing countries in Asia.

3.1.3.2 Types of studies

From the approved protocol, this review of epidemiological association considered any analytical observational studies (case-control studies, cohort studies and analytical cross-sectional studies).

3.1.3.3 Types of outcomes

The focus was to summarise the prevalence of childhood overweight and obesity within developing countries in Asia and synthesise the best available evidence on the relationship between dietary patterns as the exposure variable and childhood overweight and obesity as the outcome.

3.1.4 Search strategy

The search strategy aimed to find both published and unpublished studies. A three-step search strategy was utilised, in which an initial limited search of MEDLINE, CINAHL and EMBASE, was undertaken to identify any existing systematic reviews on this topic. Other electronic databases searched included: ProQuest, Web of Science, and Scopus. This was followed by analysis of the text words contained in the title and abstract, and the index terms used to describe the article. A second search using all identified keywords and index terms was undertaken across all included databases. Thirdly, the reference list of all identified reports and articles were searched for additional studies. The search for unpublished studies included ProQuest (for theses and dissertations), MEDNAR, conference abstracts, Government Reports and Dissertation Abstracts.

The following search terms were used and they were divided into four key areas: (1) Dietary pattern: Diet, diet pattern, diet intake, diet habit, diet quality, diet index, diet variety, diet score, food pattern, food consumption, food choices, food selection, food intake, eating pattern, eating selection and eating choices; (2) Developing countries in Asia (based on World Bank Classification of Countries, 2011 to exclude Singapore, Korea, and Japan as the developed countries in Asia): South East Asia, Malaysia, Indonesia, Cambodia, Philippines, Thailand, Laos, Myanmar, Vietnam, Brunei, India and China; (3) Obesity: Obesity, overweight, body mass index, Body Mass Index (BMI), body weight and weight status; and (4) Children: Children ≤18 years of age. The search strategy used in MEDLINE is included as an example (Appendix 3.2).

The search was not restricted by language and 10 non-English language studies were retrieved (Spanish: 1 and Chinese: 9), but not included for assessment due to language barrier of the reviewers. Each database was searched from inception to September 2011.

3.2 Method of the review

All studies identified during the database search were assessed for relevance to the review based on the information contained in the title, abstract and description/MESH heading by two independent reviewers. When the reviewers disagreed, the third reviewer was consulted until consensus was reached. Full articles were retrieved for all studies that appeared to meet inclusion criteria and those requiring further investigation to determine whether the study met inclusion criteria. Contacts were made with a number of authors of included studies to obtain additional information of potential relevance to address the review aims. Five authors responded and three provided additional raw data on associations found between childhood overweight/obesity and specific dietary pattern reported in their respective publications.[93, 337, 338]

3.2.1 Assessment of methodological quality

All papers selected for inclusion were assessed independently by two reviewers using standardised critical appraisal instruments from the JBI-MAStARI (Appendix 3.3). When there was no agreement, the third reviewer was consulted. Appendix 3.7 shows the summary of critical appraisal of included studies.

3.2.2 Data collection

Following quality assessment, data was extracted from included studies by two reviewers independently using an adapted version of the standardised JBI data extraction form (Appendix 3.4). The adaptation was intended to include details that were not included in the original standardised JBI data extraction template which were relevant to the review objectives. Studies were described in terms of design, sample characteristics, classification of overweight and obesity, measurement of dietary pattern exposure and outcomes.

3.2.3 Data synthesis

Meta-analysis was not possible because of the heterogeneity of studies in terms of methodology, statistical analyses and outcomes. A narrative summary of the results is provided.

3.3 Results

Figure 3-1 summarises the flow chart of identifying included studies. The search process identified 2080 studies. After removing duplicates, 1478 abstracts were reviewed and 1449 studies excluded as not meeting inclusion criteria. Twenty-nine studies were included for critical appraisal and their full text were examined in more detail. After examining against JBI critical appraisal criteria, fifteen were eligible for methodological quality assessment, and qualified for inclusion into the systematic review (Table 3-1 and

Table 3-2). Two of the fifteen studies were longitudinal,[339, 340] one was case-control[247] and remainder were cross-sectional analytic studies.[93, 94, 98, 245, 246, 263, 274, 337, 338, 341, 342]

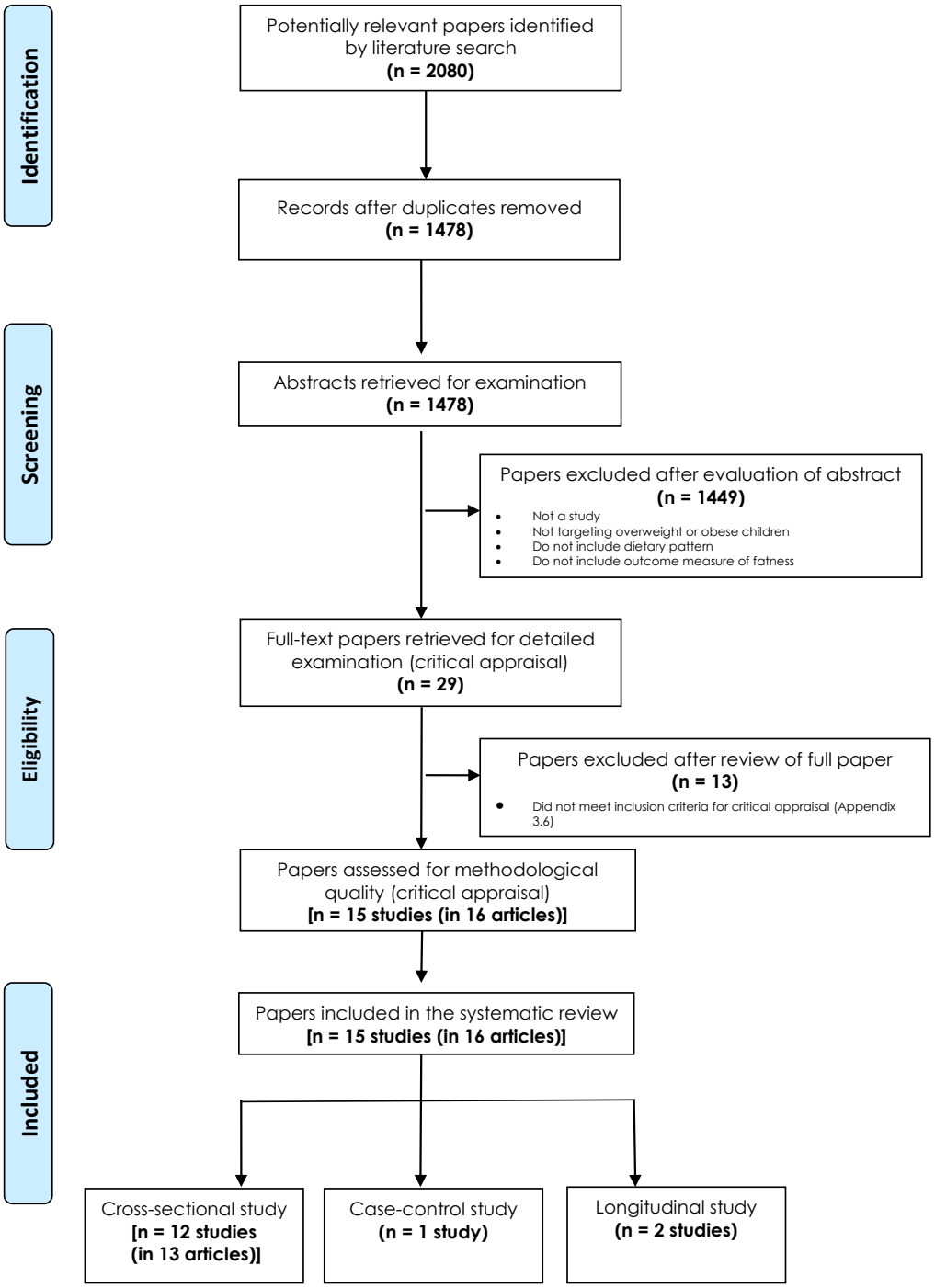

Figure 3-1: Flow of method of determining studies to be included in the review

3.3.1 Description of studies

Table 3-1: Number of studies found and retrieved

Number of studies found	Number selected for retrieval
1478	29

Table 3-2: Number of studies included and excluded

Number of studies included	Number of studies excluded
15	14

3.3.1.1 Quality of included studies

Details of the quality appraisal results for each included study are given in Appendix 3.7. Only two studies fulfilled all design quality requirements (9/9),[98, 339] with two studies achieving the lowest score of 5/9.[41, 338] Study populations tended to be representative[41, 94, 98, 245-247, 263, 337, 339-343] and the majority adequately described the background characteristics of the selected group.[93, 94, 245, 246, 263, 274, 337, 339-342] Fourteen studies identified confounding factors and used appropriate statistical analyses for adjustment purposes[93, 94, 98, 245-247, 263, 274, 337-343] and all studies measured weight status reliably using valid anthropometric methods.[41, 93, 94, 98, 245-247, 263, 274, 337-343] Both longitudinal[339, 340] and case-control[247] studies described the follow-up period but only one longitudinal study[339] described people who withdrew and included them in the analysis.

3.3.1.2 Description of included studies

All 15 studies (in 16 articles) were published between 2000 and 2011 in the English language. The included studies are listed according to study designs; Appendix 3.5 (longitudinal[339, 340], case-control[247] and cross-sectional studies).[41, 93, 94, 98, 245, 246, 263, 274, 337, 338, 341, 342] Data collection was conducted in preschools or kindergartens, schools, health centres, industries or local communities. Nine of the studies focused on urban areas,[93, 94, 98, 246, 247, 263, 338, 339, 342, 343] two included participants from different levels of modernisation or socioeconomic status,[274, 340] one from industry sites,[337] one involved

both urban and rural settings,[341] one sampled across the national population[245] and one study did not specify beyond stating that it was conducted in a district that encompasses both urban and rural populations.[94]

The included studies involved a total of 51,570 participants. The majority of studies focused on adolescents[41, 93, 94, 246, 274, 343] or included both adolescents and younger children.[98, 245, 337, 338]Only two studies included infants and toddlers.[98, 342] Most studies were from China,[94, 98, 245, 263, 340-343] followed by India,[93, 337] Thailand,[247, 338] Vietnam,[246, 339] Indonesia[274] and Malaysia.[41] All but one study included both genders [41, 93, 94, 98, 245-247, 263, 274, 337, 339-343] and that study only included females.[338]

The reference standards used to classify weight status outcomes varied, and included the IOTF 2000 classification,[94, 246, 263, 337, 338, 340, 341] WHO, 1995 or 2005/7 standards,[41, 98, 341, 342] BMI-for-age developed by CDC 1990 or 2000[93, 274, 341] or respective national standards; Indian,[337] Chinese (China Working Group for Obesity, BMI-for-age)[245, 341] and Thai growth chart for age 2 to 7 years.[247] Some studies used more than one classification.[93, 337, 341] Most studies reported dietary patterns based on behaviour and food group or nutrient consumption, with only a few analysing quantified dietary intakes based on a validated FFQ[246, 339] or 3-day food/diet record.[41] Seven studies used a combination of at least two types of dietary assessment methods in assessing dietary pattern.[94, 245, 247, 338, 340, 342, 343]

3.3.2 Findings of the review

3.3.2.1 Prevalence of childhood overweight and obesity within developing countries in Asia

Prevalence rates of adolescents overweight and obesity using IOTF classification standards in the cross-sectional studies, ranged from 5.1% in Manipur, India in 2005-2006[93] to 19.9% in Xi'an City, China (2004).[94] Within the one Chinese study, the prevalence rates varied by several percentages based on the standard used; 18.7% (IOTF) vs. 21.4% (WHO), 20.1% (US, CDC 2000) and 21.7% (China standards),[341] illustrating a methodological difficulty to accurately quantifying the prevalence of obesity in this region. Within the three main age groups (Appendix 3.5), there was no specific trend for increasing prevalence with increased age. The effect of urbanisation on obesity was not

seen clearly in this review because the majority of studies were conducted in urban areas.[93, 94, 98, 246, 247, 263, 338, 339, 342, 343] In one Chinese study, there was no difference in the prevalence of overweight and obesity according to setting.[341] Gender differences were not observed except in China where a higher prevalence of overweight[98] and obesity[245, 341, 342] amongst boys than girls was reported in four different studies. Higher prevalence was reported in Chinese studies of specific cities[94, 263, 341, 343] as compared to China's nationwide data.[245] In terms of secular trends, the two longitudinal studies did not demonstrate a significant increase in children's body weight status between baseline and follow-up (Appendix 3.5).[339, 340] During the one-year period, Huynh and colleagues recorded an increase of 0.1 in BMI z-score amongst Vietnamese pre-schoolers[339] while the study in China reported a 0.1% decrease in prevalence of overweight amongst the overweight children after 2 years follow-up.[340]

3.3.2.2 Relationship between dietary patterns and overweight and obesity in children of developing countries in Asia

The summary of associations between dietary pattern and childhood obesity for all included studies is shown in Appendix 3.5. [41, 93, 94, 98, 245-247, 263, 274, 337-343] Four approaches were used in reporting dietary patterns: nutrient intakes, food group consumption, dietary behaviour (eating out, fast food consumption, snacking, drinking sugar-sweetened beverages and eating sugar and sweets)[93, 94, 246, 274, 337, 338, 341-343] and child feeding behaviour (maternal feeding practices and children's eating pace and response towards food).[94, 98, 247, 263, 343]

Two cross-sectional studies examining nutrients intake in China found significant associations between high energy intakes and childhood overweight[342] and obesity,[94] but the longitudinal study in China found no significantly increased risk (RR: 0.80, 95% CI 0.60 to 1.10, $P>0.05$).[340] The same longitudinal study reported that having a high carbohydrate diet (>70% of energy) was protective against childhood overweight.[340] The follow-up study of Vietnamese pre-schoolers found that boys with the highest tertile of protein intake were at risk of having increased BMI one year later.[339] In a cross-sectional study of younger Chinese children and adolescents in Beijing those who consumed alcohol more than once a week had higher odds of overweight and obesity.[341]

In terms of intake reported by food groups, irregular (≤ 2 times a week) intake of high-fibre and non-sweet fruits amongst young Thai children and not eating other vegetables besides green leafy vegetables over a week for Indian adolescents were associated with a higher prevalence of overweight[247] and obesity.[93] However, in the same Indian study, no significant association was reported for not eating green leafy vegetables at all.[93] Chinese adolescents who reported ever having eaten preserved fruits[343] and Vietnamese adolescents who consumed fruits and vegetables frequently[246] had lower odds of overweight and obesity compared to those who did not. There were conflicting results for consumption of meat and milk products. In the Chinese longitudinal study, high meat intakes were associated with an increased risk of overweight for children who were overweight but not in those who were normal weight at baseline.[340] In a cross-sectional study in China, female adolescents who consumed mutton and beef soup had a higher prevalence of overweight and obesity[343] but in the national Chinese cross-sectional study, those who ate large amount of meat and meat products (≥ 200g) daily did not.[245] Amongst young Thai children, drinking sweetened fresh milk and/or yogurt frequently was positively associated with childhood overweight[247] while in the national Chinese study with mixed age groups, high dairy product consumption (≥ 100g) was not associated with overweight and obesity, but a high daily intake of cooking oil (≥ 25g) was.[245]

The type of food was found to be related to overweight and obesity.[337, 343] The results for eating fast food were equivocal with one Chinese study reporting increased prevalence of overweight and obesity with fast food consumption[343] while another Chinese[342] and an Indonesian study[274] found no association. The possible reason explaining the observed differences could be the subjectivity of different questionnaires used in these studies, particularly the definitions and understandings of fast food. Similarly, the results from six included cross-sectional studies investigating snacking were mixed with increased prevalence of overweight and obesity being associated with snacking in one Chinese study[341] and with consumption of one serving of hot chips per week in a Thai study.[338] In contrast, other studies from India[93] and China[94, 343] demonstrated inverse associations between snacking and risk of adolescent obesity, while an Indonesian study found no significant association between snacking while watching television and increased body weight.[274] Perhaps more surprisingly, an inconsistent finding was also observed for the association between drinking sugar-sweetened beverages and adolescent obesity. Studies

that included a measure of dietary intake in China[94, 343] and Vietnam[246] demonstrated positive associations between overweight and obesity and sugar-sweetened beverages, but Shan and colleagues who used a dietary habit questionnaire in a Chinese study found no significant relationship.[341] Consumption of sweets and chocolates by Chinese adolescent girls was associated with an odds ratio for obesity half that of those who consumed no sweets or chocolates (OR: 0.50, 95% CI: 0.30 to 0.80, P <0.05).[343]

A cross-sectional study conducted in Beijing demonstrated significant association between specific maternal feeding practices and childhood obesity.[263] Young children whose mothers restricted their consumption of snacks were more frequently associated with overweight than those who had unrestricted snacks.[263] Four studies demonstrated positive associations between child eating behaviours and increased prevalence of overweight and/or obesity.[94, 98, 247, 343] In young children, eating at a fast pace (≤2 chews per swallow),[98] being more responsive when interacting with parent(s) during eating time, enjoying food and not being a picky-eater[247] as well as adolescents practicing non-fussy eating[94, 343] were associated with higher odds of becoming overweight/ obese.

3.4 Discussion

This review has been the first to collate evidence on epidemiological associations between dietary patterns and overweight/obesity of children living in Asian developing countries, and has identified several significant yet inconclusive statistical associations.

3.4.1 Prevalence of childhood overweight and obesity within developing countries in Asia

We were unable to assess the true magnitude and draw definitive conclusions about the prevalence of childhood obesity in the Asian developing countries due to lack of standardised definitions. While previous authors have shown that some developing countries in Asia had the lowest prevalence Globally,[2, 6] by including articles up to 2011, we found a relatively high prevalence of overweight in India (specifically at the industrial sites)[337] and in China.[94, 341] A decade ago, Tee reported a prevalence of less than one percent in Vietnam, Laos and Philippines,[3] but the Vietnamese study included in this review showed a prevalence of adolescent obesity of 2% in Ho Chi Minh City

(2004).[246] Previous studies had observed a higher prevalence of obesity amongst children from higher income families; and urban areas,[96, 271, 273, 332] an observation congruent with this review. [93, 94, 98, 246, 247, 263, 338, 339, 342, 343] In a review of worldwide trends, Wang and Lobstein confirmed that children in lower and middle-income countries, especially those growing up in urban environments and following a Western lifestyle, face a major risk of obesity.[6] Their 2006 paper reported higher obesity prevalence amongst school-aged children compared to pre-schoolers across developed countries,[6] which was not seen in this review. The higher prevalence of overweight and obesity in Chinese boys observed in our review can be partly explained by the traditional Chinese culture placing more emphasis on boys and intensified by 'one-child' policy, promoting more attention given to the boys, including food and nutrition aspects.[98]

3.4.2 Relationship between dietary patterns and overweight and obesity in children in developing countries in Asia

With economic globalisation, Asian countries have experienced significant environmental and social change. The shifts in dietary pattern during the nutrition transition typically involve decreased consumption of traditional foods (for example, rice and rice products and wheat and wheat products) coupled with increased consumption of edible oils and animal products, resulting in an overall increased intake of energy dense foods and decreased fibre consumption.[22] In this review, several dietary patterns were associated with an increased prevalence of childhood obesity although the results were equivocal for several dietary relationships. Wide variation in dietary measures between studies limited the ability to elucidate a clear relationship between dietary patterns and obesity.

Results from this review found inconsistent relationships between high energy and high fat diets and childhood obesity, an observation congruent with a review on relative contribution of energy intake and energy expenditure and its association with childhood obesity in Western countries that reported similar finding of conflicting evidence.[185] With the westernisation of the Asian diet, an overall increase of energy and fat intake by the population is inevitable. High energy density diets are biologically more likely to increase BMI through excess energy from fat being readily stored in adipose tissue depots at very high efficiency levels.[344] At present, the body of evidence for this relationship

in Western countries is only strong and consistent for dietary energy density and increased adiposity in adults, with a moderate and strong positive association observed in children and adolescents.[186] There is an urgent need to quantify energy density in future dietary research to ascertain the underlying causal relationship between dietary pattern and childhood obesity.[22] The longitudinal study in China failed to find a relationship between high fat intake and obesity but they did find that high carbohydrate intake was protective against obesity.[340] A traditional Asian diet is rich with plant-based carbohydrate sources comprising more than 70% of total energy.[345]

We found mixed associations for fruit and vegetable intake, consistent with the results of a recent systematic review on the relationship of fruit and vegetable intake with adiposity in children from both developed and developing countries.[212] These findings contradicted earlier evidence that high fruit and vegetable consumption was beneficial amongst Western children.[35, 172] Eating more fruit and vegetables in Asian developing countries might not reduce the prevalence of childhood obesity. This observation may possibly be due to preparation methods in Asian cuisines that could substantially increase the energy density of the diet[22, 345] such as stir-frying or deep-frying vegetables with oil and preserving fruits with added sugar. Children who consumed more meat and who drank meat-based soup were likely to have a higher total energy intake,[340, 343] consistent with the dietary patterns reported in Bogalusa Heart Study, where overweight American children ate more mixed meats, poultry, seafood, eggs, pork, and beef.[35] As the nutrition transition occurs in developing countries, a higher intake of animal protein contributing to higher kilojoule intake are commonly reported,[3, 5, 22] although one included study failed to observe an increased rate of overweight and obesity with a meat intake of more than 200g daily.[245] The inconsistent findings for overweight and obesity and consumption of milk and milk products might be explained by the significant addition of sucrose or glucose syrup to milk and milk products as a flavour enhancer in the Asian market.[345]

Although data from the included studies did not allow definitive conclusions to be made about fast food, the fast food industry is expanding rapidly in Asian developing countries increasing the energy density of Asian diet. [3, 4, 22] Eating away from home has been found to be associated with higher total energy intake and fats amongst adolescents especially in the US.[346] Interestingly, in Lachat *et al.*'s systematic review on eating away

from home and its association with dietary intake, studies from Kenya and Vietnam reported that choosing traditional foods when eating out contributed to improved diet quality with similar or lower energy intakes,[346] making the availability of traditional meals outside the home an important factor. Similarly, the included studies produced conflicting results for snacking when compared with reports from developed countries.[38, 347-349] Both Western-style and 'local' snacks are widely available in developing countries, and it is possible that the local style snacks have lower energy density. There were positive associations between sugar-sweetened beverages and overweight and obesity in the included studies that more accurately measured dietary intake, but not in those that measured food habits, justifying the need for a valid and reliable measurement tool to be developed to quantify intake correctly. While some studies in the US demonstrated that sugar-sweetened beverages were associated with change in BMI,[34, 35] a meta-analysis showed that the relationship between sugar-sweetened beverages and BMI among Western children and adolescents was near zero.[36] In a systematic review of sugar-sweetened beverages and obesity, Gibson concluded that positive associations of sugar-sweetened beverages with weight status may be more likely in any population with high and frequent intakes, irrespective of ethnicity and country.[350]

With only one study on maternal feeding practices, it is difficult to make conclusions. Both positive[262, 264] and negative[264] associations between restrictive practices and prevalence of overweight and obesity, have been reported in the literature from high income countries. At present, young mothers in Asia are shifting away from traditional parenting styles to adopting Western styles, a transformation that may have an adverse impact on the development of overweight and obesity in children. A fast pace of eating was associated with higher BMI in younger children, a finding consistent across different age groups in studies in Korea and the US.[351, 352] Those who demonstrated a better interaction response with their parent(s) during feeding time, who enjoyed food and were unselective about their food, were at increased odds of gaining weight in a Chilean and Australian study.[353, 354] Although direct causality cannot be established, retraining and normalising children's eating behaviour could significantly impact on regulation of gastrointestinal hormone response.[355, 356]

3.4.3 Strengths and limitations of the review

This is the first systematic review conducted to explore the association between dietary patterns and childhood overweight and obesity for developing countries in Asia. Although findings were inconsistent due to the range of dietary patterns and lack of standardisation in measuring childhood overweight and obesity, it has provided a summary of the present state of the problem and highlighted methodological implications for further studies, particularly in terms of the use of agreed obesity standards and validated dietary intake measures. Using the JBI protocol, effort has been made to obtain the most rigorous data at every step to ensure quality when conducting this systematic review.

The review is presented with a few limitations. The review process itself may have been biased by the exclusion of nine studies published in Chinese language. The key limitations are in the evidence base itself, particularly in the heterogeneity of the studies and their measures of dietary patterns and obesity standards, preventing meta-analysis. Most of the studies while well-conducted were of low methodological design. The cross-sectional design of the majority of the included studies meant that we were unable to assess incidence of overweight and obesity or to establish causal relationships between dietary factors and childhood obesity.[41, 93, 94, 98, 245, 246, 263, 274, 337, 338, 341, 342] Aside from the methodological heterogeneity, comparison is problematic as each included study examined their own particular geographical, cultural and behavioural determinants.

While most studies reported adjusting for confounders in their statistical analyses, one study did not perform multivariate analysis[41] (and was excluded when discussing the relationship between dietary patterns and childhood overweight/ obesity) while another study did not perform multiple logistic regression analysis due to small sample size.[340] One study reported statistical analysis as coefficients rather than by odds ratio.[339] While most studies had representative samples, three were limited in representativeness by the use of convenience sampling[338] or purposive sampling.[93, 274] There is the possibility of measurement error due to mis-reporting, recall bias and the used of non-validated tools used for dietary assessment. Questionnaires used in some studies were mainly self-reported by parents, children or adolescents themselves[41, 93, 94, 98, 245-247, 263, 274, 337-343] while one study used questionnaires not validated in the test sample.[247]

Studies were mainly conducted amongst adolescents,[41, 93, 94, 246, 274, 343] limiting the generalizability to other age groups.

3.5 Conclusion

The prevalence of childhood overweight and obesity was found to vary across the developing countries in Asia. This review is the first to describe the associations between dietary patterns and overweight and obesity in children living in this region and found several potential yet inconclusive associations were found. The key limitation was the heterogeneity of studies in terms of measures of dietary patterns and obesity standards.

Implications for practice and for research are assigned Joanna Briggs Levels of Evidence (Appendix 3.9)

3.5.1 Implications for practice

Clinicians should monitor the effects of dietary change on the weight and health status of children in countries experiencing the economic transition[93, 94, 98, 245-247, 263, 274, 337-343] (JBI Level of Evidence 3).

3.5.2 Implications for research

It is clear that high quality research is required to accurately inform the evidence base. There is a need for valid and reliable measures of dietary intake,[41, 246, 339] use of standardised international cut-offs for overweight and obesity in addition to national measures to allow international comparisons,[94, 246, 263, 337, 338, 340, 341] (JBI Level of Evidence 3) and prospective studies aimed at examining the causal relationship between Asian children's dietary pattern and childhood overweight and obesity incidence in the culturally diverse developing countries of Asia.[339, 340](JBI Level of Evidence 3).

Chapter 4 Systematic Review Paper 2: Quality of dietary intake methodology and reporting of epidemiology studies in developing Asian countries

This chapter was published in 2014.

Yang WY, Burrows T, MacDonald-Wicks, Williams LT, Chee WSS & Collins CE. Quality of dietary intake methodology and reporting in epidemiology studies examining relationship between dietary patterns and childhood obesity in Asian developing countries: a systematic review. Nutrition and Dietetics. 2014; 71: 201-209

The work presented in the manuscript was completed in collaboration with the co-authors (Appendix 4.0). Permission to reproduce the manuscript has been granted by the publishers.

4.1 Introduction

Childhood obesity is a global health challenge of the 21st century. In 2010, 80% of overweight children under the age of five resided in developing countries.[1] These developing countries have experienced dramatic increase in the relative percentage change of childhood obesity of 65% over the last two decades when compared to developed nations (48%).[1] The childhood obesity epidemic will place an increasing demand on the densely populated developing countries in the Asian region and their health care systems if left unchecked.[5] Obesity incidence is related on part to the shift in Asian dietary patterns away from a traditional diet to a more westernised diet in conjunction with increasing sedentary behaviours.[5, 22, 28] The subsequent adverse health consequences then track into adulthood.[11, 30, 154, 333]

Measuring dietary intake in overweight and obese children has become an imperative given the relationship between diet, obesity and health.[154, 275] Monitoring dietary intake allows for surveillance and tracking of children's dietary patterns in relation to body weight and subsequent use of the data to model food-based guidelines for obesity prevention.[172] Therefore, for a study to have good external validity, the reporting of dietary intake data must be methodologically sound, however, little information is known about dietary intakes from developing Asian countries and the quality of the assessment methods.

It is difficult to assess the diets of children.[172, 275, 276] The methodological issues of gathering dietary data from children are similar to adults, with additional concerns closely linked to the age-related abilities of the children to self-report on diet, and whether parents might be reasonable or accurate proxies.[283, 289] Mis-reporting, especially over-reporting, could be more common amongst younger and overweight children than in the older populations,[293] highlighting the need to choose an appropriate dietary assessment tool validated for use with paediatric populations. The validity of a dietary tool refers to its ability to measure what it is intended to measure while the reproducibility of a tool means its ability to produce very similar results when used on repeated occastions.[287] The lack of Asian population-specific dietary assessment tools coupled with the diverse and changing food patterns within the Asian region could potentially limit the validity and reproducibility of dietary assessment methods that were validated initially in other

populations. Measurement errors associated with dietary assessment tools could attenuate associations between diet and health status making them difficult to be detected, and therefore, justifying closer quality monitoring of dietary studies in this region.[357]

Given the lack of existing reviews from the Asian region on dietary assessment methodologies, the aim of this paper was to evaluate the quality of reporting of dietary intake methods in epidemiological studies looking at the relationship between dietary outcome and childhood overweight and obesity in developing Asian countries.

4.2 Methods

4.2.1 Search strategy, selection criteria and selection procedures

The methodological details on search strategy and selection processes of the included studies have been published elsewhere.[7] Briefly, the included papers were retrieved using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) reporting guidelines for systematic reviews.[358] Inclusion criteria were any analytical observational studies and children ≤ 18 years who resided in developing countries in Asia region reporting dietary intake. The search terms were divided into four key areas: (1) Dietary pattern: Diet, diet pattern, diet intake, diet habit, diet quality, diet index, diet variety, diet score, food pattern, food consumption, food choices, food selection, food intake, eating pattern, eating selection and eating choices; (2) Developing countries in Asia (based on World Bank Classification of Countries, 2011 to exclude Singapore, Korea and Japan as the developed countries in Asia); (3) Obesity: Obesity, overweight, body mass index, BMI, body weight and weight status; and (4) Children ≤ 18 years of age. A three-step search strategy was utilised to find both published and unpublished studies. Firstly, a limited search of MEDLINE, CINAHL and EMBASE was conducted to identify any existing systematic reviews on this topic.Additional electronic databases searched included: ProQuest, Web of Science and Scopus. Subsequently, a second search was undertaken using all identified keywords and index terms across all databases. Each database was searched from inception to September 2011, with an English language restriction. Thirdly, the reference list of all identified reports and articles were searched for additional studies to ensure all articles were most up to date and all relevant papers were retrieved. The search for unpublished studies included ProQuest (for theses and

dissertations), MEDNAR, conference abstracts, Government Reports and Dissertation Abstracts. All studies were assessed for relevance based on title, abstract and description/MESH heading by two independent reviewers (WYY and LJM). The papers were subsequently appraised using standardised critical appraisal instruments from the JBI and when there was lack of consensus, a third reviewer was consulted (LTW). Data extraction was conducted using an adapted version of the JBI standardised data extraction form.

4.2.2 Critical appraisal and data extraction of dietary assessment methodology and reporting

Dietary assessment methods and reporting quality of the dietary assessment for all articles included were evaluated against a recently published checklist for quality of dietary reporting developed by the ACAORN (Appendix 4.1).[85] The checklist was adapted based on two toolkits i.e. the dietary assessment methods checklist of Nelson and colleagues[86] and the EURReca scoring system.[87] Nelson et al's toolkit provided definitions of dietary assessment methods while scoring criteria was from EURReca. The final checklist consisted of six components: methodology validated in similar population, appropriate validation statistics used, data collection quality, reporting of scoring or details of food composition database, and two specific parameters related to the dietary assessment method used.

For studies that referenced a validation study as their dietary assessment method, the relevant references were retrieved and assessed for study design (validation study), appropriateness of the population, comparative method used and statistical analyses undertaken. The sample size, type of population and explanation of statistical analyses in the validation study contributed the majority of the total quality rating score (4/7), while reporting on personnel involved in collecting and checking dietary data, and scoring method of included articles had two points in the quality rating criteria. A summary score of all components was calculated with a maximum score of 7 and studies were given a rating of poor (≤ 2), acceptable (≥ 2.5 to <3.5), good (≥ 3.5 to <5.0) or excellent (≥ 5.0).

Data was extracted into standardised tables independently by two reviewers (WYY and TB) and cross-checked for completeness and accuracy. Both reviewers achieved good

agreement of scoring for all included studies; hence no third reviewer was required. A meta-analysis was not possible due to heterogeneity of methodology, exposures and outcomes of the included studies. A narrative summary of the results is provided in terms of study characteristics, dietary assessment methods and reporting quality.

4.3 Results

4.3.1 General description of included studies:

The search process identified 2080 studies and sixteen articles were identified reporting on 15 individual studies. The JBI quality appraisal results revealed that only two studies fulfilled all design quality requirements (9/9)[98, 339] and two studies achieving the lowest score of 5/9.[41, 338] Study populations tended to be representative.[93, 94, 245, 246, 263, 274, 337, 339-342]

All included studies were published between 2000 and 2011. Two of the fifteen studies were longitudinal,[339, 340] one was case-control[247] and others were cross-sectional.[93, 94, 98, 245, 246, 263, 274, 337, 338, 341, 342] Most studies focused on adolescents[41, 93, 94, 246, 274, 343] or included both adolescents and younger children.[98, 245, 337] Data collection was conducted in preschools or kindergartens, schools, health centres, industries or local communities. The majority of studies focused on urban areas.[93, 94, 98, 246, 247, 263, 338, 339, 342, 343]

4.3.2 Dietary assessment methods and dietary outcome associated with childhood overweight and obesity

The most commonly used dietary assessment method was study-specific dietary questionnaires[86] reported in ten out of fifteen studies.[93, 94, 98, 263, 274, 337, 338, 341-343] The set of questions were exclusively developed with no validation reported and sample of questionnaires were not included in all studies. Next most commonly used were 24-hour DR (n=4 studies),[94, 245, 340, 342]half of these studies conducted 3-day[245, 340] and another half did 1-day recall.[94, 342] Three studies administered FFQ[246, 247, 339] and one study used unweighed FR.[41] Two studies used a combination of different dietary assessment methods.[94, 247] (Table 4-1)

Table 4-1: Summary table of dietary reporting quality rating of included studies

Study Design		Longitudinal		Case-Control	Cross-sectional				
QUALITY RATING CRITERIA		Hunyh *et al* 2011	Wang *et al* 2003	Thongbai *et al* 2011	Bishwalata *et al* 2010	Collins*et al* 2008	Jeemon *et al* 2009	He *et al* 2000	Tang *et al* 2010
Study population		4 to 5 years M:670,F:337 Vietnam	6 to 13 years M: 51, F: 44 China	3 to 5 years M: 336, F: 279 Thailand	12 to 19 years M&F: 2957 India	12 to 15 years M: 815, F: 916 Indonesia	10 to 19 years M:1581, F:1853 India	0.1 to 6.9 years M: 748, F: 574 China	11 to 16 years M:1332, F:1328 Vietnam
Is there a dietary method validation study?		Yes	No	No	No	No	No	No	Yes
Study tool		Adapted FFQ	3-day, 24-hr DR	Adapted FFQ	Study-specific dietary questionnaire	Study-specific dietary questionnaire	Study-specific dietary questionnaire	Study-specific dietary questionnaire	FFQ
Dietary pattern reporting approach		• Nutrients intake	• Nutrients intake • Food groups consumption	• Food and food groups consumption	• Food groups consumption	• Food consumption • Dietary habits	• Dietary habits	• Food and food groups consumption • Dietary habits	• Nutrients intake • Food consumption
Validation tool		Repeat24-hr DR	NA	NA	NA	NA	NA	NA	4-day, 24-hr DR
1. Validation study sample & sample size (max 1 point)		0[b]	0	0	0	0	0	0	0.5[c]
2. Statistics to assess validity (max 3 point)		0	0	0	0	0	0	0	3[c]
3. Data collection (max 1 point)		0.5	1	0	0	0.5	0.5	0	0.5
4. Scoring Method(max 1 point)		1	1	0.5	0	0	0.5	0	0.5
FFQ	5. Frequency scale (max 1 point)	0.5	NA	1	NA	NA	NA	NA	1
	6. Seasonality (additional 0.5 point)	0	NA	0	NA	NA	NA	NA	0
FR/ RM	5. Number of days recall (max 1 point)	NA	1	NA	NA	NA	NA	NA	NA
	6. Use of multiple pass and aids/ prompts (additional 0.5 point)	NA	0	NA	NA	NA	NA	NA	NA
DH	5. Time-scale (max 0.5 point)	NA	NA	NA	NA	NA	NA	NA	NA
	6. Use of 24-hour recall and aids/ prompts (max 1.0 point)	NA	NA	NA	NA	NA	NA	NA	NA
DQ	5. Questionnaire details provided (max 1 point)	NA	NA	NA	0	0.5	0	0	NA
	6. Factor analysis (additional 0.5 point)	NA	NA	NA	0	0	0	0	NA
Total Score (7/7)		2	3	1.5	0	1	1	0	5.5
Dietary reporting quality rating[a]: Poor (≤ 2), Acceptable (≥ 2.5 to <3.5), Good (≥ 3.5 to <5.0),Excellent (≥ 5.0)		Poor	Acceptable	Poor	Poor	Poor	Poor	Poor	Excellent

[a] Assessed with adapted checklist for dietary intake methodology reporting, [b] Validation Study (Hunyh et al, 2008), [c] Validation study (Hong et al 2010)

FFQ: Food Frequency Questionnaire, 24-hr DR: 24-hour Diet Recall, FR: Food Record, RM: Recall Method, Diet History: DH, Dietary Questionnaire: DQ, NA: Not Applicable, M: Male, F: Female

Study Design / Quality Rating Criteria		Cross-sectional							
		Jiang *et al* 2006	**Jiang *et al* 2009**	**Li *et al* 2007**	**Li *et al* 2008**	**Li *et al* 2010**	**Pawloski *et al* 2010**	**Shan *et al* 2010**	**Zalilah *et al* 2006**
Study Population		2 to 6 years M: 518, F: 412 China	1 to 2.9 years M&F: 290 China	7 to 17 years M:3927,F:2899 China	11 to 17 years M: 899, F: 893 China	11 to 17 years M: 899, F: 893 China	9 to 18 years F: 342 Thailand	6 to 18 years M:10602,F:10596 China	11 to 15 years M:3353,F:3202 Malaysia
Is there a dietary method validation study?		No	No	No	No	No	No	No	No
Study tool		Study-specific dietary questionnaire	1-day, 24-hr DR	3-day, 24-hr DR	• Study-specific dietary questionnaire • 1-day, 24-hr DR	Study-specific dietary questionnaire	Study-specific dietary questionnaire	Study-specific dietary questionnaire	3-day food/diet record
Dietary pattern reporting approach		• Child feeding practices	• Nutrients intake • Food consumption	• Nutrients intake • Food and food groups consumption	• Nutrients intake • Food and food groups consumption • Dietary habits	• Food and food groups consumption • Dietary habits	• Food and food groups consumption • Dietary habits	• Food consumption	• Nutrients intake
Validation tool		NA	NA	NA	NA	NA	NA	NA	NA
1. Validation study sample & sample size (max 1 point)		0	0	0	0	0	0	0	0
2. Statistics to assess validity (max 3 point)		0	0	0	0	0	0	0	0
3. Data collection (max 1 point)		0	1	1	0.5	0	0	0.5	1
4. Scoring Method(max 1 point)		0	0.5	0.5	0	0	0	0	1
FFQ	5. Frequency scale (max 1 point)	NA	NA	NA	NA	NA	NA	NA	NA
	6. Seasonality (additional 0.5 point)	NA	NA	NA	NA	NA	NA	NA	NA
FR/ RM	5. Number of days recall (max 1 point)	NA	0	1	0	NA	NA	NA	1
	6. Use of multiple pass and aids/ prompts (additional 0.5 point)	NA	0	0	0	NA	NA	NA	0.25
DH	5. Time-scale (max 0.5 point)	NA	NA	NA	NA	NA	NA	NA	NA
	6. Use of 24-hour recall and aids/ prompts (max 1.0 point)	NA	NA	NA	NA	NA	NA	NA	NA
DQ	5. Questionnaire details provided (max 1 point)	0	NA	NA	0	0	0	0	NA
	6. Factor analysis (additional 0.5 point)	0	NA	NA	0	0	0	0	NA
Total Score (7/7)		0	1.5	2	0.5	0	0	0.5	3.25
Dietary reporting quality rating[a]: Poor (≤ 2), Acceptable (≥ 2.5 to <3.5), Good (≥ 3.5 to <5.0),Excellent (≥ 5.0)		Poor	Poor	Poor	Poor	Poor	Poor	Poor	Acceptable

[a] Assessed with adapted checklist for dietary intake methodology reporting

FFQ: Food Frequency Questionnaire, 24-hr DR: 24-hour Diet Recall, FR: Food Record, RM: Recall Method, Diet History: DH, Dietary Questionnaire: DQ, NA: Not Applicable, M: Male, F: Female

Seven studies described dietary outcome based on habits related to food and dietary intake such as snacking, eating out, or breakfast consumption.[93, 94, 98, 274, 337, 338, 343] Another seven studies reported nutrient intakes,[41, 94, 245, 246, 339, 340, 342] and twelve studies reported food and food group consumption according to the national selection guide of the respective country.[93, 94, 98, 245-247, 274, 338, 340-343]

4.3.3 Dietary assessment methods reporting quality

Twelve of the sixteen articles were rated as 'poor', scoring less than 2/7 for their dietary assessment methods' reporting quality,[93, 94, 98, 247, 263, 274, 337-339, 341-343] three were rated as 'acceptable'[41, 245, 340] and only one was 'excellent' (≥ 5).[246] (Table 4-1)

The non-standardised and non-validated study-specific dietary questionnaire was the main dietary assessment method reported by cross-sectional studies included in this review which were rated as 'poor' .[93, 94, 98, 263, 274, 337, 338, 341, 343] The questionnaire content was not well described and tended to be broad in scope, limiting the ability to fully assess their content for quality evaluation. Questionnaires were self-reported by either parents for children below 7 years (n=3 studies)[98, 247, 263] or by children and adolescents themselves (aged between 9 and 19 years) (n=4 studies).[93, 94, 338, 343]

Studies administering 24-hour DRs rated as either 'acceptable'[245, 340] or 'poor' for dietary reporting quality.[94, 342] The difference in the rating of these studies was mainly attributed to the number of days for recall (ranging between one and three) and inclusion of weekdays and weekends in the methodology. Those studies with more days had better ratings.[245, 340] No studies used the multiple pass protocol[281, 359] or reported the use of additional aids for portion size estimation in their 24-hour DR studies. One study that administered repeated FRs was rated as 'acceptable'.[41]

In studies using FFQ (longitudinal,[339] case-control[247] and cross-sectional[246]), two of the studies were rated as 'poor' and one study as 'excellent'. All reported the frequency scale used but the effect of seasonality was not mentioned. Two studies [246, 339] used FFQs that had been validated[246, 339] although only Tang *et al.* (2010)[246] used a tool validated in a population of similar age and ethnicity.[246] In this case, the statistical methods

assessing the FFQ validity was appropriate (mean comparison, weighted Kappa and Bland-Altman plot).[246]

Across all studies, trained personnel such as healthcare professionals and researchers were involved in collecting dietary data,[41, 94, 245, 246, 274, 337, 339-342] but only two of these studies specified that the data was checked or reviewed for completeness or accuracy.[41, 340] The national food composition databases used for dietary analysis were reported in only six articles; namely the China Food Composition Tables,[245, 340, 342] the Vietnam National Food Composition Tables[246, 339] and the Nutrient Composition of Malaysian Foods,[41] all of which were appropriately applied to the study population.

4.4 Discussion

This review is the first to our knowledge to evaluate the quality of dietary methodology reporting in developing Asian countries in studies investigating dietary intake and obesity. All included studies were published over the past decade which highlights the increasing importance of research on dietary intakes in this region. This systematic review indicates that reporting of dietary data from the fifteen eligible studies was predominantly of 'poor' quality, with only one study rated as of 'excellent' methodological quality. Quality of the included studies was limited by the lack of detailed reporting of dietary assessment method and the validity of the method used, training of personnel involved in collecting data, and reference to food composition databases for analyses. This finding is consistent with the findings from a recent systematic review primarily in developed countries that also identified sub-optimal quality of dietary methods and dietary intake reporting in child and adolescent obesity intervention trials.[85]

The quality rating was directly related to the choice of dietary assessment method, and in this review, a poor quality rating was obtained by studies using the non-standardised and non-validated study-specific dietary questionnaire. Despite the recommendation for each dietary assessment method to be fully described in published reports,[86] these questionnaires lacked detailed description and differed in their reporting. This method is popular for being relatively straightforward to administer and associated with a lower respondent burden and requires less intensive work than development and validation when designing a FFQ. However, like other retrospective assessment methods, it

predominantly relies on memory, hence, has its limitations.[286] In the Asian region, there is a smaller number of registered dietitians per population when compared to developed countries[360] with fewer research dietitians available, which could result in usage of simpler dietary assessment methods. While there is a need for dietary assessment methods for research purposes, initial efforts need to be directed to validation of some standardised tools for this region, including both brief and comprehensive approaches. In the included studies, using parents as proxy reporters for younger children and direct reporting by the older children reduce the possibility of mis-reporting bias associated with age-specific related cognitive ability.[282, 283]

The 24-hour DR is one of the most widely used dietary assessment tools in countries such as the US.[281] Its popularity is due to a relatively low participant burden, reduced potential to interfere with usual dietary behaviour and its appropriateness when cooperation or literacy of respondents is limited.[288] However, standardised approaches should be followed when using this method.[281, 287] Although a 24-hour DR is affected by larger random error due to within-person variation of food intake, this barrier can be overcome with repeated administrations,[281] which was addressed partially by the four studies using 24-hour DR[94, 245, 340, 342] in this review. These studies did not report using the higher quality 24-hour DR methodology used in US i.e. automated multiple pass method (AMPM).[281, 359] The US's AMPM was developed based on cognitive principles, using five passes to enhance recall in order to tackle the common dietary reporting weaknesses associated with the traditional administrative method.[359] Applying this version of the dietary recall methodology could promote overall accuracy of dietary reporting amongst the younger and overweight Asian population.

FFQs were more likely than study-specific dietary questionnaires to be evaluated for validity and reliability in terms of assessing usual dietary intake, although they are not without limitations.[361] The development and validation of a FFQ requires a systematic approach, including development of a representative food list with seasonality factored in for items such as fruit and vegetables, appropriate quantification of portion sizes, standardised data collection and analysis of nutrient intakes using country-specific databases before the tool is made available for use more broadly.[285, 288] Only one study reported detailed validation of the FFQ tool.[246] The lack of reporting or reference to seasonality or in all FFQs[246, 247, 339] could be partly explained by the fact that in South

East Asian countries, most fruits and vegetables are available all year round. FFQs are restricted by the concept of portion size and frequency, which may be beyond the cognitive ability of children below 10 years of age.[276] The cognitive abilities of children's reporting of food intake were first discussed by Baranowski and Domel. They reported seven categories of potential errors associated with this age-group.[299] Therefore, studies that fail to consider children's limited ability to recall and estimate portion size could result in substantial measurement error.[281]

Studies utilizing the unweighed FR were rated better in this review, but it was used only in one study. Reporting bias related to changing intakes may be more prominent with FRs compared to DRs or FFQs in children and adolescents[293] which is likely to prevent wide usage, especially for body weight-related studies such as those included in this review. The repeated weighed FR is considered the gold standard of dietary assessment methods,[295] however, no studies included in this review utilised this method. The weighed FR is of limited practicality in epidemiological studies, especially those involving large populations. The majority of studies included in this review involved sample sizes of more than 500 participants[41, 93, 94, 98, 245-247, 263, 274, 337, 339, 341, 343] hence the lack of use of this tool. The cost of administration is considerably higher compared to other dietary assessment methods, hence less favourable in the developing Asian countries with limited research resources. It also has the greatest bias towards under-reporting in older children and adolescents, which could restrict its use.[276, 288, 293]

Previous reviews, including our own, have noted little published evidence from developing Asian countries on childhood obesity and its causative factors.[7, 63, 64] The few childhood obesity intervention studies undertaken in this region also omitted details on dietary assessment tools used and dietary data reporting,[74, 75, 80] despite diet being one of the key aetiological factors for development of childhood obesity and a cornerstone of successful interventions in weight management. It is clear that dietary methods are given the least attention compared to other health behaviours and their usage and outcomes rarely reported in the methodology and results section of literature.[85, 172] Urgent attention is required to include reporting on dietary intakes and more in-depth analysis of all study designs from the Asia region.

Poor reporting of dietary assessment methodology limits the ability to replicate studies, leading to potential measurement bias and compromises interpretation of findings related to dietary intake. To obtain an accurate measure of dietary intake, it is essential to use valid dietary assessment tools.[172, 275] If piloting and validation of dietary assessment tools is not conducted in a sample similar to the population under study, it could affect the validity and reproducibility of the tool, increasing the likelihood of measurement errors.[86] No studies were retrieved which utilised nutritional biomarkers. Ideally, biomarkers such as doubly labelled water or urinary nitrogen should be utilised to provide independent measures of validity for energy and protein intake, respectively. However, such methods are expensive and provide data on a limited range of nutrients, preventing usage when resources are constrained, as in developing countries.[279] Hence, it is recommended that validation studies with the selected dietary assessment method referenced against at least one other dietary method, or biomarker be conducted in subsample of population of interest.

4.4.1 Strengths

This review is the first to summarise the methodological issues in dietary intake measurement and reporting quality within epidemiology studies of dietary outcome and body weight in children and adolescents in developing Asian countries. The appraisal processes involved two independent reviewers in the original review and the dietary reporting quality appraisal stages to minimize reporting bias.

4.4.2 Limitations

In the review methodology, exclusion of nine studies published in the Chinese language during the selection procedures of the retrieval process could potentially restrict its results generalisability as a whole to the entire Asia region. Studies in this review were predominantly cross-sectional and dietary outcomes were described in a wide variety of ways. The heterogeneity of the study design and their measures of dietary outcome prevent meta-analysis to be conducted. The dietary questionnaires from the included studies were unavailable and were not detailed in the included studies, which restricted in-depth reporting in this review.

4.4.3 Recommendation

To date, there is no consensus regarding the best dietary assessment method to measure dietary intake of overweight and obese children in the developing Asian countries. The application of a checklist to rate the quality of the dietary assessment methods should encourage researchers in this region to fully describe their dietary methods and to use valid dietary intake measures in future studies. While tools chosen for dietary studies should first undergo validation for Asia and quality appraisal prior to implementation, further work is required to tailor dietary assessment methods to age-specific cognitive and social developmental needs for children in this region. Such methods should be evaluated for differential dietary reporting by body weight status in view of the dramatic change in the prevalence of childhood obesity in this region.

4.5 Conclusion

There is an urgent need for valid and reliable dietary assessment methods and data reporting on the dietary intake amongst children for use in developing Asian countries. Higher quality research needs to be conducted using validated tools and dietary methods to be described adequately, to accurately inform the evidence base of studies in this region in identifying and tackling dietary patterns associated with childhood obesity.

Chapter 5 Methods Paper 1: Studying the Family Diet - An investigation into association between diet, lifestyle and weight status in Malaysian families

This chapter was published in 2015.

Yang WY, Burrows T, Collins CE, MacDonald-Wicks L, Williams LT & Chee WSS. Studying the Family Diet: An investigation into association between diet, lifestyle and weight status in Malaysian families. Malaysian Journal of Nutrition. 2015; 21(2): 139-154

The work presented in the manuscript was completed in collaboration with the co-authors (Appendix 5.0). Permission to reproduce the published manuscript has been granted by the publishers. Please note, to publish this paper, the journal required the term 'carer' to be replaced with 'caregiver' and the term 'Malay language' to be replaced with '*Bahasa Malaysia*'.

The following documents have been included in the Appendices: study ethics approval (Appendix 5.1– only first page), study recruitment flyer (Appendix 5.2), study consent form (Appendix 5.3), study information sheet (Appendix 5.4) and study questionnaire for child participant (Appendix 5.5– only Section A, B and E; Section C and D excluded due to copyright).

5.1 Introduction

Malaysia is currently experiencing an escalation in the prevalence of childhood obesity due to the nutrition and lifestyle transition associated with rapid economic development and urbanisation. The transition is characterised by a shift away from high energy burning activities of daily life to sedentary lifestyles, and a traditional grain-based diet to one which is high in animal products, oils and fats.[28] Recent reports have estimated that approximately 34.5% of children aged between seven to twelve years residing in urban areas in Malaysia are classified as overweight or obese.[9] The magnitude of childhood obesity may be greater for Malay children than other ethnicities in view of its large proportion within the population of Malaysia.[10] Malays of all age groups make up 67.4% of the Malaysian population. The consequences of childhood obesity are significant for several reasons including physically, socially, psychologically and economically. Also obesity has been shown to track into adulthood.[30] Recently, there has been a dramatic rise in the prevalence of MetS amongst Malaysian primary school children who are obese thus increasing the risk of chronic diseases.[19]

While dietary intake is important in the aetiology of obesity, it is rarely well reported in the literature.[172] Little data is available on children's dietary patterns and lifestyle factors contributing to obesity in Asian developing countries and findings from existing studies demonstrated inconclusive dietary associations with childhood obesity,[7] primarily due to methodological issues related to dietary assessment tools used.[40] Dietary studies on Malaysian children are uniformly lacking in terms of exploring dietary intake and obesity relationships within the family context.[9]

The family environment is an important setting for influencing the eating and physical activity behaviours of young children. The construction and experience of a child's environment can be carried forward to the next generation via parenting styles, attitudes and lifestyle behaviours.[239] Although past research has shown positive associations between an authoritarian parenting style and risk of overweight in children, current evidence is equivocal.[239, 261] The traditional parenting style within the obesogenic environment in Asian developing countries may or may not be impacting on child's body weight status, highlighting the need for further research in Asian populations.

The primary aim of the Family Diet study is to determine the associations between dietary factors, lifestyle factors, and anthropometric measures of Malay school children aged 8 to 12 years in urban areas of the *Klang Valley*, Malaysia. The purpose of this paper is to describe: 1) the rationale and methodology of this study including the development and selection of study measures and 2) the pilot testing of the study protocols for implementation in the Malaysian setting.

5.2 Methods

5.2.1 Ethics, study design and sampling

Approval was obtained from the relevant ethics committees of the University of Newcastle (H-2013-0065) and International Medical University, Malaysia (IMU 275/2013). In Malaysia, as compulsory schooling commences at age seven, primary schools were used as recruitment sites. The Malaysian Ministry of Education and State Education Departments were approached, and permission was granted for school-based research. This study used a cross-sectional design and was conducted in urban areas in the *Klang Valley*, Malaysia. The location was chosen based on convenience of access to one state and one Federal Territory located in the centre of Peninsular Malaysia. The state of *Selangor* has a population of 5.46 million and 91.4% urbanisation.[10] The Federal Territory of *Kuala Lumpur* has a population of 1.67 million populations and 100% urbanisation.[10] Multi-stage sampling methods were used as shown in Figure 5-1. Eight national primary schools within the identified zones of *Kuala Lumpur* and *Selangor*, respectively were selected based on simple random sampling while cluster sampling was implemented to select a minimum of three primary schools from each state. The total number of participants for each school was calculated based on probability proportionate to sample size method.[362] This probability was derived from the final estimated sample size required, total number of students per school and proportions of students with Malay ethnicity. Within primary 3, 4 and 5 levels (children aged 8 to 12 years) at each selected school, simple random sampling was undertaken and the main caregivers of Malay schoolchildren were invited to participate in the study. The sample size needed was estimated on observed prevalence of breakfast skipping (32.1%) (Ruzita, unpublished) using EPI-info™ version 5.0 statistical package (5% margin of error and 95% confidence level). This variable was chosen as it was included in this study's questionnaire on food

habits. The estimate of 283 families was increased by 28 to adjust for a non-response rate of 10%, giving a final estimate of 311 families. Two to four people per family were anticipated to participate.

5.2.2 Recruitment and participants

Invitations to participate were distributed by the school administrator to the children in selected primary 3 to primary 5 classes at each school. Interested families were invited to return completed consent forms to the school. The Participant Information Sheet and Consent Form were available in both English and Malay languages to enable clear understanding of the content. Willing families were screened for eligibility by the doctoral candidate researcher (WYY) and enrolled after providing informed consent. For inclusion into this study, respondents had to be from a Malay family with the main caregiver(s) living full time with a child who had no concurrent medical conditions. The main caregiver was defined as a parent or a person related to the family who made the main decision in terms of food purchasing, preparation and feeding the child, for example, a grandparent. The flow of recruitment and data collection is shown in Figure 5-2. Data collections started in August 2013 and assessments were conducted either at school or the home based on families' preferences. To obtain the main caregiver's follow-up 24-hour DRs, a phone call was conducted within 3 to 6 months of recruitment.

5.2.3 Outcome Measures

The study measures included family socio-demographics, dietary intake, parental attitudes, beliefs and practices about child feeding and obesity proneness, levels of physical activity, and body weight status. The main caregivers completed all study measures, while the children underwent anthropometric measurements and interviews on dietary intake and physical activity.

5.2.3.1 Family socio-demographic

Families' socio-demographic were collected using 12 items. Six items gathered data on gender, date of birth of the child, parents' employment status, parents' highest educational level, family size and total monthly income. Six other items explored the families' food attainment including preparation and mealtime habits, pocket money provided to child,

main shopping location, main food purchaser, main food preparer, mealtime(s) together; and child's main mealtime supervisor.

5.2.3.2 Dietary intake

Information on dietary intake was collected using interviewer-administered 24-hour DRs, and supplemented with the FHQ. A search of the literature did not provide a dietary assessment tool validated and suitable for all participants within Malaysian families. Hence this study used standardised 24-hour DRs as the main dietary assessment method, as they are an internationally accepted method for assessing usual dietary intake.[281] The repeat 24-hour DRs followed the protocol developed based on the United States Department of Agriculture (USDA)'s AMPM [281] and adapted the Australian National Nutrition Survey 24-hour DR procedures.[363] The adapted protocol aimed to improve the dietary intake methodological quality within the Malaysian population sample, as recommended by this study's systematic review on dietary assessment methodology and reporting in developing Asian countries.[40] The 24-hour DRs (two on weekdays and one on weekend) collected detailed information on all food and beverage consumed on the day prior to interview, from midnight to midnight, including time of consumption, the occasion (e.g. breakfast), food descriptions detailed enough to allow for accurate food coding; the amount eaten; the source of foods, and whether the food was prepared and consumed at home. Five phases were used according to the protocol: (1) Phase One - an initial 'quick list' where participants reported all the food and beverage consumed without interruption from the researchers; (2) Phase Two - participants were provided the opportunity to report any forgotten foods from a list of food categories commonly omitted in 24-h recall reporting; (3) Phase Three - participants reported the location and time each eating occasion began and named the occasion; (4) Phase Four - research personnel probed for more detailed information about the food and the portion size, in addition to reviewing the eating occasions and times between the eating occasions; (5) Phase Five (the final review) - participants were asked about any other item not already reported.

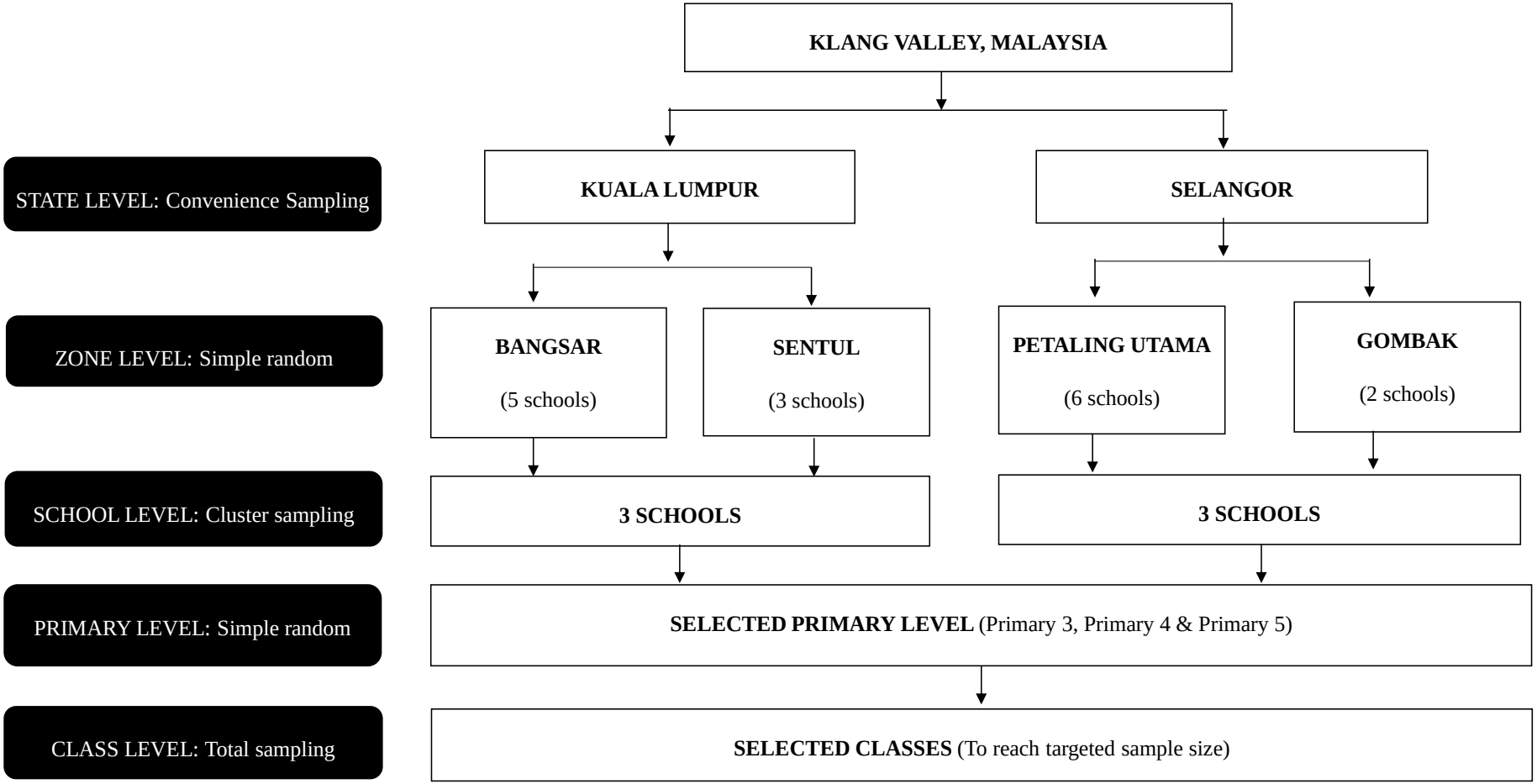

Figure 5-1: Multi-stage sampling for the Family Diet Study

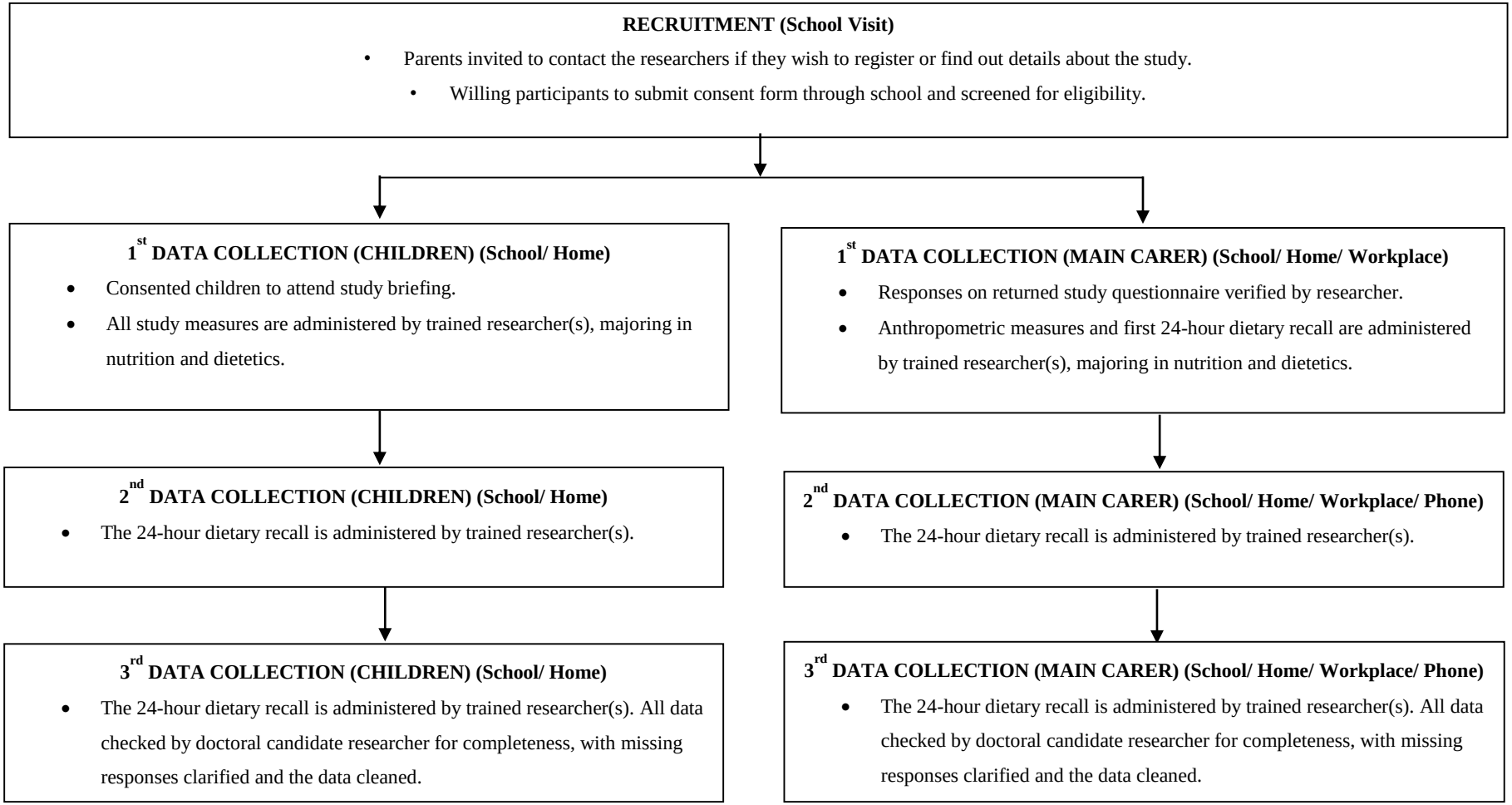

Figure 5-2: Flow of recruitment and data collection throughout study period

For mixed dishes, participants were asked about the amount of each ingredient used, the number of serving sizes for each recipe, and the serving sizes for each recipe, and the amount from each mixed dish they consumed. At the first interview, participants were shown food photographs and common household measures (i.e., cups, glasses, bowls, plates and spoons) to assist in the estimation of portion size. They were given a booklet containing similar photographs to be used in subsequent phone-call interviews.

The DRs were analysed using Nutritionist Pro™ software and nutrient data from the Malaysian Nutrient Composition of Foods [364] and Singapore Nutrient Composition of Foods databases.[365] For mixed or composite dishes, the individual ingredients were entered. For foods missing from the databases, nutrient content information was obtained from commercial packaging and entered into the database software. Methods to determine implausible energy intake were compared to reference standards as detailed elsewhere.[82]

The supplementary dietary assessment method, the FHQ, specifically asked about the frequency of intake of the general food groups (e.g., fruits, vegetables and dairy products, etc.), dietary habits (e.g., drinking sweetened beverages, snacking, skipping breakfast, eating out, taking supplements, etc.) and sedentary behaviours (e.g., watching television, playing video games, etc.). This questionnaire had 13 items targeting children and 12 items targeting the main caregiver but excluded questions on pocket money provided, and was adapted from the Australian Eating Survey FFQs' supplementary questions.[366] The Australian survey was translated into *Bahasa Malaysia* with permission and local food terms were incorporated and verified by an independent staff of a linguistic department. This tool was chosen because it is relatively straightforward to administer, has been demonstrated to be associated with lower participant burden,[281] and allows for comparisons to be made with existing Australian data. The tool aimed to provide information on urban Malay families' usual food behaviours over a period of 6 months. An individual response for each question was required and response categories for frequency of food groups and dietary habits were divided into daily, weekly or monthly categories. For the two questions on sedentary activities, the responses for time spent watching television included: '0 to 1 hour per day'; '2 to 3 hours per day'; '4 to 5 hours per day'; and '6 or more hours per day', whilst responses for playing computer games

were: ‘Never’; ‘Less than once per week’; ‘1 to 2 per week’; ‘3 to 4 per week’; ‘5 to 6 per week’; or ‘Everyday’.

5.2.3.3 Child feeding practices

The mother (or in the situation where the mother is not applicable, the other main caregiver) completed the 31-item validated CFQ which assessed parents’ beliefs, attitudes, and practices about child feeding and obesity proneness. The English language version of the CFQ[(266)] was used with permission from the author whilst the Malay version was obtained from a local researcher who adapted and translated the original CFQ.[(269)] The *Bahasa Malaysia* version of the CFQ was tested for comprehension and found to have an internal reliability of 0.73.[(269)] The questionnaire was designed to be completed by parents of children aged 2 to 11 years, and consisted of seven domains: (1) Perceived feeding responsibility (PFR); (2) Perceived parent overweight (PPO); (3) Perceived child overweight (PCO); (4) Concerns about child overweight (CCO); (5) Restriction (REST); (6) Pressure to eat (PTE); (7) Monitoring (MONI). A 5 point Likert scale contained possible responses ranging from ‘disagree’ (= 1) to ‘agree’ (= 5) or ‘never’ (= 1) to ‘always’ (= 5) depending on the domain. Scoring was based on the mean of items under each different subscale. PFR was scored on a mean of 3 items with higher scores indicating higher levels of perceived parental feeding responsibility. The mean of PRO and PCO indicated parents’ perception of their own weight status throughout life and parents’ perception of their children’s weight status, respectively. Higher scores of CCO represented higher levels of concern about their child’s weight. REST scores indicated levels of parental restriction, higher scores of PTE indicated higher parental pressure to eat, and higher MONI scores indicated higher levels of parental monitoring.[(266)]

5.2.3.4 Physical activity

Data on physical activity were obtained from the validated short-form self-administered International Physical Activity Questionnaire-Short Form (IPAQ-SF) given to the main caregiver(s)[(367)] and the Physical Activity Questionnaire for Children (PAQ-C) given to the children.[(368)] Both tools were chosen because of the lack of a single validated and appropriate questionnaire available for the local population that could be used to assess physical activity for different age groups of participants within this study. The IPAQ-SF

in *Bahasa Malaysia* used was adapted from the *Bahasa Malaysia* version of IPAQ Long-Form, known as IPAQ-M. It was recently tested for its reliability and validity amongst the Malay population in Malaysia.[367] The IPAQ-SF is a self-administered questionnaire designed for persons aged 15 to 69 years to explore the amount of time they spent being physically active in the last seven days. The total physical activity score is the summation of the duration (in minutes) and frequency (days) of walking, moderate-intensity and high-intensity activities. Median values and inter-quartile ranges can be computed for walking, moderate-intensity activities, high-intensity activities and a combined total physical activity score. There were three categories of physical activity: low, moderate and high.[367] The original PAQ-C is a self-administered, 10-item, 7-day recall questionnaire assessing general levels of physical activity of children approximately 8 to 14 years old.[368] The *Bahasa Malaysia* version of PAQ-C was used with permission from the Public Health Institute, Malaysia. PAQ-C assesses the level of physical activity from the last seven days. Item 1 focuses on spare time activity, Items 2 to 8 cover physical activities during physical education, recess, lunch, after school, evenings, weekends and during free time while Item 9 refers to physical activity level for all days of the week including weekend, with each item scoring on a 5-point Likert scale. An average score of 1 indicated low physical activity, scores between 1 and 5 indicated medium physical activity and 5 indicated high physical activity.

5.2.3.5 Anthropometry

Body weight, height, WC and BF were measured by researchers according to standard protocols, either in the fasting state or at least 2-h post prandial. Participants were instructed to wear light clothing and, to remove shoes and any heavy objects prior to measurement. Each anthropometric measure was taken twice. If the second measurement was within 0.5kg for weight, or 0.5cm for height and WC, or 1.5% for BF, the mean of the first two measures was used, and if outside that range, a third measure was taken and the median value was used.

Body weight was measured to the nearest 0.1kg using a TANITA digital weighing scale. The weighing scale was calibrated with a standard weight at the beginning of the study and the scale showed zero before each measurement. Participants were required to stand on the middle of the weighing scale with minimal movement, arms by their sides and

looking straight ahead for the body weight to be recorded. Height was measured to the nearest 0.1cm using a SECA Bodymeter 206 microtoise. The microtoise was placed on a flat floor, pulled up against a smooth wall, secured by the upper side and reading zero on the floor surface before each measurement. Participants were instructed to stand straight with feet together, heels, buttocks and upper part of the back touching the wall, hands by the side with the head remaining in the Frankfurt Plane position. The head of the measuring board was placed firmly down the vertex and the reading was taken from the number on scale where the red line position touched the participant's head. For WC, participants were required to stand upright in a relaxed manner, feet comfortably apart, weight evenly balanced on both feet and with their arms folded across their chest. The participant's top of the iliac crest was palpated with the researcher standing behind and the correct site was marked on the skin, followed by locating and marking the lower costal border. A non-extensible SECA 201 measuring tape was placed circulating the body, mid-way between the earlier two landmarks and the measurement was recorded to the nearest 0.1cm. BF percentage was measured using a Maltron BF-907 bioelectrical impedance analysis machine. The standardised protocol recommended by the manufacturer was followed and pre-preparation required was informed to the study participants. Participants laid on a flat surface in a supine position with hands and legs slightly apart. The researcher attached four electrodes on the right side of the body, each on the hand, wrist, foot and ankle. Upon activating the instrument, pre-collected data on age, gender, body weight, height, nationality and physical activity classification were entered. The physical activity classification included 'Normal', 'Sports' or 'Athletes' and was defined by the manufacturer as follows; 'Sports: for those who train regularly (e.g., vigorous training three or four times a week'), 'Athlete: for full-time professional athletes'. Participants who were not categorised into these two categories, were classified as 'Normal'. The BF percentage reading was recorded to the nearest 0.1%.

BMI was calculated according to standardised equations and categorised using WHO BMI-for-age growth reference (5 to 19 years old) [104] for children and using BMI Asian classification for ≥ 18 years.[369] BMI z-scores were calculated using WHO AnthroPlus software version 1.0.4 (WHO, Geneva, Switzerland).[370] WC of children was compared against newly developed percentile curves for Malaysian children and adolescents aged 6.0 to 16.9 years old,[126] whilst adult results were compared to the Malaysian standards for adult obesity.[369] The child's birth weight was collected at the initial interview.

5.2.4 Pilot Testing and Quality Assurance

Five percent of the targeted sample size was included in a pilot study to test the protocol in terms of flow, timeline, recruitment and feasibility. The pilot study also aimed to identify any other challenges in implementing the main study. This pre-testing of procedures and instruments was designed to identify and correct poorly constructed questions, and to estimate time needed for completion. To enhance study quality, data collection followed a standardised procedure and all data collectors with expertise in this method (majoring in nutrition and dietetics) were trained by a doctoral candidate researcher (WYY) prior to the assessment sessions. The same assessors were used where practicable for repeat assessments for participating families. All data were checked by trained research personnel for completeness, with missing responses clarified and data cleaned. This process was designed not to influence the participants to answer questions that they may not have wanted to answer otherwise.

5.2.5 Statistical Analyses

Normality checking and descriptive statistics were first conducted for dietary intakes and food habits, physical activity, parental child feeding practices, and body weight status. Statistical methods for testing the relationships between variables, including differences by gender and body weight status groups; and associations between the children and their main caregiver(s)' dietary and lifestyles factors (both parametric and non-parametric tests) were explored to address the aims of the main study using statistical software STATA version 11.2.

5.3 Results

Sixteen families met the inclusion criteria and consented to participate in this pilot study (4 father-mother-child families, 1 father-child family and 11 mother-child families). Eleven families completed all measures (three caregivers did not complete the third follow-up 24-hour DR and two families withdrew). The children were all measured at school while caregivers were measured at school, their homes or at their workplaces. Of the follow-up DRs of caregivers, six were interviewed face-to-face and others were completed through phone-calls. During face-to-face sessions, all participants were able

to complete the questionnaires, participated in anthropometric measures and reported dietary intake based on the study protocol. The participants were encouraged to seek clarification from the research personnel throughout the process.

Descriptive characteristics of the pilot participants are presented in Table 5-1 and Table 5-2. The mean (SD) BMI for children, fathers and mothers were 19.4(6.2)kg/m^2, 27.5(2.1)kg/m^2 and 27.7(6.8)kg/m^2, respectively, indicating that the majority were either in the overweight or obese category. The parents were mostly employed full-time, had tertiary education and earned an income above RM5000 per month. Mothers were the main food purchaser (67%), food preparer (93%) and mealtime supervisor (93%). Of the seven subdomains of child feeding practices, PFR had highest median score of 4. Children (71%) and mothers (54%) ate breakfast at home; however, fathers mainly had breakfast while travelling to work or at work (80%). The proportion of this pilot study's participants consuming fruit and vegetables on a daily basis was generally low. The children consumed only 29% and 8% of the food as fruit or vegetables, respectively. The mothers consumed 15% and 69% of the food as fruit or vegetables, respectively. The fathers consumed 20% of food as vegetables and no fruits. Daily snacking was reported to be uncommon for half of the children and all of the parents in this sample. Less than one serve daily of sweetened beverages was reported by 36% of children, 60% of fathers and 46% of mothers. Two-thirds of the families reported consuming Western-style fast food one to four times a month. Half of the children reported watching television for two to three hours daily while a majority of the parents reported watching less than one hour (60% fathers and 62% mothers).

As a result of the pilot study and feedback from the participants: the number of 24-hour DRs was reduced from three to two (one on the weekdays and one on the weekends) to reduce participant burden; the workplace was included as an alternative to home for main caregiver(s) as a venue for assessment; and the use of telephone was offered as an option for the follow-up DR interview. These changes aimed to promote participation and increase participants' adherence to the protocol while reducing their burden. The prevalence of breakfast skipping observed in the children in the pilot study was found to be lower than published estimates (14%), hence the sample size was reduced from 311 to 200 families (5% margin of error and 95% confidence level) for the main study.

Table 5-1: Pilot participants' anthropometry, socio-demographic and family food attainment characteristics

		Child (n=14)	Father (n=5)	Mother (n=13)	Others (n=0)
Anthropometry		**Mean (SD)**			
Age (year)		10.4 (0.6)	45.4 (6.1)	40.0 (5.5)	NA
Birth Weight (kg)		3.2 (0.5)	NA	NA	
Body Weight (kg)		37.0 (14.0)	76.5 (4.3)	67.3 (15.4)	
Height (cm)		136.9 (7.9)	167.0 (7.6)	156.2 (5.5)	
Body Mass Index (kg/m^2)		19.4 (6.2)	27.5 (2.1)	27.7 (6.8)	
Body Mass Index z-score		0.4 (2.2)	NA	NA	
Waist circumference (cm)		66.6 (16.4)	95.3 (1.5)	82.8 (12.8)	
Body Fat (%)		27.8 (9.1)	28.4 (3.1)	36.7 (6.0)	
Socio-demographic		**n (%)**			
Employment Status	Full-time	NA	10 (83.3)	10 (71.4)	NA
	Self-employed		1 (8.3)	3 (21.4)	
	Others		1 (8.3)	1 (7.1)	
Highest Education Level	Secondary	NA	4 (33.3)	7 (50.0)	NA
	College/University		8 (66.7)	7 (50.0)	
Family size					
5 or less		7 (50.0)			
6		5 (35.7)			
7 and above		2 (14.3)			
Family income					
< RM3500		5 (35.7)			
RM3501 – RM5000		2 (14.3)			
RM5001 and above		7 (50.0)			
Pocket money provided to child					
<RM9.99		3 (21.4)			
RM10.00 – RM14.99		6 (42.9)			
RM20 and above		5 (35.7)			
Family food attainment and living condition related to food habits					
Main shopping location					
Wet market		9 (64.3)			
Supermarket		5 (35.7)			
Hypermarket		10 (71.4)			
		Child	**Father**	**Mother**	**Others**
Main food purchaser		NA	4 (33.3)	12 (66.7)	0
Main food preparer		NA	1 (8.3)	13 (92.9)	1 (8)
Main child mealtime supervisor		NA	3 (25.0)	13 (92.9)	0
Family mealtime together					
Never		1 (7.1)			
1 - 2 times		2 (14.3)			
6 – 7 times		11 (78.6)			

NA=Not Applicable

Table 5-2: Pilot participants' dietary intake, child feeding practices, food habits and physical activity characteristics

	Child (n=14)	Father (n=5)	Mother (n=13)
Energy & Macronutrients		**Median (IQR)**	
Energy (kcal)	1531 (996)	1959 (186)	1566 (746)
Carbohydrate (g)	238.2 (91.1)	256.2 (32.3)	212.3 (129.0)
Protein (g)	67.6 (27.7)	72.9 (19.4)	54.1 (32.7)
Fat (g)	48.4 (32.4)	76.0 (9.5)	53.8 (18.1)
Child Feeding Practices Scores		**Median (IQR)**	
Perceived feeding responsibility	4.0 (1.4)		
Perceived parental overweight	3.0 (0.5)		
Perceived child overweight	3.0 (0.8)		
Concern child overweight	3.2 (1.0)		
Restriction	3.9 (0.5)		
Pressure to eat	3.9 (1.0)		
Monitoring	3.9 (2.0)		
Specific food habits		**n (%)**	
Vitamin and mineral supplements			
Yes	10 (71.4)	2 (40.0)	6 (46.2)
No	4 (28.6)	3 (60.0)	7 (53.9)
Location of breakfast			
At home	10 (71.4)	1 (20.0)	7 (53.9)
At school/ On the way to work/ at work	2 (14.3)	4 (80.0)	3 (23.1)
Don't eat breakfast	2 (14.3)	0	1 (7.7)
Others	0	0	2 (15.4)
Amount of fruits consumed			
None/ less than 1 per week	3 (21.4)	1 (20.0)	1 (7.7)
1 to 6 per week	7 (50.0)	4 (80.0)	10 (76.9)
Once to 3 per day	4 (28.6)	0	2 (15.4)
Frequency of vegetables consumed at dinner			
Never	3 (23.1)	0	1 (7.7)
1 to 4 per week	9 (69.2)	4 (80.0)	3 (23.1)
5 or more per week	1 (7.7)	1 (20.0)	9 (69.2)
Frequency of dairy products consumed			
Never/ less than 1 per month	2 (14.3)	2 (40.0)	5 (38.5)
1 per week or less	2 (14.3)	2 (40.0)	3 (23.1)
2 to 6 per week	3 (21.4)	1 (20.0)	1 (7.7)
1 to 6 per day	7 (50.0)	0	4 (30.8)
Frequency of sweetened beverages consumed			
Less than 1 per day	5 (35.7)	3 (60.0)	6 (46.2)
1 to 3 per day	8 (57.1)	2 (40.0)	5 (38.5)
4 or more per day	1 (7.1)	0	2 (15.4)
Frequency of eating dinner in front of TV			
Never/ less than once a week	4 (28.6)	3 (60.0)	6 (46.2)
1 to 4 per week	8 (57.2)	2 (40.0)	4 (30.8)
5 to 7 per week	2 (14.3)	0	3 (23.1)
Frequency of snacking			
Less than once per day	7 (50.0)	5 (100.0)	13 (100.0)
1 to 2 per day	6 (42.9)	0	0
3 to 4 per day	1 (7.1)	0	0
Frequency of eating out			
Never/ less than once a week	0	2 (40.0)	4 (30.8)
1 to 6 per week	13 (92.9)	3 (60.0)	9 (69.2)
1 or more per day	1 (7.1)	0	0
Frequency of Western fast food consumed			
Never/ less than once a month	2 (14.3)	2 (40.0)	3 (23.1)
1 to 4 per month	10 (71.4)	3 (60.0)	8 (61.5)
1 to 6 per week	2 (14.3)	0	2 (15.4)
Physical Activity			
Duration of watching TV			
0 to 1 hour per day	5 (35.7)	3 (60.0)	8 (61.5)
2 to 3 hours per day	7 (50.0)	2 (40.0)	4 (30.8)
4 to 5 hours per day	2 (14.3)	0	1 (7.7)
Frequency playing computer/video games			
Never/ Less than once a week	3 (21.4)	0	7 (53.8)
1 to 2 per week	6 (42.9)	2 (40.0)	3 (23.1)
3 to 7 per week	5 (35.7)	3 (60.0)	3 (23.1)

NA=Not Applicable

5.4 Discussion

The rationale and methodology behind the Family Diet Study in Malaysia have been described in detail. A literature search showed that this is the first research study exploring weight, diet and lifestyle factors affecting Malay primary school children and their caregiver(s) within the context of family using the same study measures for dietary intake, physical activity and body weight status. The experience and processes involved will benefit future studies in the area of childhood obesity, particularly those conducted in the Asian region.

In Malaysia, there are limited data assessing children and adolescents' dietary intake patterns compared to those available for adults. There are few published studies from developing Asian countries investigating childhood obesity and its causative factors[7] with few valid and reliable dietary assessment tools and limited reporting of children's dietary intake.[40] While it is difficult to assess children's diet accurately,[172] the degree of mis-reporting of energy intake among Malaysian children has rarely been investigated.[82] To select the most appropriate dietary assessment tool for study participants,[281] the ultimate goal is to choose a method suitable for the study design and which is able to evaluate the outcome of interest with maximum validity. Despite limitations, the 24-hour DR method has been found to be an adequate method for measuring dietary intake when compared to the gold standard of DLW.[282] Further, it addresses the local concerns associated with administration such as participant burden and resource constraint. Reducing DRs to two days in the current study should still be sufficient to allow for estimating the true distribution of the sample's mean intake for energy and macronutrients.[371]

The preliminary findings of Malay children and their parents' body weight status show that the majority in this small urban sample were either overweight or obese, consistent with other results amongst Malaysian populations.[9, 372] Low fruit and vegetable intake amongst the children were similar or lower than rates in other studies.[373] However, the lack of snacking reported by these children is inconsistent with a previous local study reporting 10-year olds snacked frequently.[46]

5.4.1 Strengths and limitations

The pilot study demonstrated that the study protocol was feasible in terms of recruitment and measurements in the Malaysian setting despite the limited ability to investigate and extrapolate the pilot results statistically due to small sample size. The processes learnt have allowed for appropriate adjustments to optimise participation and accuracy before the main trial. Clear documentation and standardised measures were used for all study participants while quality assurance steps throughout the study enhanced the quality of data collection. Although the main study is cross-sectional and therefore, unable to test causal relationships, it will provide important data on the associations of diet and lifestyle factors with body weight status. Limitations include measurement bias due to self-reported food habits, physical activity and feeding practices, however, standardised protocols allow for verification of responses when required.

5.5 Conclusion

The Family Diet Study will be the first to identify factors associated with Malay child weight status, including weight of caregivers, dietary intake, parenting style, physical activity and lifestyle pattern within the context of the family. The results will inform intervention research adapted to the local environment in addressing childhood obesity.

Chapter 6 Methods Paper 2: Prevalence of energy intake mis-reporting in Malay children

This chapter was published in 2014.

Yang WY, Burrows T, Collins CE, MacDonald-Wicks L, Williams LT, Chee WSS. Prevalence of energy intake mis-reporting in Malay children varies based on application of different cut-points. Journal of Tropical Pediatrics. 2014;60(6):472-475.

The work presented in the manuscript was completed in collaboration with the co-authors (Appendix 6.0). Permission to reproduce the published manuscript has been granted by the publishers.

6.1 Background

Accurate dietary reporting is important both at individual and population levels when investigating relationships between dietary intake and health status.[154, 275] Assessing children's dietary intake is particularly challenging due to age-related abilitiy to self-report,[172, 275, 276, 293] whether parents are reasonable or accurate proxies and other factors.[283, 289]

Dietary mis-reporting undermines the validity of reported energy intakes,[304] and could attenuate results evaluating diet and weight status relationships, increasing the risk of a type two error when assessing effectiveness of dietary intervention programmes. Although under-reporting is commonly reported,[88, 304] over-reporting is less often evaluated but could potentially be more prevalent amongst children.[293]

In the absence of direct measures of total EE such as doubly labelled water, cut-points can be used to identify mis-reporters.[283] While there are no international standards, Goldberg equations,[88, 89] Torun cut-point[90] and Black & Cole[91] methods are commonly used.

The degree of energy mis-reporting among Malaysian children has rarely been investigated. The aim of this paper was to identify the prevalence of energy mis-reporting amongst a sample of Malay children by applying commonly used cut-points.

6.2 Subjects and Methods

6.2.1 Study population

Participants were children aged 9 -11 years recruited from a national primary school in *Kuala Lumpur*, whose families provided written informed consent. Inclusion criteria were Malay family with main carer(s) living full time with their child who had no concurrent medical conditions. Approval was obtained from the ethics committees of University of Newcastle and International Medical University, Malaysia.

6.2.2 Measurements

6.2.2.1 Dietary intake

Participants were interviewed at home or school between August and September 2013 using repeated 24-hour DRs method on two weekdays and one weekend day. The 24-hour DRs adapted the protocols of USDA's AMPM[281] and the Australian National Nutrition Survey 1995[363] 24-hour DR procedures. Information on foods and beverages consumed the day prior to interview were collected using a five phase approach [281] supported by food photographs and local household measures. The recalls were analysed using Nutritionist Pro™ and nutrient data from the Malaysian Nutrient Composition of Foods (1997) [364] and Singapore Nutrient Composition of Foods databases.[365]

6.2.3 Anthropometric measures

Participants were weighed in light clothing on portable scales (TANITA Corporation Japan). Height was measured with microtoise (SECA Bodymeter 206, Germany). BMI was calculated according to standardised equations and categorised using WHO BMI-for-age Z scores (5 to 19 years old).[103]

6.2.4 Cut-points for energy mis-reporting in children

BMR, was calculated using FAO/WHO/UNU (1985) for children aged 3-18 years [374] and Malaysian-specific (for boys aged 11-15 years and girls aged 10-14 years).[375] Estimated ER was based on FAO/WHO/UNU Expert Consultation on Human Energy Requirement (for 1-18 years).[376] Physical activity level (PAL) factor of 1.55 was applied to BMR and estimated ER equations, in recognition of the exceptionally low physical activity of Malaysian children.[238] Three cut-points (Goldberg equations,[88, 89] Torun cut-point[90] and Black & Cole method[91] were applied (Table 6-1). Dietary outliers[38] and Malaysian RNI for energy[173] also applied.

Table 6-1: Cut-points used to determine energy mis-reporting

Goldberg equation 1991[89]	Torun cut-point[90]	Goldberg equation 2000[88]	Black & Cole method[91]
• Identify under-reporters based on EI: BMR ratio (<1.35) • No longer recommended	• Classifies under, acceptable and over-reporters based on an EI : BMR ratio: • 1 to 5 years: <1.28 (UR), 1.28–1.79 (AR), >1.79 (OR) • 6 to 18 years: • Boys: <1.39 (UR), 1.39–2.24 (AR), >2.24 (OR) • Girls: <1.30 (UR), 1.30–2.10 (AR), > 2.10 (OR)	• Classifies under, acceptable and over-reporters • Cut offs values are the confidence limit of agreement between EI:BMR and PAL [95% CL = PAL x exp(±2 x S/100)/√n]	• Cut-points based on 95% confidence limits of agreement between EI and total EE measured by doubly labelled water • Classifies under, acceptable and over-reporters based on EI: estimated EE ratio of <0.76 (UR), 0.76 - 1.24 (AR), > 1.24 (OR)

AR: Acceptable-reporter, BMR: Basal Metabolic Rate, CL: Confidence limit, EE: Energy expenditure, EI: Energy intake, OR: Over-reporter, PAL: Physical Activity Level, UR: Under-reporter

6.2.5 Statistical analysis

Statistical analyses were conducted using STATA version 11.2. As data were not normally distributed, Wilcoxon rank sum tests were used to test sex differences and Fisher's exact test was used to test differences in proportions across categories of energy intake reporting.

6.3 Results

Fourteen families completed data for all measures. Descriptive characteristics of the 14 children are shown in Table 6-2. No between-sex differences were observed for age, anthropometric measures or energy intake (P>0.05). Energy mis-reporting was prevalent in 11 (78.4%) of 14 children (Table 6-3). Seven to eight children under-reported compared to four or fewer over-reporters, and mis-reporting was independent of body weight status. Nine participants were classified into the same category of energy reporting for all three cut-points. Use of newer methods [88, 91] resulted in a higher proportion of over-reporters (up to 28.5%). No outliers in energy intake were found in this small sample. Nine children (64%) did not meet the RNI for energy while four children exceeded it.

Table 6-2: Participant characteristics (n=14), Median (IQR)

Variable	Boys (n=8)	Girls (n=6)
Age (years)	10.0 (9.8, 11.4)	10.3 (10.2, 10.5)
Weight (kg)	36.0 (26.4, 45.8)	36.9 (22.7, 38.0)
Height (cm)	134.6 (131.0, 144.2)	136.8 (128.5, 145.1)
Energy (kcal/day)	1531 (1141, 2038)	1558 (988, 2117)
BMI (kg/m^2)	19.1 (14.1, 25.3)	18.4 (13.7, 20.9)
BMI Category:		
Severe thinness	0	0
Thinness	1	1
Normal	3	3
Overweight	1	1
Obese	3	1

Table 6-3: Energy mis-reporting classification using various cut-points (n=14)

Classification of Mis-reporting	Different combination of BMR predictive equations and cut-points								
	BMR (WHO1985) [374] & Goldberg 1991[89]	BMR (MAL)[375] & Goldberg 1991[89]	BMR (WHO1985)[374] & Torun[90]	BMR (MAL)[375] & Torun[90]	BMR (WHO1985)[374] & Black and Cole[a][91]	BMR (MAL)[375] & Black and Cole[a][91]	BMR (WHO1985)[374] & Goldberg 2000[a][88]	BMR (MAL) [375] & Goldberg 2000[a][88]	EEE (WHO2005)[376] & Black and Cole[a][91]
Under-reporters	8 (57.0%)	7 (50.0%)	8 (57.0%)	7 (50.0%)	8 (57.0%)	7 (50.0%)	8 (57.0%)	7 (50.0%)	7 (50.0%)
Acceptable reporters	6 (43.0%)	7 (50.0%)	5 (36.0%)	6 (43.0%)	3 (21.5%)	4 (28.5%)	3 (21.5%)	3 (21.5%)	5 (36.0%)
Over-reporters	NA	NA	1 (7.0%)	1 (7.0%)	3 (21.5%)	3 (21.5 %)	3 (21.5%)	4 (28.5%)	2 (14.0%)

BMR: Basal Metabolic Rate, WHO: World Health Organisation, MAL: Malaysian-specific, EEE: Estimated Energy Requirement, NA: Not Applicable

[a]Physical activity level (PAL) factor of 1.55

6.4 Discussion

This paper is the first to report the prevalence of energy mis-reporting in Malaysian children according to different cut-points. Both under- and over-reporting were more prevalent than in other children dietary studies.[306, 307]

More over-reporters were identified when physical activity level or energy expenditure was included in the analysis. Mis-reporting was increased by using Goldberg[9] and Black & Cole,[12] specifically the upper confidence limit. The inclusion of measures of energy output factors accounts for physiological variability within the population under study, increasing the validity of the cut-point method.

Knowledge of population-specific BMR is valuable when applying cut-points to avoid misclassification. In this study, fewer under-reporters were identified using Malaysian BMR classifications, partly due to overestimation of BMR using the FAO/WHO/UNU (1985) predictive equations.[375]

Unsurprisingly given the proportion of under-reporters, the majority of the children's energy intakes were below the RNI, which was based on the FAO/WHO/UNU method of estimating energy requirements for Malaysian children and adolescents. [173]

6.5 Conclusion

Energy mis-reporting, particularly under-reporting, is common amongst Malay children and varies with cut-point applied. Objective evaluation of total EE using doubly labelled water would help identify which cut-points method is most accurate in the Malay paediatric population.

Chapter 7 Results Paper 1: Children's dietary pattern and association with body weight status

This chapter is submitted for review as a paper to Asia Pacific Journal of Public Health in March 2016.

Yang WY, Burrows T, MacDonald-Wicks L, Williams LT, Collins CE, Chee WSS. Dietary energy intake is associated with body mass index amongst plausible energy reporters in urban Malay children: evidence from The Family Diet Study. Under review. Asia Pacific Journal of Public Health. Submitted 27th March 2016.

The work presented in the manuscript was completed in collaboration with the co-authors (Appendix 7.0).

7.1 Introduction

Malaysia is a developing Asian country which is experiencing the worldwide trend of increasing prevalence of childhood obesity.[1] A nationwide study published in 2013 found approximately 34.5% of urban primary school-aged children were either overweight or obese,[9] consistent with data in developed countries.[1] Although no significant ethnic differences have been reported, the magnitude of child obesity may be greater for Malay children based on their substantial proportion within the Malaysian population [67.4% Malay versus (vs.) 32.6% others].[10]

Diet is an important contributor to energy imbalance and specific eating patterns including increased consumption of sweetened beverages, candies and processed meats have been shown to be associated with overweight status amongst children in the United States.[35] Although little published research has been reported on the dietary intake-obesity relationship within developing Asian countries, a systematic review found the associations between diet and childhood obesity to be inconclusive, primarily due to a lack of studies and methodological issues.[7]

Over the past two decades, Malaysia has undergone rapid nutrition and lifestyle transition, characterised by a shift away from high energy activities of daily living to a sedentary lifestyle, and from a traditional grain-based diet to one high in animal products, oils and fats.[22] The few dietary studies of Malaysian children reported on selective dietary profile either of nutrient intakes; food habits, or individual dietary practices.[9, 41, 49] This limits the ability to ascertain the link between diet and body weight status despite the rising prevalence of childhood obesity. Importantly, accurate assessment of the children's dietary intake is a difficult task[307] and energy mis-reporting among Malay children has been shown to be common.[82] The aim of the current paper is to describe the dietary intake of primary school-aged Malay children in comparison to national recommendations and by body weight status.

7.2 Methods

7.2.1 Study design and participants

The Family Diet Study used a cross-sectional design and was conducted from August 2013-October 2014 in the urbanized areas, central of Peninsular Malaysia [*Kuala Lumpur* (100% urbanisation) and *Selangor* (91.4% urbanisation)].[10] The full study methodology is detailed elsewhere.[81] Approval was obtained from the ethics committees of University of Newcastle, Australia (H-2013-0065) and International Medical University, Malaysia (IMU 275/2013). The Malaysian education ministry and departments gave permission to contact selected schools. Multi-stage sampling was used for recruitment, including convenience, simple random and cluster sampling. Using the pilot study data on prevalence of skipping breakfast (14%) and the EPI-info™ version 5.0 statistical package, the study sample size required was estimated to be 220 participants (5% margin of error and 95% confidence level). This variable was chosen as it was included in this study's questionnaire on food habits.

Interested families provided informed written consent with child assent and were screened for eligibility based on study inclusion/exclusion criteria. Study participants included Malay families with one or two main carer(s) living full time with a child in 8 to 12 year age range. Exclusion criteria included children with known medical conditions that could influence body weight, metabolic rate or appetite, including asthma, Type 1 diabetes or use of medications associated with weight change such as oral steroids.

7.2.2 Measurements

7.2.2.1 Family socio-demographic data

Participating families completed a written survey that collected data on socio-demographics including family size, family monthly total income, weekly pocket money provided to the participating child, parental employment status and highest education level.

7.2.2.2 Anthropometry

Participants were weighed in light clothing on portable scales (TANITA Corporation Japan). Height was measured with microtoise (SECA Bodymeter 206, Germany). All measurements were taken by trained research personnel. BMI was calculated and categorised using WHO, BMI-for-age Z score (5 to 19 years old)[104] while the BMI z-score were calculated using WHO AnthroPlus software version 1.0.4 (WHO, Geneva, Switzerland).[370]

7.2.2.3 Dietary intakes measurement and assessment

Dietary intake data was collected using interviewer-administered 24-hour recalls (one weekday and one weekend) based on a five pass method.[281, 363] The dietary data was supplemented with a FHQ adapted from the supplementary section of an Australian food frequency questionnaire with permission (CEC).[366] This questionnaire collected information on frequency of general food group intakes, dietary habits and sedentary behaviours. The FHQ had 13-items (children) and 12-items (main caregiver excluding question on pocket money provided), and was translated into the Malay language with local food terms verified by an independent linguistic department.

The individual mean daily nutrient intakes were derived from the 24-hour recall data and analysed using Nutritionist Pro™ Diet Analysis (Axxya Systems, Washington, United States of America) utilizing the Malaysian Nutrient Composition of Foods (1997)[364] and complemented by the Food Composition Guide Singapore (shares similar food with Malaysia).[365] Additional recipes and nutrient content or supplement information were collected and entered into the database software.

The nutrient intake values were compared with the age-relevant RNI for Malaysia.[173] While the variable on energy intake adjusted for body weight was added, the Black and Cole method[91] was applied to identify energy mis-reporting. BMR was calculated using the only Malaysian-specific equation for children[375] while a physical activity level factor of 1.55 was used to estimate TEE. Classification of energy reporting was based on the ratio of reported energy intake to TEE [<0.76 (under-reporter), 0.76 - 1.24 (plausible), >1.24 (over-reporter)].[91]

Foods obtained from recalls were first divided into six major food groups and nine sub-groups. Mixed dishes were assigned a major food group based on primary ingredients e.g. fried rice into 'Cereals/tubers/grains'. Foods with no single food type accounting for at least 60% by weight were classified as a mixed food. Ten food groups based on the Malaysian Food Pyramid[174] and similarities of the item's physical or preparation characteristics[35] were identified (Appendix 7.1): Cereals; Fruits/vegetables; Meats; Dairy; Sugar-sweetened beverages; Western fast food; Snacks; Sweets; Oils; and Mixed food. The number of servings for the six main food groups was calculated by aggregating the total amounts for each food group and dividing by the standard serving size from the MDG.[174] The number of daily servings consumed was compared to MDG recommendations.[174]

7.2.3 Statistical analysis

Analyses were carried out using STATA version 11.2 (StataCorp, Texas, United States of America). Descriptive statistics were applied to socio-demographic, anthropometry and dietary intake data. Normality checking found data distributions to be either normally distributed or skewed to the right. Parametric and non-parametric tests were used respectively for comparisons by gender, national recommendations and body weight categories. Dietary intakes were tested for associations with BMI z-score for whole sample and plausible energy reporters using chi-squared tests and Pearson/Spearman correlation tests based on normality. Dietary variables with the highest adjusted coefficient of determination, R^2 and value $P<0.05$ from the univariate regressions were retained for subsequent multivariate linear regression model building using a forward stepwise approach. Age and gender were included to control for potential confounders.

7.3 Results

7.3.1 Study participants

A total of 1372 invitations were sent across five schools. Of the 793 invitations returned, 53% provided parental consent and child assent. After eligibility screening, 315 participants were enrolled into the study; of these, 236 participants completed all measures and were eligible for analysis (74% response rate).

7.3.2 Family socio-demographic

Socio-demographic data are shown in Table 7-1. Approximately half were female (52.5%) with the majority of family dyads being child-mother (n=182). Mean (95% CI) child age was 9.9 (9.8, 10.0) years. A large proportions of parents worked full-time (76.9% fathers and 49.4% mothers) while a third of mothers were housewives. Ninety percent of parents had attained at least secondary level education, and most had at least five family members living together (79.3%). Two-thirds of the families reported monthly income above MYR2500 (estimated USD705), indicative of low socio-economic status.[10]

7.3.3 Anthropometry

Mean (95% CI) body weight and height for children was 32.3 (31.0 - 34.6)kg and 133.2 (132.2 - 134.2)cm respectively (Table 7-1). Using the WHO 2007 BMI-for-age,[104] 60.2% of the children were classified as normal weight, 13.1% overweight, 16.5% obese, and 10.2% in the thinness/severe thinness category. Similar distributions were observed for both genders.

Table 7-1: Socio-demographic and anthropometric characteristics of participants in The Family Diet Study

Socio-demographic	All Children (N=236)		Boys (n=112)		Girls (n=124)	
			n (%)			
Family size						
3	10 (4.2)		4 (4)		6 (5)	
4	39 (16.5)		20 (18)		19 (15)	
5	73 (30.9)		42 (3)		31 (25)	
6	53 (22.5)		20 (18)		33 (27)	
7 and above	61 (25.9)		26 (23)		35 (28)	
Family monthly total income						
< MYR1500	34 (14.4)		16 (14)		18 (15)	
MYR1501 – MYR2500	59 (25.0)		23 (21)		36 (29)	
MYR2501 – MYR3500	35 (14.8)		14 (13)		21 (17)	
MYR3501 – MYR5000	43 (18.2)		22 (20)		21 (17)	
MYR5001 and above	65 (27.5)		37 (33)		28 (23)	
Weekly pocket money provided to child						
<MYR5.00	9 (3.8)		6 (5)		3 (2)	
MYR 5.01 – MYR9.99	16 (6.8)		5 (5)		11 (9)	
MYR 10.00 – MYR14.99	46 (19.5)		19 (17)		27 (22)	
MYR 15.00 – MYR19.99	61 (25.9)		29 (26)		32 (26)	
MYR 20.00 and above	104 (44.1)		53 (47)		51 (41)	
	Fathers	**Mothers**	**Fathers**	**Mothers**	**Fathers**	**Mothers**
Parental Employment Status						
Part-time	8 (3.6)	14 (6.0)	6 (6)	5 (5)	2 (2)	9 (7)
Full-time	173 (76.9)	115 (49.4)	78 (74)	59 (54)	95 (80)	56 (45)
Self-employed	42 (18.7)	32 (13.7)	21 (20)	14 (13)	21 (18)	18 (15)
Pensioner	2 (0.9)	0	1 (1)	0	1 (1)	0
Housewife	0	72 (30.9)	0	31 (28)	0	41 (33)
Parental Highest Education Level						
No formal education	5 (2.2)	4 (1.7)	3 (3)	2 (2)	2 (2)	2 (2)
Primary	19 (8.4)	19 (8.2)	7 (7)	9 (8)	12 (10)	10 (8)
Secondary	119 (52.7)	124 (53.5)	52 (49)	49 (45)	67 (56)	75 (61)
College/University	83 (36.7)	85 (36.6)	45 (42)	49 (45)	38 (32)	36 (29)

Socio-demographic	All Children (N=236)	Boys (n=112)	Girls (n=124)
Anthropometry		**Mean (95% CI)**	
Age (year)	9.9 (9.8-10.0)	9.8 (9.7-10.0)	9.9 (9.8-10.1)
Body Weight (kg)	32.3 (31.0-34.6)	32.0 (30.2-33.8)	32.6 (30.6-34.6)
Height (cm)	133.2 (132.2-134.2)	132.7 (131.3-134.2)	133.5 (132.2-134.9)
Body Mass Index (kg/m^2)	17.9 (17.4-18.5)	17.9 (17.2-18.6)	18.0 (17.1-18.9)
BMI z-score	0.20 (-0.01-0.42)	0.34 (0.03-0.64)	0.08 (-0.22-0.39)
		n (%)	
BMI classification			
z < -3SD (Severe thinness)	3 (1.3)	1 (1)	2 (2)
-3SD < z < -2SD (Thinness)	21 (8.9)	7 (6)	14 (11)
-2 SD < z < +1SD (Normal weight)	142 (60.2)	70 (63)	72 (58)
+1SD < z < +2SD (Overweight)	31 (13.1)	16 (14)	15 (12)
z > +2 SD (Obesity)	39 (16.5)	18 (16)	21 (17)

MYR: Malaysian Ringgit, SD: Standard Deviation; IQR: Inter-quartile Range; CI: Confidence Interval

7.3.4 Dietary intakes

Table 7-2 summarizes child dietary intakes in comparison with two reference standards: RNI[173] and MDG.[174] Mean energy intake for girls under 10 years of age was significantly higher than the RNI (1803kcal vs. 1590kcal, *P*=0.0041). For children 10-12 years of age, only 7.4% of boys and 18.6% of girls met the RNI for energy of 2180kcal and 1990kcal, respectively. The RNI for protein was met by the majority of the children of different age range and gender (73% to 98%). Within each sub-group, a large proportion of children did not meet the RNI for micronutrients; thiamin (75.4%-96.3%), niacin (75.4%-94.9%) and calcium (83.1%-100%). While the recommended number of servings for 'Meat/poultry/fish' group was met, other food groups were well below the national recommended intakes (*P*<0.001) (refer Table 7-2).

Approximately one-third of the children were classified as energy mis-reporters with 141 reporting plausible intakes.[91] Significantly more overweight or obese children than underweight children were identified as under-reporters (57.4% vs. 5.6%). There were significantly more over-reporters amongst the underweight children than other weight categories (22.0% vs. 4.9%) (χ^2=35.46, *P*<0.001) (Appendix 7.2). Home was the main venue for breakfast (77.8%), with 6.5% of children reporting skipping breakfast and no significant difference by gender or body weight status. The mean (95% CI) energy, carbohydrate, protein and fat intake per day were 1698(1637 - 1759)kcal, 229(220 -238)g, 65(62-67)g and 58(56-61)g, respectively. Girls had significantly higher intakes of Vitamin C and calcium compared to boys (36.1mg vs. 24.8mg, *P*=0.007; 411.7mg vs. 349.9mg, *P*=0.007, respectively). The majority of the children were reported to not have fruits, legumes and dairy every day, and girls reported higher intakes of condiments (*P*=0.03), mixed food (*P*=0.015), and pastries and dessert (*P*<0.001) than boys (Appendix 7.3).

Table 7-2: Comparing dietary intake with Malaysian Recommended Nutrient Intake and Malaysian Dietary Guidelines Recommended Serving Sizes

Gender	Age	Nutrient	Mean (95% CI)	% RNI	< RNI, No. (%)	RNI	Food Groups	Mean (95% CI)	% RNI	< RSS, No. (%)	RSS
Boys (n=112)	8.0 to 9.9 years (n=58)	Energy (kcal)	1639 (1536-1742)*	92	39 (67)**	1780	Cereals/tubers/ grains	4.0 (3.6-4.4)*	81	47 (81)	5
		Protein (g)	64 (58-70)*	200	6 (10)	32	Fruits	0.3 (0.2-0.4)*	16	57 (98)	2
		Thiamin (mg)	0.7 (0.6-0.8)*	75	46 (79)	0.9	Vegetables	0.4 (0.2-0.6)*	12	58 (100)	3
		Riboflavin (mg)	1.0 (0.9-1.1)	111	28 (48)**	0.9	Meat/poultry/fish	2.3 (1.9-2.7)	116	27 (47)	2
		Niacin (mg)	8 (7-9)*	68	46 (79)	12	Legumes	0.06 (0.02-0.10)*	37	58 (100)	1
		Vitamin C (mg)	39 (27-51)	111	38 (65)**	35	Milk and dairy products	0.2 (0.1-0.3)*	11	58 (100)	2
		Vitamin A (µg)	599 (522-676)*	120	25 (43)	500					
		Iron (mg)	14 (12-16)*	156	14 (24)	9					
		Calcium (mg)	423 (367-479)*	61	51 (88)	700					
	10.0 to 12.0 years (n=54)	Energy (kcal)	1667 (1556-1778)*	77	50 (93)**	2180	Cereals/tubers/ grains	4.0 (3.6-4.4)*	57	51 (94)	7
		Protein (g)	63 (57-69)*	141	12 (22)	45	Fruits	0.2 (0.1-0.3)*	10	54 (100)	2
		Thiamin (mg)	0.6 (0.5-0.7)*	50	52 (96)	1.2	Vegetables	0.5 (0.2-0.8)*	17	52 (96)	3
		Riboflavin (mg)	0.9 (0.8-1.0)*	66	49 (91)**	1.3	Meat/poultry/fish	2.3 (2.0-2.6)	90	32 (59)	2.5
		Niacin (mg)	8 (7-9)*	49	50 (93)	16	Legumes	0.20 (-0.002-0.4)*	50	51 (94)	1
		Vitamin C (mg)	44 (30-58)*	68	42 (78)**	65	Milk and dairy products	0.08 (0.02-0.13)*	4	54 (100)	2
		Vitamin A (µg)	612 (511-713)	102	34 (63)	600					
		Iron (mg)	15 (13-17)	99	34 (63)	15					
		Calcium (mg)	358 (306-410)*	36	54 (100)	1000					

RNI: Recommended Nutrient Intake; RSS: Recommended Serving Size; *Significant difference (Z-test comparison with RNI/ RSS); **Significant difference (Pearson Chi-squared test by gender for intake below RNI/ RSS)

Gender	Age	Nutrient	Mean (95% CI)	% RNI	< RNI, No. (%)	RNI	Food Groups	Mean (95% CI)	% RNI	< RSS, No. (%)	RSS
Girls (n=124)	8.0 to 9.9 years (n=65)	Energy (kcal)	1803 (1660-1946)*	113	25 (39)**	1590	Cereals/tubers/ grains	3.9 (3.6-4.3)*	78	51 (79)	5
		Protein (g)	69 (64-74)*	216	1 (2)	32	Fruits	0.4 (0.2-0.6)*	21	64 (99)	2
		Thiamin (mg)	0.7 (0.6-0.8)*	83	49 (75)	0.9	Vegetables	0.5 (0.3-0.7)*	16	63 (97)	3
		Riboflavin (mg)	1.1 (1.0-1.2)*	118	31 (48)**	0.9	Meat/poultry/fish	2.4 (2.1-2.7)*	120	27 (42)	2
		Niacin (mg)	9 (8-10)	78	49 (75)	12	Legumes	0.06 (0.01-0.10)*	98	63 (97)	0.5
		Vitamin C (mg)	59 (46-72)*	168	27 (42)**	35	Milk and dairy products	0.33 (0.19-0.47)*	17	63 (97)	2
		Vitamin A (µg)	663 (559-767)*	133	29 (45)	500					
		Iron (mg)	14 (12-16)*	158	14 (22)	9					
		Calcium (mg)	496 (424-568)*	71	54 (83)	700					
	10.0 to 12.0 years (n=59)	Energy (kcal)	1669 (1540-1798)*	84	48 (81)**	1990	Cereals/tubers/ grains	4.0 (3.6, 4.4)*	60.0	58 (98)	6
		Protein (g)	61 (55-67)*	132	16 (27)	46	Fruits	0.3 (0.2, 0.4)*	14.1	58 (98)	2
		Thiamin (mg)	0.6 (0.5-0.7)*	56	55 (93)	1.1	Vegetables	0.4 (0.2, 0.6)*	14.8	59 (100)	3
		Riboflavin (mg)	0.9 (0.9-1.3)*	91	35 (59)**	1.0	Meat/poultry/fish	1.9 (1.6, 2.2)	95.4	34 (58)	2
		Niacin (mg)	8 (7-9)*	48	56 (95)	16	Legumes	0.14 (0.03, 0.25)*	44.5	58 (98)	1
		Vitamin C (mg)	66 (42-90)	101	43 (73)**	65	Milk and dairy products	0.21 (0.09, 0.33)*	10.4	58 (98)	2
		Vitamin A (µg)	705 (480-930)	118	40 (68)	600					
		Iron (mg)	13 (11-15)	96	35 (59)	14					
		Calcium (mg)	454 (393-515)*	45	58 (98)	1000					

RNI: Recommended Nutrient Intake; RSS: Recommended Serving Size; *Significant difference (Z-test comparison with RNI/ RSS); **Significant difference (Pearson Chi-squared test by gender for intake below RNI/ RSS)

7.3.5 Body weight status and dietary intakes

For the whole sample, obese children reported significantly lower energy intakes compared to other weight categories when energy intake was adjusted for body weight (kcal/kg) (F=36.21, *P*<0.001), and they reported consuming more 'Cereals' and less 'Sugar sweetened beverages' (grams) compared to normal weight children (F=2.74, *P*=0.029; F=11.04, *P*=0.012, respectively). There were no other significant differences between dietary intakes and BMI categories (Table 3). When examining BMI z-score (Table 7-3), there were three positive relationships with intake of Vitamin A (*r*=0.20, *P*=0.002), iron (*r*=0.13, *P*=0.044) and the 'Cereals' groups (*r*=0.14, *P*=0.034). Children's reported energy intake adjusted for body weight was moderately strong and inversely correlated with BMI z-score (*r*=-0.60, *P*<0.001).

In the sub-group analysis of plausible energy reporters (n=141), significant differences were found between BMI categories and dietary intakes for energy, all macronutrients and some micronutrients (Table 7-3). BMI z-score was significantly associated with energy intake (*r*=0.53), macronutrients [carbohydrate (*r*=0.39), protein (*r*=0.34) and fat (*r*=0.40)], micronutrients [thiamin (*r*=0.25), riboflavin (*r*=0.30), niacin (*r*=0.36), vitamin A (*r*=0.31), iron (*r*=0.37) and calcium (*r*=0.27)]. It was also associated with the food groups of 'Cereals' (*r*=0.23), and 'Meats' (*r*=0.18) groups (Table 7-3). Univariate regression coefficients and their 95% confidence intervals were reported (Table 7-3). Multiple regression analysis indicated that total energy intake (β= 0.0029, *P*<0.001), iron (β= 0.0261, *P*=0.006), energy adjusted for body weight (β= -0.0988, *P*<0.001) and age (β= -0.6598, *P*<0.001) were significant predictors of child's BMI z-score. In the final model, these dietary intakes explained 86.0% of the variation in BMI z-score amongst children with plausible energy reporting.

Table 7-3: Differences in dietary intakes by BMI category and associations between dietary intakes and child's BMI z-score

Nutrients/ Food Groups	ALL CHILDREN (N=236)				PLAUSIBLE REPORTERS (n = 141)			
	BMI category							
	Thinness (n=24)	Normal (n=142)	Overweight (n=31)	Obese (n=39)	Thinness (n=12)	Normal (n=93)	Overweight (n=17)	Obese (n=19)
	Mean (SD)							
Energy (kcal)[a]	1695 (532)	1693 (479)	1623 (434)	1778 (488)	1502 (273)***	1613 (219)***	1873 (262)***	2026 (298)***
Carbohydrate (g)[a]	232.4 (65.1)	226 (71.4)	224.9 (58.3)	240.6 (69.1)	216.3 (45.8)**	213.7 (38.9)**	251.8 (43.3)**	274.2 (48.5)**
Protein (g)[a]	63.6 (25.9)	64.9 (22.4)	60.5 (19.9)	66.4 (25.1)	54.0 (14.7)*	63.2 (18.0)*	71.2 (16.6)	76.8 (19.3)*
Fat (g)[a]	56.2 (23.1)	59.1 (20.6)	53.6 (20.7)	60.8 (21.0)	46.7 (11.8)**	56.3 (12.5)**	64.1 (13.7)**	68.7 (16.0)**
Energy/ body weight (kcal/kg)[a]	78.1 (26.5)***	62.0 (19.8)***	42.3 (12.0)***	36.5 (10.2)***	69.2 (9.2)***	59.0 (10.4)***	49.7 (6.5)***	41.9 (7.8)***
Percent energy from carbohydrate (%)[a]	55.7 (6.1)	53.3 (6.4)	55.9 (6.8)	54.4 (6.3)	57.9 (7.0)*	52.9 (5.7)*	54.0 (4.8)	54.2 (5.8)
Percent energy from protein (%)	14.7 (2.7)	15.4 (3.7)	15.0 (3.0)	14.9 (3.4)	14.3 (3.1)	15.7 (3.6)	15.3 (3.0)	15.3 (3.9)
Percent energy from fat (%)	29.6 (4.8)	31.3 (5.5)	29.1 (6.0)	30.6 (4.6)	27.8 (4.8)	31.4 (5.2)	30.8 (4.6)	30.4 (4.3)
Cereals (g) [a]	413.1 (140.0)	397.7 (161.2)*	405.7 (143.4)	482.2 (199.7)*	412.8 (151.6)	393.0 (152.9)*	449.9 (146.4)	520.9 (245.3)*
	Median (IQR)							
Thiamin (mg)	0.6 (0.3)	0.6 (0.4)	0.6 (0.3)	0.6 (0.3)	0.5 (0.2)	0.6 (0.4)	0.7 (0.3)	0.8 (0.3)
Riboflavin (mg) [b]	0.9 (0.6)	0.8 (0.5)	0.9 (0.6)	1.0 (0.8)	0.8 (0.4)**	0.8 (0.4)**	1.1 (0.4)**	1.3 (0.6)**
Niacin (mg) [b]	7.9 (5.2)	7.3 (6.2)	7.8 (7.7)	7.0 (4.3)	6.0 (2.8)**	7.3 (5.4)	11.3 (5.1)**	9.1 (4.0)
Vitamin C (mg)	45.6 (43.1)	27.5 (52.2)	35.1 (53.5)	26.3 (58.9)	39.0 (31.9)	27.6 (47.5)	53.4 (59.7)	38.1 (78.0)
Vitamin A (µg) [b]	440.3 (349.7)	513.9 (408.9)	508.7 (317.8)	684.3 (516.5)	424.0 (230.0)**	498.3 (342.3)**	533.6 (280.4)	847.3 (613.1)**
Iron (mg) [b]	11.9 (9.4)	11.9 (8.4)	14.2 (7.5)	12.9 (8.7)	10.2 (5.2)	11.7 (7.0)**	15.5 (6.2)	15.7 (8.2)**
Calcium (mg)	346.9 (200.8)	374.7 (304.0)	383.8 (266.6)	376.3 (209.0)	336.6 (138.7)	365.9 (246.3)	452.8 (241.0)	455.8 (306.8)
Fruits/vegetables (g)	54.5 (138.8)	28.5 (97.0)	32.0 (107.5)	66.0 (143.5)	27.8 (91.8)	29.5 (92.0)	35.5 (111.0)	16.0 (209.5)
Meats (g)	113.0 (65.0)	113.5 (119.5)	168.0 (114.0)	115.5 (199.0)	118.3 (47.3)	115.5 (115.0)	176.0 (113.5)	219.0 (215.0)
Dairy (g)	0 (0)	0 (75.0)	0 (10.5)	0 (80.0)	0 (0)	0 (15.8)	0 (12.3)	0 (100.0)
Sugar sweetened beverages (g)	143.0 (155.0)	140.0 (250.0)*	193.0 (250.0)*	48.5 (141.0)*	122.8 (214.0)	133.0 (247.0)	237.5 (220.5)	48.5 (317.0)
Sweets (g)	47.8 (115.3)	62.5 (68.3)	63.0 (83.5)	73.1 (96.2)	40.0 (89.8)	61.5 (60.7)	70.0 (79.5)	77.0 (82.0)
Oils (g)	28.5 (38.3)	20.5 (29.0)	30.0 (35.0)	26.0 (36.5)	22.3 (38.0)	23.0 (26.0)	33.5 (36.0)	27.0 (43.0)
Snack (g)	0.5 (30.5)	4.9 (27.1)	0 (15.3)	0 (21)	1.5 (30.5)	4.9 (21.0)	0 (15.3)	0 (21.0)
Western fast food (g)	0 (0)	0 (24.0)	0 (0)	0 (0)	0 (0)	0 (31.5)	0 (0)	0 (0)
Mixed food (g)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

	ALL CHILDREN (N=236)	PLAUSIBLE REPORTERS (n = 141)	
	BMI Z-score		
	Correlation Coefficient, *r*	Correlation Coefficient, *r*	Regression coefficients[e]
Energy (kcal)	0.04	0.53[c,***]	0.003 (0.002,0.004)***
Carbohydrate (g)	0.01	0.39[c,***]	0.014 (0.008,0.019)***
Protein (g)	0.03	0.34[c,***]	0.029 (0.016, 0.043)***
Fat (g)	-0.04	0.40[c,***]	0.046 (0.028, 0.064)***
Energy/ body weight (kcal/kg)	-0.59[c,***]	-0.68[c,***]	-0.092 (-0.109, -0.075)***
Percent energy from carbohydrate (%)	0.02	-0.08	-0.022 (-0.068, 0.025)
Percent energy from protein (%)	0.04	0.05	0.021 (-0.056, 0.098)
Percent energy from fat (%)	0.05	0.06	0.018 (-0.035, 0.072)
Thiamin (mg)	-0.02	0.25[d,**]	1.240 (0.357, 2.124)*
Riboflavin (mg)	0.03	0.30[d,***]	1.400 (0.736, 2.062)***
Niacin (mg)	0.009	0.36[d,***]	0.130 (0.065, 0.194)***
Vitamin C (mg)	-0.06	0.06	-0.0002 (-0.0041, 0.0037)
Vitamin A (µg)	0.20[d,**]	0.31[d,***]	0.0007 (0.0001, 0.0013)*
Iron (mg)	0.13[d,*]	0.37[d,***]	0.093 (0.053, 0.134)***
Calcium (mg)	0.06	0.27[d,**]	0.002 (0.001, 0.004)**
Cereals (g)	0.14[c,*]	0.23[c,**]	0.002 (0.001, 0.004)**
Fruits/vegetables (g)	0.02	0.005	0.0006 (-0.0021, 0.0033)
Meats (g)	0.07	0.18[d,*]	0.004 (0.001, 0.007)**
Dairy (g)	-0.006	0.06	0.003 (-0.0004, 0.0056)*
Sugar-sweetened beverages (g)	-0.10	-0.004	-0.0003 (-0.0016, 0.0010)
Snacks (g)	-0.13[d,*]	-0.14	-0.004 (-0.014, 0.006)
Western fast food (g)	-0.01	0.005	0.002 (-0.003, 0.008)
Sweets (g)	-0.01	0.11	0.002 (-0.002, 0.006)
Oils (g)	0.08	0.11	0.006 (-0.004, 0.015)
Mixed food (g)	0.02	0.02	-0.003 (-0.015, 0.008)

BMI: Body Mass Index; SD: Standard Deviation; IQR: Inter-quartile Range; [a]ANOVA F-test by body weight status, [b]Kruskal-Wallis by body weight status, [c]Pearson correlation coefficient, [d]Spearman correlation coefficient, [e]Univariate coefficients and 95% confidence intervals, Significant (* $P<0.05$, ** $P<0.01$, *** $P<0.001$)

7.4 Discussion

The current study aimed to comprehensively describe the dietary intake of urban Malay children aged between 8 and 12 years in comparison to national recommendations and by body weight status. The main findings indicate that the majority of the children had dietary intakes below recommendations, despite a prevalence of overweight and obesity of 30%. Clear relationships between dietary intakes and body weight status were found after adjusting for energy mis-reporting. This study extends previous research[9, 45, 180] by comprehensively describing dietary intakes of the children in terms of food groups and macro- and micronutrient profiles and associations with body weight.

Child body weight status showed the coexistence of the dual burden of malnutrition, a common problem in developing countries.[22] A significant percentage of the children were overweight or obese, similar to other studies amongst children in Malaysia[9] and regionally.[1] Despite this, 10% of children were classified as underweight, a figure higher than the 6.4% in the recent nationwide nutrition survey in 2013 (6.4%).[9] The difference in rates can be attributed to the application of different sampling protocol of two population surveys. The findings highlight pockets of under-nutrition among urban communities, which warrants further attention.

The prevalence of breakfast skipping in this sample was lower than that reported in similar age groups locally[45, 46, 49] and internationally.[377] The lack of difference in this food habit is contrary to associations with increasing BMI among children and adolescents observed across different countries.[45, 49, 377] While healthy food choices and breakfast type may play similar importance to the frequency of breakfast consumption, the common Malaysian breakfast choices including fried rice, fried noodles and *nasi lemak* (coconut milk steamed rice with condiments)[46] are high in fat and energy, but low in micronutrients. This could adversely impact the child's nutrient adequacy and diet quality.

Consistent with other Malaysian dietary studies, we found that the majority of children 10-12 years of age did not meet the RNI for energy.[9, 43, 180] Majority of children did not meet key micronutrients (thiamin, niacin and calcium)[9, 43] nor the recommended number of servings for major food groups, except for 'Meats'.[180] The lower than recommended

energy and nutrient intakes reported in this sample are reflected in the median number of servings for the major food groups. Consumption of modified and refined grain products (e.g. fried rice, pastries and desserts) and processed meats (nuggets and sausages) contributed to higher overall intake of protein and 'Meats' and 'Cereals' groups, as well as increased total fat and decreased micronutrients intakes. Previous studies among children in United States have shown that low nutrient-dense foods were major contributors to overweight status.[35]

The large number of energy mis-reporters identified in the current study was consistent with a local study,[180] and their exclusion yielded divergent results on the association between dietary intakes and body weight status. The positive relationship of Malay children's energy intake and BMI z-score conforms to the hypothesised relationship between dietary intake and body weight.[7, 82] The fact that the obese participants in this study reported the lowest energy intake adjusted for body weight compared to children in other weight categories corresponds well to other studies; locally[41] and internationally.[196] While it is difficult to assess the independent effects of energy intake, such observations emphasize the influence of energy mis-reporting and body weight as potential confounders in dietary studies, and should be evaluated and taken into consideration in dietary studies of different populations specifically from the developing countries. We found a higher prevalence of under-reporters of energy intake amongst those with higher BMI, and higher prevalence of over-reporters amongst those with lower BMI, consistent with observations in Australian children.[307]

Dairy intake, specifically milk intake, has been shown to be positively correlated with the calcium intake in children and both were observed to be low in our study.[378] Poh *et al.* had previously reported a decrease in the prevalence of meeting the RNI for calcium from infancy to primary-school aged children (from 17% to 65%).[9] Children in the current study also reported low intakes of non-dairy food sources of calcium such as green leafy vegetables and legumes. With no previous data on food consumption available for comparison, the significance of low calcium intake is unknown and its effect on bone mineral status of Malaysian children remains under studied. While children consumed slightly more vegetables than fruit, their intakes were still well below the national recommendation for five servings of fruit and vegetables daily, and much lower than the WHO population goals of ≥400g per day.[210] The poor reported intake of vegetables

could be due to food neophobia[43] and lack of fruit and vegetables at home that may significantly influence the children's actual consumption.[180]

The current study focuses on a relatively large sample size of the urban Malay population to minimise variation in socio-demographic and food culture shown to influence children dietary patterns. The study included analysis of energy mis-reporting as a potential yet significant confounder of dietary intake. Despite the absence of direct energy expenditure measurements, the use of age-appropriate and local equations for BMR increases the accuracy of the estimation of total energy expenditure. Limitations include: the cross-sectional design of the study preventing examination of causal relationships between dietary factors and childhood obesity; high prevalence of energy mis-reporting as a source of error along with social desirability bias to under-report with increasing awareness of childhood obesity in the developing country. Additional limitations include the lack of direct measurement of physical activity of the children as an influence on overall energy balance, and the lack of precision when comparing to the broad RNI age group values rather than individually measured or estimated requirements.

Conclusion

The majority of Malay children had dietary intakes below recommendations despite high prevalence of overweight and obesity. Clear evidence for a positive moderate association between dietary intake and weight status was found after excluding energy mis-reporters. Both over-nutrition and under-nutrition were observed in this sample of urban Malay children, reflecting Malaysia's epidemiology transition. These results have important implications for obesity-related research targeting Malaysian children and support the need for specific nutrition intervention programmes to improve overall dietary patterns. Further validation work is warranted in the area of dietary assessment to minimise the impact of energy mis-reporting and to determine which cut-point method is most appropriate for this population.

Chapter 8 Results Paper 2: Association within Malay family dyads for body weight status and dietary intakes

This chapter was published in February 2016.

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The work presented in the manuscript was completed in collaboration with the co-authors (Appendix 8.0). Permission to reproduce the manuscript has been granted by the publishers.

8.1 Introduction

The rise in adult and childhood obesity prevalence is a global public health concern especially in developing countries.[1, 379] Asian nations have undergone substantial nutrition transition over past two decades. Specifically, Malaysia has experienced a shift away from high energy activities of daily living and a traditional grain-based diet to one which is high in animal products, oils and fats.[5] An adverse outcome of this shift is the onset of obesity.[30] Approximately 34.5% of urban primary school-aged children are overweight or obese,[9] which is consistent with developed countries.[1, 5, 380] The latest Malaysian NHMS of 11.4 million people revealed that two-thirds of adults aged ≥ 18 years were overweight or obese.[381] The consequences of obesity in adulthood[382] and childhood[30] are physically, psychosocially and economically detrimental with greater impacts seen in obese children.[30]

Childhood obesity has a multi-factorial aetiology, with children of developing countries being far less studied than developed countries.[7] Obesity in developing countries is predominantly to be considered to be driven by environmental factors rather than genetics, given the rapid increase in the prevalence of obese children occurring within a relatively stable population in a short time frame.[5] Obesity is more prevalent within families, suggesting an intergenerational transmission of obesity,[5, 52] especially from mothers.[243] Previous reviews on twins, adoption and family studies reported that inheritance is able to account for 25% to 40% of inter-individual difference in obesity, indicating the majority of the familial influence is environmentally related than genetic.[5] Golan and Crow emphasised that childhood obesity occurs within the context of the family, which is impacted by the obesogenic environment.[243]

Representing the first social context for children, the family environment is where parents model eating and physical activity behaviours.[254] There are numerous parental factors affecting their children, including nutritional knowledge, modelling of eating and lifestyle behaviours, feeding practices and the types of foods made available to children.[254] There is growing evidence in developed countries of the associations of dietary intake between children and their parents.[60, 62] Although studies have examined some subgroup dietary intakes in developing countries,[9, 383] little is known about the relationship between

dietary intakes within family members.[59] These data can help inform the development of effective family-based interventions in Malaysia.

There are few Malaysian dietary intake studies that have investigated body weight status, and reported on the association between these factors within the family context. Specifically for Malay ethnicities, obesity could have a greater impact based on the Malaysian population proportion (67.4% Malay versus 32.6% other).[10] The present study aimed to report, among Malay families, the prevalence of energy mis-reporting and dietary relationships within family dyads. We hypothesised that child-parent dietary intakes would be moderately related and that child-mother dyads would be stronger than those for child-father dyads.

8.2 Materials and methods

This cross sectional study of Malay families examined dietary and lifestyle factors associated with body weight status in urbanized areas in central Malaysia (*Klang Valley*). The full study methodology of the Family Diet Study has been reported elsewhere[81] and complies with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[384] Approval was obtained from the ethics committees of the University of Newcastle, Australia (H-2013-0065) and the International Medical University, Malaysia (IMU 275/2013). Permission was obtained from the Malaysian Ministry of Education and Education Departments for school-based research (August 2013 to October 2014).

8.2.1 Study Population

Using EPI-INFO version 5.0 (http://wwwn.cdc.gov/epiinfo), the sample size was estimated to be 220 families based on the prevalence of breakfast skipping (14%) observed in the pilot study (margin of error, 5% and confidence level at 95%).[81] This variable was chosen because data on other dietary variables amongst Malaysian primary school children were lacking at the time that the study was planned. Participants were recruited using multi-stage sampling methods. Parents of selected Malay schoolchildren in Primary 3, 4 and 5 (8-12 years) were invited to participate by the school administrators. Willing families were asked to return completed consent forms with child assent. Parents

were screened for eligibility based on study inclusion/exclusion criteria. Inclusion criteria included a Malay family with at least one main caregiver(s) living full time with their child who had no concurrent medical conditions.

8.2.2 Measurements

8.2.2.1 Family socio-demographic

Assessments were conducted either at school (98%) or in the participant's home (2%). The parent(s) completed a written survey that collected data on socio-demographic background as well as family food purchasing, preparation and mealtime habits.

8.2.2.2 Dietary intake collection and assessment

Participants [child and their parent(s)] provided dietary intake data using interviewer administered 24-h DRs on two occasions (one weekday and one weekend), supplemented with a FHQ. The 24-h DRs collected detailed information on all foods and beverages consumed on the day prior to interview by adapting the five pass approach of the USDA's AMPM[281] and the Australian National Nutrition Survey 24-h dietary recall procedures.[363] FHQ was adapted with permission from the supplementary section of an Australian FFQ[366] (translated into Malay language and verified by incorporating local food terms). The FHQ consisted of 13 items for children and 12 items for the main caregiver, including items on the frequency of general food groups (fruit, vegetables and dairy product consumption) and dietary habits (sweetened beverages, snacking, breakfast intake, eating out and supplements).

Individual mean daily nutrient intakes were analysed using NUTRITIONIST PRO (Axxya Systems, Washington, US) utilizing the Malaysian Nutrient Composition of Foods[364] and Food Composition Guide Singapore.[365] Additional information on recipes and nutrient content from commercial packaging were entered separately into the database as required. Completed 24-h DRs were checked for outliers based on energy intakes (< 2090kJ or > 20900kJ)[38] and the Black and Cole method[91] was applied to identify energy mis-reporting [<0.76 (under-reporting), 0.76-1.24 (acceptable), >1.24 (over-reporting)].[82]

Mean dietary intake was calculated for energy, macronutrients [carbohydrate, protein, fats and percentage energy (%E) from each macronutrient], micronutrients (thiamin, riboflavin, niacin, vitamin C, vitamin A, iron and calcium), food groups ('cereals and grains', 'fruit and vegetables', 'meat/poultry/fish/legumes" and 'milk and milk products') and sub-food groups ('sugar-sweetened beverages', 'snack, 'Western fast food', 'sweets', 'oils' and 'mixed food'). The total energy and nutrient intake values were compared with the age-relevant RNI for Malaysia[173] whereas serving size was calculated for each food group (aligned with MDG).[174, 176]

8.2.2.3 Anthropometric measures

Body weight and height were measured in accordance with standard study protocols by trained research personnel.[81] Briefly, participants were instructed to wear light clothing and to remove any heavy objects prior to measurement sessions. Body weight was measured to the nearest 0.1kg using a digital weighing scale (TANITA Corporation, Tokyo, Japan), and height was measured to the nearest 0.1cm using a microtoise (SECA Bodymeter 206, Seca GmbH & Co. KG, Hamburg, Germany). BMI was calculated according to standardised equations and categorised using WHO BMI-for-age growth reference (5 to 19 years old)[103] for children and the BMI Asian classification for ≥ 18 years.[369] BMI Z-scores were calculated using WHO AnthroPlus version 1.0.4 (WHO, Geneva, Switzerland).[370]

8.2.3 Statistical analysis

Statistical analyses were carried out using STATA, version 11.2 (StataCorp, College Station, TX, USA). Data for each child, mother and father were checked for normality using histograms and descriptive statistics. Parametric tests were used for normally distributed variables and nonparametric tests were used for skewed variables. Associations between BMI and dietary intakes within family dyads were undertaken using appropriate correlation tests determined by normality. Dietary correlations were classified as weak, r<0.30; moderate, r=0.30-0.49; and strong, r≥ 0.50.[62] Univariate regressions for each dietary intake variable were performed with adjustment by child's total energy intake, age and BMI. For child-mother dyads, variables with P<0.05 were retained to build subsequent multivariate linear regressions for the child's fat intake (the

dietary variable with highest adjusted coefficient of determination, R^2) using a forward selection approach.

8.3 Results

8.3.1 Socio-demographic

A total of 1372 invitations were sent. After eligibility screening, 315 participants were enrolled and 236 participants completed all measures (Appendix 8.1). More mothers (n=182) than fathers (n=92) participated with similar number of boys (n=112) and girls (n=124). The mean (95% CI) age of the children was 9.9 (9.8, 10.0) years. Fathers were significantly older than the mothers [41.5 versus 39.3 years, P<0.01]. The majority of parents were employed full-time (76.9% fathers and 49.4% mothers) and attained secondary school level of education (52.7% fathers and 53.5% mothers). Hypermarket was the main food shopping location (59.3%), and mothers were the main food purchaser (68.2%), food preparer (92.4%) and mealtime supervisor (88.1%). Daughters were supervised more during mealtimes than were sons (94.4% versus 81.3%, P<0.01). Up to 80% of families reported they ate dinner together three times or more in a week.

8.3.2 Body weight status and dietary intakes

The mean (95% CI) BMI was 17.9(17.2, 18.6) kg m^{-2} for a child, 25.9(25.0, 26.8) kg m^{-2} for fathers and 27.1(26.4, 27.8) kg m^{-2} for mothers(Table 8-1). Daughters had significantly higher Vitamin C and calcium intakes than sons (36.1mg versus 24.8mg; 411.7mg versus 349.9mg; P<0.01, respectively). As shown in Table 8-1, fathers consumed more than mothers in terms of energy, all macronutrients and most micronutrients. Many family members did not meet the recommended daily servings based on MDG[174, 176] for six food groups (Appendix 8.2 and Appendix 8.3). The majority of energy and nutrient intakes were below national recommendations[173] with significant energy mis-reporters identified:[91] mothers (55.5%), fathers (40.2%) and children (40.2%).

Table 8-1: Descriptive characteristics of participants in the Family Diet Study

Variables	All Children n=236	Son n=112	Daughter n=124	Father n=92	Mother n=182
Anthropometry			**Mean (95 % CI)**		
Age	9.9 (9.8, 10.0)	9.8 (9.7, 10.0)	9.9 (9.8, 10.1)	41.5 (40.4, 42.7)**	39.3 (38.6, 40.0)
Body Weight (kg)	32.3 (31.0, 34.6)	32.0 (30.2, 33.8)	32.6 (30.6, 34.6)	72.6 (69.8, 75.5)***	64.0 (62.1, 65.8)
Height (cm)	133.2 (132.2, 134.2)	132.7 (131.3, 134.2)	133.5 (132.2, 134.9)	167.2 (165.9, 168.6)***	153.6 (152.8, 154.4)
Body Mass Index (kg/m^2)	17.9 (17.4, 18.5)	17.9 (17.2, 18.6)	18.0 (17.1, 18.9)	25.9 (25.0, 26.8)	27.1 (26.4, 27.8)
BMI z-score	0.20 (-0.01, 0.42)	0.34 (0.03, 0.64)	0.08 (-0.22, 0.39)	NA	NA
Dietary intakes					
Energy (kJ/day)	7104 (6849, 7360)	6916 (6602, 7226)	7276 (6874, 7678)	8188 (7736, 8636)***	6322 (6079, 6565)
Carbohydrate (g/day)	229.1 (220.3, 237.9)	223.1 (211.7, 234.4)	234.6 (221.2, 247.9)	264.1 (248.8, 279.4)***	201.5 (193.4, 209.6)
Protein (g/day)	64.5 (61.5, 67.4)	63.7 (59.4, 68.0)	65.1 (61.1, 69.2)	74.3 (69.7, 79.0)***	57.8 (54.9, 60.7)
Fat (g/day)	58.4 (55.7, 61.0)	56.8 (53.4, 60.3)	59.8 (55.7, 63.8)	67.0 (62.5, 71.4)***	52.5 (49.9, 55.2)
Percentage energy from carbohydrate (%)	54.1 (53.2, 54.9)	53.8 (52.6, 55.1)	54.3 (53.2, 55.1)	54.2 (53.3, 55.4)	53.6 (52.6, 54.5)
Percentage energy from protein (%)	15.2 (14.8, 15.6)	15.3 (14.7, 16.0)	15.1 (14.5, 15.7)	15.3 (14.7, 15.9)	15.4 (14.8, 15.9)
Percentage energy from fat (%)	30.7 (30.0, 31.4)	30.8 (29.7, 31.9)	30.6 (29.8, 31.5)	30.4 (29.5, 31.3)	31.1 (30.3, 31.8)
			Median (IQR)		
Thiamin (mg/day)	0.6 (0.4)	0.6 (0.4)	0.6 (0.3)	0.7 (0.4)***	0.6 (0.3)
Riboflavin (mg/day)	0.9 (0.6)	0.8 (0.6)	0.9 (0.6)	1.0 (0.7)***	0.8 (0.5)
Niacin (mg/day)	7.4 (6.3)	7.4 (5.7)	7.5 (6.1)	9.0 (6.6)***	6.4 (4.7)
Vitamin C (mg/day)	31.5 (52.3)	24.8 (39.8)**	36.1 (57.9)	28.7 (39.9)	28.5 (52.4)
Vitamin A (µg/day)	521.9 (417.4)	512.1 (444.3)	531.8 (409.3)	670.3 (503.9)**	535.7 (425.3)
Iron (mg/day)	12.3 (7.7)	12.1 (9.4)	12.6 (7.2)	15.1 (11.4)**	11.5 (7.7)
Calcium (mg/day)	374.4 (289.4)	349.9 (248.7)**	411.7 (308.5)	400.9 (276.3)	380.8 (259.5)

Significant (* p<0.05, ** p<0.01, ***p<0.001)

Table 8-2: Correlations of body mass index and dietary intakes in different dyads of participants (all and sub-group) of the Family Diet Study

Variables	ALL PARTICIPANTS			PLAUSIBLE ENERGY REPORTERS		
	Mother-Father n=44	Child-Father n=92	Child-Mother n=182	Mother-Father n=14	Child-Father n=34	Child-Mother n=52
	Correlation Coefficient, *r*					
Body Mass Index[a]	**0.26****	**0.37****	**0.34*****	-0.27	0.21	**0.45*****
Dietary intake						
Energy[a]	0.18	0.16	0.13	-0.25	-0.09	0.23
Carbohydrate[a]	**0.35***	0.17	0.06	**0.54***	-0.11	0.15
Protein[a]	**0.39****	**0.23***	**0.26****	0.49	**0.44****	**0.43****
Fat[a]	0.10	0.10	**0.21****	0.17	0.07	**0.35***
Percentage energy from carbohydrate[a]	**0.38***	0.03	**0.20****	**0.77****	0.33	**0.36****
Percentage energy from protein[a]	**0.67*****	**0.35****	**0.22****	**0.71****	**0.41***	**0.36****
Percentage energy from fat[a]	0.29	0.12	**0.26****	0.65*	0.33	**0.35***
Thiamin[b]	0.26	0.15	**0.17***	0.30	0.08	0.16
Riboflavin[b]	0.27	**0.30****	**0.25****	0.28	0.26	-0.02
Niacin[b]	0.17	0.10	0.07	0.42	0.001	0.22
Vitamin C[b]	**0.53****	-0.09	0.13	0.46	-0.05	0.18
Vitamin A[b]	**0.63*****	0.16	**0.16***	**0.78****	0.32	-0.03
Iron[b]	**0.48****	0.15	0.07	0.46	0.27	-0.11
Calcium[b]	**0.45****	**0.30****	0.12	0.38	0.19	-0.06
Cereals and grains[a]	**0.30****	0.05	0.10	0.42	0.24	0.12
Fruit and vegetables[b]	**0.61*****	0.08	**0.33*****	**0.71****	-0.04	0.25
Meat/poultry/ fish/ legumes[b]	**0.51****	0.18	0.14	**0.72****	0.21	0.10
Milk and milk products[b]	0.21	0.13	0.08	0.29	0.07	0.14
Sugar-sweetened beverages[b]	**0.38***	-0.02	0.09	0.48	-0.17	0.14
Snack[b]	0.28	-0.08	0.13	0.36	0.0004	0.14
Western fast food[b]	**0.72*****	-0.02	**0.17***	**0.71****	0.02	**0.32***
Sweets[b]	0.25	0.09	0.05	0.45	0.12	0.08
Oils[b]	**0.61*****	**0.22***	**0.16***	**0.84*****	0.18	0.12
Mixed food[b]	0.21	0.16	0.03	0.73**	NA	0.13

NA: Not Applicable; [a] Pearson correlation coefficient, [b] Spearman correlation coefficient, (* p<0.05, ** p<0.01, ***p<0.001), The r values in bold indicate significant correlations.

8.3.3 Associations between child and parents

The child's BMI was positively associated with parental BMI (Table 8-2). In the sub-group analysis of plausible energy reporters, only the BMI association for child-mother dyads strengthened (n=52, r=0.45; P<0.001). The dietary intake relationship for mother-father dyads was moderate (0.35-0.72) whereas that for child-parent dyads was in the weak-to-moderate range (0.16-0.35). The child's diet was more strongly associated with mothers than fathers for protein (r=0.26; P<0.01 versus r=0.23; P<0.05), %E from fat (r=0.26; P<0.01 versus r=0.12; P>0.05), fat (r=0.21; P <0.01 versus r=0.10; P>0.05), %E from carbohydrate (r=0.20; P<0.01 versus r=0.03; P>0.05) and thiamin (r=0.17; P<0.01 versus r =0.15; P>0.05). More than half of the significant correlations within father-mother dyads were classified as strong. When considering plausible energy reporters only, the number of significant dietary correlations reduced for all dyads. For child-mother dyad food group intakes, opposing trends were observed for fast food consumption, which achieved a stronger association, while fruit and vegetable intakes were no longer significantly associated.

The univariate regression of dietary intakes for different child-parent dyads is provided in the Appendix 8.4. It is shown that child-mother dyads had stronger associated dietary variables than the child-father dyads. Multiple regression analysis revealed that maternal %E from fat (β=0.09, p<0.01) and thiamin (β=0.08, p<0.05) intake were significant predictors of child's dietary fat intake. In the final model, the mother's %E from fat alone explained 81% (adjusted R^2=0.81) of the variation in the child's fat intake.

8.4 Discussion

The present study examined the relationships between dietary intakes and body weight status of child-parent dyads in Malay families. Despite the findings being distorted by energy intake mis-reporting, the results supports the hypothesis of clear child-parent dietary relationships. For child-mother dyads, there were weak-to-moderate positive correlations for eight dietary variables (protein, fat, %E carbohydrate, %E fat, thiamin, fruit and vegetables, and Western fast foods), whereas for child-father dyads, there were weak-to-moderate positive correlations for five dietary variables (protein, %E protein, riboflavin, calcium and oils); suggesting that mothers have a greater influence on child

dietary intakes. Mother-father dietary relationships were consistently more strongly correlated with each other than with the intake of the child.

Although the study participants reported dietary intakes below the recommended RNI[173] and MDG,[174, 176] consistent with other nationwide dietary studies,[9, 184] this may be reflective of energy intake mis-reporting given the high proportion of family members who are overweight and obese. This confounds the dietary intake results. When analysis was completed for plausible energy reporters, there were opposing trends in several dietary correlations for child-mother dyads illustrating the potential impact of reporting bias on dietary data. More mothers mis-reported than fathers and children, supporting the evidence indicating that females are more likely to under-report than males.[385] Regardless of their limited age-related abilities and body weight status, children may be more accurate energy intake reporters than adults.[283] The significant proportion of Malay parents and children found to be overweight or obese was congruent with other studies in Malaysia,[9, 372] regionally[1, 379] and internationally.[1, 380] The present study found a stronger association between parents and their child's BMI than another Malaysian study.[248] This difference is likely a result of the self-reported measures used in the previous study[248] instead of direct measurement, indicating a closer body weight status resemblance within Malay child-parent dyads.

Relationships between Malay child-parent dyads and dietary intakes were positive, however, the strength of the relationships was weak-to-moderate, consistent with previous studies in Western families.[60, 62] Given that 80% of the families reported having dinner together regularly, it was expected that parental modelling during mealtime would occur. However, evidence of the effectiveness of parental modelling remains inconclusive.[58] Cultural and familial beliefs, attitudes and practices surrounding food and eating could be exerting a stronger influence than other factors, particularly in the Asian setting.[52, 59] The weak-to-moderate correlations suggest that factors such as community and school, peer influence or media may also contribute.[62, 254]

The findings from the present study reinforce past research[60, 62] indicating that dietary intakes in child-mother dyads are more strongly related than child-father dyads. Malay mothers had the primary responsibility for meals for their primary school-age children and supervised their daughters more than sons during mealtime. Studies have shown that

parental intake may influence child intake as a result of the types of food available and accessible at home.[58, 59] The strength of the child-mother associations may be explained by the proportion of mothers that were housewives in the present study, enabling them to spend more time with their children than the fathers. This may change with increasing numbers of mothers entering full-time employment in the fast growing country. One Asian study demonstrate that families with working women tend to eat out frequently and that their children exert considerable influence on food choice in that setting.[240]

Child-parent dietary correlations were stronger for macronutrients than for other dietary components. Wang *et al.*[62] also found variations in child-parent dyads across dietary profiles. The association between fruit and vegetable intakes of the child and mother are consistent with findings in a previous review.[58] Maternal %E from fat was the strongest predictor of child dietary fat intake, suggesting this variable may better indicate parental associations with the diet of children than overall energy intake.[62] Research in developed nations has implicated the %E from fat in the development and maintenance of obesity,[59] possibly associated with stronger child-mother dyads accessing and sharing food items within same environment.[243]

8.4.1 Strengths and limitations

The strengths of the present study include the reporting of a broad range of dietary intake variables by child and parent dyads as well as food purchasing/preparation and mealtime supervision data obtained in a relatively large sample. The data was adjusted for potential confounders, including analysis of a sub-sample of accurate energy intake reporters. The limitations include the cross-sectional design which limits the ability to establish causal relationships between child-parent intakes and obesity. The study deliberately focused on an urban Malay population, which limits the generalisability of data to the broader Malaysian population. A further limitation is potential measurement bias as a result of self-reported food habits and dietary recall; however, standardised protocols allow for verification of responses when required. Future research should consider following families prospectively to investigate whether family dyad dietary relations track over time. This should include families of multi-ethnicities to allow findings to be generalised.

8.5 Conclusion

There is clear child-parental dietary intake relationship in urban Malay families, especially child-mother dyads. Despite a significant proportion of families being overweight or obese, the majority reported dietary intakes below recommended levels. The present study provides insights with respect to development of targeted family-based obesity interventions emphasising the parental role in improving family dietary patterns as part of a strategy to manage childhood obesity in Malaysia.

Chapter 9 Discussion and recommendations

9.1 Overview

Each paper in Chapter 3 to 8 discussed the key findings of the individual studies in detail. This chapter outlines the key findings of the body of research and summarises and compares them to the existing literature in the field (Section 9.2). This includes findings in relation to the body weight status in developing Asian countries (Section 9.2.1), dietary intakes in developing Asian countries (Section 9.2.2), associations between dietary patterns and childhood obesity (Section 9.2.3), and associations within Malay family dyads for body weight status and dietary intake (Section 9.2.4). Section 9.3 provides an overall summary of the findings in relation to the predetermined hypotheses. The strengths and limitations of this research are discussed in Section 9.4. Finally, the chapter closes with an overall summary of the implications of the research findings (Section 9.5) and concluding remarks (Section 9.6).

9.2 Summary of findings and discussion

9.2.1 Body weight status in developing Asian countries

In the studies conducted in this thesis [systematic review 1 (Chapter 3), pilot study (Chapter 5) and cross-sectional study (Chapter 7 and Chapter 8)], findings on the prevalence of childhood overweight and obesity within the developing countries in Asia were presented. To summarise, the studies showed a wide range and high prevalence of childhood overweight and obesity in certain parts of developing countries within Asian with no specific trend over the last two decades. In Chapter 3, variety of obesity standards were applied to classify childhood overweight and obesity across the countries. Using the IOTF classification standards for comparison, studies conducted in urban (China) and industrial areas (India), and in children from higher income families (India, China, Thailand and Vietnam) found higher prevalence rates, similar to figures reported in developed countries of the Western regions of around 25%.[92] Importantly, the results clearly demonstrated that developing countries in Asia experiencing nutrition transition, reported a higher prevalence of childhood overweight and obesity. This observation is

closely related to the level of urbanization. The more urbanised the area, (as defined by the density of population and type of commercial activities within the specific area) coupled with significant changes on nutrition and lifestyle, are likely to contribute to more rapid prevalence rates of childhood obesity in these countries.[6, 23]

While the cross-sectional study (Chapter 7 and 8) conducted specifically in Malay families concurred with findings of childhood obesity prevalence trending similarly to developed countries, the parents were heavier as denoted by BMI than their counterparts in the developed countries. The difference for the adult population is mainly due to the application of the BMI Asian classification for ≥ 18 years that classified overweight at BMI 23.0kg/m^2 and obesity at BMI at 27.5kg/m^2,[369] as opposed to the WHO BMI cut-points of 25.0 kg/m^2 for overweight and 30.0 kg/m^2 for obesity.[386] The Malaysian health authorities in 2004[369] adopted the lower cut-points for adult overweight and obesity given the increasing evidence that the Asian adult populations had higher risk of chronic diseases such as CVD and type 2 diabetes at lower BMI than the existing WHO cut-point for overweight.[386] However, to facilitate international comparisons, all categories of BMI classifications should be used when reporting adult body weight status (i.e. 18.5, 23.0, 25.0, 27.5, 30.0, 32.5kg/m^2).[386]

Results amongst the Malay children in addition to obesity also revealed pockets of under-nutrition in the urban setting (Chapter 7). Evidence has shown that coexistence of under-nutrition and over-nutrition is a common characteristic of developing countries.[22, 23] The demand of a dual burden of malnutrition will place increased pressures on health care systems and the economic cost especially for developing countries needs to be considered. Therefore, further efforts to optimise nutritional status across the weight spectrum of the paediatric population are warranted.

9.2.2 Dietary intakes in developing Asian countries

The systematic review presented in Chapter 4 is the first review that systematically evaluated the quality of dietary assessment methodology and reporting in epidemiology studies examining relationships between dietary outcomes and childhood obesity in developing Asian countries. Using the appraisal checklist developed by the ACAORN,[85] the study found large discrepancies in the quality of dietary assessment tool used, and many studies did not report sufficient details of the method, specifically on the validation

aspects of assessment instruments used and/or information on confounders that could influence the interpretation of dietary intake assessment and reporting. While usage of 24-hour DRs and FFQs were similar, unweighed FR/food diaries were more frequently utilised. However, the reporting quality of FFQs which tended to be higher than food diaries/ records and DRs was similar across developing Asian countries and developed countries. With 15 included studies, the most commonly used dietary assessment method was dietary questionnaires and the majority of the studies were given 'poor' ratings for dietary assessment reporting. In the developing Asian countries, usage of the non-standardised and non-validated dietary questionnaire was popular due to the overall lack of validated tools specific to this population group. Despite being simpler than FFQ, the unvalidated dietary questionnaire was the primary reason for the poor quality rating of the majority of included studies in the review. These results were generally different from the evidence reported from the developed countries on quality of dietary methods and dietary intake reporting in child and adolescent obesity intervention trials. Therefore, there is an urgent need for the development of validated dietary assessment methods tailored to the diverse populations in Asia. Higher quality research using validated tools and dietary methods can subsequently be conducted, and for these tools and methods to be described adequately in studies from the developing Asian countries.

Evidence from the literature has demonstrated that when DLW is considered as the gold standard to measure total EE, energy mis-reporting is highly prevalent in developed countries across age categories, especially under-reporting. Factors such as gender and body weight status have important implications in terms of the likelihood of accurate energy intake reporting.[172, 275, 276] Therefore, care should be taken when collecting dietary intake data. The EI mis-reporting of Malay families was presented for the pilot sample (Chapter 6) and the cross-sectional study (Chapter 7 and 8). As there were no international standards to identify mis-reporters in the absence of direct measures of total EE, different cut-points including Goldberg equations,[88, 89] Torun cut-point[90] and Black & Cole method[91] were evaluated in the pilot study sample. Results showed that energy mis-reporting is common with more under-reporters, however the proportion of the cohort that mis-reports varies according to cut-points applied. Furthermore, there were significant differences in the proportion of Malay children classified as energy mis-reporters when applying BMR calculated using FAO/UNU/WHO (1985) and Malaysian-specific equations. Similarly, in the Family Diet Study, a large proportion of energy mis-

reporters were identified using Black & Cole method;[91] mothers (55.5%), fathers (40.2%) and children (40.2%). While mis-reporting was independent of body weight status in the pilot sample, obese children and their mothers in the cross-sectional study were more likely to under-report compared to other body weight status. These findings in the Malay families support that EI mis-reporting is widespread and should be taken into consideration in all dietary studies to increase the validity of dietary data.

Dietary intakes for children and parents enrolled in the Family Diet Study were presented in Chapter 7 and 8, respectively. Dietary intake was collected twice (one weekday and one weekend) using interviewer-administered 24-hour DRs based on a five pass method and supplemented with a food habits questionnaire. Home was the main breakfast venue, with few participants (10%) reported skipping breakfast. The majority of participants' dietary intakes reported nutrient and food group intakes that were sub-optimal and consistently below the Malaysian national recommended targets for RNI and food serving sizes. The results may be reflective of energy intake mis-reporting given the high proportion of individuals observed to be overweight and obesity observed in these Malay families (Chapter 7 and 8). Additionally, more children and their mothers who were in the obese category were identified as under-reporters (data not presented). However, these dietary intakes were comparable to data from the nationwide Malaysian nutrition surveys for children and adults suggesting widespread of reporting bias across the population.

9.2.3 Associations between dietary patterns and childhood obesity

The Systematic Review 1 presented in Chapter 3 was the first literature review that examined the associations between dietary patterns and childhood overweight/ obesity in developing Asian countries. The results highlighted that with limited number of studies (15 studies in 16 articles) included up to September 2011, the heterogeneous nature and poor methodological quality of the studies made it difficult to draw conclusions on dietary pattern-overweight/obesity relationships in children from the developing countries in Asia. While there were wide variations in the reporting of dietary intake and food patterns across studies in terms of nutrient intakes, food groups, dietary behaviour and feeding practices, large discrepancies were also found in the dietary assessment methods, statistical analyses and outcomes used. Poor dietary assessment methodology made

findings equivocal, hence harder to interpret and closely associated with issues such as validity and energy mis-reporting that may confound the dietary intake data.

The narrative summary provided an insight into the dietary relationships with overweight/obesity amongst children from developing Asian countries. Dietary patterns that were likely to be associated with higher risk of childhood overweight and obesity included highest tertile of energy and protein intakes, highest quartile of meat intake, consumed no vegetables for one week or eating fruit less than 2 times weekly, presence of snacking, frequent eating fast food (≥ 3 times per week) and frequent intake of sugar-sweetened beverages besides specific chid feeding behaviour (eating quickly, not selective about food choices, enjoyed food and experienced maternal restriction to snacks). However, several other dietary patterns were associated with lower risk of childhood obesity in those reported high carbohydrate diet (>70% of %E), highest quartile fruit and vegetables intakes, and maternal encouragement to eat often. These findings were consistent with the body of evidence from the developed countries for EI,[185, 191, 308, 387] macronutrients,[37, 190, 204-206] dietary behaviours[34, 36, 37, 208] and feeding practices.[264, 265] The universal observation from both developed and developing countries illustrates clearly the complexity of investigating food and eating behaviours and relating these to the development of childhood obesity.

The results from the cross-sectional study (Chapter 7) also described on dietary intake of the primary school-aged Malay children (n=236) by body weight status. The initial findings when EI was adjusted for body weight (kcal/kg), obese children were reporting significantly lower EIs compared to other weight categories. The reported EI adjusted for body weight was moderately strong and inversely correlated with BMI z-score. Contrary to the popular hypothesis, inverse relationships between EI and obesity in paediatric population have been published in the literature[195-197] including one study from Malaysia.[41] This is closely related to substantial reporting bias amongst overweight and obese individuals irrespective of age.[385, 388]

Given the high prevalence of energy mis-reporting identified in the pilot sample (Chapter 6), in-depth analyses of accurate energy reporters (n=141) was performed in Chapter 7. Importantly, in this sub-group, results showed significant differences between BMI categories and dietary intakes for energy, all macronutrients and some micronutrients

(riboflavin, niacin, vitamin A and iron) besides clear positive relationship between plausible energy reporters' EI with BMI z-score. Higher intakes were consistently found in obese and/or overweight children. Multiple regression analyses also indicated that higher energy intake was associated with higher BMI z-score. Recent evidence from two large studies from United States[193, 194] and Australia[192] has demonstrated promising results in relation to the associations between EI and adiposity in children. Hence, the possibility remains that relative hyperphagia of specific foods may contribute to excess total EI and is an important determinant of obesity in children. Future longitudinal studies are warranted to elucidate the actual mechanism.

9.2.4 Association within Malay family dyads for body weight status and dietary intake

Chapter 8 provides evidence that there may be significant relationships within Malay family dyads for body weight status and dietary intake. The study is novel, representing the first research in the Asia region to evaluate the body weight status and dietary intake resemblance using a standardised methodology within urban Malay families by including both child and their parents. Results found that children's BMI was positively associated with parental BMI [child-father dyads (n=92) and child-mother dyads (n=182)]. However, in the sub-group analysis of plausible energy reporters, only the relationship for child-mother dyad body weight status remained significant [child-father dyad (n=34) and child-mother dyad (n=52)]. Importantly, this concurs with previous literature from both developed countries[53, 159, 187, 241-244] and developing countries,[54, 55, 93, 245-248] and highlighted that this relationship appears to be an important predictor of childhood obesity. The stronger maternal influence suggests both genetic and environmental factors related to diet and physical activities closely interacting and impacting on the child body weight status.

An additional key finding from Chapter 8 was that the child's diets were associated with their parents and resembled more closely the mother's intakes than the father's. The child-parent dietary correlations were stronger for macronutrients than other dietary components (food groups and micronutrients). The multiple regression analyses demonstrated that maternal percentage energy from fat largely explained the variation in children's fat intake. This supports the hypothesis that there would be an association between dietary intakes of the children and their main carer(s), and consistent with the

body of evidence that child-mother dietary intakes were more related than that of child-father intakes.[60, 62, 252] The significance of the findings calls for further investigation, as parental dietary intake could have important implications for the development of overweight and obesity in Malay children through exposure to similar obesogenic environment and should be the focal point for interventions seeking to impact on child dietary patterns.

Interestingly, mother-father dietary relationships were consistently more strongly correlated with each other than with the intake of the child, for majority of nutrients and food groups. This should be considered in light that up to 80% of the families in the cross-sectional study reported having at least three dinners together in a week. While the results are similar to a recent family diet quality study from Australia,[60] the inferences regarding intake patterns relative to the roles of mother and/or father and how they influence the child's diet remain unclear. More studies examining the Malay family dynamic, especially the role of the head of household from a cultural perspective and its impact on dietary intakes are warranted.

9.3 Findings in relation to pre-determined hypotheses

In summary, the research findings lead to the assessment of the pre-determined hypotheses as follow:

1. The prevalence of childhood overweight and obesity in developing Asian countries will be similar to that of developed countries.

The study findings support this hypothesis partially because included studies that were conducted at rural or non-industrial areas found much lower prevalence rates (5.1%) of childhood overweight and obesity compared to the developed countries. However, the higher prevalence rates at urban and industrial areas (19.9%) were closer to figures reported in developed countries.

2. The dietary patterns of children from developing Asian countries are associated with increased risks of overweight and obesity.

The study findings support part of this hypothesis. Several significant but inconsistent statistical associations between dietary patterns and overweight/obesity in children and adolescents of developing Asian countries were found as summarised in Table 9-1 (refer to Results section of Appendix 3.10).

Table 9-1: Main findings of associations between dietary patterns and childhood overweight/obesity

Dietary Pattern	Findings	
	Increased Risk (OR/RR)	Lower Risk (OR/RR)
High energy diet	• 1.80 (95%CI 1.10, 2.90, P<0.05)	• 0.80 (95%CI 0.60, 1.10, P>0.05)
Low intake of fruit and vegetables	• 2.34 (95%CI 1.04, 5.24, P<0.001); • 2.00 (95%CI 1.10, 3.40, P<0.05)	• 1.33 (95%CI 0.44, 4.05, P>0.05); • 0.70 (95%CI 0.50, 1.00, P>0.05)
High meat consumption	• 2.40 95%CI 1.00, 5.60, P<0.05)	• 1.70 (95%CI 1.00, 2.70, P>0.05)
Eating out	• 12.00 (95%CI 7.70, 18.70, P<0.001); • 1.70 (95%CI 1.04, 2.90, P<0.05)	• 1.20 (95%CI 0.60, 2.40, P>0.05)
Fast food intake	• 1.50 (95%CI 1.12, 2.02, P<0.05)	• NA
Presence of snacking	• 2.34 (95%CI 1.01, 5.54, P=0.05); • 1.26 (95%CI 1.13, 1.40, P<0.05)	• 0.80 (95%CI 0.48, 1.32, P=0.377); • 0.60 (95%CI 0.30, 0.99, P<0.05); • 0.60 (95%CI 0.40, 0.90, P<0.05);
Drinking sugar-sweetened beverages	• 1.60 (95%CI 1.02, 2.50, P<0.05); • 1.70 (95%CI 1.10, 2.70, P<0.05)	• 0.93 (95%CI 0.82, 1.05, P>0.05)

NA: Not Applicable; OR: Odds Ratio; RR: Relative Risk

3. The quality and reporting of dietary assessment methods used in studies examining the relationship between dietary outcome and childhood obesity in developing Asian countries will be similar to that of developed countries.

The study findings support this hypothesis partially. The most commonly used dietary assessment method in studies examining the relationship between dietary outcome and childhood obesity in developing Asian countries differed from the methods used in childhood obesity intervention trials from developed countries in that there were more studies using dietary questionnaires and fewer using unweighed FR/food diary methods [dietary questionnaires (n = 10 vs. 4), unweighed FR/food diary (n = 1 vs. 13), 24-hour DR (n = 4 vs. 5), and FFQ (n = 3 vs. 4)]. Differences were also found for the quality of dietary methodology reporting within individual studies. More studies were given a 'poor' rating for developing Asian countries (75%) than developed countries (52%) while

lesser studies in the developing Asian countries were rated as 'excellent' (n = 1 vs. 3). The only similarity across developing Asian countries and developed countries was the reporting quality of FFQ, which overall tended to be higher than FR/food diaries and DRs.

4. The protocol of the pilot study for the Family Diet Study will be feasible for main trial implementation.

The results from the pilot study support this hypothesis as it showed overall feasibility of the study protocol but required some modifications in sample size, participant recruitment and dietary assessment methodology prior to implementation of the main study.

5. The dietary intakes of the Malay children and their main carer(s) will not match national food group recommendations or provide sufficient intake of key nutrients, compared to the national recommendations for nutrient intakes.

The study findings partially support this hypothesis as few intakes matching the recommendations while others were below the recommended levels. The research found that the mean intakes of the following nutrients meeting the RNIs:

- *Protein [children (174%), father (120%) and mother (105%)];*
- *Vitamin A [children (119%), father (148%) and mother (138%)];*
- *Iron [children (128%) and father (188%)]; and,*
- *Vitamin C [children (115%)]*

The study participants' mean nutrient intakes did not meet the RNIs for:

- *Energy [children (92%), father (80%) and mother (69%)];*
- *Thiamin [children (67%), father (65%) and mother (56%];*
- *Riboflavin [children (98%), father (87%) and mother (83%)];*
- *Niacin [children (62%), father (61%) and mother (50%)]; and,*
- *Calcium [children (54%), father (54%) and mother (55%)]*

For the food groups, the children and mothers met the recommended serving sizes for 'Meat/poultry/fish' (106%) and legumes (108%), respectively. However, other food groups were well below the national recommended intakes for all participants:

- *'Cereals/tubers/grains' [children (69%), father (60%) and mother (57%)];*
- *Fruit [children (15%), father (31%) and mother (27%)];*
- *Vegetables [children 15%(), father (31%) and mother (36%)]; and,*
- *'Milk and dairy products' [children (11%), father (3%) and mother (9%)]*

6. The prevalence of overweight and obesity amongst participants in the Family Diet Study will be similar to the developed countries.

The study findings support this hypothesis for the children but do not support for the parents. The prevalence of overweight and obesity among Malay children using WHO BMI-for-age growth reference (5 to 19 years old) (boys: 30.0%, girls: 29.0%) was similar to developed countries of the Western regions. Using BMI Asian classification for ≥ 18 years, higher prevalence of overweight and obesity were found amongst the parents than their counterparts in the developed countries.

7. The prevalence of EI mis-reporting amongst the participants in both pilot and main study of the Family Diet Study will be similar to that of developed countries.

The pilot study findings do not support this hypothesis. Based on different cut-points, a higher proportion of Malay children were classified as EI mis-reporters with under-reporters (50% to 57%) and over-reporters (≤ 29%) compared to figures reported from some developed countries [Japanese children (under-reporters 32% and over-reporters 15%), Australian children (under-reporters 5% to 7% and over-reporters 2% to 3%) and European children (under-reporters 8% and over-reporters 3%).

The main study findings support this hypothesis partially:

- *The prevalence of Malay children classified as EI mis-reporters, inclusive of under- and over-reporters (40%) were similar to Japanese children (47%), and however, were much higher than Australian and European children (7%-10%).*
- *As for the parents, the proportions of energy mis-reporters are higher [mothers (56%) and fathers (40%)] when compared to adult dietary studies from some developed countries; Spain [women (27%) and men (21%)] and United Kingdom [women (48%) and men (29%)].*

- *Different results were also observed compared to developed countries according to body weight status. Less obese Malay children under-reported (46%) than to obese Swedish adolescents (58%) but more obese Malay mothers under-reported (70%) than Spanish females (20%-33%).*

8. There will be an association between dietary intakes and body weight status of the children.

The study findings support this hypothesis only among the plausible energy reporters for EI, all macronutrients, some micronutrients (thiamin, riboflavin, niacin, vitamin A, iron and calcium), 'Cereals', and 'Meats' groups. No associations were found for vitamin C, and other food groups (fruit and vegetables, dairy; sugar-sweetened beverages; Western fast food; snacks; sweets; oils; and mixed food).

9. There will be an association between dietary intakes of the children and their main carer(s).

The study findings support this hypothesis. The dietary intake relationship for the child-parent dyads was in the weak-to-moderate range (0.16-0.35) for protein, fat, %E carbohydrate, %E fat, %E protein, thiamin, riboflavin, calcium, fruit and vegetables, Western fast foods and oils.

10. There will be stronger dietary associations for child-mother dyads than child-father dyads.

The study findings support this hypothesis. For child-mother dyads, there were weak-to-moderate positive correlations for eight dietary variables (protein, fat, %E carbohydrate, %E fat, thiamin, fruit and vegetables and Western fast foods) while for child-father dyads, there were weak-to-moderate positive correlations for five dietary variables (protein, %E protein, riboflavin, calcium and oils).

11. There will be an association between body weight status of the children and their main carer(s).

The study findings support this hypothesis. The BMI of the child was positively associated with father's BMI (r=0.37, P<0.01) and mother's BMI (r=0.34; P<0.01).

12. There will be stronger association for body weight status of child-mother dyads than child-father dyads.

The study findings support this hypothesis only in the sub-group analysis of plausible energy reporters. The BMI association for child-mother dyads were stronger than child-father dyads (r=0.45, P<0.001 vs. r=0.21, P>0.05).

9.4 Strengths and limitations of the research project

Specific strengths and limitations related to the individual research aims, and overall study designs were addressed in the published papers presented in the preceding chapters (Chapter 3 to 8). However, the important strengths and limitations of the body of research are summarised collectively as follows.

9.4.1 Systematic reviews

Strengths

This thesis presents two reviews which were the first thorough and up-to-date literature reviews to provide a summary of the present state of problems for developing countries in Asia. These reviews were reported according to the international reporting guideline, the PRISMA reporting guidelines for systematic reviews.[358] The first review used the JBI standardised critical appraisal instruments while the second review used the appraisal checklist developed by the ACAORN to ensure only reliable data were evaluated in the results. The appraisal and data extraction processes involved two independent reviewers (and a third reviewer in the event of disagreement) that minimised reporting bias.

Limitations

The primary limitation of the reviews was the exclusion of ten studies published in non-English language [Spanish (n=1) and Chinese (n=9)] during the selection procedures of the retrieval process. Given that the reviews were focusing on developing Asian countries including China, the exclusion may influence the generalisability of the results as a whole

to the entire Asia region. However, evidence has shown that no systematic bias was found from the use of language restrictions.[389] In addition, the search strategy included studies up to September 2011 and with the growing research interest in this area of childhood obesity, there is a need for ongoing updates of the review. Another limitation was the heterogeneity of the studies and their measures of dietary patterns and obesity standards, preventing meta-analysis for the first review.

9.4.2 Pilot study

Strengths

The pilot study allowed the study protocol for the Family Diet Study to be tested in terms of flow, timeline, recruitment and feasibility before the main study in the Malaysian setting. As the modifications were aimed to address the local concerns such as participant burden and resource constraint, the processes learnt benefitted the main study through appropriate adjustments that optimised participation and improved the accuracy of data collected. It is the first study to explore the degree of EI mis-reporting in Malaysian children according to different cut-points. This evaluation enabled the identification of appropriate cut-points to be applied in this population for the main study, despite the absence of direct measurement of total EE.

Limitations

The main limitation of the pilot study is that it was small and that results may not be applicable to other population groups and may overestimate the occurrence and magnitude of mis-reporting. The varying results of the energy mis-reporters according to cut-points prevented the identification of which equation would be most appropriate for this population.

9.4.3 Cross-sectional study

Strengths

This study is novel as it is the first research study exploring into association between diet, lifestyle and body weight status affecting Malay primary school children and their caregiver(s) within the family context. Comprehensive individual assessment using the same study measures for dietary intake, physical activity and body weight status within a

relatively large sample of Malay families enabled this hypothesis to be tested using trained personnel and standardised methodology. The revised study protocol promotes completion of data collection of enrolled participants in the cross-sectional study (non-response rate improved from 31% to 25%), reinforcing the importance of pilot study. In addition, the cross-sectional study addressed an important research question pertaining to the nutritional adequacy of an extensive dietary intake profile (macronutrients, micronutrients and food groups) of Malay children and their parents and the parental role in food purchasing/ preparation/ mealtime supervision. Therefore, the research makes an important contribution towards understanding the child and family diet, and its relationship to the weight status.

All outcome measures were collected using validated tools and techniques, which improved the validity and hence the reliability of results. The inclusion of analysis of energy mis-reporting as a potential yet significant confounder of dietary intake, which is a novel approach that allowed true associations to be established. The standardised coding of food obtained from recalls and the detailed dietary methodology reporting based on the ACAORN checklist allows the information to be replicated in future studies, addressing the limitation identified in the second review in this thesis.

Limitations

Limitations of the cross-sectional study include that the study design was observational in nature and thus causality cannot be inferred from the results. This means that associations found between dietary intake and body weight status of the Malay children and within family dyads require further investigation using prospective studies. The demographic characteristics of the recruited families (Malay ethnicity and urban residents) limited the generalizability of the findings, however, the implementation of multi-stage sampling methods aimed to improve the representation of the urban sample in this research. Furthermore, the novel yet exploratory nature of this research may have attracted some false positive results due to multiple statistical testing. Therefore, replication of the study in nationally representative sample is warranted. The self-reported dietary intake, lifestyle and child feeding practices were subjective assessments and could therefore be affected by reporting bias and social desirability, which were handled appropriately through standardized protocols to reduce the impact on results. Black and Cole method was chosen for this study as the search of the literature did not

provide a suitable cut-point to identify mis-reporting for all participants within Malaysian families, calling for future research in this area. Contrary to the Malay children's dietary intake results, the analyses of child-parent dietary intake data was limited to the investigation of energy intake mis-reporting. The child-parent associations could be confounded by body weight status which warrant further data exploration.

9.5 Summary of the implications of the body of research

9.5.1 Recommendations for research

The body of research presented in this thesis provides key recommendations for researchers currently investigating family diet and association with childhood obesity, and recommendations that could be considered in the development of obesity intervention programmes for childhood obesity. Recommendations are also provided for future dietary studies to evaluate other environmental factors linked to the aetiology of childhood obesity.

Firstly, the heterogeneity in the prevalence of overweight and obesity among children residing in the developing Asian countries indicates for usage of standardised measures to define childhood overweight and obesity, and should be consistent internationally. This will enable researchers to accurately compare research findings across different populations in this region. In addition, the higher prevalence of obesity in Malay adults in this research compared to their counterparts in both developed and developing countries highlights the need for more research on appropriate BMI cut-off points and their associations with comorbidities for Asian populations to inform the body of evidence. Secondly, the discrepancies in the reporting of dietary patterns in children and adolescents, which were concurred by high prevalence of studies with "poor" quality rating for dietary assessment methods call for higher quality dietary studies. It is acknowledged that some important methodological factors commonly associated with dietary studies in developing Asian countries include limited reporting the details of the dietary assessment method chosen, lack of the validity of the method used, training of personnel involved in collecting data and reference to food composition databases for dietary analysis.

Therefore, it is important for researchers conducting studies in Asia to evaluate the appropriateness and quality of identified dietary assessment methods for research in various populations in the developing countries. Researchers must also begin to include studies conducted in other languages especially Chinese when updating the systematic review, reporting data in a consistent and comparable manner to maximise the usability of the published literature. Future studies are recommended in several area of dietary intake assessment. The body of research highlights the need to: (i) develop dietary assessment tools and conduct validation studies with selected dietary assessment method referenced against at least one other dietary method or biomarker, and (ii) apply the recommended checklist [adapted from Nelson and colleagues,[86] and the EURReca[87]] when conducting dietary studies which allows quality rating besides encouraging researchers to fully describe dietary methods and use of valid dietary intake measures.

Results from the cross-sectional study highlight a high prevalence of sub-optimal nutrient intakes relative to national recommendations and EI mis-reporters among Malay families. When conducting future studies that require dietary intake assessment, researchers are recommended to: (i) ensure adherence to a standardised dietary assessment protocol that utilised validated tools, (ii) involve trained personnel with background in nutrition and dietetics to conduct dietary assessment, (iii) examine and audit the dietary data collected, (iv) identify and evaluate the impact of EI mis-reporting, and (v) evaluate dietary intake data by body weight status considering the coexistence of under-nutrition and over-nutrition in majority of developing countries. Furthermore, regular monitoring of consumption patterns and evaluation of nutritional adequacy of dietary intakes compared to dietary recommendations will also provide insight into when guidelines need revision in this population, currently undergoing rapid nutrition transition. In addition, more research is indicated specifically on EI mis-reporting in both children and adults in developing Asian countries. The main research aim is to determine which cut-point method is most accurate in this population. This can be achieved by directly assessing the EE and physical activity using validated tools such as DLW and accelerometers, respectively alongside with robust and validated dietary methods.

Pilot studies are is needed to assist researchers from developing Asian countries in designing research studies. It is particularly important because pilot study allows the assessment of feasibility and testing of study protocol, methods and tools given that

resources and budget are generally constrained in the developing countries. Hence, the opportunity to adapt and refine the study protocol to suit the local context prior to the implementation of main study highlights the importance of doing this as first step.

The results from the cross-sectional study regarding the family dyads body weight status and dietary relationships are promising, however, must be tested in prospective cohort studies. This will enable researchers to track changes in body weight status and dietary intake over time. Based on our findings, some early indicators of the Malay children's body weight status may involve age, dietary energy, iron, maternal %E from fat and maternal thiamine intake. Further research is required to confirm whether both parents or one parent (specifically mothers) are implicated as the main causative factor in the development of childhood obesity in order to identify key intervention strategies to optimise dietary patterns within families. Therefore, the current challenge is to identify the most important environmental factor(s) contributing to overweight and obesity in Malay children. Evidence to date posits that the aetiology is likely to be different compared to children in developed countries due to the influence of exposures to different obesogenic environment. This work is needed before effective obesity intervention trials to prevent and treat childhood obesity in Malaysia can be formulated.

9.5.2 Recommendations for practice

This body of research has practical implications for children, parents, healthcare professionals, government agencies and international bodies.

Findings from this research highlight that a large proportion of Malay families (children aged 8-12 and their parents) were classified either as overweight or obese and majority consuming sub-optimal dietary intakes. In particular, reported dietary intakes for energy and most micronutrients were below national recommendations. This research suggests that it is important that healthcare professionals (including general practitioners, paediatricians and dietitians) and government agencies target children and their parents from birth in order to monitor body weight status and improve dietary behaviours and overall diet quality throughout the life span, particularly in the growth and development stages. This primary preventative approach is crucial to promote optimal short- and long-term outcomes for the child and family. General practitioners and paediatricians could perform measurements of body weight status indicators (e.g. body weight, height, WC

and percentage BF) during routine child's immunisations, health consultations and follow-ups. This will allow tracking of body weight status changes over the years. General practitioners and paediatricians could recommend an individual dietetic consultation as part of lifestyle intervention when signs of excessive weight gain/loss that potentially lead to malnutrition are identified. In addition, overweight or obese children could receive an automatic referral to health clinic for dietitian's consultation when identified through regular school health screening programme. International bodies like WHO are recommended to review the growing body of evidence on body weight status and the associations with risk of chronic diseases for Asian populations. There is a need to consider to re-define population-specific cut-points for effective policy and intervention strategies to better manage the global obesity epidemic.

The involvement of parents is essential in improving family dietary patterns and overall family and home environment. However, further research is needed to identify the optimal strategy that is feasible and cost effective to deliver intervention programmes in this setting. Dietetic consultations may be required as part of the lifestyle intervention and could include receiving advice on physical activity and undergoing behavioural therapy. Until the optimal dietary management is fully elucidated, dietetic practice should be guided by the best available evidence to ensure dietary approaches are in line with the Malaysian RNIs and national dietary recommendations.

Dietitians should be aware that primary school-aged children and their parents generally do not consume foods in accordance with the national food group and nutrient recommendations, despite a significant proportion being overweight or obese. The sub-optimal intakes may be affected by energy mis-reporting, hence those who are likely to mis-report (i.e. overweight/obese individual, and female adults) should be evaluated cautiously during dietetic consultation. When dietitians assess dietary intake, the dietary assessment method should be appropriately chosen based on age-specific cognitive and social development needs of the children. Individual dietary counselling could involve the parent(s) while aiming for healthy eating patterns that optimise total dietary EI in attempt to manage overweight and obesity in children. Furthermore, the children's body weight may be modifiable by conducting nutritional interventions that target the mother.

Lastly, the body of research suggests there is a need for health authorities to collaborate with education authorities and food agencies to establish routine monitoring of the population health and nutritional status, especially the paediatric group from birth onwards. For adults, the continuation of health status monitoring can be done through routine health screening programme at workplace or at the community level. Basic anthropometric measures such as body weight and height are simple yet important indicators of growth which can easily be conducted at any setting especially in developing countries where resources may be restricted. The government agencies may consider conducting nationally representative nutrition and dietary surveys regularly to assess and inform the need to revise the Malaysian RNIs, given that the majority of the population sample surveyed were not meeting the recommended nutrient intakes, despite a large proportion of the children and adults being overweight or obese. In attempt to address the triple burden of malnutrition (under-nutrition, micronutrient deficiencies and over-nutrition), specific nutrition programmes should be designed to improve the overall dietary patterns of the population. Well-targeted programmes tailored to different age group will yield more beneficial results and outcome measures.

9.6 Concluding Remarks

The research reported in this thesis provides important insights into a number of areas of childhood obesity in developing Asian countries, particularly in regards to study design and feasibility, obesity standards, dietary assessment methodology and quality of reporting, and aspects of family environment. Nutrient intakes of Malay children and their parents are commonly sub-optimal and were found to be below recommended serving sizes for food groups and nutrient consumption levels. This occurs despite a high prevalence of overweight and obesity. The mismatch suggests that EI mis-reporting is common in this population. There is an urgent need for valid and reliable dietary assessment methods and objective evaluation of the total EE. The results of this study add valuable insight into the associations between body weight status and dietary intake within Malay family dyads.

It is important that healthcare professionals and government agencies establish routine monitoring of the population health and nutritional status while developing strategies that aim to improve family dietary patterns and overall diet quality. This primary preventive

approach is imperative given that childhood obesity together with dietary patterns, health and well-being have been shown to track into the future.

References

1. de Onis M, Blössner M, Borghi E. Global prevalence and trends of overweight and obesity among preschool children. Am J Clin Nutr. 2010;92(5):1257-1264.

2. Kelishadi R. Childhood overweight, obesity, and the metabolic syndrome in developing countries. Epidemiol Rev. 2007;29:62-76.

3. Tee ES. Obesity in Asia: prevalence and issues in assessment methodologies. Asia Pac J Clin Nutr. 2002;11:S694-S701.

4. Popkin BM, Gordon-Larsen P. The nutrition transition: worldwide obesity dynamics and their determinants. Int J Obes Relat Metab Disord. 2004;28(S3):S2-S9.

5. Lobstein T, Baur L, Uauy R. Obesity in children and young people: a crisis in public health. Obes Rev. 2004;5:4-85.

6. Wang Y, Lobstein T. Worldwide trends in childhood overweight and obesity. Int J Pediatr Obes. 2006;1(1):11-25.

7. Yang WY, Williams LT, Collins C, *et al.* The relationship between dietary patterns and overweight and obesity in children of Asian developing countries: A Systematic Review. JBI Database of Systematic Reviews and Implementation Reports. 2012;10(58):4568-4599.

8. Bong ASL, Safurah J. Obesity among years 1 and 6 primary students in Selangor Darul Ehsan. Mal J Nutr. 1996;2:21-27.

9. Poh BK, Ng BK, Siti Haslinda MD, *et al.* Nutritional status and dietary intakes of children aged 6 months to 12 years: findings of the Nutrition Survey of Malaysian Children (SEANUTS Malaysia). Br J Nutr. 2013;110(SupplementS3):S21-S35.

10. Department of Statistics M. Population Distribution and Basic Demographic Characteristics Report 2010 (Updated 05/08/2011). Kuala Lumpur, Malaysia: Department of Statistics, Malaysia.2010.

11. Reilly JJ, Methven E, McDowell ZC, *et al.* Health consequences of obesity. Arch Dis Child. 2003;88(9):748-752.

12. Biro FM, Wien M. Childhood obesity and adult morbidities. Am J Clin Nutr. 2010;91(5):1499S-1505S.

13. Reilly JJ, Kelly J. Long-term impact of overweight and obesity in childhood and adolescence on morbidity and premature mortality in adulthood: systematic review. Int J Obes. 2011;35(7):891-898.

14. Lim SS, Vos T, Flaxman AD, *et al.* A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 2012;380(9859):2224-2260.

15. Gupta N, Goel K, Shah P, *et al.* Childhood Obesity in Developing Countries: Epidemiology, Determinants, and Prevention. Endocr Rev. 2012;33(1):48-70.

16. Li C, Ford ES, Zhao G, *et al.* Prevalence of pre-diabetes and its association with clustering of cardiometabolic risk factors and hyperinsulinemia among U.S. adolescents: National Health and Nutrition Examination Survey 2005-2006. Diabetes Care. 2009;32(2):342-347.

17. Haines L, Wan KC, Lynn R, *et al.* Rising incidence of type 2 diabetes in children in the U.K. Diabetes Care. 2007;30(5):1097-1101.

18. Freedman DS, Mei Z, Srinivasan SR, *et al.* Cardiovascular risk factors and excess adiposity among overweight children and adolescents: the Bogalusa Heart Study. J Pediatr. 2007;150(1):12-17.

19. Wee BS, Poh BK, Bulgiba A, *et al.* Risk of metabolic syndrome among children living in metropolitan Kuala Lumpur: a case control study. BMC Public Health. 2011;11:333.

20. Quah YV, Poh BK, Ismail MN. Metabolic Syndrome Based on IDF Criteria in a Sample of Normal Weight and Obese School Children. Mal J Nutr. 2010;16(2):207-217.

21. IOTF. Global strategies to prevent childhood obesity: Forging a societal plan that works.2006.

22. Popkin BM. The shift in stages of the nutrition transition in the developing world differs from past experiences. Mal J Nutr. 2002;8(1):109-124.

23. Popkin BM, Adair LS, Ng SW. Global nutrition transition and the pandemic of obesity in developing countries. Nutr Rev. 2012;70(1):3.

24. WorldBank. Updated Income Classifications. 2015; http://data.worldbank.org/news/2015-country-classifications. Assessed 2015/08/25

25. Omran AR. The epidemiological transition: a theory of the epidemiology of population change. The Millbank Quarterly. 2005;83(4):731-757.

26. Popkin BM. Global nutrition dynamics: the world is shifting rapidly toward a diet linked with noncommunicable diseases. Am J Clin Nutr. 2006;84(2):289-298.

27. Tee ES. Nutrition of Malaysians: where are we heading? Mal J Nutr. 1999;5:87-109.

28. Ismail MN. The nutrition and health transition in Malaysia. Public Health Nutr. 2002;5(1A):191-195.

29. Khor GL. Food availability and the rising obesity prevalence in Malaysia. International e-Journal of Science, Medicine & Education. 2012.

30. Berenson GS. Health consequences of obesity. Pediatr Blood Cancer. 2012;58(1):117-121.

31. Cole TJ, Bellizzi MC, Flegal KM, *et al.* Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ. 2000;320(7244):1240-1243.

32. Reilly JJ, Kelly J, Wilson DC. Accuracy of simple clinical and epidemiological definitions of childhood obesity: systematic review and evidence appraisal. Obes Rev. 2010;11(9):645-655.

33. Liu A, Byrne NM, Kagawa M, *et al.* Ethnic differences in body fat distribution among Asian pre-pubertal children: A cross-sectional multicenter study. BMC Public Health. 2011;11(500).

34. Ludwig DS, Peterson KE, Gortmaker SL. Relation between consumption of sugar-sweetened drinks and childhood obesity: a prospective, observational analysis. Lancet. 2001;357(9255):505-508.

35. Nicklas TA, Yang SJ, Baranowski T, *et al.* Eating patterns and obesity in children: The Bogalusa Heart Study. Am J Prev Med. 2003;25(1):9-16.

36. Forshee RA, Anderson PA, Storey ML. Sugar-sweetened beverages and body mass index in children and adolescents: a meta-analysis. Am J Clin Nutr. 2008;87(6):1662-1671.

37. Weijs PJ, Kool LM, van Baar NM, *et al.* High beverage sugar as well as high animal protein intake at infancy may increase overweight risk at 8 years: a prospective longitudinal pilot study. Nutr J. 2011;10(95).

38. Field AE, Austin SB, Gillman MW, *et al.* Snack food intake does not predict weight change among children and adolescents. Int J Obes Relat Metab Disord. 2004;28(10):1210-1216.

39. Thibault H, Carriere C, Langevin C, *et al.* Prevalence and factors associated with overweight and obesity in French primary-school children. Public Health Nutr. 2013;16(02):193-201.

40. Yang WY, Burrows T, MacDonald-Wicks L, *et al.* Quality of dietary assessment methodology and reporting in epidemiology studies examining relationship between dietary outcome and childhood obesity in developing Asian countries: A systematic review. Nutr & Diet. 2014;71:201-209.

41. Zalilah MS, Khor GL, Kandaiah M, *et al.* Dietary intake, physical activity and energy expenditure of Malaysian adolescents. Singapore Med J. 2006;47 (6):491-498.

42. Pon LW, Kandaiah M, Mohd Nasir MT. Body image perception, dietary practices and physical activity of overweight and normal weight Malaysian female adolescents. Mal J Nutr. 2004;10(2):131-147.

43. Zalilah MS, Khor GL, Mirnalini K, *et al.* Food Neophobia and Nutritional Outcomes in Primary School-Children. J Community Nutrition. 2005;7(3):121-129.

44. Elias S, Hashim Z, Marjan Z, *et al.* Relationship Between Blood Lead Concentration And Nutritional Status Among Malay Primary School Children In Kuala Lumpur, Malaysia. Asia Pac J Public Health. 2007;19(3):29-37.

45. Soo KL, Wan Abdul Manan WM, Abdul Manaf H, *et al.* Dietary practices among overweight and obese Chinese children in Kota Bahru, Kelantan. Mal J Nutr. 2011;17(1):87-95.

46. Norimah AK, Poh BK, Ismail MN. Food habits and dietary intake among adolescents in Malaysia: A review. Mal J Nutr. 2007;13(2):S1.

47. Norimah AK, Toh SM. Association of sugar intake and sweetened beverage consumption with BMI among primary school children in Klang Valley. Paper presented at MASO 2009 Scientific Conference2009. 31-32.

48. Lew K, Barlow PJ. Dietary practices of adolescents in Singapore and Malaysia. Singapore Med J. 2005;45(6):282-288.

49. Moy FM, Gan CY, Siti Zaleha MK. Eating Patterns of School Children and Adolescents in Kuala Lumpur. Mal J Nutr. 2006;12(1):1-10.

50. Firouzi S, Poh BK, Ismail MN, *et al.* Sleep habits, food intake, and physical activity levels in normal and overweight and obese Malaysian children. Obes Res Clin Pract. 2014;8(1):e70-e78.

51. Norimah AK, Mohd Nasir MT, Hazizi AS, *et al.* Association of body weight status and socio-demographic factors with food habits among preschool children in Peninsular Malaysia. Mal J Nutr. 2014;20(3):303-315.

52. Pollard TM, Rousham EK, Colls R. Intergenerational and familial approaches to obesity and related conditions. Ann Hum Biol. 2011;38(4):385-389.

53. Semmler C, Ashcroft J, van Jaarsveld CH, *et al.* Development of overweight in children in relation to parental weight and socioeconomic status. Obesity. 2009;17(4):814-820.

54. Vergara-Castaneda A, Castillo-Martinez L, Colin-Ramirez E, *et al.* Overweight, obesity, high blood pressure and lifestyle factors among Mexican children and their parents. Environ Health Prev Med. 2010;15(6):358-366.

55. Baygi F, Dorosty AR, Kelishadi R, *et al.* Determinants of childhood obesity in representative sample of children in north East of Iran. Cholesterol. 2012;2012(10).

56. Birch LL, Davison KK. Family environmental factors influencing the developing behavioral controls of food intake and childhood overweight. Pediatr Clin North Am. 2001;48(4):893-907.

57. Patrick H, Nicklas TA. A Review of Family and Social Determinants of Children's Eating Patterns and Diet Quality. J Am Coll Nutr. 2005;24(2):83-92.

58. Pearson N, Biddle SJH, Gorely T. Family correlates of fruit and vegetable consumption in children and adolescents: a systematic review. Public Health Nutr. 2009;12(2):267-283.

59. Savage JS, Fisher JO, Birch LL. Parental Influence on Eating Behavior: Conception to Adolescence. J Law Med Ethics. 2007;35(1):22-34.

60. Robinson LN, Rollo ME, Watson J, *et al.* Relationships between dietary intakes of children and their parents: a cross-sectional, secondary analysis of families participating in the Family Diet Quality Study. J Hum Nutr Diet. 2014:1-9.

61. Hall L, Collins CE, Morgan PJ, *et al.* Children's Intake of Fruit and Selected Energy-Dense Nutrient-Poor Foods Is Associated with Fathers' Intake. J Am Diet Assoc. 2011;111(7):1039-1044.

62. Wang Y, Beydoun MA, Li J, *et al.* Do children and their parents eat a similar diet? Resemblance in child and parental dietary intake: systematic review and meta-analysis. J Epidemiol Community Health. 2011;65(2):177-189.

63. Oude Luttikhuis H, Baur L, Jansen H, *et al.* Interventions for treating obesity in children. Cochrane Database Syst Rev. 2009;3.

64. Ho M, Garnett SP, Baur L, *et al.* Effectiveness of lifestyle interventions in child obesity: systematic review with meta-analysis. Pediatrics. 2012;130:e1647-1671.

65. Collins CE, Warren JM, Neve M, *et al.* Measuring effectiveness of dietetic interventions in child obesity: A systematic review of randomized trials. Arch Pediatr Adolesc Med. 2006;160(9):906-922.

66. Glenny AM, O'Meara S, Melville A, *et al.* The treatment and prevention of obesity: a systematic review of the literature. Int J Obes Relat Metab Disord. 1997;21(9):715-737.

67. Summerbell CD, Ashton V, Campbell KJ, *et al.* Interventions for treating obesity in children. Cochrane Database Syst Rev. 2003;3.

68. Whitlock EP, O'Connor EA, Williams SB, *et al.* Effectiveness of weight management interventions in children: a targeted systematic review for the USPSTF. Pediatrics. 2010;125(2):2009-1955.

69. Golan M. Parents as agents of change in childhood obesity – from research to practice. Int J Pediatr Obes. 2006;1(2):66-76.

70. Okely AD, Collins CE, Morgan PJ, *et al.* Multi-Site Randomized Controlled Trial of a Child-Centered Physical Activity Program, a Parent-Centered Dietary-Modification Program, or Both in Overweight Children: The HIKCUPS Study. J Pediatr. 2010;157(3):388-394.e381.

71. Magarey AM, Perry RA, Baur LA, *et al.* A parent-led family-focused treatment program for overweight children aged 5 to 9 years: the PEACH RCT. Pediatrics. 2011;127(2):214-222.

72. Robertson W, Thorogood M, Inglis N, *et al.* Two-year follow-up of the 'Families for Health' programme for the treatment of childhood obesity. Child Care Health Dev. 2012;38(2):229-236.

73. Hughes AR, Stewart L, Chapple J, *et al.* Randomized, controlled trial of a best-practice individualized behavioral program for treatment of childhood overweight: Scottish Childhood Overweight Treatment Trial (SCOTT). Pediatrics. 2008;121(3):e539-546.

74. Jiang JX, Xia XL, Greiner T, *et al.* A two year family based behaviour treatment for obese children. Arch Dis Child. 2005;90(12):1235-1238.

75. Woo KS, Chook P, Yu CW, *et al.* Effects of diet and exercise on obesity-related vascular dysfunction in children. Circulation. 2004;109(16):1981-1986.

76. Huang SH, Weng KP, Hsieh KS, *et al.* Effects of a classroom-based weight-control intervention on cardiovascular disease in elementary-school obese children. Acta Paediatr Taiwan. 2007;48(4):201-206.

77. Lee A, Ho M, Keung VM, *et al.* Childhood obesity management shifting from health care system to school system: intervention study of school-based weight management programme. BMC Public Health. 2014;14(1128).

78. Xu F, Wang X, Ware RS, *et al.* A school-based comprehensive lifestyle intervention among Chinese kids against Obesity (CLICK-Obesity) in Nanjing City, China: the baseline data. Asia Pac J Clin Nutr. 2014;23(1):48-54.

79. Siti Sabariah B, Ruzita AT, Poh BK. The H.E.B.A.T! Program: A randomized control trial intervention to combat childhood obesity in Negeri Sembilan, Malaysia. Paper presented at 30th Scientific Conference of the Nutrition Society Malaysia; Kuala Lumpur2015. 58-59.

80. Sharifah WW, Nur HH, Ruzita AT, *et al.* The Malaysian Childhood Obesity Treatment Trial (MASCOT). Mal J Nutr. 2011;17(2):229-236.

81. Yang WY, Burrows T, MacDonald-Wicks L, *et al.* Studying the Family Diet: An investigation into the association between diet, lifestyle and weight status in Malaysian families. Mal J Nutr. 2015;21(2):139-154.

82. Yang WY, Burrows T, Collins CE, *et al.* Prevalence of energy intake misreporting in Malay children varies based on application of different cut points. J Trop Pediatr. 2014;60(6):472-475.

83. Yang WY, Burrows T, MacDonald-Wicks L, *et al.* Dietary energy intake is associated with body mass index among urban Malay children: findings from a cross-sectional study. BMC Pediatr. 2015.

84. Yang WY, Burrows T, MacDonald-Wicks L, *et al.* The Family Diet Study: A cross-sectional study into the associations between diet, food habits and weight status in Malay families. J Hum Nutr Diet. 2015.

85. Burrows T, Golley RK, Khambalia A, *et al.* The quality of dietary intake methodology and reporting in child and adolescent obesity intervention trials: a systematic review. Obes Rev. 2012;13(12):1125-1138.

86. Nelson M, Margetts BM, Black AE. Correspondence. Metabolism. 1993;42(2):258-259.

87. Serra-Majem L, Frost Andersen L, Henríque-Sánchez P, *et al.* Evaluating the quality of dietary intake validation studies. Br J Nutr. 2009;102(SupplementS1):S3-S9.

88. Black AE. Critical evaluation of energy intake using the Goldberg cut-off for energy intake:basal metabolic rate. A practical guide to its calculation, use and limitations. Int J Obes Relat Metab Disord. 2000;24(9):1119-1130.

89. Goldberg GR, Black AE, Jebb SA, *et al.* Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivation of cut-off limits to identify under-recording. Eur J Clin Nutr. 1991;45(12):569-581.

90. Torun B, Davies PS, Livingstone MB, *et al.* Energy requirements and dietary energy recommendations for children and adolescents 1 to 18 years old. Eur J Clin Nutr. 1996;50 Suppl 1:S37-80.

91. Black AE, Cole TJ. Within- and between-subject variation in energy expenditure measured by the doubly-labelled water technique: implications for validating reported dietary energy intake. Eur J Clin Nutr. 2000;54(5):386-394.

92. Ng M, Fleming T, Robinson M, *et al.* Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2014;384(9945):766-781.

93. Bishwalata R, Singh AB, Singh AJ, *et al.* Overweight and obesity among schoolchildren in Manipur, India. Natl Med J India. 2010;23(5):263-266.

94. Li M, Dibley MJ, Sibbritt D, *et al.* Factors associated with adolescents' overweight and obesity at community, school and household levels in Xi'an City, China: Results of hierarchical analysis. Eur J Clin Nutr. 2008;62 (5):635-643.

95. Anuar Zaini MZ, Lim CT, Low WY, *et al.* Factors affecting nutritional status of Malaysian primary school children. Asia Pac J Public Health. 2005;17(2):71-80.

96. Khor GL, Noor Safiza MN, Rahmah R, *et al.* The Third National Health and Morbidity Survey (NHMS III) 2006: Nutritional Status of Children Aged 0 to Below 18 Years. Mal J Nutr. 2008;14(2):S6.

97. Norimah AK, Lau KK. Nutritional status among Chinese preschoolers in Subang Jaya, Selangor. Mal J Nutr. 2000;6(1):45-53.

98. He Q, Ding ZY, Fong DYT, *et al.* Risk factors of obesity in preschool children in China: A population-based case-control study. Int J Obes. 2000;24 (11):1528-1536.

99. Guo X, Zheng L, Li Y, *et al.* Differences in lifestyle behaviors, dietary habits, and familial factors among normal-weight, overweight, and obese Chinese children and adolescents. Int J Behav Nutr Phys Act. 2012;9(120).

100. Khadilkar VV, Khadilkar AV, Cole TJ, *et al.* Overweight and obesity prevalence and body mass index trends in Indian children. Int J Pediatr Obes. 2011;6(2-2):e216-e224.

101. Hazreen MA, Su TT, Jalaludin MY, *et al.* An exploratory study on risk factors for chronic non-communicable diseases among adolescents in Malaysia: overview of the Malaysian Health and Adolescents Longitudinal Research Team study (The MyHeART study). BMC Public Health. 2014;14(3).

102. WHO. Physical status: the use and interpretation of anthropometry. Geneva: World Health Organization.1995.

103. WHO. WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development. Geneva: World Health Organization. 2006.

104. WHO. Growth Chart for Children 5–19 years. Geneva: World Health Organization. 2007.

105. Kuczmarski RJ, Ogden CL, Guo SS, *et al.* 2000 CDC growth charts for the United States: Methods and development. Vital Health Stat. 2002;11(246).

106. WHO. Use and interpretation of anthropometric indicators of nutritional status. Bulletin of the World Health Organization. 1986;64(6):929-941.

107. Kasmini K, Idris MN, Fatimah A, *et al.* Prevalence of overweight and obese school children aged between 7 to 16 years amongst the major 3 ethnic groups in Kuala Lumpur, Malaysia. Asia Pac J Clin Nutr. 1997;6(3):172-174.

108. Zalilah MS, Bond JT, Johnson NE. Nutritional status of primary school children from low income households in Kuala Lumpur. Mal J Nutr. 2000;6:17-32.

109. Moy FM, Gan CY, Siti Zaleha MK. Body mass status of school children and adolescents in Kuala Lumpur, Malaysia. Asia Pac J Clin Nutr. 2004;13(4):324-329.

110. Rampal L, Rampal S, Khor GL, *et al.* A national study on the prevalence of obesity among 16,127 Malaysians. Asia Pac J Clin Nutr. 2007;16(3):561-566.

111. Khor GL, Noor Safiza MN, Rahmah R, *et al.* Nutritional Status of Children below Five Years in Malaysia: Anthropometric Analyses from the Third National Health and Morbidity Survey III (NHMS, 2006). Mal J Nutr. 2009;15(2):121-136.

112. Khor GL, Chee WS, Shariff ZM, *et al.* High prevalence of vitamin D insufficiency and its association with BMI-for-age among primary school children in Kuala Lumpur, Malaysia. BMC Public Health. 2011;11(95).

113. Mei Z, Grummer-Strawn LM, Pietrobelli A, *et al.* Validity of body mass index compared with other body-composition screening indexes for the assessment of body fatness in children and adolescents. Am J Clin Nutr. 2002;75(6):978-985.

114. Consultation WE. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004;363(9403):157-163.

115. Cole TJ, Faith MS, Pietrobelli A, *et al.* What is the best measure of adiposity change in growing children: BMI, BMI %, BMI z-score or BMI centile? Eur J Clin Nutr. 2005;59(3):419-425.

116. de Onis M, Lobstein T. Defining obesity risk status in the general childhood population: Which cut-offs should we use? Int J Pediatr Obes. 2010;5(6):458-460.

117. Lee RD, Nieman DC. Anthropometry. In: Lee RD, Nieman DC, editors. Nutritional Assessment. 5th ed. New York: McGraw Hill. 2010.

118. McCarthy HD, Cole TJ, Fry T, *et al.* Body fat reference curves for children. Int J Obes. 2006;30(4):598-602.

119. Williams DP, Going SB, Lohman TG, *et al.* Body fatness and risk for elevated blood pressure, total cholesterol, and serum lipoprotein ratios in children and adolescents. Am J Public Health. 1992;82(3):358-363.

120. Liu A, Byrne NM, Kagawa M, *et al.* Ethnic differences in the relationship between body mass index and percentage body fat among Asian children from different backgrounds. Br J Nutr. 2011;106(09):1390-1397.

121. Freedman DS, Wang J, Maynard LM, *et al.* Relation of BMI to fat and fat-free mass among children and adolescents. Int J Obes. 2005;29(1):1-8.

122. Deurenberg P, Deurenberg-Yap M, Guricci S. Asians are different from Caucasians and from each other in their body mass index/body fat per cent relationship. Obes Rev. 2002;3(3):141-146.

123. McCarthy HD, Jarrett KV, Crawley HF. The development of waist circumference percentiles in British children aged 5.0 - 16.9 y. Eur J Clin Nutr. 2001;55:902-907.

124. Brambilla P, Bedogni G, Moreno LA, *et al.* Crossvalidation of anthropometry against magnetic resonance imaging for the assessment of visceral and subcutaneous adipose tissue in children. Int J Obes Relat Metab Disord. 2006;30(1):23-30.

125. de Moraes ACF, Fadoni RP, Ricardi LM, *et al.* Prevalence of abdominal obesity in adolescents: a systematic review. Obes Rev. 2011;12(2):69-77.

126. Poh BK, Jannah AN, Chong LK, *et al.* Waist circumference percentile curves for Malaysian children and adolescents aged 6.0 -16.9 years. Int J Pediatr Obes. 2011;6(3-4):229-235.

127. NHMRC. How to use the evidence:assessment and application of scientific evidence. Canberra: Australian Government.2000.

128. Egan KB, Ettinger AS, Bracken MB. Childhood body mass index and subsequent physician-diagnosed asthma: a systematic review and meta-analysis of prospective cohort studies. BMC Pediatr. 2013;13:121.

129. Black MH, Zhou H, Takayanagi M, *et al.* Increased asthma risk and asthma-related health care complications associated with childhood obesity. Am J Epidemiol. 2013;178(7):1120-1128.

130. Rzehak P, Wijga AH, Keil T, *et al.* Body mass index trajectory classes and incident asthma in childhood: results from 8 European Birth Cohorts--a Global Allergy and Asthma European Network initiative. J Allergy Clin Immunol. 2013;131(6):1528-1536.

131. Narang I, Mathew JL. Childhood obesity and obstructive sleep apnea. J Nutr Metab. 2012;2012.

132. Kang KT, Lee PL, Weng WC, *et al.* Body weight status and obstructive sleep apnea in children. Int J Obes. 2012;36(7):920-924.

133. Neuschwander-Tetri BA, Caldwell SH. Nonalcoholic steatohepatitis: summary of an AASLD Single Topic Conference. Hepatology. 2003;37(5):1202-1219.

134. Schwimmer JB, Deutsch R, Kahen T, *et al.* Prevalence of fatty liver in children and adolescents. Pediatrics. 2006;118(4):1388-1393.

135. Patton HM, Yates K, Unalp-Arida A, *et al.* Association between metabolic syndrome and liver histology among children with nonalcoholic Fatty liver disease. Am J Gastroenterol. 2010;105(9):2093-2102.

136. Abrams P, Levitt Katz LE. Metabolic effects of obesity causing disease in childhood. Curr Opin Endocrinol Diabetes and Obes. 2011;18(1):23-27.

137. Cote AT, Harris KC, Panagiotopoulos C, *et al.* Childhood obesity and cardiovascular dysfunction. J Am Coll Cardiol. 2013;62(15):1309-1319.

138. van Emmerik NM, Renders CM, van de Veer M, *et al.* High cardiovascular risk in severely obese young children and adolescents. Arch Dis Child. 2012;97(9):818-821.

139. Kelishadi R, Mirmoghtadaee P, Najafi H, *et al.* Systematic review on the association of abdominal obesity in children and adolescents with cardio-metabolic risk factors. J Res Med Sci. 2015;20(3):294-307.

140. Coatmellec-Taglioni G, Ribiere C. Factors that influence the risk of hypertension in obese individuals. Curr Opin Nephrol Hypertens. 2003;12(3):305-308.

141. Daniels SR. Complications of obesity in children and adolescents. Int J Obes. 2009;33(1):20.

142. Paulis WD, Silva S, Koes BW, *et al.* Overweight and obesity are associated with musculoskeletal complaints as early as childhood: a systematic review. Obes Rev. 2014;15(1):52-67.

143. Griffiths LJ, Parsons TJ, Hill AJ. Self-esteem and quality of life in obese children and adolescents: a systematic review. Int J Pediatr Obes. 2010;5(4):282-304.

144. Miller CT, Downey KT. A Meta-Analysis of Heavyweight and Self-Esteem. Personality and Social Psychology Review. 1999;3(1):68-84.

145. Lowry KW, Sallinen BJ, Janicke DM. The Effects of Weight Management Programs on Self-Esteem in Pediatric Overweight Populations. J Pediatr Psychol. 2007;32(10):1179-1195.

146. Griffiths LJ, Dezateux C, Hill A. Is obesity associated with emotional and behavioural problems in children? Findings from the Millennium Cohort Study. Int J Pediatr Obes. 2011;6(2-2):30.

147. Hamzaid H, Talib RA, Azizi NH, *et al.* Quality of life of obese children in Malaysia. Int J Pediatr Obes. 2011;6(5-6):450-454.

148. Ul-Haq Z, Mackay DF, Fenwick E, *et al.* Meta-analysis of the association between body mass index and health-related quality of life among children and adolescents, assessed using the pediatric quality of life inventory index. J Pediatr. 2013;162(2):280-286.

149. Finkelstein EA, Ruhm CJ, Kosa KM. Economic causes and consequences of obesity. Annu Rev Public Health. 2005;26(1):239-257.

150. Müller-Riemenschneider F, Reinhold T, Berghöfer A, *et al.* Health-Economic Burden of Obesity in Europe. Eur J Epidemiol. 2008;23(8):499-509.

151. Wang LY, Denniston M, Lee S, *et al.* Long-term Health and Economic Impact of Preventing and Reducing Overweight and Obesity in Adolescence. J Adolesc Health. 2010;46(5):467-473.

152. Usfar AA, Lebenthal E, Atmarita, *et al.* Obesity as a poverty-related emerging nutrition problems: the case of Indonesia. Obes Rev. 2010;11(12):924-928.

153. Tan AKG, Dunn RA, Samad MIA, *et al.* Sociodemographic and Health-Lifestyle Determinants of Obesity Risks in Malaysia. Asia Pac J Public Health. 2011;23(2):192-202.

154. Maffeis C. Aetiology of overweight and obesity in children and adolescents. Eur J Pediatr. 2000;159(1):S35-S44.

155. Ramachandrappa S, Farooqi IS. Genetic approaches to understanding human obesity. J Clin Invest. 2011;121(6):2080-2086.

156. Allison DB, Kaprio J, Korkeila M, *et al.* The heritability of body mass index among an international sample of monozygotic twins reared apart. Int J Obes Relat Metab Disord. 1996;20(6):501-506.

157. Stunkard AJ, Harris JR, Pedersen NL, *et al.* The body-mass index of twins who have been reared apart. N Engl J Med. 1990;322(21):1483-1487.

158. Haworth CM, Plomin R, Carnell S, *et al.* Childhood obesity: genetic and environmental overlap with normal-range BMI. Obesity. 2008;16(7):1585-1590.

159. Parsons TJ, Power C, Logan S, *et al.* Childhood predictors of adult obesity: a systematic review. Int J Obes Relat Metab Disord. 1999;23(8):S1-107.

160. Bergin JE, Neale MC, Eaves LJ, *et al.* Genetic and environmental transmission of body mass index fluctuation. Behav Genet. 2012;42(6):867-874.

161. Prentice A, Jebb S. Energy intake/physical activity interactions in the homeostasis of body weight regulation. Nutr Rev. 2004;62(Suppl S2):S98-104.

162. WHO. Diet, Nutrition and the Prevention of Chronic Diseases. Geneva: World Health Organization.2002.

163. WHO. Population-based prevention strategies for childhood obesity: report of a WHO forum and technical meeting. Geneva: World Health Organization.2010.

164. Hill JO, Wyatt HR, Peters JC. Energy Balance and Obesity. Circulation. 2012;126(1):126-132.

165. Wells JCK, Siervo M. Obesity and energy balance: is the tail wagging the dog[quest]. Eur J Clin Nutr. 2011;65(11):1173-1189.

166. Hall KD, Heymsfield SB, Kemnitz JW, *et al.* Energy balance and its components: implications for body weight regulation. Am J Clin Nutr. 2012;95(4):989-994.

167. Bleich SN, Ku R, Wang YC. Relative contribution of energy intake and energy expenditure to childhood obesity: a review of the literature and directions for future research. Int J Obes. 2011;35(1):1-15.

168. Prentice AM, Jebb SA. Obesity in Britain: gluttony or sloth? BMJ. 1995;311(7002):437-439.

169. Swinburn BA, Jolley D, Kremer PJ, *et al.* Estimating the effects of energy imbalance on changes in body weight in children. Am J Clin Nutr. 2006;83(4):859-863.

170. Livingstone MB. Epidemiology of childhood obesity in Europe. Eur J Pediatr. 2000;159(1):S14-S34.

171. FAO. Human Energy Requirement: Report of a Joint FAO/WHO/UNU Expert Consultation. Rome: Food and Agriculture Organization of the United Nations.2004.

172. Collins CE, Watson J, Burrows T. Measuring dietary intake in children and adolescents in the context of overweight and obesity. Int J Obes. 2010;34(7):1103-1115.

173. NCCFN NCCoFaN. Recommended Nutrient Intakes for Malaysia. Putrajaya: National Coordinating Committee on Food and Nutrition, Ministry of Health.2005.

174. NCCFN NCCoFaN. Malaysian Dietary Guidelines for Children and Adolescents - Summary. Putrajaya: Ministry of Health. 2013.

175. Lee RD, Nieman DC. Standards for Nutrient Intake. In: Lee RD, Nieman DC, editors. Nutritional Assessment. 5th ed. New York: McGraw Hill. 2010.

176. NCCFN NCCoFaN. Malaysian Dietary Guidelines: Ministry of Health. 2010.

177. WHO. A framework for implementing the set of recommendations on the marketing of foods and non-alcoholic beverages to children. Geneva: World Health Organzation.2012.

178. Livingstone MB, Pourshahidi LK. Portion size and obesity. Adv Nutr. 2014;5(6):829-834.

179. Zalilah MS, Khor GL, Sarina S, *et al.* The relationship between household income and dietary intakes of 1-10 year old urban Malaysian. Nutr Res Pract. 2015;9(3):278-287.

180. Woon FC, Chin YS, Kaartina S, *et al.* Association between Home Environment, Dietary Practice, and Physical Activity among Primary School Children in Selangor, Malaysia. Mal J Nutr. 2014;20(1):1-14.

181. Nurliyana AR, Mohd Nasir MT, Zalilah MS, *et al.* Dietary patterns and cognitive ability among 12- to 13 year-old adolescents in Selangor, Malaysia. Public Health Nutr. 2015;18(2):303-312.

182. Chee WSS, Ismail MN, Ng KK, *et al.* Food intake assessment of adults in rural and urban areas from four selected regions in Malaysia. Mal J Nutr. 1997;3:91-102.

183. Norimah AK, Safiah M, Jamal K, *et al.* Food Consumption Patterns: Findings from the Malaysian Adult Nutrition Survey (MANS). Mal J Nutr. 2008;14(1):25-39.

184. Mirnalini K, Zalilah MS, Safiah MY, *et al.* Energy and Nutrient Intakes: Findings from the Malaysian Adult Nutrition Survey (MANS). Mal J Nutr. 2008;14(1):1-24.

185. te Velde SJ, van Nassau F, Uijtdewilligen L, *et al.* Energy balance-related behaviours associated with overweight and obesity in preschool children: a systematic review of prospective studies. Obes Rev. 2012;13:56-74.

186. Perez-Escamilla R, Obbagy JE, Altman JM, *et al.* Dietary energy density and body weight in adults and children: A Systematic Review. J Acad Nutr Diet. 2012;112(5):671-684.

187. Davison KK, Birch LL. Child and parent characteristics as predictors of change in girls' body mass index. Int J Obes Relat Metab Disord. 2001;25(12):1834-1842.

188. Newby PK. Are dietary intakes and eating behaviors related to childhood obesity? A comprehensive review of the evidence. J Law Med Ethics. 2007;35(1):35-60.

189. Maffeis C, Talamini G, Tato L. Influence of diet, physical activity and parents' obesity on children's adiposity: a four-year longitudinal study. Int J Obes Relat Metab Disord. 1998;22(8):758-764.

190. Magarey AM, Daniels LA, Boulton TJ, *et al.* Does fat intake predict adiposity in healthy children and adolescents aged 2--15 y? A longitudinal analysis. Eur J Clin Nutr. 2001;55(6):471-481.

191. Jago R, Baranowski T, Baranowski JC, *et al.* BMI from 3-6 y of age is predicted by TV viewing and physical activity, not diet. Int J Obes Relat Metab Disord. 2005;29(6):557-564.

192. Elliott SA, Truby H, Lee A, *et al.* Associations of body mass index and waist circumference with: energy intake and percentage energy from macronutrients, in a cohort of Australian children. Nutr J. 2011;10(58).

193. Berkey CS, Rockett HR, Field AE, *et al.* Activity, dietary intake, and weight changes in a longitudinal study of preadolescent and adolescent boys and girls. Pediatrics. 2000;105(4):e56-65.

194. Berkey CS, Rockett HH, Willett WC, *et al.* Milk, dairy fat, dietary calcium, and weight gain: A longitudinal study of adolescents. Arch Pediatr Adolesc Med. 2005;159(6):543-550.

195. Gazzaniga JM, Burns TL. Relationship between diet composition and body fatness, with adjustment for resting energy expenditure and physical activity, in preadolescent children. Am J Clin Nutr. 1993;58(1):21-28.

196. Hassapidou M, Fotiadou E, Maglara E, *et al.* Energy Intake, Diet Composition, Energy Expenditure, and Body Fatness of Adolescents in Northern Greece. Obesity. 2006;14(5):855-862.

197. Garaulet M, Martinez A, Victoria F, *et al.* Difference in dietary intake and activity level between normal-weight and overweight or obese adolescents. J Pediatr Gastroenterol Nutr. 2000;30(3):253-258.

198. Rolls BJ. The relationship between dietary energy density and energy intake. Physiol Behav. 2009;97(5):609-615.

199. Drewnowski A. Energy density, palatability, and satiety: implications for weight control. Nutr Rev. 1998;56(12):347-353.

200. Savage JS, Fisher JO, Marini M, *et al.* Serving smaller age-appropriate entree portions to children aged 3-5 y increases fruit and vegetable intake and reduces energy density and energy intake at lunch. Am J Clin Nutr. 2012;95(2):335-341.

201. Leahy KE, Birch LL, Rolls BJ. Reducing the energy density of multiple meals decreases the energy intake of preschool-age children. Am J Clin Nutr. 2008;88(6):1459-1468.

202. Cotton JR, Burley VJ, Weststrate JA, *et al.* Dietary fat and appetite: similarities and differences in the satiating effect of meals supplemented with either fat or carbohydrate. J Hum Nutr Diet. 2007;20(3):186-199.

203. Robertson SM, Cullen KW, Baranowski J, *et al.* Factors Related to Adiposity Among Children Aged 3 to 7 Years. J Am Diet Assoc. 1999;99(8):938-943.

204. Rolland-Cachera MF, Deheeger M, Akrout M, *et al.* Influence of macronutrients on adiposity development: a follow up study of nutrition and growth from 10 months to 8 years of age. Int J Obes Relat Metab Disord. 1995;19(8):573-578.

205. Ohlund I, Hernell O, Hornell A, *et al.* BMI at 4 years of age is associated with previous and current protein intake and with paternal BMI. Eur J Clin Nutr. 2010;64(2):138-145.

206. Hornell A, Lagstrom H, Lande B, *et al.* Protein intake from 0 to 18 years of age and its relation to health: a systematic literature review for the 5th Nordic Nutrition Recommendations. Food Nutr Res. 2013;23(57).

207. Sanigorski AM, Bell AC, Swinburn BA. Association of key foods and beverages with obesity in Australian schoolchildren. Public Health Nutr. 2007;10(2):152-157.

208. Malik VS, Willett WC, Hu FB. Sugar-sweetened beverages and BMI in children and adolescents: reanalyses of a meta-analysis. Am J Clin Nutr. 2009;89(1):438-439.

209. Malik VS, Schulze MB, Hu FB. Intake of sugar-sweetened beverages and weight gain: a systematic review. Am J Clin Nutr. 2006;84(2):274-288.

210. Nishida C, Uauy R, Kumanyika S, *et al.* The joint WHO/FAO expert consultation on diet, nutrition and the prevention of chronic diseases: process, product and policy implications. Public Health Nutr. 2004;7(1A):245-250.

211. Newby P. Plant foods and plant-based diets: protective against childhood obesity? Am J Clin Nutr. 2009 May 1, 2009;89(5):1572S-1587S.

212. Ledoux TA, Hingle MD, Baranowski T. Relationship of fruit and vegetable intake with adiposity: a systematic review. Obes Rev. 2010;12(5):e143-e150.

213. Epstein LH, Gordy CC, Raynor HA, *et al.* Increasing fruit and vegetable intake and decreasing fat and sugar intake in families at risk for childhood obesity. Obes Res. 2001;9(3):171-178.

214. Kaiser KA, Brown AW, Bohan Brown MM, *et al.* Increased fruit and vegetable intake has no discernible effect on weight loss: a systematic review and meta-analysis. Am J Clin Nutr. 2014;100(2):567-576.

215. Janssen I, Katzmarzyk PT, Boyce WF, *et al.* Comparison of overweight and obesity prevalence in school-aged youth from 34 countries and their relationships with physical activity and dietary patterns. Obes Rev. 2005;6(2):123-132.

216. Van Der Horst K, Paw MJ, Twisk JW, *et al.* A brief review on correlates of physical activity and sedentariness in youth. Med Sci Sports Exerc. 2007;39(8):1241-1250.

217. Hinkley T, Crawford D, Salmon J, *et al.* Preschool children and physical activity: a review of correlates. Am J Prev Med. 2008;34(5):435-441.

218. Reilly JJ. Physical activity, sedentary behaviour and energy balance in the preschool child: opportunities for early obesity prevention. . Proc Nutr Soc. 2008;67(3):317-325.

219. Marshall SJ, Biddle SJ, Gorely T, *et al.* Relationships between media use, body fatness and physical activity in children and youth: a meta-analysis. Int J Obes Relat Metab Disord. 2004;28(10):1238-1246.

220. DeMattia L, Lemont L, Meurer L. Do interventions to limit sedentary behaviours change behaviour and reduce childhood obesity? A critical review of the literature. Obes Rev. 2007;8(1):69-81.

221. Reilly JJ, Penpraze V, Hislop J, *et al.* Objective measurement of physical activity and sedentary behaviour: review with new data. Arch Dis Child. 2008;93(7):614-619.

222. Tudor-Locke C, Craig CL, Beets MW, *et al.* How many steps/day are enough? for children and adolescents. Int J Behav Nutr Phys Act. 2011;8(78).

223. Bradley RH, McRitchie S, Houts RM, *et al.* Parenting and the decline of physical activity from age 9 to 15. Int J Behav Nutr Phys Act. 2011;8(33).

224. WHO. Physical activity and young people. World Health Organization. 2015 updated January 2015; http://www.who.int/mediacentre/factsheets/fs385/en/. Assessed 2015/0918

225. NICE. Promoting physical activity for children and young people: National Institute for Health and Care Excellence. 2009.

226. AHA. The AHA's Recommendations for Physical Activity in Children. 2015 updated 2014/11/10; http://www.heart.org/HEARTORG/GettingHealthy/HealthierKids/ActivitiesforKids/The-AHAs-Recommendations-for-Physical-Activity-in-Children_UCM_304053_Article.jsp. Assessed 2015/09/17

227. Tucker P. The physical activity levels of preschool-aged children: A systematic review. Early Childhood Res Q. 2008;23(4):547-558.

228. WHO. Prevalence of insufficient physical activity among school going adolescents. Geneva: World Health Organization. 2010; http://www.who.int/gho/ncd/risk_factors/physical_activity_text/en/. Assessed 2015/09/20

229. Ridley K, Ainsworth BE, Olds TS. Development of a compendium of energy expenditures for youth. Int J Behav Nutr Phys Act. 2008;5(45).

230. Telford RD, Cunningham RB, Telford RM, *et al.* Determinants of childhood adiposity: evidence from the Australian LOOK study. PLoS ONE. 2012;7(11):21.

231. Reilly JJ, Ness AR, Sherriff A. Epidemiological and physiological approaches to understanding the etiology of pediatric obesity: finding the needle in the haystack. Pediatr Res. 2007;61(6):646-652.

232. Pearson N, Biddle SJ. Sedentary behavior and dietary intake in children, adolescents, and adults. A systematic review. Am J Prev Med. 2011;41(2):178-188.

233. Dietz WH, Jr., Gortmaker SL. Do we fatten our children at the television set? Obesity and television viewing in children and adolescents. Pediatrics. 1985;75(5):807-812.

234. Tremblay MS, LeBlanc AG, Kho ME, *et al.* Systematic review of sedentary behaviour and health indicators in school-aged children and youth. Int J Behav Nutr Phys Act. 2011;8(1).

235. Lau XC, Chong KH, Poh BK, *et al.* Physical Activity, Fitness and the Energy Cost of Activities: Implications for Obesity in Children and Adolescents in the Tropics. In: Jeyakumar H, editor. Adv Food Nutr Res: Academic Press. 2013. 49-101.

236. Mo-Suwan L, Nontarak J, Aekplakorn W, *et al.* Computer Game Use and Television Viewing Increased Risk for Overweight among Low Activity Girls: Fourth Thai National Health Examination Survey 2008-2009. Int J Pediatr. 2014;2014.

237. Ghavamzadeh S, Khalkhali HR, Alizadeh M. TV viewing, independent of physical activity and obesogenic foods, increases overweight and obesity in adolescents. J Health Popul Nutr. 2013;31(3):334-342.

238. Sharifah WW, Hana H, Ruzita AT, *et al.* Objectively Measured Habitual Physical Activity and Sedentary Behaviour in Obese and Non-Obese Malaysian children. J Trop Pediatr. 2014;60(2):161-163.

239. Sleddens EF, Gerards SM, Thijs C, *et al.* General parenting, childhood overweight and obesity-inducing behaviors: a review. Int J Pediatr Obes. 2011;6(2-2):e12-27.

240. Wang MC, Naidoo N, Ferzacca S, *et al.* The Role of Women in Food Provision and Food Choice Decision-Making in Singapore: A Case Study. Ecol Food Nutr. 2014;53(6):658-677.

241. Keane E, Layte R, Harrington J, *et al.* Measured Parental Weight Status and Familial Socio-Economic Status Correlates with Childhood Overweight and Obesity at Age 9. PLoS ONE. 2012;7(8):e43503.

242. Lee K, Kwon ER, Park TJ, *et al.* Parental overweight as an indicator of childhood overweight: how sensitive? Asia Pac J Clin Nutr. 2006;15(2):196-200.

243. Golan M, Crow S. Targeting parents exclusively in the treatment of childhood obesity:long-term results. Obes Res. 2004;12(2):357 - 361.

244. Sekine M, Yamagami T, Hamanishi S, *et al.* Parental obesity, lifestyle factors and obesity in preschool children: results of the Toyama Birth Cohort study. J Epidemiol. 2002;12(1):33-39.

245. Li Y, Zhai F, Yang X, *et al.* Determinants of childhood overweight and obesity in China. Br J Nutr. 2007;97(1):210-215.

246. Tang KH, Nguyen HHDT, Dibley MJ, *et al.* Factors associated with adolescent overweight/obesity in Ho Chi Minh city. Int J Pediatr Obes. 2010;5(5):396-403.

247. Thongbai W, Fongkaew W, Kennedy CM, *et al.* Risk factors contributing to overweight among preschool children. Pacific Rim Int J Nurs Res. 2011;15(1):13-27.

248. Serene TE, Shamarina S, Mohd NM. Familial and socio-environmental predictors of overweight and obesity among primary school children in Selangor and Kuala Lumpur. Mal J Nutr. 2011;17(2):151-162.

249. Linabery AM, Nahhas RW, Johnson W, *et al.* Stronger influence of maternal than paternal obesity on infant and early childhood body mass index: the Fels Longitudinal Study. Pediatr Obes. 2013;8(3):159-169.

250. Ghosh A. Rural-Urban Comparison in Prevalence of Overweight and Obesity Among Children and Adolescents of Asian Indian Origin. Asia Pac J Public Health. 2011;23(6):928-935.

251. Towns N, D'Auria J. Parental perceptions of their child's overweight: an integrative review of the literature. J Pediatr Nurs. 2009;24(2):115-130.

252. Beydoun MA, Wang Y. Parent–child dietary intake resemblance in the United States: Evidence from a large representative survey. Soc Sci Med. 2009;68(12):2137-2144.

253. Raynor HA, Van Walleghen EL, Osterholt KM, *et al.* The relationship between child and parent food hedonics and parent and child food group intake in children with overweight/obesity. J Am Diet Assoc. 2011;111(3):425-430.

254. Davison KK, Birch LL. Childhood overweight: a contextual model and recommendations for future research. Obes Rev. 2001;2(3):159-171.

255. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. Med Sci Sports Exerc. 2000;32(5):963-975.

256. Gustafson SL, Rhodes RE. Parental correlates of physical activity in children and early adolescents. Sports Med. 2006;36(1):79-97.

257. Young EM, Fors SW, Hayes DM. Associations between perceived parent behaviors and middle school student fruit and vegetable consumption. J Nutr Educ Behav. 2004;36(1):2-8.

258. Spurrier NJ, Magarey AA, Golley R, *et al.* Relationships between the home environment and physical activity and dietary patterns of preschool children: a cross-sectional study. Int J Behav Nutr Phys Act. 2008;5.

259. Gattshall ML, Shoup JA, Marshall JA, *et al.* Validation of a survey instrument to assess home environments for physical activity and healthy eating in overweight children. Int J Behav Nutr Phys Act. 2008;5.

260. Darling N, Steinberg L. Parenting Style as Context: An Integrative Model. Psychol Bull. 1993;113(3):487-496.

261. Pai HL, Contento I. Parental perceptions, feeding practices, feeding styles, and level of acculturation of Chinese Americans in relation to their school-age child's weight status. Appetite. 2014;80:174-182.

262. Faith MS, Scanlon KS, Birch LL, *et al.* Parent-child feeding strategies and their relationships to child eating and weight status. Obes Res. 2004;12(11):1711-1722.

263. Jiang J, Rosenqvist U, Wang H, *et al.* Risk factors for overweight in 2- to 6-year-old children in Beijing, China. Int J Pediatr Obes. 2006;1 (2):103-108.

264. Hurley KM, Cross MB, Hughes SO. A Systematic Review of Responsive Feeding and Child Obesity in High-Income Countries. J Nutr. 2011;141(3):495-501.

265. Wardle J, Carnell S. Parental feeding practices and children's weight. Acta Paediatr Suppl. 2007;96(454):5-11.

266. Birch LL, Fisher JO, Grimm-Thomas K, *et al.* Confirmatory factor analysis of the Child Feeding Questionnaire: a measure of parental attitudes, beliefs and practices about child feeding and obesity proneness. Appetite. 2001;36(3):201-210.

267. Costanzo PR, Woody EZ. Domain-specific parenting styles and their impact on the child's development of particular deviance: the example of obesity proneness. J Soc Clin Psych. 1985;3:425-445.

268. Collins C, Duncanson K, Burrows T. A systematic review investigating associations between parenting style and child feeding behaviours. J Hum Nutr Diet. 2014;27(6):557-568.

269. Noor AM, Leelavathi M, Shamsul AS, *et al.* Parental concerns and control in feeding of 9 to 12-year-old children in a primary school in Kuala Lumpur, Malaysia. Mal J Nutr. 2012;18(1):47-55.

270. Wan Abdul Manan WM, Norazawati AK, Lee YY. Overweight and obesity among Malay primary school children in Kota Bharu, Kelantan: Parental beliefs, attitudes and child feeding practices. Mal J Nutr. 2012;18(1):27-36.

271. Dearth-Wesley T, Wang H, Popkin BM. Under- and overnutrition dynamics in Chinese children and adults (1991-2004). Eur J Clin Nutr. 2007;62(11):1302-1307.

272. Zhang YX, Wang SR. Secular trends in body mass index and the prevalence of overweight and obesity among children and adolescents in Shandong, China, from 1985 to 2010. J Public Health. 2012;34(1):131-137.

273. Kosulwat V. The nutrition and health transition in Thailand. Public Health Nutr. 2002;5(1a):183-189.

274. Collins AE, Pakiz B, Rock CL. Factors associated with obesity in Indonesian adolescents. Int J Pediatr Obes. 2008;3 (1):58-64.

275. Magarey A, Watson J, Golley RK, *et al.* Assessing dietary intake in children and adolescents: Considerations and recommendations for obesity research. Int J Pediatr Obes. 2011;6(1):2-11.

276. Livingstone MBE, Robson PJ, Wallace JMW. Issues in dietary intake assessment of children and adolescents. Br J Nutr. 2004;92:213-222.

277. Poh BK, Tham KBL, Wong SN, *et al.* Nutritional Status, Dietary Intake Patterns and Nutrition Knowledge of Children Aged 5-6 Years Attending Kindergartens in the Klang Valley, Malaysia. Mal J Nutr. 2012;18(2):231-242.

278. Koo HC, Poh BK, Ruzita AT. Assessment of knowledge, attitude and practice towards whole grains among children aged 10 and 11 years in Kuala Lumpur, Malaysia. Int J Food Sci Nutr Diet. 2015;4(1):171-177.

279. Rockett HRH, Breitenbach M, Frazier AL, *et al.* Validation of a Youth/Adolescent Food Frequency Questionnaire. Prev Med. 1997;26(6):808-816.

280. McPherson RS, Hoelscher DM, Alexander M, *et al.* Dietary Assessment Methods among School-Aged Children: Validity and Reliability. Prev Med. 2000;31(2):S11-S33.

281. Thompson FE, Subar AF. Dietary assessment methodology. In: Coulston AM, Boushey CJ, editors. Nutrition in the prevention and treatment of disease. 2nd ed. San Diego, Canada: Academic Press. 2008. 3-39.

282. Burrows TL, Martin RJ, Collins CE. A Systematic Review of the Validity of Dietary Assessment Methods in Children when Compared with the Method of Doubly Labeled Water. J Am Diet Assoc. 2010;110(10):1501-1510.

283. Burrows TL, Truby H, Morgan PJ, *et al.* A comparison and validation of child versus parent reporting of children's energy intake using food frequency questionnaires versus food records: Who's an accurate reporter? Clin Nutr. 2013;32(4):613-618.

284. Reinaerts E, de Nooijer J, de Vries NK. Parental versus child reporting of fruit and vegetable consumption. Int J Behav Nutr Phys Act. 2007;4.

285. Willet W, Lenart E. Food Frequency Methods. In: Willet W, editor. Nutritional Epidemiology. 3rd ed. United States of America: Oxford University Press. 2012.

286. ACAORN. Dietary intake assessment - Questionnaire. Australian Child & Adolescent Obesity Research Network. 2010; http://www.acaorn.org.au/streams/nutrition/assessment-methods/questionnaire.php. Assessed 2013/04/18

287. Lee RD, Nieman DC. Measuring Diet. In: Lee RD, Nieman DC, editors. Nutritional Assessment. 5th ed. New York: McGraw Hill. 2010.

288. Cade J, Thompson R, Burley V, *et al.* Development, validation and utilisation of food-frequency questionnaires - a review. Public Health Nutr. 2002;5(4):567-587.

289. Baranowski T. 24-Hour Recall and Diet Record Methods. In: Willet W, editor. Nutritional Epidemiology. 3rd ed. New York: Oxford University Press. 2012.

290. Dodd KW, Guenther PM, Freedman LS, *et al.* Statistical Methods for Estimating Usual Intake of Nutrients and Foods: A Review of the Theory. J Am Diet Assoc. 2006;106(10):1640-1650.

291. ACAORN. Dietary intake Assessment - 24-hr recall. Australian Child & Adolescent Obesity Research Network. 2010; http://www.acaorn.org.au/streams/nutrition/assessment-methods/24hr-recall.php. Assessed 2014/09/10

292. ACAORN. Dietary intake assessment - Food frequency questionnaire. Australian Child & Adolescent Obesity Research Network. 2010; http://www.acaorn.org.au/streams/nutrition/assessment-methods/ffq.php. Assessed 2015/8/19

293. Forrestal SG. Energy intake misreporting among children and adolescents: a literature review. Matern Child Nutr. 2011;7(2):112-127.

294. ACAORN. Dietary intake assessment - Diet History. Australian Child & Adolescent Obesity Research Network. 2010; http://www.acaorn.org.au/streams/nutrition/assessment-methods/diet-history.php. Assessed 2015/08/19

295. ACAORN. Dietary intake assessment - Weighed food records. Australian Child & Adolescent Obesity Research Network. 2010; http://www.acaorn.org.au/streams/nutrition/assessment-methods/weighed-food-records.php. Assessed 2013/04/18

296. Clavering EK, McLaughlin J. Children's participation in health research: from objects to agents? Child Care Health Dev. 2010;36(5):603-611.

297. Docherty S, Sandelowski M. Focus on qualitative methods: Interviewing children. Res Nurs Health. 1999;22(2):177-185.

298. Irwin LG, Johnson J. Interviewing Young Children: Explicating Our Practices and Dilemmas. Qual Health Res. 2005;15(6):821-831.

299. Baranowski T, Domel SB. A cognitive model of children's reporting of food intake. Am J Clin Nutr. 1994;59(1):212S-217S.

300. Frobisher C, Maxwell SM. The estimation of food portion sizes: a comparison between using descriptions of portion sizes and a photographic food atlas by children and adults. J Hum Nutr Diet. 2003;16(3):181-188.

301. Collins CE, Bucher T, Taylor A, *et al.* How big is a food portion? A pilot study in Australian families. Health Promot J Austr. 2015;26(2):83-88.

302. Foster E, Matthews JNS, Lloyd J, *et al.* Children's estimates of food portion size: the development and evaluation of three portion size assessment tools for use with children. Br J Nutr. 2008;99(01):175-184.

303. Biro G, Hulshof KF, Ovesen L, *et al.* Selection of methodology to assess food intake. Eur J Clin Nutr. 2002;56(2):S25-32.

304. Livingstone MBE, Black AE. Markers of the Validity of Reported Energy Intake. J Nutr. 2003;133(3):895S-920S.

305. Lanctot JQ, Klesges RC, Stockton MB, *et al.* Prevalence and characteristics of energy underreporting in African-American girls. Obesity. 2008;16(6):1407-1412.

306. Murakami K, Miyake Y, Sasaki S, *et al.* Characteristics of under- and over-reporters of energy intake among Japanese children and adolescents: The Ryukyus Child Health Study. Nutrition. 2012;28(5):532-538.

307. Rangan A, Flood V, Gill T. Misreporting of Energy Intake in the 2007 Australian Children's Survey: Identification, Characteristics and Impact of Misreporters. Nutrients. 2011;3(2):186-199.

308. McGloin AF, Livingstone MB, Greene LC, *et al.* Energy and fat intake in obese and lean children at varying risk of obesity. Int J Obes Relat Metab Disord. 2002;26(2):200-207.

309. Tak NI, Te Velde SJ, De Vries JHM, *et al.* Parent and child reports of fruit and vegetable intakes and related family environmental factors show low levels of agreement. J Hum Nutr Diet. 2006;19(4):275-285.

310. Schoeller DA, van Santen E. Measurement of energy expenditure in humans by doubly labeled water method. J Appl Physiol. 1982;53(4):955-959.

311. NICE. Obesity guidance on the prevention, identification, assessment and management of overweight and obesity in adults and children. UK: National Institute for Health and Clinical Excellence. 2006 (Updated 2014).

312. Barlow SE. Expert Committee Recommendations Regarding the Prevention, Assessment, and Treatment of Child and Adolescent Overweight and Obesity: Summary Report. Pediatrics. 2007;120(Supplement 4):S164-S192.

313. WHO. Obesity: Preventing and managing the global epidemic. Geneva: World Health Organisation.1998.

314. Kirschenbaum DS, Gierut K. Treatment of childhood and adolescent obesity: an integrative review of recent recommendations from five expert groups. J Consult Clin Psychol. 2013;81(2):347-360.

315. Epstein LH, Myers MD, Raynor HA, *et al.* Treatment of pediatric obesity. Pediatrics. 1998;101:S554-570.

316. Stewart L, Reilly JJ, Hughes AR. Evidence-based behavioral treatment of obesity in children and adolescents. Child Adolesc Psychiatr Clin N Am. 2009;18(1):189-198.

317. Crocker MK, Yanovski JA. Pediatric Obesity: Etiology and Treatment. Pediatr Clin North Am. 2011;58(5):1217-1240.

318. Summerbell CD, Waters E, Edmunds LD, *et al.* Interventions for preventing obesity in children. Cochrane Database Syst Rev. 2005;3.

319. Miccuci S, Thomas H, Vohra J. The effectiveness of school-based strategies for the primary prevention of obesity and for promoting physical activity and/or nutrition, the major modifiable risk factors for Type 2 diabetes: a review of reviews. Hamilton, Canada: Public Health Research, Education and Development Programme; Effective Public Health Practice Project.2002.

320. Waters E, de Silva-Sanigorski A, Hall BJ, *et al.* Interventions for preventing obesity in children. Cochrane Database Syst Rev. 2011;12.

321. Campbell K, Waters E, O'Meara S, *et al.* Interventions for preventing obesity in children. Cochrane Database Syst Rev. 2002;2.

322. Mo-suwan L, Pongprapai S, Junjana C, *et al.* Effects of a controlled trial of a school-based exercise program on the obesity indexes of preschool children. Am J Clin Nutr. 1998;68(5):1006-1011.

323. Li Y, Hu X, Zhang Q, *et al.* The nutrition-based comprehensive intervention study on childhood obesity in China (NISCOC): a randomised cluster controlled trial. BMC Public Health. 2010;10(229).

324. Jiang J, Xia X, Greiner T, *et al.* The effects of a 3-year obesity intervention in schoolchildren in Beijing. Child Care Health Dev. 2007;33(5):641-646.

325. Singhal N, Misra A, Shah P, *et al.* Effects of controlled school-based multi-component model of nutrition and lifestyle interventions on behavior modification, anthropometry and metabolic risk profile of urban Asian Indian adolescents in North India. Eur J Clin Nutr. 2010;64(4):364-373.

326. Wafa SW, Talib RA, Hamzaid NH, *et al.* Randomized controlled trial of a good practice approach to treatment of childhood obesity in Malaysia: Malaysian Childhood Obesity Treatment Trial (MASCOT). Int J Pediatr Obes. 2011;6(2-2):23.

327. Kelishadi R, Azizi-Soleiman F. Controlling childhood obesity: A systematic review on strategies and challenges. J Res Med Sci. 2014;19(10):993-1008.

328. Berge JM, Everts JC. Family-Based Interventions Targeting Childhood Obesity: A Meta-Analysis. Child Obes. 2011;7(2):110-121.

329. Brown T, Summerbell C. Systematic review of school-based interventions that focus on changing dietary intake and physical activity levels to prevent childhood obesity: an update to the obesity guidance produced by the National Institute for Health and Clinical Excellence. Obes Rev. 2009;10(1):110-141.

330. Epstein LH, Valoski A, Wing RR, *et al.* Ten-Year Outcomes of Behavioral Family-Based Treatment for Childhood Obesity. Health Psychol. 1994;13(5):373-383.

331. Baranowski T, O'Connor T, Johnston C, *et al.* School year versus summer differences in child weight gain: a narrative review. Child Obes. 2014;10(1):18-24.

332. de Onis M, Blössner M. Prevalence and trends of overweight among preschool children in developing countries. Am J Clin Nutr. 2000;72(4):1032-1039.

333. Whitlock EP, Williams SB, Gold R, *et al.* Screening and Interventions for Childhood Overweight: A Summary of Evidence for the US Preventive Services Task Force. Pediatrics. 2005;116(1):e125-e144.

334. Snethen JA, Broome ME, Cashin SE. Effective weight loss for overweight children: a meta-analysis of intervention studies. J Pediatr Nurs. 2006;21(1):45-56.

335. De Cruz AE, Phillips S, Visch M, *et al.* The junk food generation: A multi-country survey of the influence of television advertisements on children. Kuala Lumpur, Malaysia: Consumer International.2004.

336. Collins CE, Warren JM, Neve M, *et al.* Systematic review of interventions in the management of overweight and obese children which include a dietary component. Int J Evid Based Healthc. 2007;5(1):2-53.

337. Jeemon P, Prabhakaran D, Mohan V, *et al.* Double burden of underweight and overweight among children (10-19 years of age) of employees working in Indian industrial units. Natl Med J India. 2009;22 (4):172-176.

338. Pawloski LR, Kitsantas P, Ruchiwit M. Determinants of overweight and obesity in Thai adolescent girls. Int J Med. 2010;3(2):353-356.

339. Huynh DTT, Dibley MJ, Sibbritt D, *et al.* Influence of contextual and individual level risk factors on adiposity in a preschool child cohort in Ho Chi Minh City, Vietnam. Int J Pediatr Obes. 2011;6 (2 -2):e487-e500.

340. Wang Y, Ge K, Popkin BM. Why do some overweight children remain overweight, whereas others do not? Public Health Nutr. 2003;6(6):549-558.

341. Shan XY, Xi B, Cheng H, *et al.* Prevalence and behavioral risk factors of overweight and obesity among children aged 218 in Beijing, China. Int J Pediatr Obes. 2010;5 (5):383-389.

342. Jiang JX, Rosenqvist U, Wang HS, *et al.* Relationship of parental characteristics and feeding practices to overweight in infants and young children in Beijing, China. Public Health Nutr. 2009;12(7):973-978.

343. Li M, Dibley MJ, Sibbritt DW, *et al.* Dietary habits and overweight/obesity in adolescents in Xi'an City, China. Asia Pac J Clin Nutr. 2010;19(1):76-82.

344. Hill JO, Melanson EL, Wyatt HT. Dietary fat intake and regulation of energy balance: implications for obesity. J Nutr. 2000;130(Suppl S2):284S-288S.

345. Popkin BM. The Nutrition Transition and Obesity in the Developing World. J Nutr. 2001;131(3):871S-873S.

346. Lachat C, Nago E, Verstraeten R, *et al.* Eating out of home and its association with dietary intake: a systematic review of the evidence. Obes Rev. 2012;13(4):329-346.

347. Burke V, Beilin LJ, Durkin K, *et al.* Television, computer use, physical activity, diet and fatness in Australian adolescents. Int J Pediatr Obes. 2006;1(4):248-255.

348. Liu Y, Zhai F, Popkin BM. Trends in eating behaviours among Chinese children (1991 - 1997). Asia Pac J Clin Nutr. 2006;15(1):72-80.

349. Nielsen SJ, Siega-Riz AM, Popkin BM. Trends in Food Locations and Sources among Adolescents and Young Adults. Prev Med. 2002;35(2):107-113.

350. Gibson S. Sugar-sweetened soft drinks and obesity: a systematic review of the evidence from observational studies and interventions. Nutr Res Rev. 2008;21(2):134-147.

351. Lee HA, Lee WK, Kong KA, *et al.* The effect of eating behavior on being overweight or obese during preadolescence. J Prev Med Public Health. 2011;44(5):226-233.

352. Berkowitz RI, Moore RH, Faith MS, *et al.* Identification of an obese eating style in 4-year-old children born at high and low risk for obesity. Obesity. 2010;18(3):505-512.

353. Santos JL, Ho-Urriola JA, González A, *et al.* Association between eating behavior scores and obesity in Chilean children. Nutr J. 2011;10(108).

354. McPhie S, Skouteris H, McCabe M, *et al.* Maternal correlates of preschool child eating behaviours and body mass index: a cross-sectional study. Int J Pediatr Obes. 2011;6(5-6):476-480.

355. Galhardo J, Hunt LP, Lightman SL, *et al.* Normalizing eating behavior reduces body weight and improves gastrointestinal hormonal secretion in obese adolescents. J Clin Endocrinol Metab. 2012;97(2):e193-201.

356. Johnson SL. Improving Preschoolers' self-regulation of energy intake. Pediatrics. 2000;106(6):1429-1435.

357. Willet W. Overview of Nutritional Epidemiology. In: Willet W, editor. Nutritional Epidemiology. 3rd ed. United States of America: Oxford University Press. 2012. 1-16.

358. Moher D, Liberati A, Tetzlaff J, *et al.* Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. BMJ. 2009;339.

359. Subar AF, Thompson FE, Potischman N, *et al.* Formative Research of a Quick List for an Automated Self-Administered 24-Hour Dietary Recall. J Am Diet Assoc. 2007;107(6):1002-1007.

360. ICDA. National Dietetic Associations (NDAs). International Confederation of Dietetic Associations. 2010; http://www.internationaldietetics.org/NDAs.aspx. Assessed 2013/04/22

361. Willet W, Lenart E. Reproducibility and validity of food frequency questionnaires. In: Willet W, editor. Nutritional Epidemiology. 3rd ed. New York: Oxford University Press. 2012. 96-141.

362. WHO. Steps in applying Probability Proportional to Size (PPS) and calculating Basic Probability Weights. Geneva: World Health Organization.2008.

363. McLennan W, Podger A. Food and Nutrient Intake. National Nutrition Survey Users' Guide. Canberra: Australian Bureau of Statistics. 1995. 13-19.

364. Tee ES, Ismail MN, Nasir MA, *et al.* Nutrient Composition of Malaysian foods. 4th ed. Kuala Lumpur: Institute for Medical Research. 1997.

365. Singapore HPB. Food Composition Guide Singapore. Singapore: Health Promotion Board. 2003; http://www.hpb.gov.sg/hpb/ere/ere070101.asp. Assessed 2014/05/27

366. Watson J, Collins C, Sibbritt D, *et al.* Reproducibility and comparative validity of a food frequency questionnaire for Australian children and adolescents. Int J Behav Nutr Phys Act. 2009;6(62).

367. Chu AH, Moy FM. Reliability and validity of the Malay International Physical Activity Questionnaire (IPAQ-M) among a Malay population in Malaysia. Asia Pac J Public Health. 2015;27(2):16.

368. Kolwaski KC, Crocker PRE, Donen RM. Physical Activity Questionnaire for Older Children (PAQ-C). The Physical Activity Questionnaire for Older Children (PAQ-C) and Adolescents (PAQ-A) Manual. Saskatoon, SK, Canada: College of Kinesiology, University of Saskatchewan 2004. 5-10.

369. MOH, ACADMED, MASO, *et al.* Clinical Practice Guidelines on Management of Obesity. Malaysia2004.

370. WHO. WHO AnthroPlus for Personal Computers Manual: Software for Assessing Growth of the World's Children and Adolescents. Geneva: World Health Organization. 2009.

371. Willet W. Correction for the Effects of Measurement Error. In: Willet W, editor. Nutritional Epidemiology. 3rd ed. New York: Oxford University Press. 2012. 287-304.

372. Khambalia AZ, Seen LS. Trends in overweight and obese adults in Malaysia (1996-2009): a systematic review. Obes Rev. 2010;11(6):403-412.

373. Yngve A, Wolf A, Poortvliet E, *et al.* Fruit and Vegetable Intake in a Sample of 11-Year-Old Children in 9 European Countries: The Pro Children Cross-Sectional Survey. Ann Nutr Metab. 2005;49(4):236-245.

374. WHO. Energy and protein requirements. Geneva: World Health Organization.1985.

375. Poh BK, Ismail M, Zawiah H, *et al.* Predictive equations for the estimation of basal metabolic rate in Malaysia adolescents. Mal J Nutr. 1999;5(1):1-14.

376. Torun B. Energy requirements of children and adolescents. Public Health Nutr. 2005;8(7a):968-993.

377. Szajewska H, Ruszczyński M. Systematic Review Demonstrating that Breakfast Consumption Influences Body Weight Outcomes in Children and Adolescents in Europe. Crit Rev Food Sci Nutr. 2010;50(2):113-119.

378. Frary CD, Johnson RK, Wang MQ. Children and adolescents' choices of foods and beverages high in added sugars are associated with intakes of key nutrients and food groups. J Adolesc Health. 2004;34(1):56-63.

379. Lee CMY, Mar-tiniuk ALC, Woodward M, *et al.* The burden of overweight and obesity in the Asia-Pacific region. Obes Rev. 2007;8(3):191-196.

380. Ogden CL, Carroll MD, Kit BK, *et al.* Prevalence of childhood and adult obesity in the United States, 2011-2012. JAMA. 2014;311(8):806-814.

381. Tahir A, Aini N. Malaysian National Health and Morbidity Survey 2011. Kuala Lumpur: Institute of Public Health.2012.

382. Yusuf S, Hawken S, Ounpuu S, *et al.* Obesity and the risk of myocardial infarction in 27,000 participants from 52 countries: a case-control study. Lancet. 2005;366(9497):1640-1649.

383. Roba AC, Gabriel-Micheal K, Zello GA, *et al.* A low pulse food intake may contribute to the poor nutritional status and low dietary intakes of adolescent girls in rural southern Ethiopia. Ecol Food Nutr. 2015;54(3):240-254.

384. von Elm E, Altman DG, Egger M, *et al.* The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: Guidelines for Reporting Observational Studies. PLoS Med. 2007;4(10):e296.

385. Mendez MA, Popkin BM, Buckland G, *et al.* Alternative Methods of Accounting for Underreporting and Overreporting When Measuring Dietary Intake-Obesity Relations. Am J Epidemiol. 2011;173(4):448-458.

386. WHO. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004;363(9403):157-163.

387. Ball GD, Marshall JD, McCargar LJ. Physical activity, aerobic fitness, self-perception, and dietary intake in at risk of overweight and normal weight children. Can J Diet Pract Res. 2005;66(3):162-169.

388. Vagstrand K, Lindroos AK, Linne Y. Characteristics of high and low energy reporting teenagers and their relationship to low energy reporting mothers. Public Health Nutr. 2009;12(2):188-196.

389. Morrison A, Polisena J, Husereau D, *et al.* The effect of English-language restriction on systematic review-based meta-analyses: a systematic review of empirical studies. Int J Technol Assess Health Care. 2012;28(2):138-144.

Appendices

Appendix 1.0: List of common Malay food and beverages

Category	Types	Examples	Detailed description[364]
Food	*Cereals (Cereals/ tubers/ grains)*	• Rice: Steamed, Fried, *Nasi Lemak* • Noodles (Vermicelli/ Yellow Mee): Fried, *Laksa* (Curry/ Assam) • *Roti canai, Roti Telur* • Potato: Fried	*Nasi Lemak*: Coconut-flavoured steamed rice with dried curry paste, fried anchovies, fried peanuts, boiled egg & sliced cucumber *Laksa* : Noodles prepared with large amount of thick gravy (either cooked in coconut milk or tamarind paste) *Roti canai/ roti telur* : Wheat flour based bread kneaded, flattened & cooked with oil in a flat pan (either plain or with added egg)
	Vegetables	• Round Cabbage/ *Kangkong*/ *Sawi*/ Mixed Vegetables/ Long Beans: Stir-fried	*Kangkong*: Water Convolvulus *Sawi:* Mustard Leaves
	Meats (Meat/ poultry/ fish/ legumes)	• Beef: Fried, *Rendang*, Curry, *Masak Kicap, Kurma* • Poultry: Fried, *Rendang*, Curry, *Masak Kicap, Masak Lemak, Masak Merah, Kurma, Masak Sambal* • Fish: Fried, Curry*, Masak Kicap, Masak Assam, Masak Sambal* • Legumes (Tofu): Fried, Soup • Egg: Fried, Omelette, Scrambled	*Rendang* : Thick gravy cooked in coconut milk until almost dry *Masak Kicap* : Gravy cooked in soy sauce *Masak Lemak* : Thick gravy cooked in coconut milk *Masak Merah* : Gravy cooked in tomato puree & some spices *Masak Sambal* : Cooked in chilli powder, shrimp & tamarind paste *Kurma* : Gravy cooked in coconut milk
	Snacks	• Currypuff, *Pisang Goreng, Keropok Lekor*, Fish/Prawn Crackers, *Cokodok* • Nugget: Chicken/ Fish • Frankfurter: Chicken/ Beef • Ice-cream	*Pisang Goreng* : Banana dipped into wheat flour batter & deep-fried *Keropok Lekor* : Deep-fried cracker made from fish paste *Cokodok* : Ingredients mashed into thick paste & deep fried
Beverages	*Western fast food* *Sugar-sweetened beverages*	• McDonalds, Kentucky Fried Chicken • Chocolate Malted Drink • Carbonated Drink • Flavoured Syrup • Cordial	

Appendix 2.0: Recommended Nutrient Intakes for Malaysia 2005: Summary Table

	Age	Energy kcal	Protein g	Calcium mg	Iron mg		Iodine µg	Zinc mg	Selenium µg	Thiamin mg	Riboflavin mg	Niacin mg NE	Folate µg	Vitamin C mg	Vitamin A µg	Vitamin D µg	Vitamin E mg
					Bioavailability												
					10%	15%											
Infants (boys)	0 - 5 months	560	11	300 (bf) 400 (ff)	*b*	*b*	90	1.1 (bf) 2.8 (ff)	6	0.2	0.3	2	80	25	375	5	3
	6 - 11 months	640	12	400	9	6	120	3.7	9	0.3	0.4	4	80	30	400	5	3
Infants (girls)	0 - 5 months	550	11	300 (bf) 400 (ff)	*b*	*b*	90	1.1 (bf) 2.8 (ff)	6	0.2	0.3	2	80	25	375	5	3
	6 - 11 months	630	12	400	9	6	120	3.7	9	0.3	0.4	4	80	30	400	5	3
Children (boys)	1 - 3 years	980	17	500	6	4	72	4.1	17	0.5	0.5	6	160	30	400	5	5
	4 - 6 years	1340	23	600	6	4	108	5.1	21	0.6	0.6	8	200	30	450	5	5
	7 - 9 years	1780	32	700	9	6	104	5.8	22	0.9	0.9	12	300	35	500	5	7
Children (girls)	1 - 3 years	910	17	500	6	4	72	4.1	17	0.5	0.5	6	160	30	400	5	5
	4 - 6 years	1290	23	600	6	4	108	5.1	21	0.6	0.6	8	200	30	450	5	5
	7 - 9 years	1590	32	700	9	6	104	5.8	22	0.9	0.9	12	300	35	500	5	7
Adolescents (boys)	10 - 12 years	2180	45	1000	15	10	144	9.0	28	1.2	1.3	16	400	65	600	5	10
	13 - 14 years	2690	63	1000	15	10	106	9.0	28	1.2	1.3	16	400	65	600	5	10
	15 years	2690	63	1000	19	12	106	9.0	28	1.2	1.3	16	400	65	600	5	10
	16 - 18 years	2840	65	1000	19	12	118	9.0	28	1.2	1.3	16	400	65	600	5	10
Adolescents (girls)	10 - 12 years	1990	46	1000	14 (nm) 33 (m)	9 (nm) 22 (m)	148	7.5	23	1.1	1.0	16	400	65	600	5	7.5
	13 - 14 years	2180	55	1000	14 (nm) 33 (m)	9 (nm) 22 (m)	98	7.5	23	1.1	1.0	16	400	65	600	5	7.5
	15 years	2180	55	1000	31	21	98	7.5	23	1.1	1.0	16	400	65	600	5	7.5
	16 - 18 years	2050	54	1000	31	21	104	7.5	23	1.1	1.0	16	400	65	600	5	7.5
Men	19 - 29 years	2440	62	800	14	9	124	6.7	33	1.2	1.3	16	400	70	600	5	10
	30 - 50 years	2460	62	800	14	9	124	6.7	33	1.2	1.3	16	400	70	600	5	10
	51 - 59 years	2460	62	800	14	9	124	6.7	33	1.2	1.3	16	400	70	600	10	10
	60 - 65 years	2010	59	800	14	9	124	6.7	33	1.2	1.3	16	400	70	600	10	10
	> 65 years	2010	59	1000	14	9	114	6.2	29	1.2	1.3	16	400	70	600	15	10
Women	19 - 29 years	2000	55	800	29	20	110	4.9	25	1.1	1.1	14	400	70	500	5	7.5
	30 - 50 years	2180	55	800	29	20	110	4.9	25	1.1	1.1	14	400	70	500	5	7.5
	51 - 59 years	2180	55	1000	11	8	110	4.9	25	1.1	1.1	14	400	70	500	10	7.5
	60 - 65 years	1780	51	1000	11	8	110	4.9	25	1.1	1.1	14	400	70	500	10	7.5
	> 65 years	1780	51	1000	11	8	98	4.3	23	1.1	1.1	14	400	70	600	15	7.5
Pregnancy	1st trimester	+0	+7.5	1000	29	20	200	5.5	25	1.4	1.4	18	600	80	800	5	7.5
	2nd trimester	+360	+7.5	1000	*c*	*c*	200	7.0	27	1.4	1.4	18	600	80	800	5	7.5
	3rd trimester	+470	+7.5	1000	*c*	*c*	200	10.0	29	1.4	1.4	18	600	80	800	5	7.5
Lactation	1st 6 months	+500	+20	1000	15	10	200	9.5 (1-3 months) 8.8 (4-6 months)	34	1.5	1.6	17	500	95	850	5	7.5
	2nd 6 months	*a*	+15	1000	15 (nm) 32 (m)	10 (nm) 21 (m)	200	7.2	39	1.5	1.6	17	500	95	850	5	7.5

Note:
(1) All RNIs are for daily intakes
(2) For all ages categories, the ending age extends till just before the beginning age of the subsequent category. For example, for the category 0-5 months, 5 months include up to 5.9 months
a - no recommendations. Energy requirement depends on amount of breastmilk produced.
b - no recommendations. Neonatal iron stores are sufficient to meet iron requirement for first 6 months in full-term infants. Premature infants and low birth weight infants require additional iron.
c - iron supplements in table form recommended for all pregnant women. In the non-anaemic pregnant woman, daily supplements of 100mg iron given during second half of pregnancy are adequate. In anaemic women, higher doses are usually required.
bf - breast fed, ff - formula fed, nm - non-menstruating, m - menstruating

Adapted from the National Coordinating Committee on Food and Nutrition, 2005[173]

Appendix 3.0: Statement of contribution and collaboration (Chapter 3 Systematic Review Paper 1)

I attest that Research Higher Degree candidate Wai Yew Yang contributed to the following paper:

The relationship between dietary patterns and overweight and obesity in children of Asian developing countries: A Systematic Review. The JBI Database of Systematic Reviews and Implementation Reports. 2012;10(58): 4568 - 4599.

Wai Yew Yang contributed to the development of the review protocol, design of the study, selection of studies for inclusion in the review, critical appraisal of included studies, data extraction and manuscript preparation. Professor Clare E Collins and Professor Lauren T Williams contributed to the design of the study, development of the search syntax and screening and methodology, was second and third reviewer for the systematic review and therefore screened and performed critical appraisal and data extraction, and contributed to the interpretation of the results and drafts of the manuscript within the capacity of their role as PhD supervisors. Professor Winnie Chee Siew Swee contributed to the interpretation of the results and drafts of the manuscript within the capacity of her role as PhD supervisor.

Professor Clare E Collins	Date: 18/11/2015
Professor Lauren T Williams	Date: 28/10/2015
Professor Winnie Chee Siew Swee	Date: 16/11/2015
Mrs Wai Yew Yang	Date: 16/11/2015
Professor Robert J Callister Deputy Head of Faculty (Research)	Date: 19/11/2015

Appendix 3.1: Permission to reproduce the published systematic review manuscript granted by the publisher

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22nd October 2015

Wai Yew Yang
PhD Candidate
The University of Newcastle

Dear Ms Wai Yew Yang,

Re: Permission to reproduce JBI Systematic Review 2012;10(58):4568-4599 in thesis.

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Sincerely,

Associate Professor Edoardo Aromataris
Director, Synthesis Science
The Joanna Briggs Institute

Appendix 3.2: Keywords used in the Search Strategy: MEDLINE

Dietary pattern	1.	Diet Surveys/ or Diet/ or diet*.mp.
	2.	Food Habits/ or diet* pattern.mp
	3.	diet* intake.mp
	4.	Food Habits/ or diet* habit*.mp
	5.	diet* score.mp
	6.	diet* quality.mp
	7.	diet* index.mp
	8.	diet* variety.mp
	9.	Food Preferences/ or food choice*.mp. or Food Habits/
	10.	Food Preferences/ or food select*.mp
	11.	Food Preferences/ or food consum*.mp or Food Habits/
	12.	Food Preferences/ or Food Habits/ or food pattern.mp
	13.	food intake.mp. or Eating/
	14.	Eating/ or eat* pattern.mp.
	15.	Food Preferences/ or eat* selection.mp.
	16.	Eating/ or Food Preferences/ or eat* choice*.mp.
	17.	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16
Location	18.	malaysia.mp or Malaysia/
	19.	brunei.mp or Brunei/
	20.	cambodia.mp. Or Cambodia/
	21.	philippines.mp or Philippines/
	22.	thailand.mp or Thailand/
	23.	vietnam.mp. or Vietnam/
	24.	myanmar.mp or Myanmar/
	25.	laos.mp or Laos/
	26.	indonesia.mp or Indonesia/
	27.	India.mp or India/
	28.	China.mp or China/
	29.	Asia, Southeastern/ or South East Asia.mp or Developing Countries/ 13. 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29
Weight Status	30.	Obesity/ or obes*.mp
	31.	overweight.mp or Overweight/
	32.	Body Mass Index.mp body mass index/
	33.	Body Mass Index/ or BMI.mp
	34.	body weight.mp or Body Weight/
	35.	Obesity/ or Body Weight/ or Body Mass Index/ or weight status.mp or Overweight/ 20. 31 or 32 or 33 or 34 or 35 or 36
	36.	17 and 30 and 37
	37.	limit 38 to "all child (0 to 18 years)"
	38.	limit 39 to humans

Appendix 3.3: JBI Critical Appraisal Instruments

JBI Critical Appraisal Checklist for Comparable Cohort/ Case Control

Reviewer _____ Date _____

Author _____ Year _____ Record Number _____

	Yes	No	Unclear	Not Applicable
1. Is sample representative of patients in the population as a whole?	☐	☐	☐	☐
2. Are the patients at a similar point in the course of their condition/illness?	☐	☐	☐	☐
3. Has bias been minimised in relation to selection of cases and of controls?	☐	☐	☐	☐
4. Are confounding factors identified and strategies to deal with them stated?	☐	☐	☐	☐
5. Are outcomes assessed using objective criteria?	☐	☐	☐	☐
6. Was follow up carried out over a sufficient time period?	☐	☐	☐	☐
7. Were the outcomes of people who withdrew described and included in the analysis?	☐	☐	☐	☐
8. Were outcomes measured in a reliable way?	☐	☐	☐	☐
9. Was appropriate statistical analysis used?	☐	☐	☐	☐

Overall appraisal: Include ☐ Exclude ☐ Seek further info. ☐

Comments (Including reason for exclusion)

Appendix 3.4: Data extraction instrument (Adapted version of Standardised JBI Data Extraction)

Authors & Year	Title	Study Design	Setting & Time - Period	Participants (Age, Gender, Sample Size & Ethnicity)	Measurement		Statistical Analysis	Overall Percentage of overweight &/or obese children	Outcome		Percentage of overweight &/or obese children, P-value	Effect Size (95% CI), P-value	Mean &/Or difference, P-value	Conclusion	Confounder	Limitation	Comment	Discussion
					Diet	Obesity			Dietary Factor	Parameters								

Appendix 3.5 Summary table of included studies using longitudinal, case-control and cross-sectional study design

Study	Setting	Participants				Dietary Assessment Method	Dietary Pattern		Outcomes	Association between dietary pattern and childhood overweight/obesity
		Age (Years)	Sample Size/ Gender	Other Characteristics	Prevalence OW/ OB		Associated with reduced prevalence/risk of overweight/obesity	Associated with higher prevalence/risk of overweight/obesity	Risk Measure (95% CI), p-value	
Longitudinal										
Huynh et al. 2011[339]	20 preschools in urban Ho Chi Minh City, Vietnam March 2005 to March 2006	4 to 5 at baseline	Baseline 670 M: 333 F: 337 One Year Follow-Up 526 (+) M: 257 (++) F: 269	Vietnamese children in selected preschools	Mean ± SD Baseline BMI z-score: 0.8 (1.3) One Year Follow-Up BMI z-score: 0.9 (1.3)	Validated FFQ	• Dietary intake with BMI changes ++	• Highest protein intake +	Coefficient • 1.17 (0.10 to 2.23), 0.032 • N/A	√ X
Wang et al. 2003[340]	8 Chinese provinces in China Year 1991 to 1993	6 to 13 at baseline	Baseline and Two Years Follow- Up 95 M: 51 F: 44	Overweight children identified from baseline study in China Health and Nutrition Survey, stratified based on weight category at baseline and follow-up period: OW → OW OW → NW NW → OW NW → NW	Baseline OW: 6.4% Follow-Up OW: 6.3%	Household food consumption and 24-hour dietary recall for 3 consecutive days	• High energy diet * & ** • High-CHO diet * & ** • High fruits and vegetables diet * & **	• High meat diet * • High fat diet * • High meat diet ** • High-fat diet **	Relative Risk • 2.40 (1.00 to 5.60), <0.05 • 1.50 (0.90 to 2.50), <0.1 • 1.70 (1.00 to 2.70). >0.05 • 1.50 (1.00 to 2.20), >0.05 • 0.8 (0.60 to 1.10), >0.05 • 0.70 (0.50 to 0.90), <0.05 • 0.70 (0.50 to 0.90), <0.05	√ X X X X √ √
Case-control										
Thongbai et al. 2011[247]	Preschools in 6 private and 5 public schools in central Thai province Year 2007 – a year ago retrospective recall	3 to 5	102 OW 513 NW M: 336 F: 279	Thai children from preschool classes in 6 private and 5 public schools	N/A	Child Eating Behaviour Questionnaire, modified FFQ, Food Parenting Practice		• High food responsiveness • High food enjoyment • Eating high-fibre, non-sweet fruit (≤ 2 times/ week) • Drinking sweetened fresh milk and other flavours/ cocoa/ yogurt (3 to 7 times/ week) • Drinking yogurt (3 to 7 times/ week)	Odds Ratio • 3.30 (1.70 to 6.50), <0.001 • 2.10 (1.10 to 3.90), 0.026 • 2.00 (1.10 to 3.40), 0.015 • 2.70 (1.50 to 4.70), 0.001 • 2.30 (1.30 to 4.00), 0.004	√ √ √ √ √

OW: Overweight (IOTF: BMI ≥ 25kg/m^2), OB: Obese, OR: Odds Ratio, CI: Confidence Interval, M: Male, F: Female, BMI: Body Mass Index, FFQ: Food Frequency Questionnaire, N/A: Not available, NW: Normal Weight, *: Overweight → Overweight, ** Overweight → Normal Weight

Study	Setting	Participants				Dietary Assessment Method	Dietary Pattern		Outcomes	Association between dietary pattern and childhood overweight/obesity
		Age (Years)	Sample Size/ Gender	Other Characteristics	Prevalence OW/ OB		Associated with reduced prevalence/risk of overweight/obesity	Associated with higher prevalence/risk of overweight/obesity	Odds Ratio (Reference: 1.00) (95% CI) p-value	
Younger Children										
He et al. 2000 [98]	8 major cities in China Sept 1996 to Feb 1997	0.1 to 6.9	661 OB 661 NW M: 748 F: 574	Chinese children in kindergarten and local child health care system	N/A	Questionnaire on feeding pattern and food preferences		High eating speed • 0.1 to 2.9 years: • 3.0 to 6.9 years:	• 1.80 (1.32 to 2.47), 0.0002 • 3.04 (2.49 to 3.70), 0.0001	√ √
Jiang et al. 2006[263]	2 Urban districts in Beijing, China March to April 2004	2 to 6	930 M: 518 F: 412	Chinese children from five large kindergartens	OW IOTF: 10.7% OB IOTF: 4.2%	Self-reported questionnaire on dietary habits and feeding practice completed by parent	• Maternal's encouragement to child to eat more often	• Maternal's restriction of snacks	• 2.68 (1.64 to 4.29), <0.001 • 0.22 (0.14 to 0.34), <0.001	√ √
Jiang et al. 2009[342]	12 community health centres from 2 urban districts in Beijing, China June to Aug 2005	1 to 2.9	145 OW 145 NW M&F: N/A	All Chinese children from selected setting	N/A	Questionnaire on feeding practices and one day 24-hr dietary recall		• Total daily energy intake • Energy percentage of Dietary Reference Intake	• 1.29 (1.05 to 2.98), 0.023 • 1.37 (1.10 to 3.05), 0.015	√ √
							• Western fast food consumption		N/A	X
Children and Adolescents										
Jeemon et al. 2009[337]	10 medium-to-large industries in the organized sector were selected from different sites across India 2002 to 2003	10 to 19	3704 M: 1851 F: 1853	Indian children of randomly selected employees of the industries sites	OW <u>Highly Urban</u> IOTF: 13.4% Indian Standard: 19.1% <u>Urban</u> IOTF: 8.5% Indian Standard: 12.7% <u>Peri-Urban</u> IOTF: 1.1% Indian Standard : 1.7%	Interviewer administered questionnaire on proportion of food consumed outside home in a week		• Eating 25% and above of weekly meals outside home	• 12.0 (7.7 to 18.7), <0.001	√
Li et al. 2007[245]	China National Nutrition and Health Survey year 2000 collected from 31 provinces from whole China Year 2002	7 to 17	6826 M: 3927 F: 2899	Chinese children of households selected in the national survey	OW China Standard: 4.5% OB China Standard: 2.2%	24-hour diet recall for 3 consecutive days (2 weekdays and 1 weekend) and weighing of home cooking oil and condiments consumption		• Consumed ≥ 25g/day of cooking oil • Consumed ≥ 200g/day of meat and meat products • Consumed ≥ 100g/day of dairy products	• 1.40 (1.20 to 1.80), <0.05 • 1.50 (1.20 to 1.80), >0.05 • 1.80 (1.40 to 2.30), >0.05	√ X X

OW: Overweight (IOTF: BMI ≥ 25kg/m^2, Indian Standard: ≥ 85th Percentile, China Standard: ≥ 85th Percentile), OB: Obese (IOTF: BMI ≥ 30kg/m^2), CI: Confidence Interval, M: Male, F: Female, NW: Normal Weight, IOTF: International Obesity Task Force, N/A: Not available

Study	Setting	Participants				Dietary Assessment Method	Dietary Pattern		Outcomes	Association between dietary pattern and childhood overweight/obesity
		Age (Years)	Sample Size/ Gender	Other Characteristics	Prevalence OW/ OB		Associated with reduced prevalence/risk of overweight/obesity	Associated with higher prevalence/risk of overweight/obesity	Odds Ratio (Reference: 1.00) (95% CI) p-value	
Children and Adolescents (cont')										
Pawloski et al. 2010[338]	Peri-urban community, 40km north of Bangkok Year 2004 to 2005	9 to 18	F: 342	Thai female students from public primary and secondary schools	OW & OB IOTF: 17.5%	Dietary behaviour instrument with FFQ component included		• Consumed one serving of chips/week	• 2.34 (1.01 to 5.54), 0.05	√
Shan et al. 2010[341]	Urban and rural districts in Beijing; resident communities, kindergartens and schools Year 2004	6 to 18	21198 M: 10602 F: 10596	Chinese children in Beijing staying with parents or guardians	OW & OB IOTF: 18.7% WHO: 21.4% US CDC 2000: 20.1% China Standard: 21.7%	Questionnaire on dietary habits		• High intake of alcohol (≥ 1 time/week)	• OW: 1.18 (1.01 to 1.39), <0.05 • OB: 1.31 (1.10 to 1.55), <0.05	√ √
								• Taking snacks (≥ 3 times/ week)	• OW: 1.26 (1.13 to 1.40), <0.05 • OB: 1.53 (1.35 to 1.72), <0.05	√
								• Eating Western fast food (≥ 3 times/ week)	• OW: 1.02 (0.80 to 1.29), <0.05 • OB: 1.50 (1.12 to 2.02), <0.05	√ √
								• Consumed sugar-sweetened drink (≥ 3 times/ week)	• OW: 0.93 (0.82 to 1.05), >0.05 • OB: 1.06 (0.92 to 1.21), >0.05	X X
Adolescents										
Bishwalata et al. 2010[93]	12 schools Imphal West District, Manipur, India Sept 2005 to Aug 2006	12 to 19	2957 M&F: N/A	Indian adolescents studying in high schools and higher secondary schools	OW WHO: 4.2% IOTF: 4.4% OB WHO: 0.8% IOTF: 0.7%	Self-administered validated questionnaire on dietary pattern		• Not eating other type of vegetables during past 1 week	• 2.34 (1.04 to 5.24), <0.001	√
								• Taking cold drinks while watching TV	• 1.07 (0.67 to 1.73), 0.773	X
								• Not eating green leafy vegetables	• 1.33 (0.44 to 4.05), 0.614	X
							• Eating between meals		• 0.45 (0.29 to 0.68), <0.0001	√
							• Eating snacks while watching television		• 0.80 (0.48 to 1.32), 0.377	X
Collins et al. 2008[274]	3 communities in Yogjakarta, Kuta, Jakarta, Indonesia Year 2002 to 2003	12 to 15	1758 M: 815 F: 916	Indonesian middle school children from 6 different schools (one public, one private)	OB US CDC 2000:8.0%	Questionnaire on fast food eating habits and other eating habits	• Snacking while watching television		N/A	X
							• Frequent fast food intake (≥ 1 time/ week)		N/A	
Tang et al. 2010[246]	Schools in Ho Chi Min City, Vietnam stratified by wealthy and less wealthy urban districts Nov to Dec 2004	11 to 16	2660 M: 1332 F: 1328	Vietnamese students from 31 junior high schools in Ho Chi Min City	OW IOTF: 11.7% OB IOTF: 2.0%	Validated FFQ	• Frequent intake of vegetables and fruits (everyday or almost every day)		• 0.30 (0.20 to 0.40), <0.05	√
								• Frequent intake of soft drink (everyday or almost every day)	• 3.00 (1.60 to 5.30), <0.05	√
							• Daily or almost daily breakfast consumed		N/A	X

OW: Overweight [IOTF: BMI ≥ 25kg/m2; WHO, 2006 (aged 0-5 years) : ≥+2SD, 2007 (aged 5-19 years) : +1SD and <+2SD; US CDC 2000: ≥ 85th Percentile; China Standard: ≥ 85th Percentile) , OB: Obese (IOTF: BMI ≥ 30kg/m2; WHO, 2006 (aged 0-5 years) : + 3SD, 2007 (aged 5-19 years) : >+2SD; US CDC 2000: ≥ 95th Percentile; China Standard: ≥ 95th Percentile],OR: Odds Ratio, CI: Confidence Interval, M: Male, F: Female, N/A: Not available, WHO: World Health Organisation, CDC: Centre for Disease Control, IOTF: International Obesity Task Force

Study	Setting	Participants				Dietary Assessment Method	Dietary Pattern		Outcomes	Association between dietary pattern and childhood overweight/obesity
		Age (Years)	Sample Size/ Gender	Other Characteristics	Prevalence OW/ OB		Associated with reduced prevalence/risk of overweight/obesity	Associated with higher prevalence/risk of overweight/obesity	Odds Ratio (Reference: 1.00) (95% CI) p-value	
Adolescents (cont')										
Li et al. 2008 (94)	30 junior high schools in 6 districts in Xi'an City, China May to Nov 2004	11 to 17	1792 (#) M: 899 (##) F: 893 (###)	Chinese adolescents attending junior high schools in Xi'an City	OW & OB IOTF: 19.9%	Self-administered questionnaire on food habits and attitude and one day 24-hour diet recall		• Having soft drink (≥ 4 times/ week)	• 1.60 (1.02 to 2.50), <0.05 #	√
								• Not fussy about foods	• 1.70 (1.20 to 2.20), <0.05 #	√
								• Highest intake of energy tertile	• 1.80 (1.10 to 2.90), <0.05 #	√
								• Having soft drink (≥ 4 times/ week)	• 1.90 (1.10 to 3.20), >0.05 ##	X
							• Not consuming preserved fruits		• 0.70 (0.50 to 1.00), >0.05 #	X
							• Having snacks one to three times a week		• 0.60 (0.40 to 0.99), >0.05 ## • 0.60 (0.30 to 0.99), <0.05 ###	X √
Li et al. 2010 (343)	30 junior high schools in 6 districts in Xi'an City, China May to Nov 2004	11 to 17	1792 (#) M: 899 (##) F: 893 (###)	Chinese adolescents attending junior high schools in Xi'an City	OW & OB IOTF: 16.3%	Self-administered questionnaire on food habits and attitude and one day 24-hour diet recall		• Daily intake of more than two bottles of soft drink	• 1.70 (1.10 to 2.70), <0.05 # • 1.90 (1.10 to 3.80), <0.05 ##	√ √
								• Not selective about foods	• 1.50 (1.10 to 2.00), <0.05 # • 1.60 (1.10 to 2.40), <0.05 ##	√ √
								• Consuming breakfast outside home	• 1.20 (0.60 to 2.40), >0.05 # • 1.70 (1.04 to 2.90), <0.05 ###	X √
								• Intake of mutton and beef soup	• 1.30 (0.80 to 2.20), >0.05 # • 0.50 (0.30 to 0.80), <0.05 ##	X
							• Consuming preserved fruits		• 0.60 (0.50 to 0.90), <0.05 # • 0.60 (0.40 to 0.80), <0.05 ##	√ √
							• Consuming sweets and chocolates		• 0.50 (0.30 to 0.80), <0.05 ##	√
							• Presence of snacking		• 0.60 (0.40 to 0.90), <0.05 ##	√
Zalilah et al. 2006(41)	14 secondary schools in Malaysia Time period of study not specified	11 to 15	6555 M: 3353 F: 3202	Malaysian male and female students of Secondary 1 and 2	OW WHO 1995: 18.3%	3-day food/diet and activity record	N/A	N/A	N/A	N/A

OW: Overweight (IOTF: BMI ≥ 25kg/m^2; WHO, 1995: ≥85th Percentile), OB: Obese (IOTF: BMI ≥ 30kg/m^2), OR: Odds Ratio, CI: Confidence Interval, M: Male, F: Female, IOTF: International Obesity Task Force, N/A: Not Applicable, #: Overall, ##: Boys, ###: Girls

Appendix 3.6: List of excluded studies

- Aggarwal T.,Bhatia RC, Singh D, Sobti, PC. Prevalence of obesity and overweight in affluent adolescents from Ludhiana, Punjab. Indian Pediatrics. 2008. 45 (6): 500-502.

Reason for exclusion: association between body weight and diet not measured (4/9)

- Alavi Naini AM, Amini M, Karajibani M, Khalilian AL, Nourisaeedloo S, Salimi M, Shafaghi KH, Yhoung-aree J. Association of obesity with food habits and body image in school children of Nakhon Pathom Province, Thailand. Iranian Journal of Public Health. 2006. 35(2): 42-48

Reason for exclusion: does not fulfil majority of main criteria, inappropriate statistics used for reporting (3/9)

- Chugh R, Puri S. Affluent adolescent girls of Delhi: eating and weight concerns. British Journal of Nutrition. 2001. 86(4): 535-542

Reason for exclusion: does not fulfil majority of main criteria (4/9)

- Goyal RK, Shah VN, Saboo BD, Phatak SR, Shah NN, Gohel MC, Raval PB, Patel SS. Prevalence of overweight and obesity in Indian adolescent school going children: Its relationship with socioeconomic status and associated lifestyle factors. Journal of Association of Physicians of India. 2010. 58 (3): 151-158

Reason for exclusion: does not fulfil majority of main criteria (4/9)

- Hong TK, Dibley MJ, Sibbritt D, Trang NHHD. Dietary behaviors and their relationship with overweight/obesity in adolescents of Ho Chi Minh City, Vietnam. International Journal of Obesity. 2008. 32: S213

Reason for exclusion: only abstract available, no full text to gather data

- Iyer U, Elayath N, Akolkar A. Magnitude and determinants of overweight and obesity in 6-12 year old school children of Vadodara City. Current Pediatric Research. 2011. 15(2): 105-109

Reason for exclusion: does not fulfil majority of main criteria (3/9)

- Jain S, Pant B, Chopra H, Tiwari R. Obesity among adolescents of affluent public schools in Meerut. Indian Journal of Public Health. 2010. 54 (3):158-160

Reason for exclusion: does not fulfil majority of main criteria (4/9)

- Kuriyan R, Bhat S, Thomas T, Vaz M, Kurpad AV. Television viewing and sleep are associated with overweight among urban and semi-urban South Indian children. Nutrition Journal.2007. 6. 25

Reason for exclusion: does not fulfil majority of main criteria, poor quality (3/9)

- Singh AK, Maheshwari A, Sharma N, Anand K. Lifestyle associated risk factors in adolescents. Indian Journal of Pediatrics. 2006. 73(10): 901-906

Reason for exclusion: does not fulfil majority of main criteria (3/9)

- Singh SK, Kapoor D, Goyal R, Rastogi A, Kumar S, Mishra OP. Childhood obesity: Contributing factors and consequences in Indian children. Diabetes and Metabolic Syndrome: Clinical Research and Reviews. 2007.1(3): 167-172

Reason for exclusion: does not fulfil majority of main criteria (4/9)

- Swaminathan S, Thomas T, Kurpad AV, Vaz M. Dietary patterns in urban school children in South India. Indian Pediatrics. 2007. 44(8): 593-596

Reason for exclusion: does not fulfil majority of main criteria (3/9)

- Wang Y, Ge K, Popkin BM. Tracking of body mass index from childhood to adolescence: a 6-y follow-up study in China. American Journal of Clinical Nutrition. 2000. 72(4): 1018-1024

Reason for exclusion: does not fulfil majority of main criteria (5/9)

- Zhang CX, Chen YM, Chen WQ, Deng XQ, Jiang ZQ. Energy expenditure and energy intake in 10-12 years obese and non-obese Chinese children in a Guangzhou boarding school. Asia Pacific Journal of Clinical Nutrition. 2008.17 (2): 235-242

Reason for exclusion: does not fulfil majority of main criteria (3/9)

Appendix 3.7: Summary table of critical appraisal of included studies (comparable cohort / case control studies)

Citation	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
Rajkumari B, Singh AB, Singh AJ, Usharani DI, Singh RKB, 2010	Y	Y	Y	Y	Y	NA	NA	Y	Y
Collins AE, Pakiz B, Rock CL, 2008	Y	Y	Y	Y	Y	NA	NA	Y	Y
He Q, Ding ZY, Fong DYT, Karlberg J, 2000	Y	Y	Y	Y	Y	Y	Y	Y	Y
Huynh DTT, Dibley MJ, Sibbritt D, Tran HTM, Le QTK, 2011	Y	Y	Y	Y	Y	Y	Y	Y	Y
Jeemon P, Prabhakaran D, Mohan V, Thankappan KR, Joshi PP, Ahmed F, Chaturvedi V, Reddy KS, 2009	Y	Y	Y	Y	Y	NA	NA	Y	Y
Jiang JX, Rosenqvist U, Wang HS, Koletzko B, Lian GL, Huang J, Greiner T, 2009	Y	Y	Y	Y	Y	NA	NA	Y	Y
Jiang J, Rosenqvist U, Wang H, Greiner T, Ma Y, Toschke AM, 2006	Y	Y	Y	Y	NA	NA	NA	Y	Y
Li M, Dibley MJ, Sibbritt DW, Yan H, 2010	Y	Y	N	Y	Y	NA	NA	Y	Y
Li M, Dibley MJ, Sibbritt D, Yan, 2008	Y	Y	Y	Y	Y	NA	NA	Y	Y
Li Y, Zhai F, Yang X, Schouten EG, Hu X, He Y, Luan D, Ma G, 2007	Y	Y	Y	Y	Y	Y	N	Y	Y
Pawloski LR, Kitsantas P, Ruchiwit M, 2010	N	Y	N	Y	Y	NA	N	Y	Y
Shan XY, Xi B, Cheng H, Hou DQ, Wang Y, Mi J, 2010	Y	Y	Y	Y	Y	NA	NA	Y	Y
Tang KH, Nguyen HHDT, Dibley MJ, Sibbritt DW, Phan, NTB, Tran TMH, 2010	Y	Y	Y	Y	Y	NA	NA	Y	Y
Wang Y, Ge K, Popkin B, 2000	Y	NA	NA	Y	Y	Y	N	Y	Y
Thongbai W, Fongkaew W, Kennedy CM, Aree P, Patumanond J, 2011	Y	NA	Y	Y	Y	NA	NA	Y	Y
Zalilah MS, Khor GL, Mirnalini K, Norimah AK, Ang M, 2006	Y	Y	N	N	Y	NA	NA	Y	Y
%	93.75	100.0	80.0	93.75	100.0	100.0	40.0	100.0	100.0

Y: Yes, N: No, NA: Not Applicable

Appendix 3.8: Main findings of the included studies

Dietary Pattern		Overweight/Obesity Promoting Factors (Significant)	Overweight/Obesity Promoting Factors (Non Significant)	Overweight/Obesity Protective Factors (Significant)	Overweight/Obesity Protective Factors (Non Significant)	Non significant and No association
Nutrient intake	Energy	• Highest intake of energy tertile (boys)[94] • Total daily energy intake[342] • Energy percentages of Dietary Reference Intake[342]				• High energy diet[340]
	Carbohydrate			• High-carbohydrate diet[340]		
	Protein	• Highest protein intake (tertile)[339]				
	Fat					• High fat diet (OW → OW) & (OW → NW)[340]
	Alcohol	• High intake of alcohol (≥ 1 time/week)[341]				
Food groups intake	Fruits and vegetables	• Not eating other type of vegetables during the past 1 week[93] • Eating high-fibre, non-sweet fruit (≤ 2 times/ week)[247]	• Not eating green leafy vegetables[93]	• Consuming preserved fruits (overall and boys)[343] • Frequent intake of vegetables and fruits (everyday or almost every day)[98] • High fruits and vegetables diet[340]	Not consuming preserved fruits (overall and boys)[94]	
	Meat and meat products	• Intake of mutton and beef soup (girls)[343] • High meat diet (OW → OW)[340]	• Consumed ≥ 200g/day of meat and meat products[245]			• Intake of mutton and beef soup (overall) [274] • High meat diet (OW → NW)[340]
	Milk and milk products	• Drinking sweetened fresh milk and other flavours/ cocoa/ yogurt (3 to 7 times/ week)[247] • Drinking yogurt (3 to 7 times/ week)[247]	• Consumed ≥ 100g/day of dairy products[245]			
	Oil	• Consumed ≥ 25g/day of cooking oil[245]				
Dietary Behaviour	Having meals outside home and eating fast food	• Eating 25% and above of weekly meals outside home[337] • Consuming breakfast outside home (girls)[343] • Eating Western fast food (≥ 3 times/ week)[341]				• Consuming breakfast outside home (overall)[93] • Frequent fast food intake (≥ 1 time/ week)[274] • Western fast food consumption[342]
	Snacking	• Taking snacks (≥ 3 times/ week)[341] • Consumed one serving of chips/week (girls)[338]		• Eating between meals[93] • Having snacks one to three times a week (girls)[94, 343] • Presence of snacking (girls)[343]	Eating snacks while watching TV[93]	• Snacking while watching television[274]
	Drinking sugar-sweetened beverages and eating sugar and sweets	• Frequent intake of soft drink (everyday/almost every day)[94, 246, 343] • Having soft drinks 4 times or more per week[94] • Daily intake of more than two bottles of soft drink[343] • Daily intake of more than two bottles of soft drink (boys)[343]	• Having soft drink (≥ 4 times/ week) (boys)[94]	• Consuming sweets and chocolates (girls)[343]		• Sugar-sweetened drink intake (≥ 3 times/ week)[341]
	Others		• Taking cold drinks while watching TV[93]			• Daily or almost daily breakfast consumed[246]
Child Feeding Behaviour	Parental feeding practice	• Maternal restriction of snacks[263]		• Maternal encouragement to child to eat more often[263]		
	Children eating speed and fussiness towards food	• Not fussy about foods (overall)[94] • Not selective about foods (overall)[343] • Not selective about foods (boys)[343] • High eating speed (≤ 2 chews/ swallow)[98] • High food responsiveness[247] • High food enjoyment[247]				

Appendix 3.9: JBI Level of Evidence

Level of Evidence	Feasibility F (1-4)	Appropriateness A (1-4)	Meaningfulness M (1-4)	Effectiveness E(1-4)	Economic Evidence
1	Metasynthesis of research with unequivocal synthesised findings	Metasynthesis of research with unequivocal synthesised findings	Metasynthesis of research with unequivocal synthesised findings	Meta-analysis(with homogeneity) of experimental studies (eg RCT with concealed randomisation) OR One or more large experimental studies with narrow confidence intervals	Meta-analysis(with homogeneity) of experimental studies (eg RCT with concealed randomisation) OR One or more large experimental studies with narrow confidence intervals
2	Metasynthesis of research with credible synthesised findings	Metasynthesis of research with credible synthesised findings	Metasynthesis of research with credible synthesised findings	One or more smaller RCTs with wider confidence intervals OR Quasi-experimental studies(without randomisation)	One or more smaller RCTs with wider confidence intervals OR Quasi-experimental studies(without randomisation)
3	a. Metasynthesis of text/opinion with credible synthesised findings b. One or more single research studies of high quality	a. Metasynthesis of text/opinion with credible synthesised findings b. One or more single research studies of high quality	a. Metasynthesis of text/opinion with credible synthesised findings b. One or more single research studies of high quality	a. Cohort studies (with control group) b. Case-controled c. Observational studies(without control group)	a. Cohort studies (with control group) b. Case-controled c. Observational studies(without control group)
4	Expert opinion	Expert opinion	Expert opinion	Expert opinion, or physiology bench research, or consensus	Expert opinion, or physiology bench research, or consensus

Appendix 3.10: Abstract for Chapter 3

Executive summary

Background

The exponential increase in prevalence of childhood obesity has become a global concern. Developing countries in Asia are at particular risk due to their stage in the epidemiological and nutrition transition.

Objectives

The review objectives were to summarize the evidence on prevalence of childhood overweight and obesity within developing countries in Asia and to synthesise the best epidemiological association between the dietary patterns of children in the developing countries in Asia and their weight status in terms of obesity.

Inclusion criteria

Types of participants

This review considered any studies that included children under 18 years of age who live in developing countries in Asia.

Types of studies

This review of epidemiological association considered any analytical observational studies (case-control studies, cohort studies and analytical cross-sectional studies).

Types of outcomes

The focus was to summarise the prevalence of childhood overweight and obesity within developing countries in Asia and synthesise the best available evidence on the relationship between dietary patterns as the exposure variable and childhood overweight and obesity as the outcome.

Search strategy

A three-step search strategy was utilised, with an initial limited search of MEDLINE, CINAHL and EMBASE to identify search terms. A second search using all identified keywords and index terms was undertaken across all included databases. Thirdly, the

reference list of all identified reports and articles were searched for additional studies. Additional electronic databases searched included: ProQuest, Web of Science, and Scopus. Each database was searched from inception to September 2011, with an English language restriction.

Methodological quality

All papers selected for retrieval were assessed independently by two reviewers using standardised critical appraisal instruments from the Joanna Briggs Institute.

Data collection

Data was extracted from included studies by two reviewers independently using an adapted version of the standardised data extraction form from the Joanna Briggs Institute.

Data synthesis

Meta-analysis was not possible because of the heterogeneity of studies in terms of methodology, statistical analyses and outcomes. A narrative summary of results is provided.

Results

Fifteen studies were included in the review. The prevalence rates of childhood overweight and obesity in Asian developing countries ranged from 5.1% to 19.9% with no specific trend in age or gender. Several significant but inconsistent statistical associations between dietary patterns and overweight/obesity in children and adolescents were found [high energy diet (OR: 1.80 95%CI 1.10 to 2.90, $p<0.05$ vs 0.80 95%CI 0.60 to 1.10, $p>0.05$), low intake of fruit and vegetables (OR: 2.34 95%CI 1.04 to 5.24, $p<0.001$; 2.00 95%CI 1.10 to 3.40, $p<0.05$ vs 1.33 95%CI 0.44 to 4.05, $p>0.05$; 0.70 95%CI 0.50 to 1.00, $p>0.05$), high meat consumption (RR: 2.40 95%CI 1.00 to 5.60, $p<0.05$ vs 1.70 95%CI 1.00 to 2.70, $p>0.05$), eating out (OR: 12.0 95%CI 7.7 to 18.7, $p<0.001$; 1.70 95%CI 1.04 to 2.90, $p<0.05$ vs 1.20 95%CI 0.60 to 2.40, $p>0.05$), fast food intake (OR: 1.50 95%CI 1.12 to 2.02, $p<0.05$), presence of snacking (OR: 2.34 95%CI 1.01 to 5.54, $p=0.05$; 1.26 95%CI 1.13 to 1.40, $p<0.05$ vs 0.80 95%CI 0.48 to 1.32,$p=0.377$; 0.60 95%CI 0.30 to 0.99, $p<0.05$; 0.60 95%CI 0.40 to 0.90, $p<0.05$) and drinking sugar sweetened beverages (OR: 1.60 95%CI 1.02 to 2.50, $p<0.05$; 1.70 95%CI 1.10 to 2.70, $p<0.05$ vs 0.93 95%CI

0.82 to 1.05, p>0.05)]. The key limitation was the heterogeneity of studies in terms of measures of dietary patterns and obesity standards.

Conclusions

The prevalence rates of childhood overweight and obesity in Asian developing countries ranged from 5.1% to 19.9% with no specific trend in age or gender. From the practice perspective, several significant yet inconsistent statistical associations between dietary patterns and childhood overweight/obesity in children and adolescents were found.

Implications for Practice

This review highlights the need for clinicians to monitor the effects of dietary change on the weight and health status of children in Asian countries.

Implications for research

There is a need for valid measures of dietary intake and use of standardised international cut-offs for overweight and obesity, and for future researchers to conduct prospective studies to determine the causal relationship between Asian children's dietary pattern and their weight status.

Keywords: Dietary pattern, Children, Overweight, Obesity, Developing countries, Asia, Systematic Review

Appendix 4.0: Statement of contribution and collaboration (Chapter 4 Systematic Review Paper 2)

I attest that Research Higher Degree candidate Wai Yew Yang contributed to the following paper:

Quality of dietary intake methodology and reporting in epidemiology studies examining relationship between dietary patterns and childhood obesity in Asian developing countries: a systematic review. Nutrition and Dietetics. 2014; 71: 201-209

Wai Yew Yang contributed to the development of the review protocol, design of the study, screening of studies included in the review, quality appraisal of included studies, data extraction and manuscript preparation. Dr Tracy Burrows contributed to the design of the study, were second reviewer and therefore, screened and performed quality appraisal and data extraction, and contributed to the interpretation of the results and drafts of the manuscript. Professor Lauren T Williams, Professor Clare E Collins, Professor Winnie Chee Siew Swee and Dr Lesley Macdonald-Wicks contributed to the interpretation of the results and drafts of the manuscript within the capacity of their role as PhD supervisors.

Professor Clare E Collins	Date: 18/11/2015
Dr Tracy Burrows	Date: 18/11/2015
Professor Lauren T Williams	Date: 28/10/2015
Dr Lesley Macdonald-Wicks	Date: 18/11/2015
Professor Winnie Chee Siew Swee	Date: 16/11/2015
Mrs Wai Yew Yang	Date: 16/11/2015
Professor Robert J Callister Deputy Head of Faculty (Research)	Date: 19/11/2015

Appendix 4.1: Adapted checklist for dietary assessment methodology reporting

Study Design	
Quality Rating Criteria	
Is there a dietary method validation study?	
Study tool	
Dietary pattern reporting approach	
Validation tool	
1. Validation study sample & sample size (max 1 point): 0.5 point if same population as for observational study; PLUS 0.5 point if n≥100 or n≥50 if biomarkers used	
2. Statistics to assess validity (max 3 point): 1 point if compare/test mean or median or difference or face validity (expert review); PLUS [choose highest value of: 0.5 point for correlation OR 1.0 adjusted correlations/ unweighted Kappa/ Cronbach alpha OR 1.5 point for deattenuated/ interclass correlations/ weighted Kappa]; PLUS 0.5 point for classification or Bland & Altman plot	
3. Data collection (max 1 point): 0.5 point if researcher administered (ie supervised, face to face or phone interview); plus 0.5 point if conducted or reviewed/checked by a trained person	
4. Scoring Method (max 1 point): 1.0 point for questionnaires - weighting of items or subscales reported; 1.0 point for nutrient calculations -relevant nutrient databases reported	
Subsequent criteria are answered based on the main dietary assessment method used in the included studies	
FOOD FREQUENCY QUESTIONNAIRE	**5. Frequency scale (max 1 point):** 0.5 point if considered; plus 0.5 point if robust portion size methodology
	6. Seasonality (additional 0.5 point): 0.5 point if considered
FOOD RECORD/ RECALL METHOD	**5. Number of days recall (max 1 point):** 0.5 point for multiple days of recall; plus 0.5 point if consideration of all days of the week
	6. Use of multiple pass and aids/ prompts (additional 0.5 point): 0.25 point if multiple pass protocol used; plus 0.25 point if aids/ prompts used for portion size estimation
DIET HISTORY	**5. Time-scale (max 0.5 point):** 0.5 point if time-scale appropriate to capture usual intake
	6. Use of 24-hour recall and aids/ prompts (max 1.0 point): 0.5 point if included 24-h recall: plus 0.5 point if aids/ prompts used for portion size estimation
DIETARY QUESTIONNAIRE	**5. Questionnaire details provided (max 1 point):** 1 point if provided as an appendix or 0.5 point if summary of items reported
	6. Factor analysis (additional 0.5 point): 0.5 point if undertaken
Total Score (Maximum 7)	
Dietary reporting quality rating: Poor (≤ 2), Acceptable (≥ 2.5 to <3.5), Good (≥ 3.5 to <5.0), Excellent (≥ 5.0)	

Appendix 5.0: Statement of contribution and collaboration (Chapter 5 Methods Paper 1)

I attest that Research Higher Degree candidate Wai Yew Yang contributed to the following paper:

Studying the Family Diet: An investigation into association between diet, lifestyle and weight status in Malaysian families. Malaysian Journal of Nutrition 2015; 21(2): 139-154.

Wai Yew Yang contributed to the study design and methodology, coordinated, carried out and supervised data collection during the study period, conducted analyses and interpreted the study results and drafted the manuscripts. Professor Lauren T Williams, Professor Clare E Collins, Professor Winnie Chee Siew Swee, Dr Tracy Burrows and Dr Lesley Macdonald-Wicks contributed to the study design and methodology, interpreted the study results, critically reviewed and contributed to drafts of the manuscript, within the capacity of their role as PhD supervisors.

Professor Clare E Collins	Date: 18/11/2015
Dr Tracy Burrows	Date: 18/11/2015
Professor Lauren T Williams	Date: 28/10/2015
Dr Lesley Macdonald-Wicks	Date: 18/11/2015
Professor Winnie Chee Siew Swee	Date: 16/11/2015
Mrs Wai Yew Yang	Date: 16/11/2015
Professor Robert J Callister Deputy Head of Faculty (Research)	Date: 19/11/2015

Appendix 5.1: Ethics approval for the Family Diet Study

HUMAN RESEARCH ETHICS COMMITTEE

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

Notification of Expedited Approval

To Chief Investigator or Project Supervisor:	**Professor Clare Collins**
Cc Co-investigators / Research Students:	**Ms Wai Yew Yang** **Doctor Lesley MacDonald-Wicks** **Associate Professor Winnie Chee Siew Swee** **Conjoint Professor Lauren Williams** **Doctor Tracy Burrows**
Re Protocol:	**The Family Diet Study - Dietary and lifestyle factors associated with weight status of Malay primary school children and their main carers at urban areas of Klang Valley, Malaysia**
Date:	**19-Apr-2013**
Reference No:	**H-2013-0065**
Date of Initial Approval:	**18-Apr-2013**

Thank you for your **Response to Conditional Approval** submission to the Human Research Ethics Committee (HREC) seeking approval in relation to the above protocol.

Your submission was considered under **Expedited** review by the Chair/Deputy Chair.

I am pleased to advise that the decision on your submission is **Approved** effective **18-Apr-2013**.

For noting:

Please make the following changes, and provide us with a copy of the finalised Participant Information Statement for our records:

1. Participant Information Statement
   a. For noting: Due to the voluntary nature of participation, please revise sub-headings 'What will you/your child have to do?' and 'What else will you have to do?'. Please change to 'What would (you/your child/your school) be asked to do?' and 'What else will you be asked to do?'

   b. Please identify the source of funding for the research within the Participant Information Statements. (eg This research is funded by...')

   c. The Participant Information Statement for Parents/Guardians refers to a follow-up

Appendix 5.2: The Family Diet Study Recruitment Flyer

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

My Family's Diet and Lifestyle – How much do you know?

The Family Diet Study

RESEARCH STUDY

www.newcastle.edu.au

Details

Interested to learn more about your family's diet and lifestyle?
The aim of this study is to find out what families are currently eating and their physical activity practices. The information will be used to identify best strategies for families in order to maintain a healthy weight.

Who can volunteer?

- Malay families with parents and/or carers living with a primary school child from Primary 3 to Primary 5
- Able to attend assessment sessions for child and family on two occasions either at school/ home/ workplace and one face-to-face or phone call follow-up

Your family will be given a book and stationary voucher following completion of the assessment sessions as compensation for your time (~1 hour each).

How do I find out more information?

Please contact Ms Wai Yew Yang, at 017-364 3844 or email: waiyew.yang@uon.edu.au for further information and to find out if you are eligible to enrol.

IMU
INTERNATIONAL MEDICAL UNIVERSITY
MALAYSIA

This project has been approved by the University's Human Research Ethics Committee, Approval No. H- 2013-0065. Should you have concerns about your rights as a participant in this study, or you have a complaint about the manner in which the study is conducted, it may be given to the researcher, or, if an independent person is preferred, to the Human Research Ethics Officer, Research Office, The Chancellery, The University of Newcastle, University Drive, Callaghan NSW 2308, Australia, telephone (02) 49216333, email Human-Ethics@newcastle.edu.au or the local independent contact in Malaysia: Institute for Research, Development & Innovation, International Medical University, No. 126, Jalan Jalil Perkasa 19, Bukit Jalil, 57000 Kuala Lumpur, Malaysia, telephone (603) 27317331, email http://www.imu.edu.my/irdi

Appendix 5.3: The Family Diet Study Consent Form

Clare Collins
PhD, BSc, Dip Nutr&Diet, Dip Clin Epi, FDAA
Professor in Nutrition and Dietetics
NHMRC CDA Research Fellow
Co-Director, Priority Research Centre in Physical Activity and Nutrition

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Faculty of Health
The University of Newcastle
Callaghan NSW 2308
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Fax 00612 49217053
Email: clare.collins@newcastle.edu.au

Participant Consent Form for the Research Project:

THE FAMILY DIET STUDY

Version 3: 7th September 2013

Professor Clare Collins, Professor Lauren Williams, Professor Winnie Chee, Dr Tracy Burrows, Dr Lesley MacDonald-Wicks, Ms Wai Yew Yang (Phd Candidate)

I agree to participate in the above research project and give my consent freely. I understand that the project will be conducted as described in the Information Statement, a copy of which I have retained. I understand I can withdraw from the project at any time and do not have to provide any reason for withdrawing. I consent to myself, my spouse (if applicable) and one other main carer involved in my family's diet to:

- have height, weight, waist and body fat measurements taken (once)
- complete a series of questionnaires in a booklet format (once)
- have food interview for my dietary intake (two times)

I understand that if I agree for my child to participate in this research, I agree to my child doing the following:

- have his/her height, weight, waist and body fat measurements taken (once)
- have food interview for his/her dietary intake (two times)

I understand that all personal information will remain confidential to the researchers and that data collected from my participation will be used in journal publications and conference presentations and may be used in future projects. My refusal to participate or withdrew from the study will not effect my relationship with the University of Newcastle, Australia and the International Medical University, Malaysia. I have had the opportunity to have questions answered to my satisfaction.

By signing below, I indicate my consent to participate in the research project conducted by Professor Clare Collins, Professor Lauren Williams, Professor Winnie Chee, Dr Tracy Burrows, Dr Lesley MacDonald-Wicks and Ms Wai Yew Yang.

Print Name *(Parent)*: _____

Signature (Parent): _____ **Date:** _____

Contact Details: e-mail_____ Phone_____

Print Name *(Child)*: _____

☐ **My parent has explained this study to me (child to tick box)** **Date:** _____

Please return the completed consent form in the envelope enclosed to Ms Wai Yew Yang to your school.
Your cooperation is greatly appreciated.

Complaints about this research

This project has been approved by the University's Human Research Ethics Committee, Approval No. H- 2013-0085.
Should you have concerns about your rights as a participant in this study, or you have a complaint about the manner in which the study is conducted, it may be given to the researcher, or, if an independent person is preferred, to the Human Research Ethics Officer, Research Office, The Chancellery, The University of Newcastle, University Drive, Callaghan NSW 2308, Australia, telephone (02) 49216333, email Human-Ethics@newcastle.edu.au or the local independent contact in Malaysia: Institute for Research, Development & Innovation, International Medical University, No. 126, Jalan Jalil Perkasa 19, Bukit Jalil, 57000 Kuala Lumpur, Malaysia, telephone (603) 27317331, email http://www.imu.edu.my/irdi

Appendix 5.4: The Family Diet Study Information Sheet

Clare Collins
PhD, BSc, Dip Nutr&Diet, Dip Clin Epi, FDAA
Professor in Nutrition and Dietetics
NHMRC CDA Research Fellow
Co-Director, Priority Research Centre in Physical Activity and Nutrition

Rm 310, Level 3 ATC Building
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Ph 02612 49215646
Fax 02612 49217053
Email clare.collins@newcastle.edu.au

Participant's Information Statement for the Research Project:

THE FAMILY DIET STUDY

Professor Clare Collins, Professor Lauren Williams, Professor Winnie Chee,
Dr Tracy Burrows, Dr Lesley MacDonald-Wicks,
Ms Wai Yew Yang (PhD Candidate)

Version 4: 7th September 2013

What is the purpose of this study?

Your family is invited to join a family focused study, mainly looking into diet and nutrition. This study involves collecting information on body weight, height, body fat and waist circumference; about the family usual food preparation and eating habits; physical activity and parenting style related to eating in families residing in Klang Valley, Malaysia. The study is being conducted by a team of researchers from The University of Newcastle, Australia and The International Medical University (IMU), Malaysia. This research is funded by The International Medical University (IMU), Malaysia.

Why is the study being undertaken?

The researchers are interested in investigating what families are currently eating to identify the best strategies for families in order to maintain a healthy weight. To do this, we will be asking you and your family about what you are currently eating and physical activity practices.

Why are you being invited to this study?

The research team has obtained the approval from The Ministry of Education and from the individual school where your child is studying to undertake this study. As a family within the school environment you are invited to participate in the study. The school is distributing this invitation to students from Primary 3 to Primary 5 on behalf of the researchers and has not provided any information about you to the researcher.

What are the inclusion/exclusion criteria for participation?

You can participate in this project if your family are:

- From the Malay ethnicity
- Living full time together with a primary school child from Primary 3 to Primary 5. If more than one child within Primary 3 to Primary 5 in the family agrees to participate, the eldest child will be invited to participate
- Able to complete a questionnaire and to be interviewed about what your family eat and practice
- Able to complete some forms about the physical activity your family do
- Able to have weight, height, body fat and waist measurements taken
- Willing to attend the required interview and measurement sessions at school and home

You will be ineligible to participate if your child:

- Have known medical conditions that could influence body weight, metabolic rate or appetite, including asthma, Type I diabetes
- Are taking medications known to be associated with weight change, including long term use of oral steroids.

What would (you/your child/your school) be asked to do?

There are several activities and assessments that the research team would be conducting. The first is f your child to attend an information briefing session with the researcher at school. When this has been done the researcher will ask your child if the following measurements can be carried out in the school. Your chil will be required to empty his/her bladder first and wear light clothing (e.g. sports attire) and remove watc wallet, keys or any other heavy objects. All results will only be known to your child and the researcher:

a. **Height**
   This is done by standing under a height measuring tool.
b. **Body weight**
   This is done by standing on the weighing scale machine.
c. **Waist circumference**
   The researcher will measure the middle section between chest and hip using a non-extensib measuring tape.
d. **Body fat**
   This is done using a special machine. The child will lie down on a flat surface and the researcher w attach one electrode at each hand and feet for a few seconds. A very small electrical current passed through the body and it won't do any harm and the child will not feel anything.
e. **Interview food intake**
   The researcher would interview your child about his/her food intake from the previous day.

Your child will bring home a series of questionnaire related to the family's educational background, income, food habits, physical activity and parenting style related to eating, to be filled out by you, your spouse (if applicable) and one other main carer involved in the food preparation and meal times of your child. This information will contribute to a better understanding of the relationship between environment and health, as well as the relationship between parent and child dietary intakes. The whole questionnaire will take around 30 minutes to 1 hour to complete.

What else will you be asked to do?

Following on from this, the researcher will arrange to meet at a time that is convenient with your family at school/ home/ workplace to interview and measure you, your spouse (if applicable) and/or one other main carer. The measurements above will be carried out and the filled questionnaire will be checked at the same time. Those involved will be required to his/her empty bladder and wear light clothing (e.g. sports attire) and remove watch, wallet, keys or any other heavy objects. The whole visit will take around 1 to 2 hours to complete. One follow-up face-to-face or phone call will be made to you, your spouse (if applicable) and/or one other main carer to complete the food intake interview.

What if I don't want to do these things?

Participation in this study is entirely your choice. You are free to withdraw at any time without giving a reason and with no penalty to you. You can even change your mind later. You need to obtain your child's consent to participate and they too have the opportunity to withdraw from the study at any time, regardless of your consent. You can withdraw from the study by contacting the co-researcher from IMU, Professor Winnie Chee at 603-86567228 or email: winnie_chee@imu.edu.my.

What will happen to the information provided?

The information will only be used for this study and will never be passed to anyone else in a way that could identify your family. The information shall be used to prepare a postgraduate thesis and, published in scientific conferences and journal articles.

How will your privacy be protected?

The information your family provide to our team will only be identified by a unique code number. Data will be securely stored and accessed only by the research team. After the completion of the study, data will be retained for 5 years then shredded.

What are the risks and benefits of participating?

Your family will receive written feedback on your body measurements, family usual food preparation and eating habits; physical activity and parenting style related to eating. If anyone from the family is identified to be at nutritional risk, you will be notified and advised to seek review by a general practitioner from the health clinic in IMU (603-2731766) or the nearest government health department for health clinic referral (603-22687333 or 603-51237333). The results from this study will be used to help the researchers to plan a more effective nutrition intervention to help Malaysian families to maintain healthy body for their future health and well being.

What do you need to do to participate?

Please discuss the study with your child first and ask whether they are happy to participate before completing the consent form. Your child's decision will not disadvantage them in any way. If everyone agrees to participate, you will keep this information sheet and will be required to sign the enclosed consent form and return it in the envelope to your school. Once the researcher has received your consent form, the researcher will contact you to screen for eligibility based on the inclusion/exclusion criteria for the study by phone to confirm your participation.

Would you like to ask the team at the University a question?

If you still have more questions, please feel free to talk to Ms Wai Yew Yang. You can contact her at 017-364 3844 or email: waiyew_yang@uon.edu.au. Thank you for thinking about joining our study. On behalf of our team:

- ***Professor Clare Collins, Professor Lauren Williams, Dr Tracy Burrows, Dr Lesley MacDonald-Wicks, Professor Winnie Chee, Ms Wai Yew Yang (PhD Candidate)***

Professor Clare Collins
Chief Investigator

Wai Yew Yang
PhD Candidate

Complaints about this research

This project has been approved by the University's Human Research Ethics Committee, Approval No. H- 2013-0065.

Should you have concerns about your rights as a participant in this study, or you have a complaint about the manner in which the study is conducted, it may be given to the researcher, or, if an independent person is preferred, to the Human Research Ethics Officer, Research Office, The Chancellery, The University of Newcastle, University Drive, Callaghan NSW 2308, Australia, telephone (00612) 49216333, email Human-Ethics@newcastle.edu.au, or the local independent contact in Malaysia: Institute for Research, Development & Innovation, International Medical University, No. 126, Jalan Jalil Perkasa 19, Bukit Jalil, 57000 Kuala Lumpur, Malaysia, telephone (603) 27317331, email http://www.imu.edu.my/irdi

Appendix 5.5: The Family Diet Study Questionnaire

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

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THE FAMILY DIET STUDY

CONFIDENTIAL

Research Team:

Professor Clare Collins, Professor Lauren Williams, Professor Winnie Chee,
Dr Tracy Burrows, Dr Lesley MacDonald-Wicks and
Ms Wai Yew Yang (PhD candidate)

Contact Person:

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Email : waiyew_yang@ucn.edu.au

Code No:

Date:

THE FAMILY DIET STUDY

PLEASE READ THESE INSTRUCTIONS BEFORE YOU START

This is a survey about food and eating habits of your family.

We would be grateful if you can complete this booklet before the scheduled first session.

Read this booklet carefully as it is divided into five sections – Section A, B, C, D and E.

- **Section A1, A2 and E** will be completed by researchers.
- **Section B, C and D** will be completed by your family [you, your spouse (if applicable), your child and/or one other main carer] and will be checked by researchers during the scheduled first session.

How to fill in Section B, C and D (for father/mother/other main carer):

1. Use pen only.
2. For each question, tick (√) on the box provided. If you are unsure which answer to choose, please tick the one which seems most applicable, rather than leaving that question blank.
3. Remember that there is no right or wrong answers.
4. When you have completed these sections, please bring along the questionnaires with you and hand it to the researchers during first session.

Thank you for playing an important part in this study.

THE FAMILY DIET STUDY

Section A1: Family's Background

	Name	Date of Birth	Age	Gender Male = M Female = F	Comments *(please leave this blank)*
Child					
Father					
Mother					
Other Main Carer (_____)					

Section A2: Family's Measurements *(to be filled in by researcher)*

	Birth Weight (kg)	Weight (kg) Trial 1	Weight (kg) Trial 2	Weight (kg) Trial 3	Height (m) Trial 1	Height (m) Trial 2	Height (m) Trial 3
Child							
Father							
Mother							
Other Main Carer							

	Waist Circumference (cm) Trial 1	Waist Circumference (cm) Trial 2	Waist Circumference (cm) Trial 3	Body Fat Trial 1	Body Fat Trial 2	Body Fat Trial 3
Child						
Father						
Mother						
Other Main Carer						

The following table will be calculated by the researcher after the measurement session

	Mean/ Median Body Weight (kg)	Mean/ Median Height (m)	Body Mass Index (kg/m^2)	Body Weight Category	Mean/ Median Waist Circumference (cm)	Waist Circumference Category	Mean/ Median Body Fat (%)	Body Fat Category
Child								
Father								
Mother								
Other Main Carer								

THE FAMILY DIET STUDY

Section B: Food Habits Questionnaire *(to be filled in by parents)*

1. Parents' Employment Status:

Father □ Full-time □ Part-time □ Self-employed □ Others (please specify: _____)

Mother □ Full-time □ Part-time □ Self-employed □ Others (please specify: _____)

2. Parents' Highest Educational Qualification:

Father □ No formal education □ Primary □ Secondary □ College/University

Mother □ No formal education □ Primary □ Secondary □ College/University

3. Family Size *(this refers to family members or helper living-in together)*:

□ 3 □ 4 □ 5 □ 6 □ 7 and above

3.1. Family Total Monthly Income:

□ Less than RM1500 □ RM1501 to RM2500 □ RM2501 to RM3500

□ RM3501 to RM5000 □ RM5001 and above

3.2. Pocket Money provided to child (for a week):

□ Less than RM5 □ RM5.01 to RM9.99 □ RM10.00 to RM14.99

□ RM15.00 to RM19.99 □ RM20.00 and above

4. Family Main Food Shopping Location:

□ Wet market (e.g. *Pasar pagi, Pasar malam, Pasar tani*)

□ Supermarket (e.g. JUSCO, Cold Storage, Village Grocer, ISETAN, Econsave)

□ Hypermarket (e.g. TESCO, Carrefour, Giant, Mydin)

□ Others (please specify: _____)

5. Family Main Food Purchaser:

□ Mother □ Father □ Grandparent □ Others (please specify: _____)

6. Family Main Food Preparer:

□ Mother □ Father □ Grandparent □ Others (please specify: _____)

7. Family Mealtime Together:

□ Never □ 1-2 times a week □ 3-5 times a week □ 6-7 times a week

7.1. Family Mealtime Child Main Supervisor *(this refers to the evening meal)*:

□ Mother □ Father □ Grandparent □ Others (please specify: _____)

THE FAMILY DIET STUDY

Section B: Food Habits Questionnaire *(to be filled in by child)*

(Think about what you ate over the last 6 months when you answer these questions)

1. Do you take vitamins and minerals supplement?

   - o Yes
     - a. How many tablets do you take each week?
       - o 2 or less
       - o 3 to 5
       - o 6 to 9
       - o 10 or more
     - b. How many years have you been taking them?
       - o 0 to 1 year
       - o 2 to 4
       - o 5 to 9
       - o 10 years or more
   - o No (proceed to question 2)

2. Where do you usually eat breakfast?

   - o At home
   - o On the way to school
   - o At school
   - o Don't eat breakfast
   - o Other (please specify:_____)

3. How many pieces of fruit do you eat? (include all types)

   - o None
   - o Less than 1 per week
   - o 1 to 2 per week
   - o 3 to 4 per week
   - o 5 to 6 per week
   - o Once a day
   - o 2 to 3 per day
   - o 4 or more per day

4. How many times a week do you eat vegetables with your meal at night?

   - o Never
   - o Less than once per week
   - o 1 to 2 per week
   - o 3 to 4 per week
   - o 5 or more per week

5. How many times a day you have a glass of milk, a tub of yoghurt or a slice of cheese?

   - o Never
   - o Less than 1 per month
   - o 1 per week or less
   - o 2 to 6 per week
   - o 1 per day
   - o 2 to 3 per day
   - o 4 to 6 per day
   - o 7 or more per day

THE FAMILY DIET STUDY

(Think about what you ate over the last 6 months when you answer these questions)

6. How many glasses of soft drink or cordial you have each day? (all types)
   - ○ Less than 1 per day
   - ○ 1 per day
   - ○ 2 to 3 per day
   - ○ 4 to 6 per day
   - ○ 7 or more per day

7. How many times a week do you eat your meal at night in front of the television?
   - o Never
   - o Less than once a week
   - o 1 to 2 per week
   - o 3 to 4 per week
   - o 5 to 6 per week
   - o Everyday

8. How much time each day do you spend watching television?
   - o 0 to 1 hour per day
   - o 2 to 3 hours per day
   - o 4 to 5 hours per day
   - o 6 or more hours per day

9. How much time each day do you spend on the computer or playing video games?
   - o Never
   - o Less than once a week
   - o 1 to 2 per week
   - o 3 to 4 per week
   - o 5 to 6 per week
   - o Everyday

10. How much money are you given each week to buy food, including snacks and drinks?
    - o RM2 or less per week
    - o RM3 to RM4 per week
    - o RM5 to RM9 per week
    - o RM10 to RM14 per week
    - ○ RM15 to RM19 per week
    - ○ RM20 or more per week

11. How many times a day do you eat snacks (potato chips, crackers)?
    - o Less than once per day
    - o 1 to 2 per day
    - o 3 to 4 per day
    - o 5 to 6 per day
    - o 7 or more per day

12. How often do you eat out?
    - o Never
    - o Less than once a week
    - o 1 to 2 per week
    - o 3 to 4 per week
    - o 5 to 6 per week
    - o Once a day
    - o 1 or more per day

13. How many times in a month you eat Western fast food (i.e. McDonalds, KFC)?
    - o Never
    - o Less than once a month
    - o 1 to 2 per month
    - o 3 to 4 per month
    - o 1 to 2 per week
    - o 3 to 6 per week
    - o Everyday

THE FAMILY DIET STUDY

Section E: Child's Food Intake Recall *(to be filled in by researcher)*

DAY 1 - 24 hour Dietary Recall

Date: _____ Day: _____

Description of food or drink	Amount & Brand	Location	Time	Remarks *(to fill-in other information)*	Researcher Notes

THE FAMILY DIET STUDY

DAY 2 - 24 hour Dietary Recall

Date: _____ Day: _____

Description of food or drink	Amount & Brand	Location	Time	Remarks (to fill-in other information)	Researcher Notes

Appendix 6.0: Statement of contribution and collaboration (Chapter 6 Methods Paper 2)

I attest that Research Higher Degree candidate Wai Yew Yang contributed to the following paper:

Prevalence of energy intake mis-reporting in Malay children varies based on application of different cut-points. Journal of Tropical Pediatrics. 2014;60(6):472-475.

Wai Yew Yang contributed to the study design and methodology, coordinated, carried out and supervised data collection during the study period, conducted analyses and interpreted the study results and drafted the manuscripts. Professor Lauren T Williams, Professor Clare E Collins, Professor Winnie Chee Siew Swee, Dr Tracy Burrows and Dr Lesley Macdonald-Wicks contributed to the study design and methodology, interpreted the study results, critically reviewed and contributed to drafts of the manuscript, within the capacity of their role as PhD supervisors.

Professor Clare E Collins	Date: 18/11/2015
Dr Tracy Burrows	Date: 18/11/2015
Professor Lauren T Williams	Date: 28/10/2015
Dr Lesley Macdonald-Wicks	Date: 18/11/2015
Professor Winnie Chee Siew Swee	Date: 16/11/2015
Mrs Wai Yew Yang	Date: 16/11/2015
Professor Robert J Callister Deputy Head of Faculty (Research)	Date: 19/11/2015

Appendix 7.0: Statement of contribution and collaboration (Chapter 7 Results Paper 1)

I attest that Research Higher Degree candidate Wai Yew Yang contributed to the following paper:

Dietary energy intake is associated with body mass index among urban Malay children: findings from cross-sectional study. Under Review. BMC Pediatrics

Wai Yew Yang contributed to the study design and methodology, coordinated, carried out and supervised data collection during the study period, conducted analyses and interpreted the study results and drafted the manuscripts. Professor Lauren T Williams, Professor Clare E Collins, Professor Winnie Chee Siew Swee, Dr Tracy Burrows and Dr Lesley Macdonald-Wicks contributed to the study design and methodology, interpreted the study results, critically reviewed and contributed to drafts of the manuscript, within the capacity of their role as PhD supervisors.

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Professor Winnie Chee Siew Swee	Date: 16/11/2015
Mrs Wai Yew Yang	Date: 16/11/2015
Professor Robert J Callister Deputy Head of Faculty (Research)	Date: 19/11/2015

Appendix 7.1: Food Grouping Scheme

	Major Food Groups	Sub Food Groups
STEP 1	• Cereals/tubers/grains • Fruits • Vegetables • Meat/poultry/fish • Legumes • Milk and dairy products	• Sugar-sweetened beverages • Western fast food • Pastries and dessert (Local & Western) • Snacks • Spreads • Sugar • Oils • Condiments • Mixed food
	Combined Food Groups	
STEP 2	• Cereals (Cereals/tubers/grains) • Fruits/vegetables • Meats (Meat/poultry/fish/legumes) • Dairy (Milk/dairy products) • Sugar-sweetened beverages • Western fast food • Snacks • Sweets (Pastries /desserts/sugar) • Oils (spreads/oils/condiments) • Mixed food	

Appendix 7.2: Classification of energy mis-reporting for all children, by gender and by BMI category

Classification of Energy Mis-reporting[a]	All Children (n=236)	Gender		BMI Category			
		Boys (n=112)	Girls (n = 124)	Thinness (n=24)	Normal (n=124)	Overweight (n=31)	Obese (n=39)
Under-reporter	54 (22.9)	31 (28)*	23 (19)	3 (13)*	20 (14)	13 (42)*	18 (46)*
Acceptable	141 (59.8)	68 (61)	73 (59)	12 (50)	93 (66)	17 (55)	19 (49)
Over-reporter	41 (17.4)	13 (12)*	28 (23)	9 (37)*	29 (20)	1 (3)	2 (5)*

BMI: Body Mass Index; [a]Black & Cole cut-point; *Significant difference (Pearson Chi-squared test between gender; by body weight status)

Appendix 7.3: Characteristics of children's dietary intakes (energy, macronutrients, micronutrients and food groups)

Energy and macronutrients	Average Daily Intake, n=236				
	Min	Mean (95% CI)			Max
Energy (kcal/d)	588	1698 (1637-1759)			3795
Carbohydrate (g/d)	88.1	229.1 (220.3-237.9)			536.8
Protein (g/d)	16.5	64.5 (61.5-67.4)			151.9
Fat (g/d)	15.2	58.4 (55.7-61.0)			142.1
Energy/ body weight (kcal/kg)	18.8	56.8 (54.0-59.7)			111.5
Micronutrients	**Min**	**25% Percentile**	**Median**	**75% Percentile**	**Max**
Thiamin (mg/d)	0.1	0.4	0.6	0.8	3.6
Riboflavin (mg/d)	0.1	0.6	0.9	1.2	3.8
Niacin (mg/d)	0.3	4.9	7.4	11.2	40.5
Vitamin C (mg/d)*	0	14.6	31.5	66.9	477.9
Vitamin A (µg/d)	68.7	383.5	521.9	800.9	5665.6
Iron (mg/d)	3.8	9.5	12.3	17.2	43.1
Calcium (mg/d)*	76.7	270.0	374.4	559.4	1715.5
Main Food Groups					
Cereals/tubers/grains					
g/d	0	294.3	397.5	532.5	941.5
Servings/d	0	3.0	3.7	4.7	7.8
Meat/poultry/fish (g)					
g/d	0	59.0	108.8	171.0	554.5
Servings/d	0	1.3	2.1	2.9	7.9
Vegetables (g)					
g/d	0	0	8.8	40.0	366.0
Servings/d	0	0	0.1	0.5	4.9
Fruits (g)					
g/d	0	0	0	55.0	300.0
Servings/d	0	0	0	0.4	3.6
Milk and dairy products (g)					
g/d	0	0	0	65.0	662.5
Servings/d	0	0	0	0.2	2.9
Legumes (g)					
g/d	0	0	0	0	300.0
Servings/d	0	0	0	0	4.6
Sub Food Groups					
Sugar-sweetened beverages (g/d)	0	18.0	134.0	274.0	1243.0
Sugar (g/d)	0	10.0	22.8	39.0	174.5
Condiments(g/d)*	0	2.5	10.0	19.4	112.5
Pastries and dessert (Local & Western) (g/d)*	0	0	30.0	81.5	778.5
Oils (g/d)	0	0	6.8	20.0	198.0
Snacks (g/d)	0	0	3.8	25.8	175.0
Western fast food (g/d)	0	0	0	0	681.9
Mixed food (g/d)*	0	0	0	0	515.0
Spreads (g/d)	0	0	0	0	40.0

*Significant differences (Mann-Whitney test between genders)

Appendix 8.0: Statement of contribution and collaboration (Chapter 8 Results Paper 2)

I attest that Research Higher Degree candidate Wai Yew Yang contributed to the following paper:

The Family Diet Study: A cross-sectional study into the associations between diet, food habits and body weight status in Malay families. Journal of Human Nutrition and Dietetics.

Wai Yew Yang contributed to the study design and methodology, coordinated, carried out and supervised data collection during the study period, conducted analyses and interpreted the study results and drafted the manuscripts. Professor Lauren T Williams, Professor Clare E Collins, Professor Winnie Chee Siew Swee, Dr Tracy Burrows and Dr Lesley Macdonald-Wicks contributed to the study design and methodology, interpreted the study results, critically reviewed and contributed to drafts of the manuscript, within the capacity of their role as PhD supervisors.

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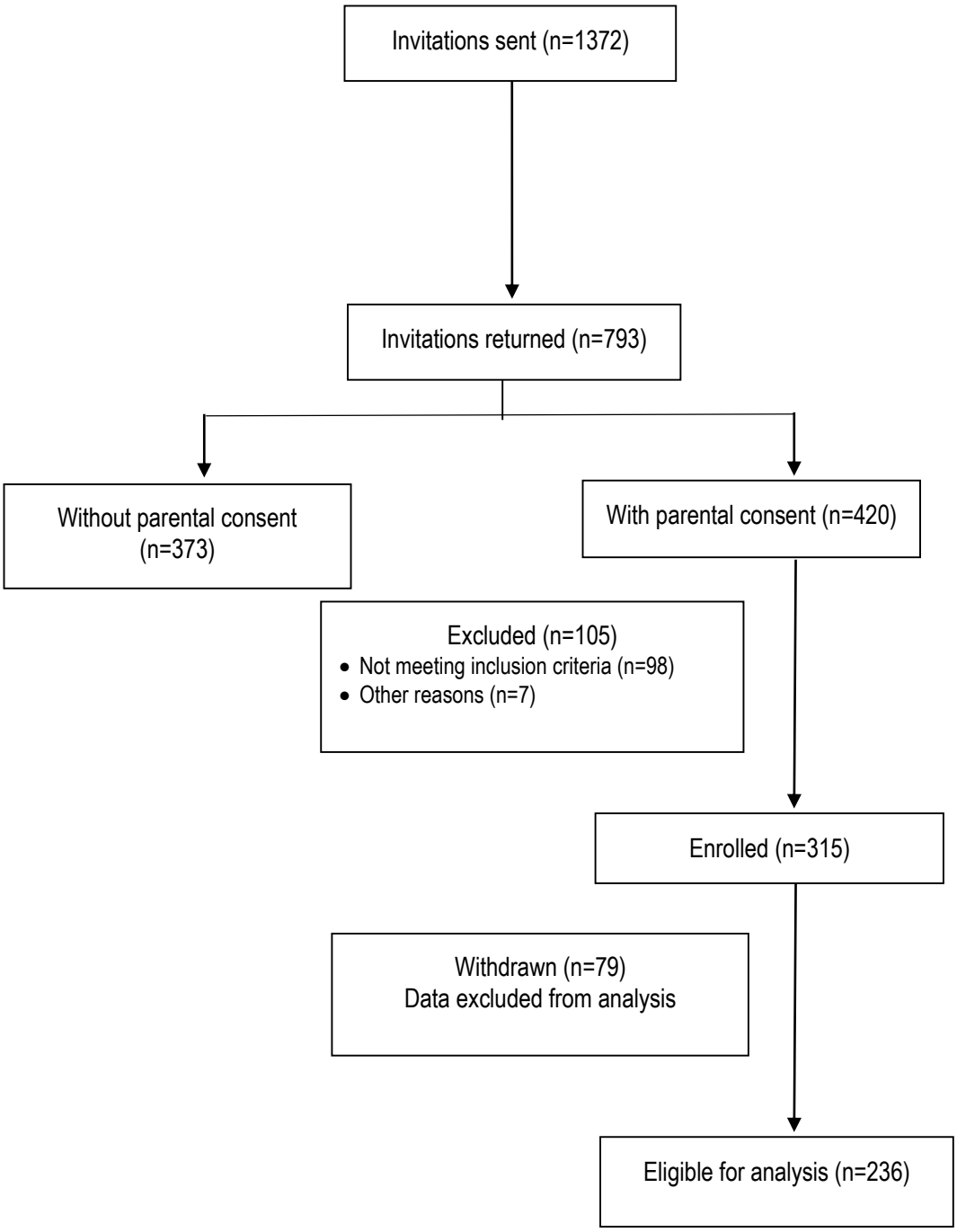
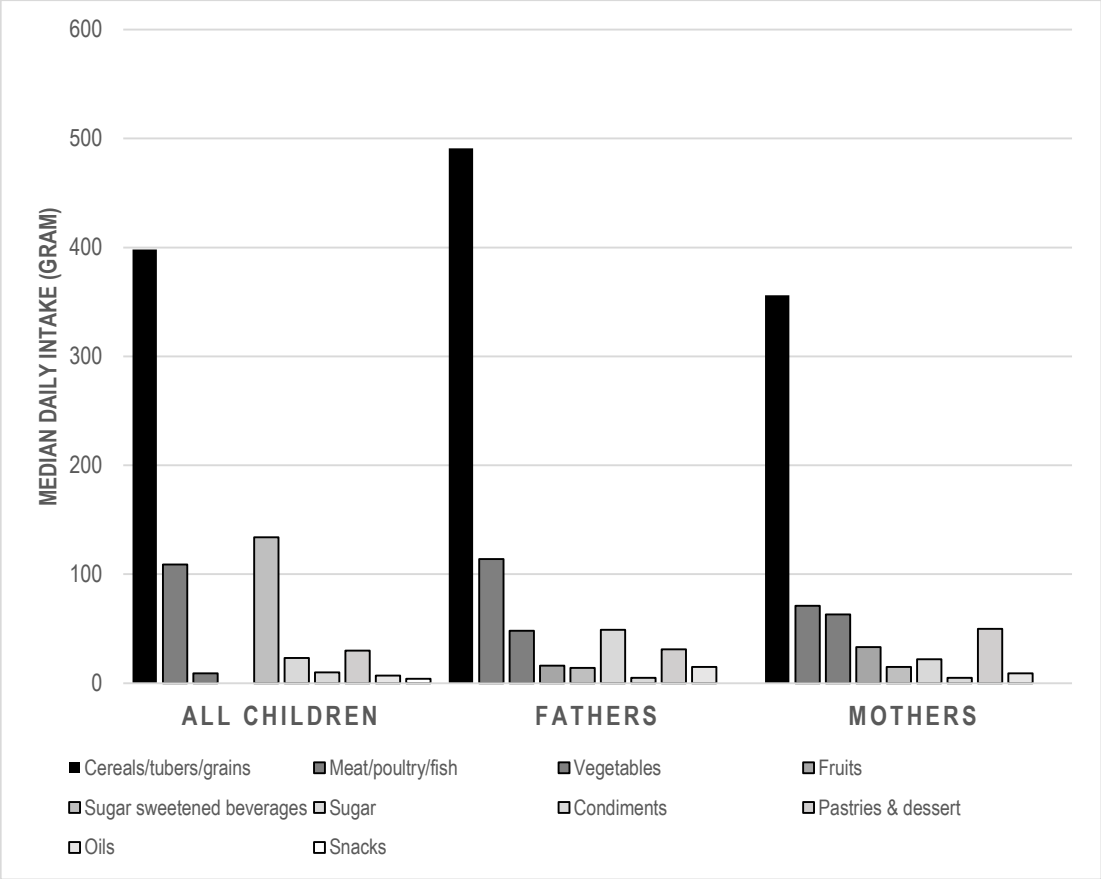
Professor Winnie Chee Siew Swee	Date: 16/11/2015
Mrs Wai Yew Yang	Date: 16/11/2015
Professor Robert J Callister Deputy Head of Faculty (Research)	Date: 19/11/2015

Appendix 8.1: Flow chart of participant recruitment and derivation



Appendix 8.2: Food groups intake of participants in the Family Diet Study



Appendix 8.3: Comparison of dietary intakes of participants of the Family Diet Study with Malaysian Recommended Nutrient Intake and Malaysian Dietary Guidelines recommended serving sizes

Participant	Nutrient	% RNI	< RNI, n (%)	Food Group	% RSS	< RSS, n (%)
Father (n=92)	Energy (kcal)	80	80 (87)	Cereals/tubers/ grains	60	90 (98)
	Protein (g)	120	29 (12)	Fruit	31	82 (89)
	Thiamin (mg)	65	81 (88)	Vegetables	31	89 (97)
	Riboflavin (mg)	87	60 (25)	Meat/poultry/fish	87	63 (68)
	Niacin (mg)	61	86 (93)	Legumes	92	85 (92)
	Vitamin C (mg)	68	72 (78)	Milk and dairy products	3	92 (100)
	Vitamin A (µg)	148	39 (42)			
	Iron (mg)	188	22 (24)			
	Calcium (mg)	54	90 (98)			
Mother (n=182)	Energy (kcal)	69	169 (93)	Cereals/tubers/ grains	57	177 (97)
	Protein (g)	105	90 (49)	Fruit	27	171 (94)
	Thiamin (mg)	56	169 (93)	Vegetables	36	175 (96)
	Riboflavin (mg)	83	139 (76)	Meat/poultry/fish	90	126 (69)
	Niacin (mg)	50	175 (96)	Legumes	108	167 (92)
	Vitamin C (mg)	71	139 (76)	Milk and dairy products	9	179 (98)
	Vitamin A (µg)	138	80 (44)			
	Iron (mg)	67	151 (83)			
	Calcium (mg)	55	169 (93)			
Children (n=236)	Energy (kcal)	92	162 (69)	Cereals/tubers/ grains	69	207 (88)
	Protein (g)	174	35 (15)	Fruit	15	233 (99)
	Thiamin (mg)	67	202 (86)	Vegetables	15	232 (98)
	Riboflavin (mg)	98	143 (61)	Meat/poultry/fish	106	120 (51)
	Niacin (mg)	62	201 (85)	Legumes	59	230 (97)
	Vitamin C (mg)	115	150 (64)	Milk and dairy products	11	233 (99)
	Vitamin A (µg)	119	128 (54)			
	Iron (mg)	128	97 (41)			
	Calcium (mg)	54	217 (92)			

RNI: Recommended Nutrient Intake; RSS: Recommended Serving Size

Appendix 8.4: Univariate regression coefficients and 95% confidence interval (CI) of dietary intakes in different dyads of participants of the Family Diet Study

Dietary Intakes	Child-Father dyads n=92	Child-Mother dyads n=182
	Regression Coefficients (95% CI)	
Energy	0.14 (-0.04, 0.31)	0.16 (-0.02, 0.35)
Carbohydrate	0.02 (-0.07, 0.11)	-0.01 (-0.10, 0.07)
Protein	0.17 (0.02, 0.32)*	0.21 (0.09, 0.33)**
Fat	-0.003 (-0.107, 0.101)	0.09 (0.01, 0.17)*
Percentage energy from carbohydrate	0.14 (-0.14, 0.41)	0.19 (0.05, 0.33)*
Percentage energy from protein	0.44 (0.15, 0.73)**	0.20 (0.07, 0.34)**
Percentage energy from fat	0.17 (-0.11, 0.46)	0.23 (0.09, 0.37)**
Thiamin	-0.006 (-0.131, 0.119)	0.01 (-0.12, 0.16)
Riboflavin	0.09 (-0.06, 0.23)	0.04 (-0.06, 0.15)
Niacin	0.04 (-0.13, 0.22)	-0.06 (-0.25, 0.13)
Vitamin C	0.12 (-0.12, 0.37)	0.27 (0.09, 0.44)**
Vitamin A	-0.04 (-0.19, 0.11)	-0.02 (-0.13, 0.10)
Iron	0.10 (-0.04, 0.23)	-0.002 (-0.145, 0.140)
Calcium	0.06 (-0.14, 0.27)	-0.005 (-0.110, 0.100)
Cereals and grains	-0.009 (-0.177, 0.158)	0.05 (-0.07, 0.18)
Fruit and Vegetables	0.02 (-0.09, 0.13)	0.24 (0.12, 0.35)***
Meat/poultry/ fish/ legumes	0.02 (-0.19, 0.24)	0.09 (-0.06, 0.24)
Milk and milk products	0.38 (-0.03, 0.79)	0.03 (-0.10, 0.16)
Sugar-sweetened beverages	-0.10 (-0.29, 0.10)	0.11 (-0.08, 0.30)
Snack	-0.08 (-0.42, 0.26)	-0.02 (-0.31, 0.26)
Western fast food	-0.19 (-0.50, 0.13)	0.16 (-0.13, 0.45)
Sweets	0.12 (-0.04, 0.28)	0.10 (-0.04, 0.24)
Oils	0.09 (-0.10, 0.27)	0.04 (-0.07, 0.15)
Mixed food	0.13 (-0.16, 0.42)	0.083 (0.003, 0.163)*

Significant (* p<0.05, ** p<0.01, ***p<0.001)