DIETARY INTAKE, EATING BEHAVIOUR, AND WEIGHT STATUS IN PRIMARY SCHOOL AGED CHILDREN IN THE WEST MIDLANDS

By

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ABSTRACT

Children are uniquely placed in a context where external influences are likely to determine their food consumption. Evidence regarding the immediate food environment's influence on dietary quality and/or weight status in children is limited. This thesis uses data from the **W**est Midlands **A**cti**V**e lifestyle and healthy **E**ating in **S**chool children (WAVES) study to explore patterns of dietary intake in children aged 5-9 years (n=1467), some of the determinants of children's dietary consumption and their associations with child weight status. Findings suggest that children's dietary consumption needs to be more healthful, and aspects of children's school and home life may have the potential to influence dietary quality and weight status. Specifically, a healthy home food environment was associated with increased fruit and vegetable intake and a lower weight status. Certain parental feeding practices, such as using food as a reward or to regulate emotion, were also associated with increased energy intake from free sugar and weight status. In conclusion, various environmental and behavioural factors are associated with children's dietary intake and as such, coordinated efforts in a variety of settings are required to affect the 'what', 'how' and 'in what context' of children's dietary consumption and consequently childhood obesity prevalence.

Dedicated to my parents

Sean and Julie Kelleher

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CONTRIBUTIONS

The studies contained within this thesis were developed by Kiya L. Hurley (KLH) in conjunction with Peymane Adab (PA; University of Birmingham), Miranda J. Pallan (MJP; University of Birmingham), and Emma R. Lancashire (ERL; University of Birmingham). The **W**est Midlands **A**cti**V**e lifestyle and healthy **E**ating in **S**chool children (WAVES) study research team, including KLH, were responsible for collecting, inputting, and cleaning the data. KLH had a lead role in facilitating the update and changes to the dietary data collection tool alongside the Nutrition Epidemiology Group at the University of Leeds. Free sugar calculations were conducted by KLH and Tania Griffin (TG; University of Birmingham) in Microsoft Excel. Goldberg calculations to define plausibility of dietary reports, calculation of portions and fruit and vegetables, and all statistical analysis were conducted by KLH in STATA 13. The Nutrition Epidemiology Group at the University of Leeds was responsible for the processing of the dietary data. KLH was responsible for the collection and downloading of the physical activity data. Medical Research Council Epidemiology Unit at the University of Cambridge was responsible for the processing of the physical activity data. KLH led the changes in content, design and dissemination of the parental questionnaire for the first follow-up of the WAVES study children. The dietary pattern generation for Chapter Six was completed by KLH using SAS 9.4 and the imputation for all chapters was conducted by KLH using REALCOM-Impute for STATA. The statistical analysis and preparation of all chapters was conducted by KLH with advice and guidance from PA, MJP, ERL, and statisticians

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ABBREVIATIONS

Terms Relating to Energy

BMR	*Basal Metabolic Rate:* the rate at which the body uses energy when it is completely at rest
EE	*Energy Expenditure:* the amount of energy used within a given timeframe
kcal	*Kilocalorie:* a measure of food energy 1 kcal = 4.18 kJ
kJ	*Kilojoule:* a measure of food energy 1kJ = 0.24 kcal
MJ	*Mega Joule:* a measure of food energy 1MJ = 1000 kJ
PA	*Physical Activity*: any movement which results in energy expenditure
PAL	*Physical Activity Level:* the ratio of daily energy expenditure to BMR

Terms Relating to Dietary Intake and Assessment

CADET	*Child and Diet Evaluation Tool:* the method of dietary data collection used within this thesis
DQI	*Diet Quality Index:* a method of assessing the quality of a diet consumed
DRV	*Dietary Reference Value:* an umbrella term used to describe RNI, LRNI, EAR and other terms related to dietary intakes
EAR	*Estimated Average Requirement:* the mean amount of energy or a nutrient needed for a population
EDNP	*Energy dense, nutrient poor:* a term to describe the nutritional quality of a food
LRNI	*Lower Reference Nutrient Intake:* an amount of a nutrient that would be sufficient for 2.5% of the population
F&V	*Fruit and vegetables:* dietary components which are good sources of vitamins, minerals, and dietary fibre
FFQ	*Food Frequency Questionnaire:* a method of dietary data collection
MW7	*McCance and Widdowson's The Composition of Foods, SeventhSummary Edition:* the UK nutrient databank
NMES	*Non-Milk Extrinsic Sugars:* a method of defining dietary sugars to consumed in limited amounts
rEI	*Reported energy intake:* the amount of energy consumed within a given timeframe
RNI	*Reference Nutrient Intake:* an amount of a nutrient that has been deemed sufficient for 97.5% of the population

Statistical Terms

CI	*Confidence Interval:* a measure of uncertainty around a population parameter estimate
RRR	*Reduced Rank Regression:* a method of data reduction - identifying a smaller number of uncorrelated components from a large data set via a set of intermediary variables
SD	*Standard Deviation:* a statistic used to describe the variation of data around the mean

Terms Relating to Body Size and Composition

BMI	*Body Mass Index:* a measure of adiposity
BMIz	*Body Mass Index z-score:* a measure of adiposity relative to a reference

	population
cm	*Centimetre:* a measure of length/height
kg	*Kilogram:* a measure of weight

Other Abbreviated Terms

CEBQ	*Child Eating Behaviour Questionnaire:* a measure of child eating behaviours
CFPQ	*Comprehensive Feeding Practices Questionnaire:* a measure of parental feeding practices
EST	*Ecological Systems Theory:* a theory that attempts to examine human behaviour within the context of their environment
FSM	*Free School Meals:* Lunches available to school children for which their parents do not have to pay the school
HFE	*Home food environment:* a set of habits, practices, and behaviours in relation to food and food consumption within the home
IMD	*Index of Multiple Deprivation:* a measure of deprivation relative to English norms
km	*Kilometre:* a measure of distance
LEA	*Local Education Authority:* local councils responisble for education within their district
NCMP	*National Child Measurement Programme:* a programme of population monitoring of child weight status in England
PTE	*Pressure to eat:* a controlling parental feeding practice
RWC	*Restriction for weight control:* a controlling parental feeding practice
WAVES	*West Midlands ActiVe lifestyle and healthy Eating in School children:* the study from which the data for this thesis was taken

Chapter One: Introduction

1.1 Aims and rationale

The aim of this chapter is to present an overview of the current literature regarding the association between diet and excess weight in childhood. This includes how childhood obesity is defined, a summary of the consequences of childhood obesity, and an outline of the contribution of the diet to the development of childhood overweight and obesity. This will provide the context and justification for the research I have conducted throughout the remainder of this thesis. The focus of this thesis is the prevention of obesity in primary-school aged children and therefore the literature reviewed concentrates largely on this age group.

1.2 Childhood obesity

1.2.1 What is obesity?

Obesity is a major public health concern among both children and adults (1, 2). It is defined as an accrual of excess body fat creating an increased risk of morbidity and early mortality (1). In childhood, it is associated with both short and long-term risks to health (**Figure 1**) and has been shown to track from childhood into adulthood, with overweight children having at least twice the risk of becoming an overweight adult compared with their healthy weight counterparts (3).

The risk of many chronic diseases increases with excess weight, including type two diabetes mellitus (4), cardio-vascular disease (4) and certain cancers (5, 6). For example, a recent study of 6328 people in the US, Australia and Finland, found that those who had a consistently high adiposity status from childhood to adulthood had a 5.4 (95%CI: 3.4 to 8.5) higher relative risk of type 2 diabetes mellitus compared to those who maintained a healthy weight at childhood and were non-obese adults (7).

It has also been estimated that between 50-60% of the UK adult population could be obese by 2050 and morbidity attributable to this shift in the population's weight is forecast to cost the NHS an additional £9.7 billion (8). However, Jounala *et al.* (2011) also highlighted that those overweight/obese children who become non-overweight /obese adults, had similar risk of adverse outcomes as their healthy weight counterparts (7). Hence, there is a growing need to identify modifiable risk factors that may halt the growing prevalence of childhood obesity, not only to improve the health of the nation, but also to reduce the strain on our health services in the future.

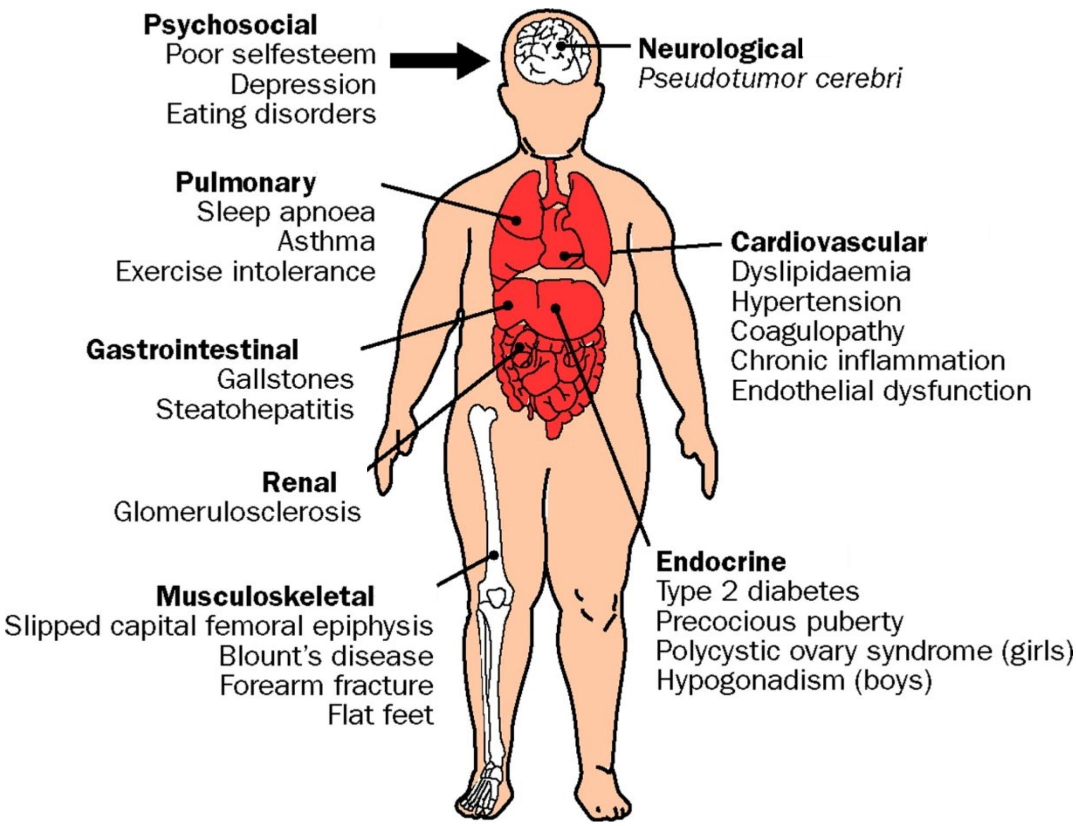

Figure 1: Consequences of childhood obesity (9)

1.2.2 Definitions of childhood overweight and obesity

In adults, body mass index (BMI) is often used to classify weight status. BMI is calculated by dividing a person's weight in kilograms by the square of their height in metres (10) and the resultant number is assigned to a weight status group based on thresholds that are associated with an increased risk of cardio-metabolic disease (**Table 1**).

Table 1: Classification of adults according to body mass index (11)

Classification	BMI	Risk of co-morbidities
Underweight	< 18.5	Low (but risk of other clinical problems increased)
Normal weight	18.5 – 24.9	Average
Overweight:		
Pre-obese	25.0 – 29.9	Increased
Obese Class I	30.0 – 34.9	Moderate
Obese Class II	35.0 – 39.9	Severe
Obese Class III	> 40.0	Very severe

Classification of weight status in children is more complicated as growth patterns differ according to the sex of the child, and BMI alters with age (12). Therefore, thresholds are usually derived from a reference population. Using a reference population allows the calculation of growth patterns for an 'average' boy and girl respectively and the distribution of measurements around the average (12). Individual children can then be compared to the growth reference. Reference data and methods used to compare children vary, with both national and international reference populations available. **Table 2** shows four of the commonly used thresholds in the UK, their reference populations, and the cut-offs used. BMI-based systems for classifying overweight and obesity can be broadly defined as distribution-based systems (such as the British 1990 (UK90) growth reference) and classification-based systems (such as International Obesity Taskforce (IOTF) thresholds). Each has their own strengths and weaknesses. For example, thresholds which define cut-offs based on distribution (e.g. 85th and 95th centile), are relatively simple to use, but have been criticised for their arbitrary choice of cut-offs and choice of reference population (13). Classification-based thresholds, on the other hand are anchored to a BMI threshold for adult morbidity and are therefore more clearly linked to prognosis. Nevertheless, these have been criticised because the rationale and representativeness of the countries used for their reference population is unclear, there are questions about assumptions of the tracking of overweight and obesity throughout childhood, and their choice of cut-off for adult age is debateable (13).

Using different systems for classifying overweight and obesity is particularly important at the individual level, but will also produce differing estimates of overweight and obesity prevalence. For example, a recent French study compared overweight and obesity prevalence in a sample of 1382 school children using the French national cut-offs, IOTF thresholds, and the World Health Organisation (WHO) reference. The WHO reference was found to classify considerably more children as overweight/obese (20% and 11.6% respectively) than the French (13.8% and 6.7% respectively) or IOTF (16.2% and 6.7% respectively) thresholds (14). Therefore, it is important to consider these differences when comparing overweight and obesity prevalence worldwide and the impact this may have when comparing study outputs.

As the sample of children analysed in this thesis was drawn from a UK population, weight status has been defined using the British 1990 (UK90) growth reference charts.

1.2.3 Strengths and limitations of body composition measurements

There are some limitations to consider when using BMI to classify excess weight. BMI is an imperfect measure. It does not directly measure body fat, but rather the relation of weight to height (15), and therefore no distinctions are made between fat mass and fat-free mass. Therefore, whilst BMI correlates well with fat mass and percentage body fat in both adults and children, it also correlates well with muscle and lean mass (15-17). Hence, whilst discussions may centre around issues to do with excess fat, this lack of distinction could lead to some people being misclassified as at an increased risk of the health consequences of obesity at a lower fat percentage, or conversely, as having a lower risk when they have a higher fat percentage. A recent systematic review and meta-analysis of 37 studies worldwide assessing the diagnostic performance of BMI as a marker for adiposity highlighted this issue, finding that sensitivity and specificity of BMI were 73% and 93% respectively (18). This suggests that whilst obese children (defined by BMI) are highly likely to have excess adiposity, over a quarter of those otherwise classified may also have high levels of excess adiposity and warrant an obese classification (18).

This is a particular issue when assessing obesity in different ethnic groups as body composition varies with ethnicity. For example, in a study of 1196 children in the US, Black and Hispanic children tended to have higher BMI-for-age than Asian or White children, and whilst in Hispanic children this was explained by higher fat mass levels, in Black children fat-free mass contributed most to this excess weight (19). There is also evidence that Asian populations may have an increased risk of health consequences at lower BMI values compared to other ethnicities, due to increased adiposity and visceral fat at lower BMIs (20-22). Hence, guidelines set out by the National Institute of Health and Care Excellence (NICE) in the UK have recommended that clinicians use lower BMI thresholds to define diabetes risk in adult Asian populations in the UK (23 kg/m^2 and 27.5 kg/m^2 for increased and higher risk, respectively; (22)). However, whilst there is a consensus that Asian populations are at increased risk at lower BMIs, the exact population thresholds to be used are still undetermined. Conclusions from several reviews have suggested that the evidence to determine alternative thresholds is still inconclusive, especially in relation to children, and as such the international cut-offs highlighted in **Table 1** were retained (21-23).

Alternative methods of assessing body composition are available, however the strengths and limitations of these must also be considered. Direct methods (such as Total Body Water, Total Body Counting, and Neutron Activation) and criterion methods (such as Dual X-Ray Absorptiometry and Hydro-densitometry) are often seen as the ‘gold standard’ in determining body composition. However, whilst they each offer a more detailed description of body composition, often these methods require expensive equipment, are affected by hydration levels, or require exposure to radiation which may preclude their use in large-scale population research (24).

BMI remains the most commonly used assessment method at a population level as it provides a relatively simple, cheap, and non-invasive measurement of weight status (25). BMI has been extensively used for some time, facilitating comparisons to local, national, and international overweight and obesity rates at both a single time point and over time. In addition, the availability of published thresholds and reference populations makes BMI a pragmatic choice when compared with other similar measures such as waist-to-height ratio where no reference populations are available (25). However, each published threshold and reference population uses different assumptions, smoothing methods, and theoretical approaches which may result in differing estimates of obesity prevalence (26). This has been shown in several studies comparing methods of defining BMI in children (26, 27). Thus, international comparisons of prevalence must be interpreted with acknowledgement of this issue.

Table 2: A summary of the most commonly used reference populations and body mass index thresholds for classifying weight status in children in the UK (12, 28)

Growth reference name	Reference population and age range	BMI cut-offs used
British 1990 growth reference (UK90)	UK population only. 0-23 years.	**Underweight:** <2nd centile for population monitoring and clinical assessment **Overweight:** ≥85th centile for population monitoring, ≥91st centile for clinical assessment **Obese:** ≥95th centile for population monitoring, ≥98th centile for clinical assessment.
International Obesity Task Force (IOTF) cut-offs	Six large, nationally representative, cross-sectional surveys from Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the United States. 2-18 years.	Age and sex specific cut-off points are extrapolated from the adult BMI cut-offs of 25 kg/m^2 and 30 kg/m^2 for overweight and obesity, respectively. Three classifications of thinness are defined from equivalent adult BMIs of 16, 17 and 18.5. For example, a boy aged 5 years old would be classified as obese at a BMI of 19.23 kg/m^2
World Health Organization (WHO) 2007 growth reference	A combination of the USA National Centre for Health Statistics 1977 pooled growth data, and the WHO Multi-centre Growth Reference Study from Brazil, Ghana, Norway, India, Oman, USA. 5-19 years.	**Thinness:** <-2 standard deviations (SD) **Overweight:** between +1SD and <+2SD **Obese:** >+2SD
United States Centres for Disease Control and prevention (CDC) 2000 growth reference	US population only. 2-20 years.	**Underweight:** 3rd and 5th centile **Overweight:** > 85th centile (90th for special health care requirements) and **Obese:** > 95th centile (97th for special health care requirements)

1.3 Epidemiology of obesity

1.3.1 International childhood obesity prevalence

Worldwide prevalence of childhood obesity has risen substantially within only one generation (2). Recent estimates from developed countries state 23.8% of boys and 22.6% of girls (ages 2-19) were overweight or obese in 2013, and rates in developing countries have increased from 8% to 13% between 1980 and 2013, using IOTF thresholds (29).

1.3.2 English childhood obesity prevalence

In England, there are two main data sources that provide information on prevalence of childhood obesity in representative samples of children: the National Child Measurement Programme (NCMP) and the Health Survey for England (HSE). The NCMP annually measures the height and weight of all children in Reception (aged 4/5 years) and Year 6 (aged 10/11 years) in state maintained primary schools. The participation rate for the most recent survey (2014/2015 academic year) was approximately 95% (30). Since 1994, the HSE has been conducted to monitor the change in the health of the population and has included children aged 2-15 years old since 1995. Random samples of English postcodes are invited to participate, from which all adults and up to two children (randomly selected) are eligible for inclusion. The household response rate of the most recent survey (2014) was 62% (31). Both surveys use the UK90 thresholds.

Current NCMP data indicates that 21.9 % of children are overweight or obese when they start school (Reception) and 33.2% are overweight or obese by their final year of Primary school (Year 6), using the UK90 thresholds (30). Although there has been an increase in childhood overweight and obesity in England since 1995, HSE data indicates that this trend has not been consistent (32). **Figure 2** shows a clear increase in prevalence from 1995-2004 and an apparent stabilisation since 2005 in children aged 2-15 years.

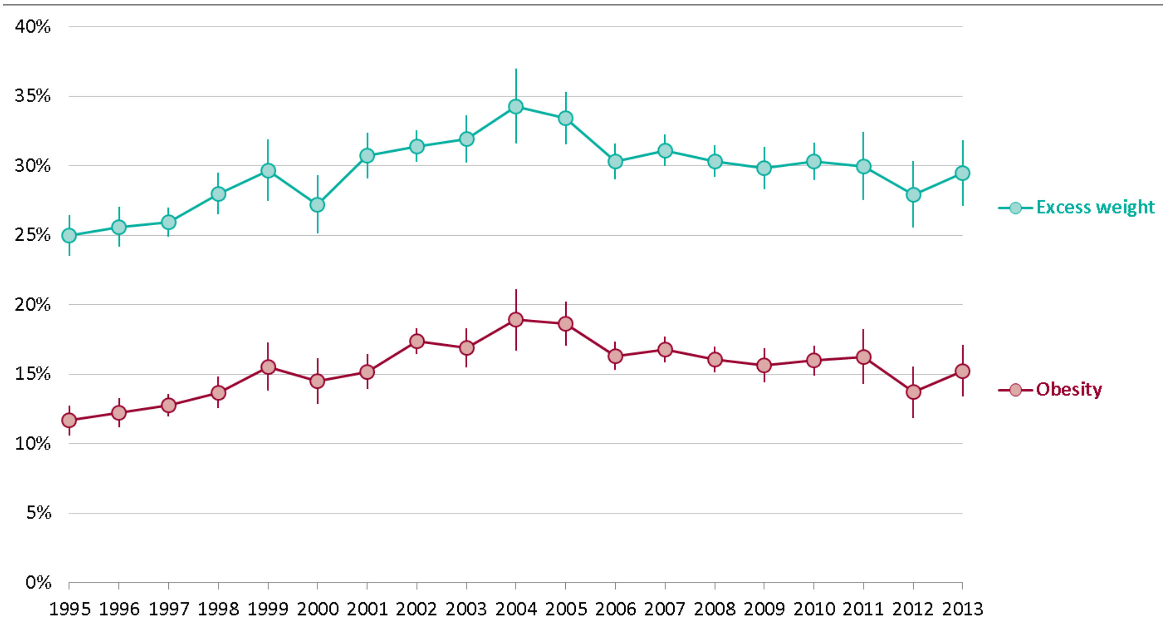

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Figure 2: Excess weight and obesity prevalence among children aged 2-15 (32)

However, further exploration of the English overweight and obesity prevalence through the NCMP data highlights differences by age, sex, ethnicity, and deprivation.

1.3.2.1 Age and Sex

Obesity prevalence in Reception boys largely decreased between the 2006/07 and 2013/14 academic years, however the prevalence in girls was less stable (**Figure 3**). Conversely, obesity prevalence in children in Year 6 of both sexes shows an increasing trend in obesity prevalence within this period. Furthermore, whilst the prevalence of obesity was similar in boys and girls in Reception (age 4-5 years), the prevalence was markedly greater in boys compared with girls in Year 6 (age 10-11 years).

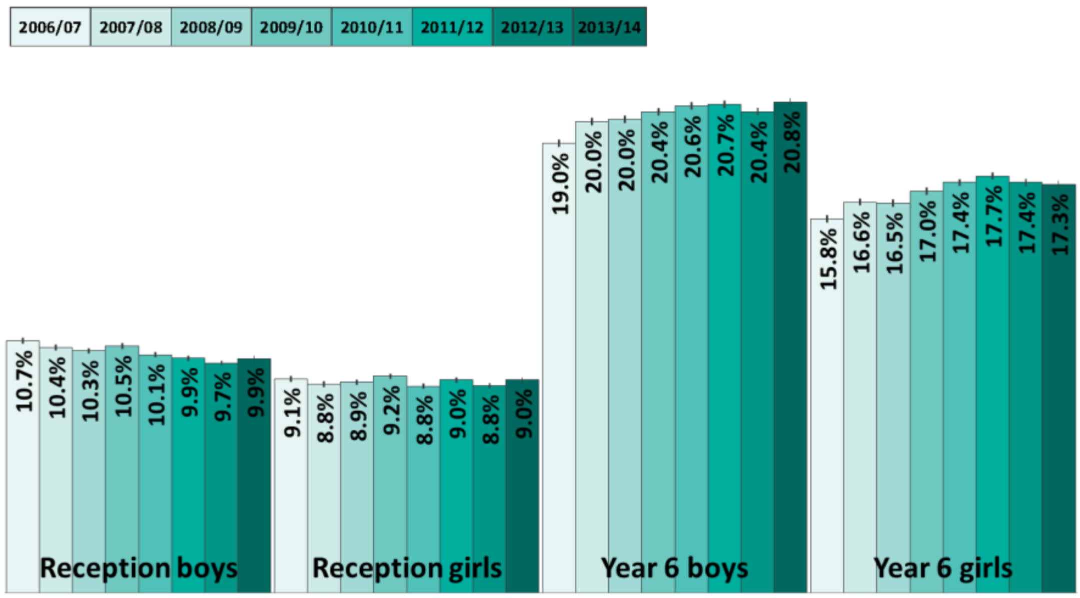

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Figure 3: Prevalence of obesity 2006/07 to 2013/14 by school year and sex (32)

1.3.3 Deprivation

Childhood obesity prevalence shows a strong relationship with deprivation. A cross-sectional analysis of over 20,000 children in the UK, undertaken between 1994-1996, showed that the odds of obesity was 30-40% higher in the most deprived groups compared to the least deprived (assessed using the Townsend score; (33)). More recently, analysis of the NCMP data (2006-2014) shows that in the most deprived decile, childhood obesity is over double that in the least deprived decile (32). Additionally, the inequalities gap in obesity rates appears to be widening. Analysis of obesity trends over time by deprivation decile shows that whilst obesity rates have decreased (Reception) or remained stable (Year 6) in the least deprived of the population, for the most deprived, rates are at best stabilising (Reception) and at worst increasing (Year 6).

1.3.4 Ethnicity

Overweight and obesity prevalence varies significantly by ethnicity (34). Whilst childhood obesity is increasing in all ethnic groups, the prevalence is greater in 'non-White' ethnic groups (35). The 2013/14 NCMP showed that by Year 6, boys from all ethnic minority backgrounds were more likely to be obese than White boys (23% mixed – 31% Bangladeshi vs. 19% White). A similar pattern was observed in girls except for Indian girls who had obesity prevalence comparable to girls of White ethnicity (32).

However, the influence of ethnicity on childhood obesity is complex and not fully understood. For example, although a greater proportion of minority ethnic groups are found in the lower quintiles of deprivation (36), the combined effects of cultural differences and material deprivation are not equal in all ethnicities. A report on obesity, ethnicity, and deprivation in London, showed that Year 6 Black girls in quintile 5 (least deprived) have a higher risk of obesity than any other ethnicity, however in quintile 1 (most deprived) their risk remains largely unchanged, whereas the risk for White, Asian, and Mixed ethnicity girls increases (37). This supports the findings of Falconer *et al.* (2014; n=2773) who recently concluded that differences in obesogenic lifestyles of different ethnicities cannot be wholly explained by deprivation (36). Black and Asian children were three times more likely to have obesogenic lifestyles even after adjustment for deprivation, further highlighting the importance of considering ethnicity when looking at the associations between various diet and lifestyle factors and weight status (36).

1.4 Public health approaches to childhood obesity

Public health approaches can be roughly defined in two ways: the narrow approach and the broad approach (38). The narrow approach focuses on the individual's behaviours as the main driver for disease and aims to identify and address problems quickly. The broad approach focuses on the wider environment, addressing the structural issues in society to try to make healthy choices easier for individuals. It links public health science with policy and uses a socio-cultural theoretical approach. Both approaches have limitations. Putting the onus on the individual to change their risk behaviour, and disregarding the fundamental environment and societal factors that may influence those behaviours, may have a limited effect. However, changing policy is challenging and time-consuming, and requires a long-term commitment to change (38).

A complex set of interacting factors is believed to lead to the development of childhood obesity (39, 40). In 2007, the Foresight report 'Tackling Obesities: future choices' presented a systems map which included 108 interacting variables that determine energy balance in the UK, highlighting the complexity of obesity and its development (41). By the time a child begins attending school, dietary choices and eating behaviours are no longer only driven by biological food cues, such as hunger and satiety, but also increasingly by the social and environmental context of food (41). Hence, approaches to prevent or treat excess weight must address elements of both the narrow and the broad approaches described above

The Ecological Systems Theory (EST) attempts to conceptualise human development from the context of its environment (42). That is, human development is a joint function of the behaviours of the person and the environment within which they find themselves (43). EST suggests that change or development of an individual's characteristics cannot be explained without consideration of the environment, or ecological niche, that person is embedded in (39). In an extension of this work, Egger and Swinburn (1997) put forward an ecological model to describe maintaining body fat stores in equilibrium (40). It described three main influences on body fat stores – the *biological* (e.g. age, sex, and genetics), the *environmental* (e.g. the physical, economic, and sociocultural environment), and the *behavioural* (e.g. complex psychological factors, including habits, emotions, and beliefs developed through a background of learning history), which are all mediated through energy intake and expenditure and moderated by physiological responses.

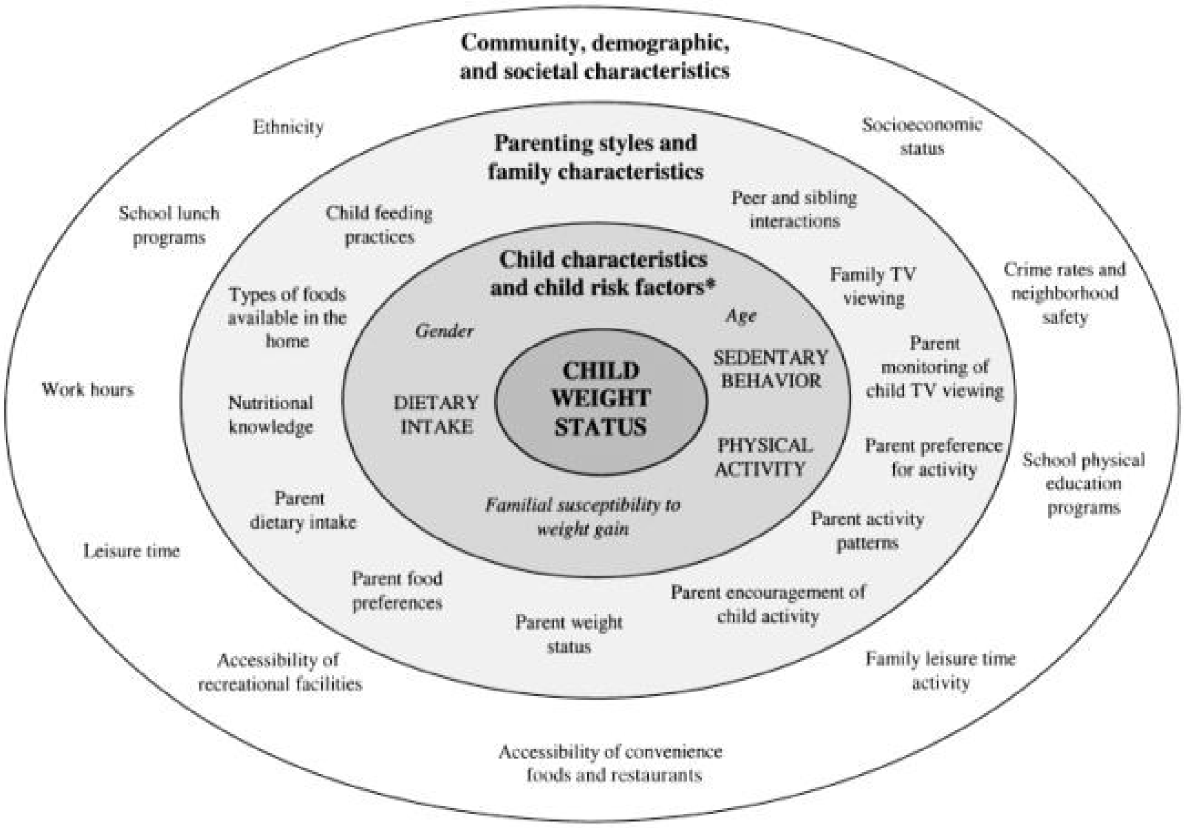
Following this, in 1999, the term 'obesogenic environment' was first defined as the "the sum of the influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals and populations" (44). Further definitions of the obesogenic environment have since been suggested, but a recent concept analysis by Gauthier and Krajicek (2013) suggests whilst an overarching definition of the obesogenic environment may be universally applicable to both children and adults, the context of childhood must be considered (45). Children are uniquely placed in society, with little autonomy over their surroundings, and experience dynamic shifts in these circumstances as they develop into adults (45). Consequently, an extension of the obesogenic environment definition was suggested that is specific to a childhood setting: "instances where a child is placed into a situation, circumstance, or surrounding where there exists the opportunity to choose, engage in, or be influenced by internal (i.e. within the home) or external structures (i.e. outside the home) where the aggregate effects promote (or result in) an abnormal, or elevated, BMI percentile." (45).

Figure 4 depicts an ecological model of the predictors of childhood overweight as developed by Davison *et al.* (2001; (39)). In this model, child weight status is not only shaped by the characteristics of the child, but is also influenced and interacts with parent/family level factors and community/society factors within which the child is placed. This puts childhood obesity in a context where a collaborative strategy addressing multiple levels of the system is required to make any significant impact (40).

1.5 Physical activity

It is important to note that whilst this thesis focuses on the role of dietary intake, energy expenditure has an equally important function in maintaining energy balance. Neither side has been found to be more influential than the other, but rather the combined effect of changing activity levels and changes in the diet has driven and continues to drive the trend towards a greater prevalence of childhood obesity (46). However, the food we eat not only provides energy, but also a range of macro- and micronutrients, which also have a role in other health outcomes. Therefore, this thesis focuses on factors affecting dietary intake, not only from the perspective of childhood obesity, but also dietary quality.

Nevertheless, as physical activity (PA) influences both dietary intake and weight gain, it is important to consider it in any analysis investigating these constructs. Measurement of PA can be conducted in a number of ways including self-report, pedometry, heart rate monitoring and accelerometry, each with their own strengths and limitations. For example, a person's heart rate is affected by factors other than PA, e.g. anxiety, making it less suited to distinguishing lower level bouts of activity (47). The method of PA assessment within the WAVES study used a combination of two techniques (heart rate and accelerometry) to determine PA via a chest worn Actiheart monitor. This method has been validated against doubly-labelled water and found good agreement between the two methods (48).



*=Child risk factors (shown in upper case lettering) refer to child behaviours associated with the development of overweight. Characteristics of the child (shown in italic lettering) interact with child risk factors and contextual factors to influence the development of overweight (i.e. moderator variables).

Figure 4: An ecological model of predictors of childhood overweight (39)

1.6 Childhood obesity and the diet

The diet is a major factor in energy imbalance and therefore a contributor to both obesity and other diet-related chronic diseases (49). Put simply, weight gain occurs when a person’s energy intake from food and drink outweighs their energy expenditure from physical activity and energy metabolism. However, as described previously, the causes of this imbalance are not as simple. The National Diet and Nutrition Survey rolling programme (NDNS RP) is an annual survey of the population’s diet and nutritional status, collected via four-day estimated food diaries (proxy-reported by parents/carers for children under 11 years old). The results from the NDNS RP highlights that mean energy intakes were close to (children under 11 years) or below (children aged 11 to 18 years and adults above 18 years) the Estimated Average Requirement (EAR; (50, 51)), however, obesity rates in all age groups are still rising.

One explanation of this apparent paradox could be the ‘energy gap’ theory. Calculations conducted by Hill *et al.* (2012), suggested that a positive energy imbalance of as little as 100 calories (418 kJ) per day could explain gradual weight gain. Therefore, changes in the diet resulting in only a small increase in energy intake and/or lifestyle changes resulting in only a small reduction in energy expenditure may have a large effect on population obesity prevalence (52). However, it is important to consider the impact of possible misreporting here as it has been shown that people generally under-report energy consumption (53).

Conventional advice for weight control has focussed on the mantra that ‘a calorie is a calorie’ regardless of its source, and therefore eating less and moving more will result in weight loss. However, emerging evidence suggests that source of calories consumed (54, 55), the environment in which we consume food (56, 57), and our eating behaviours (58) are important in determining our food consumption. It is this knowledge that has sparked interest in the wider context of food and eating; investigating what we eat, how we eat, and why we eat certain foods and food groups rather than focussing solely on energy balance.

The diet and the context of eating are risk factors for the development of excess weight that are potentially modifiable and relevant at all levels of the EST. This thesis explores several potential influences on childhood excess weight within several different contexts (school, home, and individual).

1.6.1 The influence of school food

Nutrient and food based standards were implemented as mandatory requirements for Primary Schools in September 2008 by the UK Department for Education (59). This was done as an attempt to curb the rising levels of obesity and as a safeguard for nutritionally vulnerable groups, such as those who are undernourished, and those taking free school meals (FSM; (60)). Schools now have an obligation to provide nutritionally balanced meals and to restrict highly processed or energy dense, nutrient poor (EDNP) foods. In 2009, the School Food Trust conducted a survey to assess children's school food intake and compared it to a similar survey undertaken in 2005 (pre-standards). The results showed that by limiting the food choices to healthier options, more pupils chose 'healthier' options like water, fruit, fruit-based desserts, vegetables and salad, milk and yoghurt, but wastage did not increase (61).

In 2010, a meta-analysis comparing school-provided lunches (SPL) to home-packed lunches (HPL), found that HPL were consistently reported to be higher in carbohydrate, total sugar, non-milk extrinsic sugar, saturated fat, and sodium (62). Evans and Cade (2007) also found that only 1.1% of HPL met the food-based standards that apply to SPL (63). This evidence provides some justification for the concern that children having HPL at school may have worse diets than those having SPL. Findings from the recent SPEEDY study by Harrison *et al*. (2013) in the UK found that food choices at lunchtime made a significant contribution to the overall diet. This study highlighted that HPL children ate almost half of their confectionary and three-quarters of their savoury snacks at lunchtime (64). Additionally, findings from the US, suggested that children having SPL from low-incomes had a higher overall diet quality than those who did not have SPL (65). However, the evidence is sparse. Further data supporting these findings in the UK may provide a rationale for further promoting uptake of SPL, particularly in those entitled to FSM.

1.6.2 The influence of the parent/family and the home

Parent/carers (subsequently referred to as parents) play a pivotal role in the development of childhood food preferences and energy intake, particularly in young children. This is achieved in a variety of ways including modelling eating behaviours, availability of food in the home, and parent nutritional knowledge. This thesis will focus on the home food environment (HFE) provided by parents, and more specifically parental feeding practices, as factors that may contribute to excess weight in childhood.

In a recent evidence review, NICE summarised the strength of the evidence for associations between selected elements of the HFE. These elements were eating food prepared outside of the home, family meals, breakfast, eating frequency, screen time, and snacking. It was concluded that there is limited evidence regarding the effect of various aspects of the HFE on child weight-related outcomes, with the strength of the evidence ranging from inconclusive (snacking and eating frequency) to strong (screen time; (66)). Therefore, there is a need for further research into the effects of the HFE on child weight status. This thesis will investigate the association between eight elements of the HFE and child adiposity, and fruit and vegetable intake.

In a review of twenty-two studies linking parental feeding practices with child weight status, restriction of foods was consistently reported to be associated with increased child adiposity (67). Restriction is thought to increase the child's desire for the restricted food and therefore opportunistic snacking occurs when that food is next available. Opportunistic snacking can lead to eating in the absence of hunger and therefore excessive energy consumption (68). However, another recent systematic review highlighted that whilst there was a clear association amongst cross-sectional studies, the findings of longitudinal studies were mixed as to whether restriction was associated with weight change over time (69). The authors suggest that this may be indicative of a reverse causality, whereby restrictive feeding practices are employed as a response to child weight, rather than a factor in excessive weight gain (69). This has also been alluded to in a small number of studies that have investigated the impact of parental perception of child weight on the relationship between restriction and weight status (70, 71). Emotional feeding (giving a child food when they exhibit a negative emotion), higher level of responsibility for feeding a child, and pressure to eat are other parental behaviours found to have associations with weight status in children (72). Behavioural studies have also shown that obese children exhibit lower responsiveness to internal satiety signals, eat faster during the course of the meal, and are more sensitive to external food cues (58). However, studies investigating the relationship between child eating behaviours and parental feeding practices and their influence on weight status are lacking and therefore this thesis will investigate this in further detail.

1.6.3 Dietary intake and weight status

People eat food, not nutrients, however it is the combinations of nutrients provided by the food consumed that determine health (73). Macronutrients are the building blocks of food. They are the elements of the diet required in the largest amounts for normal growth and development. Each has particular functions in the human body, for example: fats are used to insulate the body and protect internal organs; proteins for growth and repair; and carbohydrates are used mainly for energy (73).

The combined results from the NDNS RP (2008-2012 and 2012-2014) suggest that the UK population consumes too much saturated fat, free sugar, and salt and not enough fruit, vegetables, oily fish and fibre, compared to UK dietary recommendations (50, 51). Despite this wider knowledge, the role of specific foods, drinks, dietary components or dietary patterns, and their contributions to childhood obesity remain unclear (49).

1.6.4 Dietary assessment

Doubly labelled water (DLW) has often been cited as the most robust measurement of energy expenditure (74). In weight-stable people, doubly labelled water can also be used to determine energy intake, as, if a person's weight is stable, their energy expenditure and intake are likely to be equal (75). However, the DLW method requires a high level of technical understanding, is relatively costly, and cannot accurately measure dietary intake that is imbalanced with energy expenditure (75). Therefore, this measure is often confined to research studies conducted in laboratory settings or as a validation technique for more subjective dietary data collection methods (75).

Subjective dietary data collection is complex due to several factors, including the population under investigation, the length of time to be studied, and purpose of the data (76). There are multiple ways of collecting individual level dietary data; however, five main methods are widely used in large-scale studies, each with their own strengths and limitations. These are direct observations, food records (weighed and estimated), 24-hour recalls (including multiple pass recalls), food-frequency questionnaires, and dietary checklists (77). **Table 3** details the strengths and limitations of each of these methods.

Advances in technology have allowed novel dietary assessment methods to be developed which aim to improve the quality of the data collected. Web-based, computer-based, and mobile data collection methods are becoming increasingly common (78). These technologies fundamentally use the same methods described in **Table 3**, however they may improve the quality of the data in various ways e.g. use of flags for missing, implausible, or incomplete answers that give the participant the opportunity to amend. Some examples of recent dietary assessment technologies used with children include the Synchronised Nutrition and Activity Program (SNAP), the Interactive Portion Size Assessment System (IPSAS), and the eButton. SNAP is web-based researcher-led software that utilises a 24-hour recall of 49 food and drink items commonly consumed in the UK (79). IPSAS is software designed for use by interviewers to clarify portion size estimation using age-specific portion size images in children aged 18 months – 16 years during or after completion of a 24-hour recall or estimated food record (80). The eButton attempts to minimise memory errors in children by using a wearable camera to take pictures of food before consumption (81). However, there are a number of disadvantages to new technologies that have hindered their wide-scale use in dietary assessment. For example, the privacy implications of wearable cameras (82), the cost associated with the extra equipment, and the need for access to the internet.

Misreporting is prevalent in dietary assessment, with problems occurring due to intentional misreporting (e.g. social desirability bias) and unintentional misreporting (e.g. errors in recalling intake or parents being unaware of their children's consumption when outside of their care, e.g. at school or in childcare; (83, 84)). Therefore, it is important to take potential misreporting into account when looking at dietary associations with health-related outcomes as misreporting may significantly affect or even mask any potential associations (85). This is particularly relevant for weight-related research as current evidence is suggestive of under-reporters expressing an obesogenic phenotype i.e. under-reporters are more likely to have a perception of being overweight and have higher sedentary behaviours (86). The Goldberg cut-offs are the most commonly used calculation for determining the plausibility of dietary data, and as such, have been used throughout this thesis.

Table 3: Description of the strengths and limitations of dietary assessment methods used in large scale studies (77, 78, 87)

Measurement	Description	Strengths	Limitations
Direct observations	Observed food and drink intake is recorded by a trained researcher	Objective assessment of intake	Expensive Limited to specific times Observation may alter usual intake, eating patterns, and behaviours
Food records	Weighed food records require an individual or investigator to weigh every food and drink consumed, including any leftovers, to determine the exact portions consumed. Estimated food records are similar; however, the portion sizes are estimated using household measures (e.g. a tablespoon), photographs, or food models.	Widely used Often record multiple days including weekend and weekday days	Can be expensive Large participant burden (e.g. Literacy skills, time) Potential for misreporting Estimated food records only have estimations of portion sizes
24-hour recalls	In a 24-hour recall, an interviewer asks the participant to recall everything they have eaten/drunk in the past 24 hours.	Can be conducted over the telephone Inexpensive Low participant burden	Multiple days are required to assess habitual intakes Portion sizes are estimated Some bias in reporting of different types of foods may occur Reliant on the participants' ability to recall the information, and therefore may not be suitable for some population groups e.g. Young children and the elderly
Multiple pass recalls	Multiple pass recall methods attempt to lessen potential recall biases by systematically conducting the recall. Different protocols achieve this in various ways; however most begin with an uninterrupted recall, followed by various prompts and clarifications, and finish with a review of what was recalled allowing for additions.	Can be conducted over the telephone Inexpensive Low participant burden	Multiple days Portion sizes are estimated Some bias in reporting of different types of foods may occur Reliant on the participants' ability to recall the information, and therefore may not be suitable for some population groups e.g. young children and the elderly

Table 3 continued

Measurement	Description	Strengths	Limitations
Food frequency questionnaires (FFQs)	A list of foods consumed with frequencies (e.g. times per day, daily, weekly etc.) within a particular period (e.g. a month, 6 months, a year). Semi-quantitative FFQs also attempt to collect information about portion sizes.	Capture habitual intake Can be self-completed Low participant burden Inexpensive Can be used in large populations	Does not measure nutrient intake Possible over-reporting of certain foods Food list may not be inclusive of all foods eaten FFQs developed for one country or sub-population may not be transferrable
Dietary checklists	A food or dietary checklist combines the food list seen in FFQs with the estimated food record. Participants prospectively record what was eaten/drunk by ticking the corresponding food on the checklist. Some checklists have additional questions which help to clarify the type of food e.g. milk or bread.	Prospective record Low participant burden Inexpensive Suitable for group level comparisons	Food list may not be inclusive of all foods eaten Dependent of the participant completing the checklist prospectively not retrospectively

1.6.5 Total energy intake

As weight gain reflects a long-term imbalance between energy intake and expenditure, total energy intake has been the logical focus of past research (88). However, given the limitations of the dietary data collection methods described previously, total energy intake trends over time in children are somewhat counterintuitive. For example, using data from the Diets of British School Children (1983) and the NDNS 1997, Gibson (2010) found that mean daily energy intake fell by 7% whilst weight, BMI, BMI z-score, and prevalence of overweight all increased within the same time period (89). Further statistical comparisons with the most recent NDNS rolling programme are hindered by methodological differences between surveys, however a continued trend of lowered energy intake is shown (51). A similar trend is seen in the US National Health and Nutrition Examination Survey (NHANES), whereby children's (aged 2-19 years) energy intake declined between 1999/2000 and

2009/2010 in both sexes, however prevalence of obesity increased only in boys (90). However, other research has suggested the decline in energy intake (between 2002-2008) is consistent with the plateau in obesity rates seen in 2009-2010 (91) and so longitudinal associations may warrant further investigation.

1.6.6 Dietary energy density

Dietary energy density (DED) is the amount of energy provided per unit of food (e.g. calories per gram). Three systematic reviews have been conducted which have concluded there is a weak-moderate association between DED and adiposity in children (92-94). Studies reporting null or inverse associations tended to be hampered by methodological differences in calculating DED and lack of power due to small sample sizes (95). Johnson *et al.* (2009) have also shown that there is only a weak correlation between DED of food alone with the DED of food plus drinks, highlighting that these two methods of defining DED maybe depicting different elements of the diet of individuals (92). Studies that have included drinks in the calculation of DED may be diluting any potential effects between DED of food and measures of adiposity, due to the lower energy density of drinks relative to food (92, 96).

1.6.7 Total fat

Fats are essential components of the diet. They provide energy, aid the absorption of fat-soluble vitamins (such as A, D, E and K), have a role in cell signalling and are structural components of cell membranes (97). Fats provide over double the amount of energy per gram (9kcal / 37kJ) than carbohydrate or protein (98), leading to the belief that diets high in fat will lead to excessive energy consumption and therefore weight gain. Current evidence supports this, as it is suggestive of a positive association between total fat intake and adiposity in children (55, 93, 99).

1.6.8 Protein

Proteins function as enzymes, as transport carriers in membranes, and as hormones. Amino acids, the building blocks of proteins, serve as precursors for nucleic acids, hormones, vitamins, and other important molecules (97). They are required for growth and repair in the body, but can also be a source of energy when carbohydrate intake is low, providing 4kcal/17kJ per gram (100). A weak positive association between protein intake and adiposity has been reported in children (101).

1.6.9 Carbohydrate

The primary function of carbohydrates is to provide energy (97). Carbohydrates can be categorised as simple and complex. Simple carbohydrates include sugars found naturally in foods and drinks such as milk, fruit, vegetables, and those added to food, such as high fructose corn syrup. Simple carbohydrates are monosaccharides and disaccharides that can be rapidly converted to their component monosaccharides for use as an immediate energy source (102). Complex carbohydrates are more varied and are typically referred to as either starches or non-starch polysaccharides (also known as dietary fibre). They are found in foods such as vegetables, whole grains, and legumes. On average, carbohydrates provide 4kcal/16kJ per gram (100).

Overall, there is no evidence of an association between total carbohydrate consumption and adiposity in children, however the composition of carbohydrates may have an association e.g. diets high in simple carbohydrates (dietary sugar) and low complex carbohydrates (101).

1.6.9.1 Dietary sugar

Dietary sugars are carbohydrates in their simplest form, most commonly monosaccharides (e.g. glucose and fructose) and disaccharides (e.g. lactose, sucrose and maltose; (97)). Sugars can be split into two main groups, those that are held within the cell structure of food, known as intrinsic sugars and those that are not, known as extrinsic. There are various definitions for extrinsic sugars; however, two very similar terms prevail in the UK. In 1991, the Committee on Medical Aspects of Food and Nutrition report set out UK dietary recommendations for non-milk extrinsic sugars (NMES). These are all extrinsic sugars, excluding lactose (found in milk and milk-products) that was deemed exempt (100). In 2002, the World Health Organisation coined the term ‘free sugars’, which although very similar, does not include the sugar from stewed, dried, and canned fruit that is included in the NMES definition (102). A recent report by the Scientific Advisory Committee on Nutrition suggested that the term ‘free sugars’ should be used in the UK to describe sugars which are to be consumed in limited amounts, and as such will be used throughout the remainder of this thesis (102, 103).

Two large public health bodies have recently called for intakes of free sugars to be reduced (102, 103). Evidence from cohort studies is suggestive of a positive relationship between dietary sugar intake and weight-related outcomes in children (104). However, a meta-analysis of RCTs found no significant effect of reducing dietary sugar consumption and change in BMI/BMI z-score over time (104). It has been suggested that this may be due to poor compliance in three of the five included studies (104). In contrast, a review of evidence related specifically to sugar-sweetened beverages conducted for NICE, concluded that there was strong evidence of a positive relationship between sugar-sweetened beverages and weight-related outcomes (66). This is likely to be due to the free sugar content of these beverages adding to excess energy intake.

1.6.9.2 Total fibre

Total fibre is the combination of dietary fibre (non-digestible carbohydrates and lignin that are intrinsic and intact in plants) and functional fibre (isolated non-digestible carbohydrates; (97)). The roles of fibre in the body include delaying gastric emptying resulting in a feeling of fullness, interference with cholesterol absorption reducing blood cholesterol concentration and improving faecal bulk and laxation (97). One theory regarding fibre's relationship with adiposity is that the increased satiety from fibre containing foods will lead to a decreased energy intake and therefore contributing to a more desirable energy balance. However, two reviews of cohort studies of children and young people suggest that there is insufficient evidence of a relationship between dietary fibre and weight-related outcomes (101).

1.6.10 Dietary patterns

Davison and Birch (2001) highlighted that dietary patterns in children need to be investigated as they are central to the development of a dietary intake that exceeds energy expenditure (39). Lobstein *et al.* (2015) reaffirmed this stating: "The promotion of energy-rich and nutrient-poor (EDNP) products will encourage rapid weight gain in early childhood and exacerbate risk factors for chronic disease in all children, especially those showing poor linear growth." (2). However, traditional nutritional epidemiology has focussed heavily on single nutrient effects on health and disease and not considered the effect of an EDNP dietary pattern (105). There are multiple methods of assessing dietary patterns including those that are *a priori* (such as diet quality indices), *a posteriori* (such as cluster and factor analysis) and, more recently, methods that combine both approaches such as reduced rank regression (106, 107). Due to these multiple methods, evidence linking dietary patterns to adiposity is mixed and limited but has shown a promising avenue for further investigation (108).

1.7 Summary

In summary, there are multiple factors contributing to the development of childhood obesity. Some of the factors that lead to poor nutritional balance and excessive energy intake are discussed above. This thesis examines some of these risk factors and their association with childhood weight status in a sample of UK children from the West Midlands.

1.8 Thesis aims and objectives

The overall aim of this thesis is to investigate the relationships between a range of environmental and behavioural factors that may be associated with specific dietary intakes and childhood overweight in an ethnically diverse sample of UK children.

This will be achieved by examining the following:

- School provided lunches and home packed lunches and their associations with overall daily diet quality and child weight status;
- The home food environment and its association with daily fruit and vegetable intake and child weight status;
- Parent feeding practices and child eating behaviours and their associations with the proportion of energy consumed from free sugars and child weight status;

- Dietary patterns and diet quality and their associations with child weight status.

1.8.1 Overview of thesis

Each chapter has been written in paper format suitable for peer review; therefore, some elements of the introduction to each chapter may be repeated (e.g. outlining the prevalence of childhood overweight/obesity). However, to aid the concision of the methodology of each chapter, Chapter 2 will describe the sample selection of the overarching WAVES study and methods of data collection that are common to many of the subsequent chapters. More specified methods are detailed in the relevant chapters.

Chapter 3 will look at the difference in consumption of food by school meal type (home-packed or school-provided lunches) and explore the association of school meal type with child weight status and compliance with the UK dietary recommendations in a 24-hour period via an adaptation of the Diet Quality Index (DQI) originally developed by Patterson *et al.* (1994; (109)).

Chapter 4 will look at the association between specific elements of the home food environment, consumption of fruit and vegetables (as a marker of diet quality), and child weight status at age 5-6 years. These will include parental self-efficacy in preparing and cooking healthy meals, parental rules regarding snacking, screen time, consuming food prepared outside of the home, and frequency of eating with the family at a table.

Chapter 5 will then focus more specifically on parental feeding practices and child eating behaviours in 7-8 year old children and their associations with the proportion of energy consumed as free sugars and child weight status.

Chapter 6 will investigate dietary patterns at 5-6 years old and their association with child weight status at age 5-6 years, 7-8 years and 8-9 years old. This will be achieved using two methods of dietary pattern identification: the adapted DQI used in Chapter 3 and Reduced Rank Regression (using the predictor variables of dietary energy density, fibre density, percentage of energy from free sugar, and the percentage of energy from fat). Associations between the resultant patterns and child weight status will be investigated.

Chapter 7 will draw conclusions about the findings of this thesis as a whole and make suggestions for future research directions.

Chapter Two: General Methods

Contributions: KLH was a member of the WAVES study research team who collected all the data contained within this thesis. Collected dietary data was processed by the Nutritional Epidemiology Group at University of Leeds (UoL), after amendments were made to align the food analysis programme with the latest UK nutrient databank and replace anomalous portion sizes. Amendments were initiated by KLH and performed by UoL. KLH had an advisory role in the amendment process. Portions of fruit and vegetables and plausibility of dietary reports were calculated by KLH. Free sugar calculations were performed by KLH and Tania Griffin (University of Birmingham (UoB)). Physical activity data was processed by the Medical Research Council Epidemiology Unit at the University of Cambridge. Mapping of the children's postcodes to generate Index of Multiple Deprivation scores, mapping of the child's height and weight data to body mass index z-scores and categorisation of ethnicity codes were performed by ERL and other researchers at UoB.

2.1 Background

Chapter Two aims to explain the sample selection of the overarching study and describe the methods of data collection common to the studies within this thesis. Methods that are specific to the individual studies will be described in the relevant chapters.

2.2 The WAVES study

Data for this thesis were taken from the baseline, first follow-up assessments, and second follow-up assessments of children participating in the **W**est Midlands **A**cti**V**e lifestyle and healthy **E**ating in **S**chool children (WAVES) study.

2.2.1 Overview of the WAVES study

The WAVES study is a cluster-randomised controlled trial evaluating the clinical and cost-effectiveness of an obesity prevention programme in an ethnically diverse population of children in the West Midlands, UK. The study was funded by the National Institute of Health Research, Health Technology Assessment programme. Ethical approval was obtained from the National Research Ethics Service Committee West Midlands - The Black Country (10/H1202/69, 25th November 2010).

2.2.2 Sampling and participants

All state-maintained mainstream primary schools within a 50km radius of the University of Birmingham (n=980) were included in the sampling frame. This included schools within a variety of Local Education Authorities in the West Midlands region, including Birmingham Central, Birmingham North, Birmingham South, Coventry, Dudley, Sandwell, Shropshire, Solihull, Staffordshire, Stoke-on-Trent, Telford and Wrekin, Walsall, Warwickshire and Wolverhampton. Information on the number of pupils, pupil ethnicity, and percentage of children receiving free school meals, at each school was provided. To obtain an ethnically diverse study sample, schools were ranked independently according to proportion of South Asian (Bangladeshi/Indian/Pakistani) and proportion of Black (African/Caribbean) pupils. The top 20% of schools for each ranking were classified as schools with a high proportion of South Asian, or Black pupils, respectively. A weighted random sample of 200 schools was then drawn with schools thus classified having a three times greater chance of selection compared with other schools. This sample was randomly ordered and schools were sequentially invited to participate until 54 schools had been recruited. During the recruitment process, response bias tests were conducted to ensure no significant difference between the participating and non-participating schools in terms of pupil ethnicity proportions, school size, and proportion of children receiving free-school meals. In total, 155 schools were approached: 90 declined; seven were excluded (three as they had less than 17 pupils in Year 1, three as they were in special measures and one due to response bias); and four did not respond.

Figure 5 shows the flow of pupils through the overarching WAVES study.

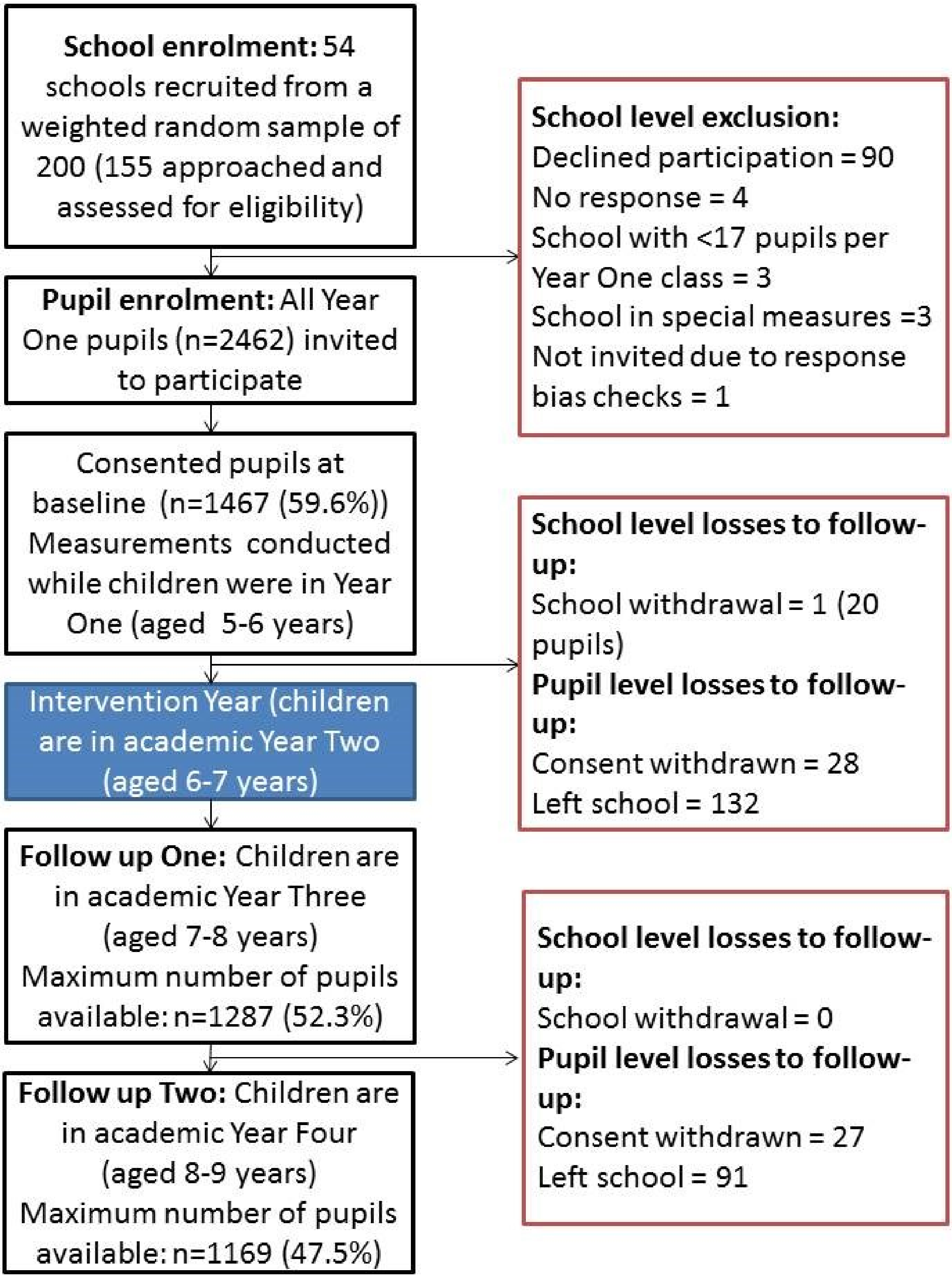


Figure 5: Flow of participants through the overarching WAVES study

For practical considerations, the WAVES study baseline measurements commenced in participating schools in either March 2011 or March 2012. Prior to the measurements, written parent/carer consent was sought for all children in academic Year 1 (aged 5-6 years, n= 2462). In addition, verbal child assent was sought prior to assessment. For further information on the sampling strategy, please refer to the WAVES study protocol (110).

2.3 Anthropometric data

Consented children took part in a series of assessments by trained researchers following standardised operating procedures. Assessments included anthropometric measures such as height, weight, and circumferences; dietary observations; physical activity assessment; and psychological evaluations such as measurements of quality of life and body satisfaction. Children attended the assessments in light clothing and height and weight measurements were taken in bare feet.

2.3.1 Body mass index

Repeat height measurements were taken to the nearest 0.1cm using a portable stadiometer (Leicester Height Measure, UK). The two measurements were averaged to give the definitive height of the child.

Weight (measured to the nearest 0.1kg) was measured using Tanita Bio-Impedance scales (Tanita BC-420MA high capacity body composition analyser, Japan). Appendix 1 (Section 9.1) contains the standard operating procedures used for the collection of height and weight.

Each child's body mass index (BMI) was calculated by dividing their weight (kg) by their squared height (m). This was then mapped onto the British 1990 (UK90) growth reference charts to assign each child an age and sex specific z-score (93) using a Microsoft Excel add-in which utilised the LMS method developed by Cole (1990; (111, 112)). A child's body mass index z-score (BMIz) signifies how many standard deviations from the UK90 reference population mean a child's BMI is. A BMIz of zero would indicate that a child's BMI is on the 50th centile of the reference population for their age and sex. Weight status was determined using the UK90 population monitoring BMI thresholds: <2nd centile is underweight; ≥2nd and <85th centile is healthy weight; ≥85th centile is overweight; and ≥95th centile is obese. These were then dichotomised into an overweight/obese group and a healthy/underweight group for use as an outcome measure.

2.4 Dietary assessment

2.4.1 Dietary data collection

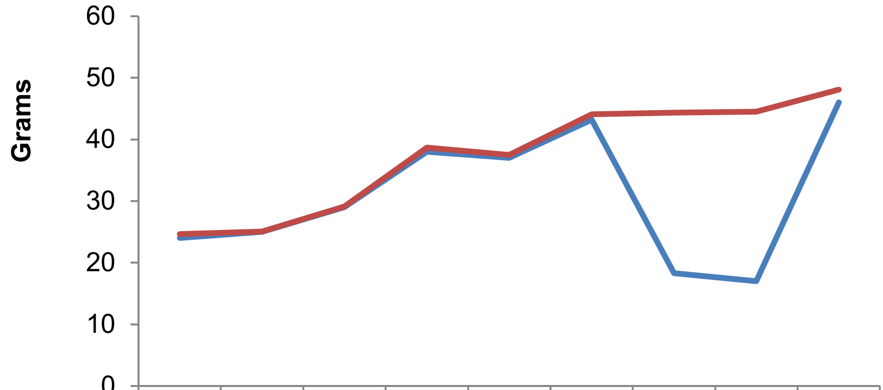
Dietary intake was assessed using a modified version of the Child and Diet Evaluation Tool (CADET) developed by the University of Leeds. CADET is a 115-item 24-hour prospective tick-list that was originally developed for use in children aged 3-7 years (113) and subsequently validated for use in children aged 8-11 years (114). The CADET offers a quick, reliable, and cost-effective method of assessing the diet of the study population with relatively low respondent burden. Comparisons to semi-weighed food records have shown that the CADET has strong nutrient correlations (ranging from 0.4 – 0.7) which are at least equal to those from other food-frequency type questionnaires (0.3-0.4; (113)). See Appendix 2 (Section 9.2) for a copy of the full CADET data collection tool.

The CADET was administered in two parts: in school and at home. In school, trained researchers recorded all food and drink consumed by each participating child throughout the school day. Before going home, children were given a tick-list for parents/carers to record all food and drink consumed from the end of the school day until starting school the following morning. An instructional DVD was provided, alongside written instructions, to aid those parents/carers for whom literacy may have been an issue. Finally, a researcher attended the school the following day to collect and evaluate the returned tick-lists. In instances where no tick-list was returned, or the tick-list had been returned blank or completed incorrectly (e.g. as a food frequency rather than a record of actual consumption), and the child was present, a one-to-one dietary recall was conducted with the child. Research into the cognitive ability of young children to recall dietary intake has highlighted concerns over the accuracy of recalls in children under 12 years old (83, 115, 116). To investigate whether this consideration biased the sample by introducing implausible dietary intakes, sensitivity analyses have been conducted on a restricted sample using only plausible reporters as determined through the Goldberg calculations (117), wherever dietary data has been assessed.

Tick-lists were then processed through the CADET Microsoft® Access-based food analysis programme by the Nutrition Epidemiology Group at the University of Leeds.

Methods for administration and analysis of CADET are fully described elsewhere (113), however some details were altered for use in the WAVES study. First, breakfast was reported prospectively to complete the 24-hour period rather than retrospectively. Second, the nutrient analysis programme used to code and analyse the tick-list items was updated with macronutrient and micronutrient information from the latest UK nutrient databank, McCance and Widdowson's *The Composition of Foods*, seventh summary edition (MW7; (118). This was done to bring the nutrient output from CADET in line with changes identified from previous nutritional surveys and changes in the manufacturing of certain products to reduce the fat, salt, and sugar content in line with government public health initiatives (119). Additionally, the weighting of the food items that compose a CADET listed food were adjusted to account for new and deleted food categories in MW7.

Third, portion sizes were amended to reflect current knowledge and ensure consistency across the age range used in CADET. The original CADET portion sizes used the 1997 National Diet and Nutrition Survey (NDNS) mean weighed consumption data by age and sex that was provided to University of Leeds Nutritional Epidemiology Group by researchers at the University of Dundee who originally analysed the NDNS data (120). Aggregated 1997 NDNS data that grouped individual foods were provided (121) and allocated with suggested weightings to CADET listed foods. However, the CADET developers highlighted that in some cases, specific age/sex groups were small leading to potentially unreliable portion sizes. For example, the portion size for porridge for boys aged six years was established from only one child (113). Therefore, portion sizes for the current version have been recalculated using the following approaches. Where few children of a specific ages and sex had consumed a particular food, resulting in an anomalous portion size, adjustments were made using portion sizes either from similar food items or, in the small number of cases where data were missing, using recent un-weighed data from the NDNS Rolling Program (2008/9-2011/12; (50)). Additionally, where portion sizes varied significantly between subsequent ages, values were interpolated using the average of portion sizes from adjacent age groups. Interpolation was used on 35% (41/115) of CADET portion sizes. An example comparing the original CADET portions with the WAVES study portions can be seen in **Figure 6**.



	Boys Aged 3	Boys Aged 4	Boys Aged 5	Boys Aged 6	Boys Aged 7	Boys Aged 8	Boys Aged 9	Boys Aged 10	Boys Aged 11
Original portions - Sugar coated cereals eg Frosties, Sugar Puffs	24	25	29	38	37	43	18	17	46
Smoothed portions - Sugar coated cereals eg Frosties, Sugar Puffs	25	25	29	39	37	44	44	44	48

Figure 6: Example of portion size smoothing for a boy's portion of sugar-coated cereal

2.4.2 Portions of fruit and vegetables

Fruit and vegetable (F&V) portions compliant with the English 5-a-day campaign were also calculated. In England, the 5-a-day campaign defines one fruit or vegetable portion size for adults and children over 11 years old to be any of the following:

- 80g of fresh, frozen, or tinned varieties of F&V
- 30g of dried fruit

- a 150 ml glass of fruit juice/smoothie (maximum contribution = one portion per day)
- three heaped tablespoons of beans and pulses (maximum contribution = one portion per day)

Portion sizes for children aged under 11 years old in England have only been defined as the following: "As a rough guide, one portion is the amount they can fit in the palm of their hand" (122). However, the Northern Ireland Public Health Agency (NIPHA) has stated that a child portion of F&V is "roughly half an adult portion" (123). Thus, fruit and vegetable portions for these analyses were assigned according to both the guidance from 5-a-day campaign and the NIPHA (122, 123).

Children were assigned one portion per 40g of fresh, frozen, or tinned F&V consumed and one portion per 15g of dried fruit consumed. One portion was assigned if the dietary report included fruit juice/smoothies and another for beans and pulses, regardless of the number of servings.

2.4.3 Free sugar intakes

Free/non-milk extrinsic (NMES) sugar is not listed in MW7 and hence, not provided in the CADET nutrient output. The foods used in CADET were therefore mapped to the nearest available food in the NDNS 1997 and the total, NMES, and intrinsic sugar amounts were noted. The proportion of NMES and intrinsic sugar was then calculated and applied to the total sugar amount in MW7. For example, if a food had a total sugar of 10g in MW7 and the proportion of NMES sugar in the NDNS equivalent food was 40%, the total amount of NMES sugars in that food was calculated to be 4g. This was completed for all foods in the CADET nutrient analysis programme and a weighted average was calculated for each of the 115 categories in CADET. The mapping exercise was conducted by two researchers at the University of Birmingham (KLH and TG). Any discrepancies were discussed and amended according to an agreed consensus. All calculations were conducted in Microsoft Excel and the resultant proportion of NMES was merged into the STATA dataset for further analysis. As was previously described, the term free sugars is used in preference to NMES throughout this thesis following recent guidance from the Scientific Advisory Committee on Nutrition (SACN), which deemed the term free sugars should be used in the UK to describe all sugars that are to be limited in the diet (102).

2.4.4 Misreporting

Misreporting in dietary evaluation can lead to errors in conclusions about dietary relationships (124). Energy intake (EI) is used as a proxy for dietary intake, working on the assumption that if EI is misreported, it is probable that other nutrients are also misrepresented (125). Validation of the reported EI rests on the fundamental equation:

$$EI = Energy\ Expenditure\ (EE) \pm changes\ in\ body\ stores$$

and the assumption that on a group level changes in body stores can be ignored (therefore EI=EE; (126)).

Assessment of misreporting in this sample was conducted in two ways. First, a pragmatic *a priori* limit was set to exclude records with over 50 ticks in CADET within a 24-hour period, as consumption of this number of different foods and beverages was deemed implausible. Data were cleaned using this limit and the dietary data of the following were excluded:

- Baseline: 8 boys and 10 girls
- Follow-up one: 1 boy and 2 girls
- Follow-up two: 5 boys and 1 girl

Further potential misreporting in this dataset was determined using the Goldberg equations (117). The Goldberg equations use the ratio between reported energy intake (rEI) and Basal Metabolic Rate (BMR) and compare this to Physical Activity Level (PAL – the ratio of EE: BMR; (127)).

BMR was estimated using age and sex specific equations from Schofield *et al.* (1985; (128)).

$$male\ BMR = 19.6 \times weight\ (kg) + 130.3 \times height\ (m) + 414.9$$

$$female\ BMR = 16.97 \times weight\ (kg) + 161.8 \times height\ (m) + 371.2$$

The Goldberg equations take into consideration duration of dietary assessment and the sample size, in addition to the error seen in calculations of BMR, PAL and rEI. However, as these limits were developed for adults without considering differences in EI due to age and sex, adaptations were required to apply them to children. Therefore, the below equations were used as suggested previously (85, 86, 129):

$$Upper\ and\ lower\ limits\ of\ plausibility = PAL \times exp\left[\pm 1.96 \times \left(\frac{S/100}{\sqrt{n}}\right)\right]$$

where

$$S = \sqrt{\frac{CV_{wEI}^2}{d} + CV_{wBMR}^2 + CV_{PA}^2}$$

Here, *S* is the index of variability in the components of energy balance. It is comprised of three coefficients of variation (CV), which aim to quantify variability around the mean: CV_{wEI} (the within subject co-efficient of variation for EI); CV_{wBMR} (the within subject co-efficient of variation for BMR); and CV_{PA} (the co-efficient of variation for physical activity (PA)). Age and sex specific reference values given in Nelson *et al*. (1989; (130)) for CV_{wEI} and CV_{wBMR} and Black (2000; (126)) for CV_{PA} were used. The number of days (*d*) was set to one, as in Börnhorst *et al*. (2013; (85)), as the analysis is based on one 24-hour dietary record per child.

Age and sex-specific levels of light PA were used (2–5 years: both sexes = 1.45; 6–10 years: males = 1.55, females = 1.50) as seen in Torun *et al*. (1996; (131)). Children with EI:BMR ratios within their age- and sex-specific range (**Table 4**) were deemed to have more 'plausible' dietary records, however validity of the specific method for determining plausibility in this sample has not been determined. Calculation and classification of misreporting was conducted in STATA 13.

To assess the potential impact of misreporting in the dietary dataset, where CADET dietary data was used, sensitivity analyses using only plausible energy reporters based on these equations were undertaken and compared to the outcome of the analysis using the full dataset.

Table 4: Plausibility ranges for the ratio of Energy Intake to Basal Metabolic Rate, calculated using Goldberg equations

	Boys (age 5)	Boys (age 6)	Girls (age 5)	Girls (age 6)
Lower plausibility limit	0.74	0.92	0.78	0.93
Upper plausibility limit	2.85	2.61	2.69	2.43

2.5 Other variables

A validated, waterproof accelerometer (Actiheart, Cambridge Neurotechnology Ltd, UK) was used to measure physical activity (PA). Children wore the accelerometer on their chest for a period of five days (including a weekend), changing the electrodes frequently to ensure adequate communication to the Actiheart monitor. The resultant data were then uploaded to the Actiheart software (version 4.0.111, Cambridge Neurotechnology Ltd, UK) and forwarded to the Medical Research Council Epidemiology Unit at the University of Cambridge for processing. Average physical activity energy expenditure (kJ/kg/day) was used as an indicator of total physical activity.

Children's sex, date of birth, ethnicity, and postcode were obtained from school records. Permission for schools to release this data formed part of the parent/carer consent. Child and parent/carer ethnicity was also requested from the parent/carer and where available this was used in preference to the school record data for the child. Parents/carers were given the ethnicity options contained within the UK census 2011. Their selections were then collapsed into four groups: (1) White; (2) South Asian; (3) Black and (4) Mixed/Other ethnicities. Detail on the composition of these four groups can be found in **Table 5**.

Table 5: Composition of the four ethnicity subgroups

Ethnicity group	Census ethnicity group
White	English / Welsh / Scottish / Northern Irish / British
South Asian	Indian Pakistani Bangladeshi
Black	African Caribbean
Mixed/Other ethnicities	Gypsy or Irish Traveler Any other White background White and Black Caribbean White and Black African White and Asian Any other Mixed / multiple ethnic background Chinese Any other Asian background Any other Black / African / Caribbean background Arab Any other ethnic group

Small area deprivation scores were used as a proxy for socioeconomic status. These were obtained using specialist software (http://geoconvert.mimas.ac.uk/) to map a child's home postcode to their English Indices of Multiple Deprivation (IMD) 2010 score and national rank. IMD contains seven domains of deprivation: income deprivation; employment deprivation; health deprivation and disability; education, skills and training deprivation; barriers to housing and services; living environment deprivation; and crime (132). The seven domains are combined into a score using the weights shown in **Table 6** and ranked by relative deprivation. IMD rank was then split into five groups using the quintile cut offs for England (133). Those in quintile 1 were in the 20% most deprived areas in England and those in quintile 5 were in the 20% least deprived areas in England.

Table 6: Domain weightings for calculation of Index of Multiple Deprivation 2010 score (133)

Domain	Domain weight
Income deprivation	22.5%
Employment deprivation	22.5%
Health deprivation and disability	13.5%
Education, skills and training deprivation	13.5%
Barriers to housing and services	9.3%
Living environment deprivation	9.3%
Crime	9.3%

This thesis uses two methods of defining dietary patterns; an *a priori* dietary quality index and a statistical method called reduced rank regression. The dietary quality index chosen was influenced by the data collected using CADET. Some dietary quality indices/scores were excluded due to requiring habitual dietary information and others due to requiring information at a level of detail not collected by the CADET e.g. type of milk consumed. From a short list of possible indices/scores the Diet Quality Index, originally developed by Patterson *et al*. (1991), was selected as the most compatible with the information provided by the CADET. Adaptations were made to the index to make it suitable for a younger population. These are described in Chapter Three, Section 3.3.2.

Methods to produce dietary patterns via reduced rank regression are described in Chapter Six, Section 6.3.3.2.

2.6 Conclusion

This chapter has outlined the methodology common to many of the subsequent chapters. Further methods specific to individual chapters will be discussed within each relevant chapter.

Chapter Three: School lunch type – Investigating the cross-sectional and longitudinal relationship with daily diet quality and child weight status

Contributions: KLH developed the idea for the study with guidance from PA, MJP, and ERL. The WAVES study research team (including KLH) were responsible for collecting, inputting, and cleaning the data. The Nutrition Epidemiology Group at the University of Leeds was responsible for the processing of the dietary data. Dietary quality index adaptations were performed by KLH. KLH also conducted the statistical analyses and wrote the chapter, guided by PA, MJP, and ERL.

3.1 Background

In England, prevalence of overweight and obesity in children increases throughout the primary school years (ages 4-11 years). The National Child Measurement Programme (NCMP) reported that 21.9% of Reception aged children (4-5 years old) and 33.2% in Year Six (10-11 years old) were overweight/obese in the 2014/15 academic year (30).

Children consume a considerable proportion of their daily food at school. For this reason, the 1945 Education Act introduced school food standards as a safety net for those who were nutritionally vulnerable (i.e. underweight, overweight, and nutritionally deficient; (134)). However, these standards were abolished by the UK government in the 1980 Education Act (60). This was followed by an increase in the prevalence of childhood obesity in England, from 1.2% in 1984 to 19.1% in 2014 (30, 135). The reasons for this increase are complex, and go far beyond school food provision, however an important part of tackling this rising prevalence is the introduction of population level measures to improve nutritional intake in children and re-balance the childhood energy equation.

In 2005, the School Meals Review Panel (SMRP) proposed new standards for school-provided lunches (SPLs) in England, which were implemented by law between 2006 and 2009. The re-introduction of school food standards followed research which suggested that when given the choice of both, children will choose less healthy food at mealtimes in preference to healthier food (136). Additionally, laboratory studies have shown that children with a familial predisposition towards obesity tend to select meals that are more energy dense than children who do not have a family history of obesity (137). Therefore, the standards aimed to restrict the provision of foods high in fat, free sugar, and salt, and set nutritional benchmarks for schools to meet (59).

The English school food standards (2006-2014) introduced two sets of guidelines for schools to follow: food-based and nutrient-based guidelines. The former set out those food and drinks to be avoided, restricted, or provided to school pupils throughout the school day (to 6pm), and the latter set out requirements for the energy content, and 13 key nutrients, in an average SPL within a 1-4 week period (59).

A recent report by the European Commission, found that all 30 European countries surveyed had mandatory or voluntary school food standards. Over 90% of these guidelines were food-based, with 68% offering additional nutrient-based guidelines (138). Reasons for providing standards appeared fairly universal with 97% of countries wishing to improve the nutritional intake of children, 94% to teach healthy habits, and 88% to reduce/prevent childhood obesity (138). School food standards are also found in non-European countries worldwide, for example in the USA (139) and Japan (140).

Research comparing the nutrient composition of primary school lunches in England, pre- and post-implementation of the standards, has shown that on average children consuming a SPL had a lower percentage of energy intake from fat and saturated fat, and a lower sodium intake, after commencement of the standards (141). Additionally, only 1.1% of home-packed lunches (HPL) were found to meet all of the food-based guidelines for school lunches. There is also some evidence to suggest that children having a SPL have a better diet over the course of the day, than those consuming HPL (141, 142).

Almost a decade on from the SMRP report, SPL were consumed by only 42.6% of the primary school population in England in the 2013/2014 academic year (143). However, in September 2014, free-school meals (FSM) were made available to all school children aged 4-7 years (Reception, Year 1, and Year 2) in England. This was introduced following a pilot in Newham and Durham, UK, in which FSM were made available to all primary school children. This universal FSM policy and awareness campaign pilot led to increased uptake of school meals by almost 30% (144), and data from Scotland indicate that uptake of SPL increased by 12% in primary schools since the introduction of this policy in lower primary school ages (P1-3, equivalent to Reception – Year 2 in England; (145)).

Despite the theoretical reasoning that increased uptake in school meals in this age group will result in healthier diets and therefore healthier weight (**Figure 7**), observational studies to date have failed to demonstrate an association between consuming a SPL and reduced weight status. However, much of the current data is from the US, or has been conducted in older age groups (pre-adolescent and adolescent); (146-148)) therefore, further research into this association in younger age groups in England is warranted.

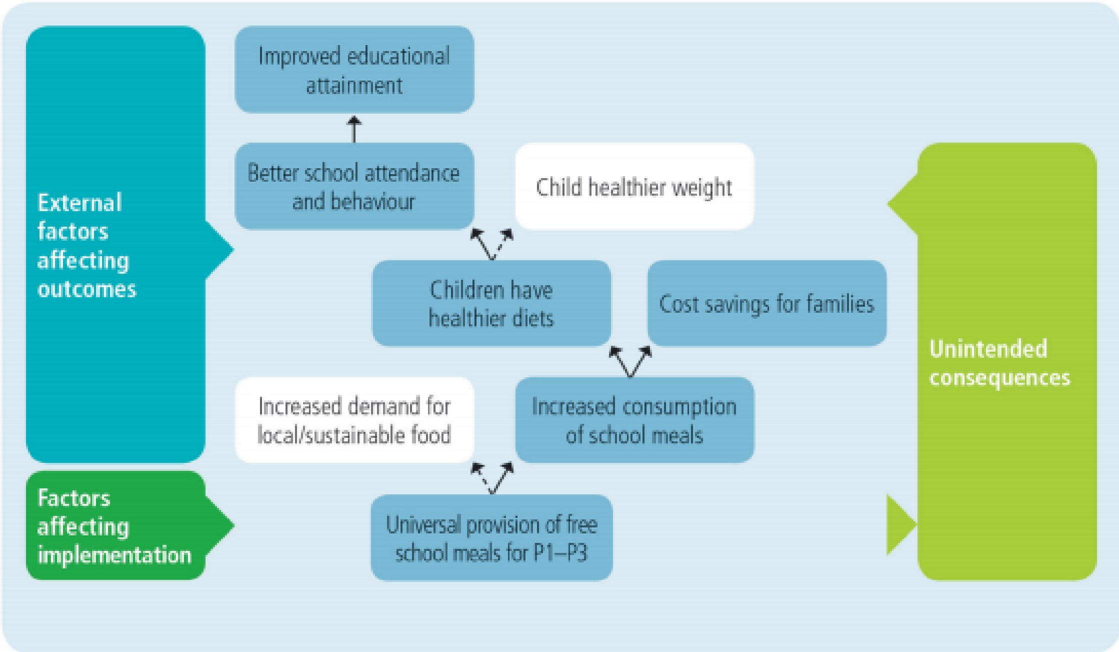


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Figure 7: Theory of change for universal free school meals (145)

Additionally, subgroup differences in dietary intake and weight status have been noted. Boys have been shown to have an increased preference for sugary foods, meat, and processed meat products, compared to girls (149) and sex of the child and socio-economic position have been shown to influence fruit and vegetable consumption (150). Furthermore, subgroup analysis of the NCMP data has shown higher obesity prevalence in boys, those in the most deprived deciles of deprivation score, and certain ethnicities (Black African, Bangladeshi and Black Other; (30)). Therefore, it is important to investigate subgroup differences further in relation to the impact of lunchtime dietary consumption on daily diet and child weight status.

3.2 Aims

This chapter explores the hypotheses that: i) school-provided lunches will provide a more nutritious lunch to children than home-packed lunches; and ii) this will lead to better nutrition overall and a reduced likelihood of overweight and obesity. Associations between school lunch type and diet quality index score, and between school lunch type and overweight/obesity will be explored. The longitudinal association between school meal type and overweight/obesity will also be explored.

The aim of this chapter is to compare the food and nutrient composition of SPL and HPL in children aged 5-6 years (both lunchtime only and daily), and their associations with 24-hour diet quality (as determined by an adaptation of the Diet Quality Index (DQI (109)) cross-sectionally. Associations with the odds of overweight/obesity at three time points (cross-sectionally at age 5-6 years, and longitudinally at ages 7-8 years and 8-9 years) will also be explored. Subgroup analysis will be conducted to investigate differences across the key demographics of ethnicity, deprivation status, and sex.

3.3 Methods

3.3.1 Dietary assessment

Researchers observed the intake of SPL and HPL using a modified version of the Child and Diet Evaluation Tool (CADET; (113)). A detailed description of the methods used to assess intake can be found in Chapter 2 (Section 2.4).

3.3.2 Dietary quality assessment

Dietary quality was assessed using an adapted version of the original Diet Quality Index devised by Patterson *et al.* (1994; (109)) to assess compliance with certain UK dietary recommendations for children. Adaptations were made to align the DQI with UK Dietary Reference Values for children aged 4-6 years (**Table 7**). A score of 0-2 was given for each element of the adapted DQI. Each individual’s scores were then summed to give a total score for each participant. Lower scores reflect a more healthful dietary pattern and therefore a better diet quality in the 24-hour period. Further information of choice of DQI score can be found in Chapter Two, Section 2.5. Histograms of the score distributions can be found in Appendix 3 (Section 9.3).

Table 7: Adaptations made to the Diet Quality Index (109)

Component	Measurement	Score	Original boundaries	Revised boundaries
Total fat [a]	% of total energy intake/day	0 / 1 / 2	<30 / 30 – 40 / >40	<35 / 35 – 45 / > 45
Saturated fat	% of total energy intake/day	0 / 1 / 2	<10 / 10 –13 / >13	<11 / 11 –14 / >14
Free sugar [b]	% of total energy intake/day	0 / 1 / 2	-	<6 / 6 –10 / >11
Fruit and Vegetables [c]	servings/day	0 / 1 / 2	≥5 / 3 –4 / 0 –2	≥5 / 3 –4 / 0 –2
Breads and Cereals [d]	servings/day	0 / 1 / 2	≥6 / 4 –5 / 0 –3	≥6 / 4 –5 / 0 –3
Protein [e]	% of RDA	0 / 1 / 2	<200 / 200 –250 / >250	<200 / 200 –250 / >250
Sodium [f]	mg/day	0 / 1 / 2	<2400 / 2400 –3400 / >3400	<700 / 700 – 1700 / >1700
Calcium [g]	% of RDA	0 / 1 / 2	>100 / 67 –100 / <67	≥100 / 79 – 99.9 / <79

[a] Boundaries altered to reflect the percentage of intake without alcohol

[b] % of energy from free sugar added to replace the Cholesterol variable which is not applicable to this population. Boundaries have been set using the Scientific Advisory Committee on Nutrition recommendations (102).

[c] Servings were considered 40g as used by the UK School Food Trust and Jennings *et al*. (2011); (59, 151)

[d] Servings defined by the CADET portion size

[e] No change to boundaries, however changed to be percentage of UK reference nutrient intake (RNI) for children aged 4-6 years

[f] Changed to reflect the UK RNI for children aged 4-6 years

[g] Measurement changed to be percentage of UK RNI and boundaries narrowed so that the lower boundary represents the UK Lower RNI for children aged 4-6 years

3.3.3 Weight status

Age and sex specific BMI z-scores calculated from the British 1990 (UK90) growth reference charts were assigned to each child (111). Dichotomised weight status based on the British 1990 (UK90) thresholds was used per methods defined Chapter 2 (Section 2.3.1). Overweight/obese children were compared to all other children.

3.3.4 Other variables

Confounding variables included sex, ethnicity, average physical activity energy expenditure (kJ/kg/day), height, and household English Indices of Multiple Deprivation (IMD) score. Detailed descriptions of the sources of these variables can be found in Chapter 2 (Section 2.5).

3.3.5 Statistical methods

All analysis was performed using STATA 13 (StataCorp, Texas, USA) using a 5% level of significance. Descriptive variables and nutrient composition were summarised using mean and standard deviation where normally distributed and median and interquartile range otherwise. Categorical variables were summarised as the number and percentage of respondents. Mixed-effect linear and logistic regression models were used to assess differences in nutrient composition and proportion of children consuming different food categories between lunch types, whilst accounting for the clustered nature of the sample. Where the residuals of a regression model were found to be skewed, a repeat test was conducted on squared-root transformed variables. In instances where the transformed variable produced residuals that were closer to normality, the p-value from the transformed test was reported. Mixed-effect logistic regression models were also developed to examine the relationship between type of lunch at age 5-6 years and weight status at three time points (aged: 5-6 years, 7-8 years, and 8-9 years). The relationship between lunch type and daily diet quality (as assessed through a DQI score) was assessed at one time point (aged 5-6 years) through mixed effect linear regression models. Further adjusted models included school as a random effect, and sex, ethnicity, household deprivation score (IMD), average physical activity energy expenditure (kJ/kg/day) and height as covariates. **W**est Midlands **A**cti**V**e lifestyles and healthy **E**ating in **S**chool children (WAVES) study trial arm allocation was included as a covariate in the further adjusted longitudinal models (7-8 years and 8-9 years).

3.3.6 Subgroup and sensitivity analysis

Models were repeated on subgroups of the sample to determine if there were variations in outcomes by the key demographics of sex (male / female), ethnicity (White / South Asian / Black / Mixed and Other ethnicities), and deprivation (quintiles 1 and 2 / quintiles 3-5).

All DQI models were repeated using only those children deemed plausible reporters via the Goldberg methods (n = 1085) to assess differences due to the inclusion of potentially implausible intakes (Chapter 2, Section 2.4.4).

Finally, all total sample further adjusted models were repeated on an imputed dataset to assess differences due to missing covariate data. Generation of imputed datasets was conducted in REALCOM-Impute (152) and analysis conducted in STATA 13. Imputation was conducted allowing for clustering of the data within the procedure. The following items were included in the imputation processes: lunch type, baseline diet quality score (DQI models only), weight status at follow ups, baseline BMI z-score, height at follow ups, physical activity expenditure at follow ups, WAVES study trial arm, ethnicity of child (White, South Asian, Black African-Caribbean and Mixed/Other ethnicities), deprivation score of household (IMD 2010), sex of the child, school free school meal entitlement proportion, school level ethnic mix (White, South Asian, Black African-Caribbean and Mixed/Other ethnicities). Ten sets of estimated parameters were then pooled and the mixed effect regression models repeated using the imputed data.

3.4 Results

3.4.1 Sample description

Of the 1467 consented children, there were 1228 (83.7%) with lunch records eligible for inclusion in this study (**Figure 8**). For the analyses investigating dietary quality over 24 hours, a further 56 children were excluded. This was due to missing out-of-school consumption information (n= 38) or where there were an implausibly high number of food items consumed in a 24-hour period (pre-determined as > 50; n=18). For the analyses investigating the likelihood of overweight/obesity over time, 29 (2.0%) pupils did not have a baseline weight status recorded, 163 (11.1%) did not have a weight status at first follow-up, and 252 (17.1%) did not have a weight status at second follow-up.

There were no differences in sex, ethnicity, deprivation level, or physical activity energy expenditure, between the children with a lunch record eligible for inclusion compared to those not included.

SPL accounted for 53.0% of lunches consumed (n=624). Children who consumed a SPL were considerably more deprived and more likely to be Black or Mixed/Other ethnicity than those who brought a HPL (**Table 8**). A smaller proportion of obese children consumed a HPL. Sex distribution, average physical activity energy expenditure, and DQI scores were similar in the two groups (**Table 8**).

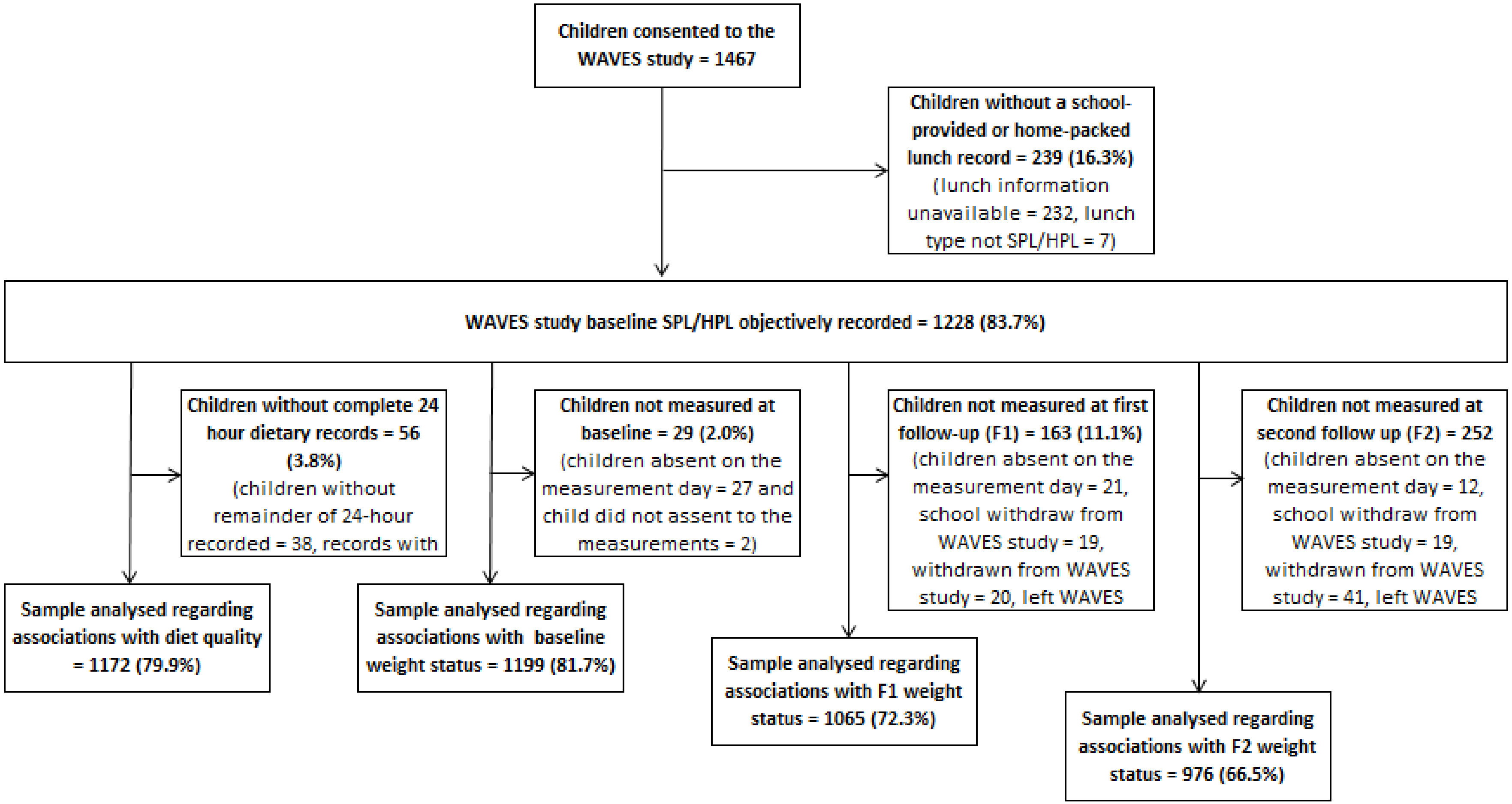


Figure 8: Flow diagram of participants from the overarching WAVES study for the Chapter 3 study sample

Table 8: Chapter 3 sample description, by lunch type consumed

	School-provided lunch (n=624)	Home-packed lunch (n=548)	p-value[a]
Age of the child (years; mean (SD); N=1172)	6.3 (0.3)	6.3 (0.3)	0.617
Sex of the child (n (%); N=1172)			
Males	306 (51.3)	291 (48.7)	reference
Females	318 (55.3)	257 (44.7)	0.310
Ethnicity (n (%); N= 1165)			
White	254 (45.9)	299 (54.1)	reference
South Asian	175 (50.9)	169 (49.1)	0.361
Black	71 (83.5)	14 (16.5)	<0.001
Mixed/Other ethnicities	119 (65.0)	64 (35.0)	<0.001
IMD quintiles (n (%); N=1159) [a]			
Quintiles 1 (most deprived)	379 (62.0)	232 (38.0)	reference
2	108 (47.2)	121 (52.8)	0.002
3	51 (42.5)	69 (57.5)	0.002
4	43 (42.6)	58 (57.4)	0.004
Quintiles 5 (least deprived)	34 (36.2)	60 (63.8)	0.010
Average physical activity energy expenditure (kJ/kg/day; mean (SD); N=956)	94.3 (24.7)	96.4 (23.5)	0.227
Weight status (n (%); N=1149) [b]			
Not overweight/obese	474 (52.3)	432 (47.7)	reference
Overweight	50 (47.6)	55 (52.4)	0.298
Obese	86 (62.3)	52 (37.7)	0.030
Baseline DQI score (mean (SD); N=1172)	7.8 (1.7)	7.6 (1.8)	0.171

IMD – Index of Multiple Deprivation; DQI – Diet Quality Index

[a] P-values for continuous variables extracted from univariate multi-level linear regression models with control for clustering. P-values for categorical variables extracted from multinomial logistic regression models with adjustment for clustering

[b] Based on the UK 1990 growth reference data (UK90) and the population thresholds of the 85th centile (overweight) and 95th centile (obese)

3.4.2 Comparison of consumption at lunchtime: School-provided and home-packed lunches

The mean lunchtime energy intake was marginally lower among pupils eating HPL compared with SPL and was lower than national recommendations for both lunch types (**Table 9**). However, the contribution of lunchtime consumption to total daily energy intake was similar (SPL (30.5% (SD 10.2)); HPL (30.1% (SD 9.4)).

SPL children consumed more protein and fat, and less carbohydrate than HPL children at lunchtime (**Table 9**). However, the SPL fat intake was still below that recommended and saturated fat intake was a smaller proportion of total lunchtime fat intake in SPL compared to HPL children (35.9% of SPL total fat consumption vs. 37.7% of HPL total fat consumption). Fibre, folate, zinc, vitamin A and vitamin C consumption were all significantly higher in SPL compared to HPL children; however, calcium consumption was lower. Sodium consumption was significantly higher in the HPL children, with intake being approximately 19% above the recommendation in this group (**Table 9**).

There were also noteworthy differences in whole food consumption by lunch type (**Figure 9**). SPL children consumed significantly less processed meat, savoury snack foods, sugar sweetened beverages, and were more likely to consume two or more portions of fruit and vegetables (F&V) at lunch. However, they were also less likely to consume milk products (e.g. yoghurt and cheese) and slightly more likely to consume a sweet snack food/dessert (e.g. cake, biscuits etc.).

Table 9: Average lunchtime nutrient consumption by lunch type and the UK Government recommendations for provision of an average primary school lunch (2006-2014)

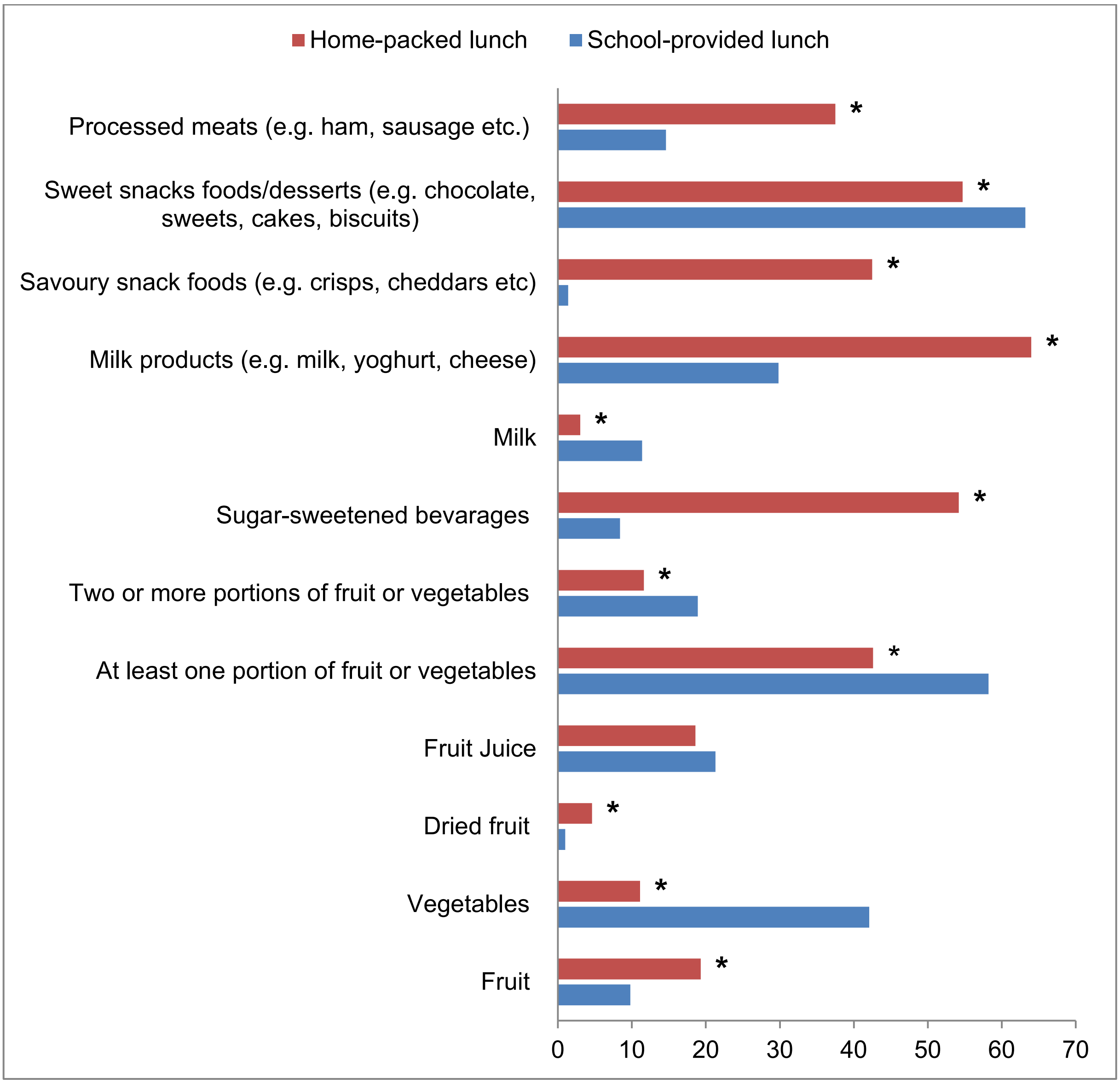
	UK Government recommendation 2006-2015 (average primary school lunch provision)		Average lunch consumed (average consumption; n= 1228)		School-provided Lunches (average consumption; n=651)		Home-packed Lunches (average consumption; n=577)		p-value [a]
	value	range							
Energy (kJ; mean (SD))	2215.0	± 110.8	2093.6	(708.3)	2126.4	(752.0)	2056.6	(654.2)	0.044
Protein (g; median (IQR))	7.5	min	17.1	(8.3)	18.3	(8.6)	15.2	(8.0)	<0.001
Carbohydrate (g; mean (SD))	70.6	min	69.1	(23.6)	67.8	(25.5)	70.5	(21.1)	0.045
Free sugar (g; median (IQR))	15.5	max	18.7	(16.1)	17.1	(16.2)	24.0	(18.1)	<0.001
Fat (g; median (IQR))	20.6	max	17.8	(12.1)	18.1	(12.8)	17.5	(11.6)	0.007
Saturated Fat (g; median (IQR))	6.5	max	6.5	(5.3)	6.5	(5.4)	6.6	(5.0)	0.197
Fibre (g; Englyst Method; median (IQR))	4.2	min	3.0	(2.2)	3.9	(3.0)	2.5	(1.3)	<0.001
Sodium (mg; mean (SD))	499.0	max	527.5	(222.8)	468.8	(213.8)	593.7	(214.1)	<0.001
Calcium (mg; median (IQR)) [b]	193.0	min	192.6	(175.8)	163.9	(159.8)	255.2	(178.1)	<0.001
Folate (μg; median (IQR)) [b]	53.0	min	46.0	(27.6)	48.2	(29.2)	44.2	(25.3)	0.128
Iron (mg; mean (SD))	3.0	min	2.1	(0.8)	1.9	(0.7)	1.9	(0.7)	<0.001
Zinc (mg; median (IQR))	2.5	min	1.7	(1.0)	1.9	(1.2)	1.6	(0.8)	<0.001
Vitamin A (μg; median (IQR))	175.0	min	117.6	(134.6)	142.2	(181.0)	106.6	(82.7)	<0.001
Vitamin C (mg; median (IQR)) [b]	10.5	min	12.1	(34.1)	15.2	(30.5)	5.4	(34.0)	<0.001

[a] mixed effect linear regression adjusted for school attended (random effect);

[b] statistical testing to examine the difference between groups performed on a square root transformed variable.

Figure 9: Percentage of pupils consuming specific food groups compared by lunch type.

* denotes significant differences in the proportion who consumed that food/drink between groups after adjustment for school attended (random effect; $p < 0.05$)



3.4.3 Overall daily diet compared by type of lunch consumed

On average, children in the total sample were consuming more free sugar and sodium than the maximum provision recommendations and had consumption levels below that recommended for fibre, folate, iron, zinc, and vitamin A (**Table 9**). Children in the total sample generally met, or were close to, the recommendations for fat, saturated fat, calcium, and vitamin C.

Over the course of the day, SPL children maintained a higher consumption of protein (4.2g), fibre (1.4g), vitamin A (69µg), vitamin C (5.3mg), iron (0.4mg) and zinc (0.5mg) and lower free sugar (11.3g), sodium (146.5mg) and calcium (91.6mg) intakes, than HPL children (**Table 10**). However, this did not necessarily mean more dietary recommendations were met, as evidenced by children having similar DQI scores regardless of lunch type consumed (**Table 8**).

3.4.4 Lunchtime associations with daily diet quality

In the total sample, consuming a HPL showed no evidence of an association with daily DQI score when compared with SPL (**Table 11**). However, subgroup analysis highlighted some noteworthy differences between groups. Significantly better diet quality for HPL compared with SPL was seen in girls, even after adjustment for confounding. This result lost significance in the analysis of plausible reporters due to a marginally wider confidence interval, however as the point estimate was similar and the confidence interval only slightly wider, the smaller sample size in the plausible reporter analysis may explain this difference in result. This was supported by a significant association seen when missing data was interpolated using multiple imputation techniques.

More affluent children consuming a HPL were also highlighted as having a better DQI score than their SPL consuming peers (**Table 11**). This significant result was maintained when the sample was restricted to plausible reporters only (**Table 12**) and within the multiply imputed sample (results not presented).

Due to the volume of tests conducted, caution must be applied when interpreting these results.

Table 10: Average daily nutrient consumption by lunch type consumed

	UK daily dietary recommendation (age 4-6 years)	Average intake (average daily consumption; n= 1172)		School-provided Lunches (average daily consumption; n= 624)		Home -packed Lunches (average daily consumption; n= 548)		
	recommendation	Median	IQR	Median	IQR	Median	IQR	p-value[a]
Energy (kJ) [b, g]	6350.0	6928.6	(2147.8)	6976.9	(2108.7)	6879.7	(2200.3)	0.980
Protein (g) [h]	19.7	55.5	(20.8)	57.5	(20.4)	53.3	(21.3)	0.001
Carbohydrate (g) [c, h]	198.4	241.9	(81.4)	242.0	(80.0)	241.1	(81.3)	0.309
Free sugar (g) [d]	19.8	74.5	(40.6)	69.8	(39.5)	81.1	(40.9)	<0.001
Fat (g) [e, h]	60.1	55.7	(23.1)	56.6	(22.8)	54.8	(22.9)	0.454
Saturated Fat (g) [f, h]	18.9	21.9	(5.3)	22.1	(10.4)	21.9	(11.5)	0.831
Fibre (g; Englyst Method) [h]	13.4	11.3	(4.9)	11.9	(4.8)	10.5	(4.5)	<0.001
Sodium (mg) [h]	700.0	1516.1	(625.0)	1447.7	(637.6)	1594.2	(593.0)	<0.001
Calcium (mg) [g]	450.0	809.6	(438.9)	782.9	(398.0)	874.4	(464.2)	<0.001
Folate (µg) [h]	100.0	198.3	(74.3)	197.0	(81.8)	200.3	(90.5)	0.651
Iron (mg) [h]	6.1	8.5	(3.1)	8.7	(3.2)	8.3	(3.0)	0.010
Zinc (mg) [h]	6.5	6.5	(2.4)	6.3	(2.8)	5.8	(2.3)	0.001
Vitamin A (µg) [h]	400	480.6	(586.5)	512.9	(674.9)	443.9	(406.7)	<0.001
Vitamin C (mg) [g]	30.0	82.2	(69.9)	84.6	(64.9)	79.3	(72.5)	<0.001

[a] mixed effect linear regression adjusted for school attended (random effect);

[b] recommendation is the average of the sex specific population estimated energy requirements provided by the Scientific Advisory Committee of Nutrition (2011)

[c] recommendation calculated as 50% of total energy recommendation

[d] recommendation calculated as 5% of total energy recommendation

[e] recommendation calculated as 35% of total energy recommendation

[f] recommendation calculated as 11% of total energy recommendation

[g] statistical testing to examine the difference between groups performed on a square root transformed variable.

[h] statistical testing to examine the difference between groups performed on a log transformed variable.

Table 11: Multi-level mixed effect linear regression models investigating the association between lunch type and 24-hour diet quality index score

Explanatory variable: school meal type (reference = school-provided lunches)	Outcome variable: Diet Quality Index score							
	Model 1[a]				Model 2[b]			
	n	B[c]	95% CI	p-value	n	B[c]	95% CI	p-value
Total sample	1168	-0.15	(-0.35, 0.06)	0.168	937	-0.10	(-0.33, 0.12)	0.371
Sex subgroups (N=1172):								
Males	594	0.01	(-0.26, 0.29)	0.924	477	0.15	(-0.16, 0.46)	0.343
Females	575	-0.31	(-0.60, -0.01)	0.040	460	-0.34	(-0.68, -0.01)	0.043
Deprivation level subgroups (N=1159):								
Most deprived (IMD groups 1-2)	837	-0.04	(-0.28, 0.20)	0.756	673	0.03	(-0.24, 0.30)	0.831
Least deprived (IMD groups 3-5)	314	-0.45	(-0.82, -0.07)	0.020	264	-0.42	(-0.85, -0.01)	0.047
Ethnicity subgroups (N=1165):								
White	550	-0.18	(-0.47, 0.10)	0.205	447	-0.18	(-0.40, 0.24)	0.618
Asian	344	-0.12	(-0.52, 0.27)	0.535	281	-0.07	(-0.50, 0.36)	0.745
Black	85	-0.09	(-0.99, 0.80)	0.828	63	-0.74	(-1.75, 0.28)	0.155
Mixed/other ethnicity	182	-0.09	(-0.58, 0.41)	0.737	146	-0.08	(-0.62, 0.45)	0.756

[a] Adjusted for clustering

[b] Additionally adjusted for sex (not included in sex sub groups); deprivation score (not included in deprivation subgroups); and ethnicity (not included in ethnicity subgroups); height; and physical activity energy expenditure (kJ/kg/day)

[c] Reference category = SPL

Table 12: Multi-level mixed effect linear regression models investigating the association between lunch type and 24-hour diet quality index score (plausible reporters only)

Explanatory variable: school meal type (reference = school-provided lunches)	Outcome variable: Diet Quality Index score							
	Model 1[a]				Model 2[b]			
	n	B[c]	95% CI	p-value	n	B[c]	95% CI	p-value
Total sample	1072	-0.12	(-0.34, 0.09)	0.257	878	-0.10	(-0.33, 0.14)	0.429
Sex subgroups (N=1072):								
Males	555	0.03	(-0.26, 0.32)	0.830	452	0.14	(-0.18, 0.46)	0.400
Females	517	-0.30	(-0.61, 0.01)	0.058	426	-0.33	(-0.67, 0.02)	0.066
Deprivation level subgroups (N=1055):								
Most deprived (IMD groups 1-2)	756	-0.01	(-0.27, 0.25)	0.930	620	0.05	(-0.24, 0.33)	0.744
Least deprived (IMD groups 3-5)	299	-0.44	(-0.83, -0.04)	0.029	258	-0.43	(-0.86, -0.001)	0.049
Ethnicity subgroups (N=1065):								
White	518	-0.18	(-0.47, 0.12)	0.245	431	-0.10	(-0.43, 0.23)	0.551
Asian	305	-0.08	(-0.50, 0.34)	0.701	256	-0.05	(-0.50, 0.41)	0.839
Black	75	-0.09	(-1.12, 0.95)	0.870	56	-0.11	(-1.34, 1.13)	0.867
Mixed/other ethnicity	167	-0.11	(-0.65, 0.42)	0.678	135	-0.09	(-0.64, 0.47)	0.758

[a] Adjusted for clustering
[b] Additionally adjusted for sex (not included in sex sub groups); deprivation score (not included in deprivation subgroups); and ethnicity (not included in ethnicity subgroups); height; and physical activity energy expenditure (kJ/kg/day)
[c] Reference category = SPL

3.4.5 Lunch type associations with child weight status

A longitudinal association was found between consuming a HPL (age 5-6 years) and a lower likelihood of overweight/obesity at F2 (age 8-9 years). This association with weight status was not seen at F1 (7-8 years) in the main analysis, however was evident in the multiple imputation analyses suggesting that the lack of significance at F1 may be due to missing data. Variation in this association in different subgroups was evident, but the results were not consistent across sensitivity analyses and were not coherent with the results of the DQI analysis. For example, despite more affluent HPL consumers having a better DQI score than SPL consumers (**Table 11**), there was no evidence of an association with weight status (**Table 13**). Conversely, despite no difference in daily DQI score between HPL and SPL consumers in more deprived subgroups (**Table 11**), there was a significant difference in odds of overweight/obesity at F1 and F2 in both the main analyses and the multiple imputation analyses (**Table 13**). The same pattern was seen in the South Asian subgroup.

Additionally, there were mixed messages in the gender subgroup analyses. For example, HPL girls were seen to have lower odds of overweight/obesity than SPL girls at F1 and F2 (**Table 13**) in the main analyses. However, the multiple imputation analysis found no evidence of an association in girls, but a significant association in HPL boys, who had a lower odds of overweight/obesity compared to SPL boys at both F1 (OR=0.47 (95% CI: 0.23, 0.97) p=0.025) and F2 (OR=0.55 (95% CI: 0.35, 0.87) p=0.013).

Table 13: Multi-level mixed effect logistic regression models investigating the association between lunch type and child weight status

	Model 1 [a]				Model 2 [b]			
Explanatory variable: school meal type (reference = school-provided lunches)	n	OR for HPL vs. SPL [c]	95% CI	p-value	n	OR for HPL vs. SPL [c]	95% CI	p-value
Outcome variable: Odds of Overweight/Obesity at Baseline								
Baseline total sample [e]	1199	0.83	(0.62, 1.09)	0.191	980	1.00	(0.71, 1.40)	0.978
Sex subgroups (N=1199):								
Males	616	0.71	(0.49, 1.04)	0.077	502	1.04	(0.65, 1.68)	0.863
Females	583	0.98	(0.64, 1.48)	0.908	478	0.91	(0.55, 1.52)	0.722
Deprivation level subgroups (N=1182):								
Most deprived (IMD groups 1-2)	869	0.88	(0.64, 1.22)	0.454	710	1.10	(0.75, 1.63)	0.613
Least deprived (IMD groups 3-5)	313	0.69	(0.39, 1.23)	0.207	270	0.63	(0.31, 1.28)	0.205
Ethnicity (N=1192)								
White	551	1.02	(0.66, 1.56)	0.935	455	1.01	(0.60, 1.68)	0.979
South Asian	362	0.88	(0.52, 1.48)	0.631	302	1.04	(0.57, 1.94)	0.877
Black	85	0.83	(0.23, 3.01)	0.781	65	1.07	(0.24, 4.71)	0.932
Mixed/Other ethnicities	194	0.81	(0.39, 1.67)	0.561	158	0.88	(0.37, 2.04)	0.759
Outcome variable: Odds of Overweight/Obesity at Follow-up One (F1)								
F1 total sample [e, f]	1043	0.73	(0.49, 1.10)	0.135	862	0.76	(0.43, 1.34)	0.347
Sex subgroups (N=1043):								
Males	540	0.70	(0.40, 1.23)	0.212	447	0.71	(0.35, 1.42)	0.328
Females	503	0.76	(0.42, 1.40)	0.385	415	0.47	(0.23, 0.97)	0.042
Deprivation level subgroups (N=1033):								
Most deprived (IMD groups 1-2)	745	0.70	(0.43, 1.13)	0.144	613	0.49	(0.28, 0.86)	0.014
Least deprived (IMD groups 3-5)	288	0.84	(0.35, 2.01)	0.689	249	0.85	(0.27, 2.66)	0.779
Ethnicity (N=1041)								
White	488	1.28	(0.69, 2.37)	0.435	406	1.04	(0.51, 2.13)	0.905
South Asian	321	0.49	(0.23, 0.99)	0.047	271	0.30	(0.12, 0.71)	0.007
Black	68	0.16	(0.01, 2.18)	0.170	51	0.01	(0.00004, 1.95)	0.086
Mixed/Other ethnicities	164	0.43	(0.12, 1.56)	0.200	134	1.37	(0.19, 9.88)	0.753

Table 13 continued overleaf

Table 13 continued.

	Model 1 [a]				Model 2 [b]			
	n	OR for HPL vs. SPL [c]	95% CI	p-value	n	OR for HPL vs. SPL [c]	95% CI	p-value
Outcome variable: Odds of Overweight/Obesity at Follow-up Two (F2)								
F2 total sample [e, f]	955	0.67	(0.46, 0.96)	0.030	793	0.55	(0.35, 0.87)	0.010
Sex subgroups (N=955):								
Males	493	0.60	(0.36, 0.99)	0.045	410	0.69	(0.35, 1.37)	0.292
Females	462	0.70	(0.40, 1.24)	0.221	383	0.63	(0.30, 1.32)	0.224
Deprivation level subgroups (N=946):								
Most deprived (IMD groups 1-2)	679	0.57	(0.37, 0.89)	0.012	562	0.43	(0.23, 0.79)	0.006
Least deprived (IMD groups 3-5)	267	1.12	(0.50, 2.52)	0.780	231	2.35	(0.80, 6.91)	0.120
Ethnicity (N=953)								
White	452	0.94	(0.55, 1.61)	0.821	382	1.10	(0.54, 2.29)	0.783
South Asian	301	0.48	(0.25, 0.92)	0.026	255	0.36	(0.14, 0.90)	0.030
Black								
Mixed/Other ethnicities	145	0.91	(0.37, 2.24)	0.842	118	0.27	(0.02, 3.95)	0.338

[a] Adjusted for school attended (random effect);
[b] Additionally adjusted for sex (not included in sex subgroups); deprivation score (not included in deprivation subgroups); ethnicity (not included in ethnicity subgroups); physical activity energy expenditure (kJ/kg/day) and height
[c] Reference category = SPL;
[d] UK 1990 growth reference charts;
[e] Additionally adjusted for WAVES study trial arm allocation and baseline BMI z-score

3.5 Discussion

3.5.1 Principal findings

This study examined the nutritional differences between consumption of SPL and HPL and investigated the relationships between type of lunch consumed, daily dietary quality, and weight status in an ethnically diverse sample of UK primary school children. SPL accounted for 53.0% of lunches consumed in the study sample. This is a considerably higher rate than the 46.3% uptake rate seen nationally in primary schools in 2013/2014 academic year (143). However, the national figure represents information from only 99 of the 154 Local Authorities in England and therefore the true national uptake rate may be higher. Additionally, as our sample was largely deprived, with 72% in the two most deprived quintiles of IMD score, a greater percentage would have been eligible for free school meals. This is reflected in the much greater proportion of children in the most deprived quintile consuming a SPL. Furthermore, whilst overweight and obesity rates within the sample were in line with England averages (approximately a fifth of the sample; (30), a larger proportion of obese children consumed a SPL than a HPL in the study sample.

There were distinct differences in the types of food eaten by each group of children at lunch, for example, those having SPL consumed more vegetables but less fruit, and more sweet snacks, but less savoury snacks than those having HPL. SPL were, on average, higher in protein, total fat, fibre, iron, zinc, vitamin A and vitamin C than HPL and were lower in carbohydrate, sodium, and calcium content. Consumption of saturated fat and folate were similar between the two groups. Caution must be applied when comparing the present results to school food recommendations for provision, as this is consumption data for one school day only, however free sugar consumption was much higher than the maximum provision recommendation in both groups, highlighting that it may represent a particular challenge for school food providers and parents alike. Differences between SPL and HPL lunchtime consumption were generally seen over the 24-hour period, with SPL children consuming more energy, protein, fibre and vitamin C, and less free sugar, sodium and calcium than HPL children over the course of a day. However, no clear relationship between lunch type and daily DQI score or child weight status was apparent in the total sample. Subgroup analysis found consuming a HPL was associated with improved daily diet quality in those in the most affluent IMD quintiles. A similar result was found for girls, however contradictory sensitivity analyses reduced the confidence in this finding. A reduced likelihood of overweight/obesity was seen in the most deprived and South Asian HPL consumers when compared to SPL consumers longitudinally.

3.6 Comparison with other literature

In line with previous research, the lunchtime nutrient consumption was generally more favourable in children having a school-provided, rather than home-packed, lunch (142, 153-155). Additionally, SPL consumption was more likely to meet the UK nutrient recommendations for school meals than HPL consumption (2006-2015; (63)).

3.6.1 Energy

In contrast to the literature, there was evidence of a small difference in energy consumption between the two groups, whereby SPL consumed more energy than

HPL. However, in a review of eight studies, Evans *et al*. (2010) found that the energy intake was significantly higher in the HPL group in seven of those studies (62). Additionally, two UK studies published since the review, reported no significant difference in energy intake between groups (64, 156). These two studies samples compromised older children (ages 9-10 years (64) and teenagers (156)), from more affluent communities, and therefore differences in the energy consumption reported may reflect the differences between study samples. However, although our finding contrasts with the current literature, the difference was on average only 70kJ (17 kcal). Given that lunchtime intake accounts for 30% of daily energy intake in this sample, such a small difference, although statistically significant, may not have clinical importance.

3.6.2 Macronutrients

Current literature on protein and carbohydrate consumption during school lunch time almost universally shows HPL children to consume less protein and more total carbohydrate, than SPL children (62, 64, 153, 157-160), which is consistent with the current study.

Information on free sugar is lacking in the current literature. Of the studies that reported a form of extrinsic sugar (non-milk extrinsic sugar, free sugar, or added sugars), HPL children consumed more extrinsic sugar than SPL children (159, 161, 162). In the present study, this was on average 7 grams more free sugar (over one teaspoon) consumed at lunchtime by HPL children, compared to SPL children. Some studies have reported only total sugar intake; however, they have also consistently shown a greater consumption of sugars in the HPL children (153, 157, 160). The latest National Diet and Nutrition Survey for England noted that for children aged 4-10 years, the major contributor to free sugar consumption was non-alcoholic beverages (soft drinks and fruit juice), with soft drinks single-handedly contributing around 30% of children's free sugar intake (50). Nearly three quarters of HPL children (73.6%) consumed either a soft drink or fruit juice with their lunch, compared to only 28.3% of SPL children. Therefore, drinks may be a main contributor to free sugar intake in this sample, especially in those having HPL. Enforced school nutrition policies that aim to restrict sugar-containing soft drinks and fruit juice may assist in reducing free sugar intake, and contribute to reducing sugar intakes and obesity prevalence in school-aged children (163, 164).

Although fat intake was significantly higher in SPL children, the average difference between the two groups was only 0.5 grams; therefore, it is unlikely to be clinically significant. This finding is in contrast to the literature where most studies found higher fat intakes in HPL children (62, 157-159, 161, 162), or no difference between the two groups (64, 156, 162). Interestingly, fat intake in both groups was below the UK government maximum recommendation for fat provision in the average primary school lunch and saturated fat intake was a smaller proportion of overall lunchtime fat intake in SPL children. This may be due to food manufacturers' efforts in recent years to reformulate high fat products to reduce the content of total and saturated fat, for example the introduction of baked crisps (142).

3.6.3 Micronutrients

In line with the majority of the literature, SPL children's sodium intakes were on average lower than HPL children's sodium intakes at lunchtime (62, 158, 160-162).

Evans *et al*. (2016) found that there was approximately 100mg persistent difference in sodium intakes between groups over the course of the day (142). A finding that is consistent with the current study whereby there was a 124.9mg difference at lunchtime and 146.5mg difference over the course of the day (HPL higher). This suggests that lunchtime intake may account for this difference. Consistent with this, high-sodium foods, such as savoury snack foods (e.g. crisps) were more commonly consumed by HPL children (42.5%), compared with only 1.5% of SPL children, in the present study.

Calcium intakes were higher in children consuming HPL than SPL; however, the difference would be provided by as little as half a 150ml glass of semi-skimmed milk (118) and may be a result of the greater proportion of HPL children consuming dairy products at lunchtime. This result is consistent with a 2010 review where seven of the eight reported studies found calcium intake to be higher in HPL (62). However, studies published since this review, have often found the groups have had equivalent intakes (156, 161) or SPL provided more calcium than HPL (157-159).

The evidence regarding difference in zinc, folate, iron, vitamin A and vitamin C are inconsistent across the literature. This may be due to the differences in data collection and analysis between studies e.g. using standard portion sizes vs. weighed food records. Additionally, the present study used an updated version of the CADET tool which drew nutrient information from the latest UK nutrient databank, McCance and Widdowson's *The Composition of Foods*, seventh summary edition (MW7; (118)). MW7 may reflect recent changes in the formulation of certain products compared to previous versions.

3.6.4 Daily dietary quality

This study was the first to assess differences in overall daily diet quality between children consuming SPL and HPLs using an objective *a priori* index to assess dietary quality. One other study has compared daily dietary intakes by lunch type to UK dietary recommendations, however in contrast to the present study, concluded that SPL children consume a healthier diet over the whole day than HPL children (142). Despite using the same dietary data collection tool (CADET), differences in conclusions may be due to several key differences between the studies. First, the two studies had different definitions of a healthful diet (i.e. an *a priori* DQI compared to a subjective conclusion based on differences between multiple nutrients). Second, dietary data from the Evans *et al.* (2016) study was collected in 2007, only one year after implementation of the school food standards had begun, and so may not reflect the standards of school meals more recently. The present study uses dietary data collected during 2011/2012 and uses the most recent UK nutrient databank as the basis for the dietary data collection tool ensuring recent product reformulations are accounted for. Finally, the present study sample was largely more deprived than the Evans *et al*. (2016) study sample (IMD median score 16.8 (IQR 21.5) vs. present study IMD median score = 37.6 (IQR 30.4)) (142).

However, it is also noteworthy that whilst in the present study, SPL children generally had more healthful intakes than HPL children (e.g. lower free sugar intakes and sodium intakes, and higher micronutrient intakes), this was not reflected in a better daily DQI score. This may be due to the fact that the DQI score was based on meeting dietary recommendations throughout the 24 period and, although the groups had significant differences in various nutrient consumption levels, where differences occurred they did not cross the recommendation threshold. For example, SPL children had lower free sugar and sodium intakes than HPL children over the 24-hour period; however, both groups had mean free sugar intakes that were over four times that of the recommendation and mean sodium intakes almost double the recommended intake. This may draw into question the value of the DQI tool as a method for assessing diet quality between groups with similar dietary intakes.

Subgroup analysis uncovered a disparity in results between sexes, with significantly better diet quality in children consuming HPL only in girls, compared to those consuming a SPL. Female HPL consumers were found to have a 0.34 better diet quality score than female SPL consumers. For an average 7000kJ daily intake, this amounts to approximately 224kJ less total energy, 58kJ less energy from total fat, and 0.23g more fibre consumed, per day. This result was not replicated in the male sample. Residual differences in whole food consumption may help to explain this sex difference in effect, with girls reporting a greater preference for and consuming more F&V (149, 165, 166) and boys reporting a greater preference for and consuming more meat/meat products (149, 167) and high fat and/or sugar foods (149).

Another subgroup difference identified was among children living in more affluent areas where HPL consumers had better DQI scores that their SPL peers. This finding was supported by the multiple imputation analysis (168). One explanation for the subgroup differences may be due to a compensatory effect of school meals, whereby if parents feel their child is consuming a healthy, balanced meal provided by the school, there is less of a need to provide this at home. This has been seen in the evaluation of the Eat Well Do Well school meal initiative in Kingston-upon-Hull where HPL children had higher intakes of fruit and yogurts outside of school, but SPL children consumed more energy dense nutrient poor foods (161).

3.6.5 Weight status

Research comparing the associations between school meal types and weight status is lacking in the literature, however, there is limited research which has investigated associations between lunch type and various other measures of adiposity and weight. Whilst these studies may be assessing a different outcome, they consistently show no difference in the mean outcome variable. For example, Whincup *et al.* (2005) found no evidence of a difference cross-sectionally, in any marker of adiposity (BMI, body fat percentage, waist circumference or sum of skinfolds), between adolescent consumers of SPL and HPL in the UK (146). Gleason and Dodd (2009) also found no significant association between participation in the National School Lunch Programme (NSLP; a government-assisted meal program providing low-cost or free meals to children in the US) and BMI in the US (169). Interestingly, in two further US studies, whilst participation in the NSLP was not significantly associated with BMI in children aged 7-12 years, observed energy intake at lunch was positively associated with BMI (147, 148). Secondary analysis to try to explain this result found that the positive relationship between energy intake at lunchtime and BMI was stronger in females and Black children (170).

The present study adds to the literature in finding no cross-sectional association between lunch type and the risk of excess weight; however, some longitudinal associations were highlighted, particularly in subgroups of the population. For example HPL consumers in the most deprived quintiles of deprivation scores and those of a South Asian ethnicity tended to have a lower likelihood of overweight and obesity than their counterparts consuming SPL. The reasons for such disparities in effect are unclear and warrant further investigation. However, there was a considerable confounder imbalance between the characteristics of HPL and SPL consumers with SPL consumers being more deprived, and were more likely to be of a Black or Mixed/Other ethnicity. There were also significantly more obese children consuming a SPL. Hence, the two subsamples differed by more than merely lunch type exposure, and in some cases the categories used to control for confounders were broad (e.g. ethnicity) therefore, the residual confounding effect on the outcomes of the present study must be considered. Additionally, although there was a difference in the observed association between meal type and weight status in boys and girls, the associations seen in the main analysis and the multiple imputation sensitivity analysis were not consistent with each other. This brings into question the rigour of this finding as it suggests the difference observed may be due to missing data (168).

3.7 Strengths and limitations

School time dietary intake was observed by trained researchers using a standard protocol. This reduced the impact of misreporting of lunchtime intakes. However, food consumed outside of school time was recorded by the child's parent/carer. Research into the cognitive ability of young children to recall dietary intake has highlighted concerns over the accuracy of recalls in children under 12 years old (83, 115, 116). Therefore, proxy-reporting of food consumed outside of school was used in this study and has been reported as the most reliable method of obtaining dietary information in children, when compared to the gold-standard of doubly-labelled water (171). Several children (n=327) did not have a viable proxy-report available, therefore, where possible, a recall was conducted with these child on the subsequent day. To investigate whether this consideration biased the sample by introducing implausible dietary intakes, sensitivity analysis was conducted on a restricted sample using only plausible reporters as determined through the Goldberg calculations (117). Additionally, the impact of missing covariate data was assessed using multiple imputation techniques. A further consideration is the fact that by utilising observed lunchtime intakes on one school day, habitual variation in lunch type was not accounted for, for example those children who only consume a packed lunch on certain days of the week.

The CADET tool uses standard portion sizes obtained from a large, nationally representative sample of UK children (113). This aids the simplicity of the tool and reduces the respondent burden. However, as dietary intake in this study is based on only one weekday record of consumption, it may not be reflective of habitual intake and therefore comparisons to the UK dietary reference values and school food standards must be interpreted cautiously.

Previous versions of the CADET have been validated in this age group (113, 114). However, the validation studies were undertaken in mainly White British children and were not completed against the gold standard in dietary data collection, i.e. doubly labelled water. Additionally, adaptations to the CADET to update it to the latest version of the UK nutrient databank (Chapter 2, Section 2.4) and smooth anomalous portion sizes may undermine the previous validation.

School nutrition/healthy eating policies are likely to influence the food consumed during school, particularly for HPL. This study did not investigate the impact of these policies on the quality of the lunches consumed. However, 20% (11/54) of the schools taking part in the WAVES study did not have a healthy eating policy (a further 5 (9%) schools did not respond to the questionnaire) and 63% of those who did have a policy believed them to be only moderately effective (172). Despite this, it is important for any future investigation of these issues to consider the impact of school policies related to food.

Finally, the DQI used UK recommendations that are specific to the age group in question. However, as the DQI was adapted specifically for use in these analyses, comparisons between this DQI and other *a priori* methods of assessing dietary quality may be problematic.

3.8 Conclusion

Analysis by school meal type in this sample revealed major differences in lunchtime foods and nutrients consumed with SPL consumption of most nutrients being more favourable than HPL, despite overall lunchtime energy intake being similar. In addition, many of these differences were also seen when 24-hour food intake was measured. Free sugar consumption represents a particular challenge, as consumption in both SPL and HPL was more than the maximum recommended for average primary school lunch provision. The development of strategies to assist providers in relation to SPLs and parent/carers in relation to HPLs to reduce their free sugar content is worth consideration. Despite the overall nutrient profile of HPL being less favourable than SPL, daily diet quality index scores were better in HPL females and those in the more affluent quintiles of deprivation, when compared to their peers consuming a SPL, and no difference was seen in the total sample. This may draw into question the utility of this DQI as the differences highlighted when looking at the foods and nutrients individually were not reflected in a difference in diet quality score. Inherent differences between the characteristics of children consuming each lunch type, and the limitations of the methods used to define weight status and lunch type, hamper conclusions regarding the associations between these variables. Future research should consider using a different definition for lunch type that takes into account any variations in habitual lunch consumption and consider the impact of covariate imbalance on proposed associations. Additionally, consideration must be given to other outcome measures that may provide greater insight into any differences in adiposity between groups.

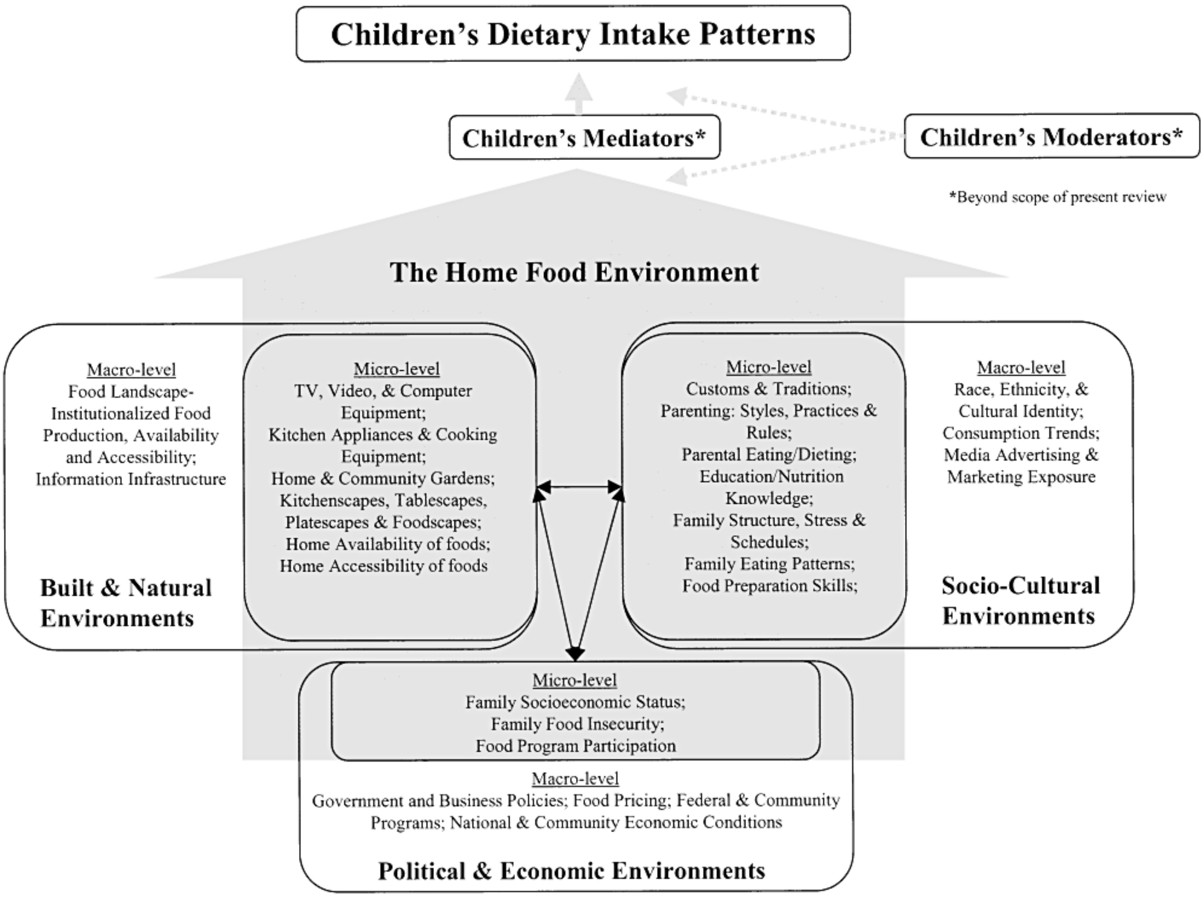
Chapter Four: The home food environment – Investigating the cross-sectional relationship with fruit and vegetable intake and child weight status

Contributions: KLH developed the idea for the study with guidance from PA, MJP, and ERL. The WAVES study research team (including KLH) were responsible for collecting, inputting, and cleaning the data. The Nutrition Epidemiology Group at the University of Leeds was responsible for the processing of the dietary data. KLH developed the home food environment score and conducted all statistical analyses. The chapter was written by KLH, guided by PA, MJP, and ERL.

4.1 Background

Obesity has been described as a normal response to an abnormal environment, also known as an 'obesogenic' environment (40). This obesogenic environment is defined as "the sum of the influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals and populations" (44). A combination of various obesogenic environments are believed to be contributing to the rising prevalence of childhood excess weight, for example the home, school, and social environment (45). In England, over a fifth of Reception children (aged 4-5 years) and a third of Year 6 children (aged 10-11 years) are now either overweight or obese (30). Additionally, there is growing evidence that children are failing to meet the UK dietary recommendations for their age, typically consuming too much saturated fat, salt, and free sugar, and too little fibre and fruit and vegetables (50). Poor dietary choices and obesity in childhood can lead to longer term consequences including cardiovascular disease, cancer, and type 2 diabetes, with the latter being seen more frequently at younger ages (9).

The home represents a major source of children's dietary intake and parents/carers are key in the development of the home food environment (HFE). Multiple models attempt to conceptualise the HFE and how it relates to childhood overweight and obesity (173, 174). One such model, developed by Rozenkranz and colleagues (2008), builds on the Ecological Systems Theory, described in Chapter 1 (Section 1.4; (175)). In this model, there are three interacting domains each with macro- and micro-level components: the Social-Cultural Environment, the Political and Economic Environment, and the Built and Natural Environment. Micro-level elements are factors that are immediate to a child's home life, e.g. family eating patterns and macro-level elements represent factors in society which have the potential to influence those in the micro-level e.g. government policies. The remainder of this chapter will focus on various micro-level elements of the HFE, with rationales for each outlined accordingly.



Reprinted from Nutrition Reviews, vol. 66, Rosenkranz, R. R. and Dzewaltowski, D. A., Model of the home food environment pertaining to childhood obesity, pgs 123-140., Copyright (2008), with permission from Oxford University Press.

Figure 10: A model of the Home Food Environment (175)

4.1.1 The built and natural environments

4.1.1.1 Availability and accessibility of food

A recent qualitative analysis with low-income parents in the US (n=60), found that over half employed permissive feeding practices with regard to snacking (e.g. having no snack rules or limits). Permissive feeding practices, leading to freer access by children to foods of their choice in the home, have been linked to overweight and obesity (176) and higher consumption of energy-dense, nutrient-poor (EDNP) foods (177). In a longitudinal study of Flemish children (n=609), the availability of unhealthy foods was negatively associated with fruit and vegetable (F&V) consumption and positively associated with excess consumption of sugar-sweetened beverages, crisps and sweets, at both baseline and follow-up (177). Furthermore, a qualitative study with adolescents in Canada (n=22) found that the availability and access to both healthy and unhealthy snacks were important in guiding their food choices (178). In US children with a low preference for F&V (aged 9-12 years; n=88), consumption of F&V has been shown to be positively associated with availability and accessibility to them (179). Given that snack foods such as cakes, biscuits, confectionary, and sugar-sweetened beverages account for much of the intake of free sugar in children (50, 180), allowing children free access to such foods may be contributing to overweight and obesity prevalence in the UK. Therefore, availability and access to F&V, rather than EDNP foods and drinks, may affect both F&V consumption and obesity prevalence.

4.1.1.2 Screen time

Screen time is a term used to describe the individual or concurrent use of various electronic media, e.g. television, computers/tablets, and mobile phones. Roberts *et al*. (2008) estimate that the average 8-13 year old child spends more time using electronic media than any other activity (bar sleeping), with an average screen time of approximately six hours per day (181). Screen time is a predominantly sedentary behaviour therefore affecting energy expenditure however, it is also believed to alter energy intake through multiple mechanisms, including increased exposure to advertisements for EDNP foods leading to increased intake of such foods (182), and disruption of the person's ability to respond to the body's food cues, e.g. hunger and satiety (183). The combination of these effects may contribute to weight gain in children. A systematic review conducted by the US Department of Agriculture (USDA; 2012) concluded that reducing sedentary behaviours (including screen time), may be an effective way of preventing overweight and obesity in adults and children (184).

Regarding F&V consumption, a review by Pearson *et al*. (2011) found evidence of a mixed association with screen time in adolescents, highlighting that whilst 26 studies found an inverse association with fruit or vegetable, or F&V consumption, a further 18 studies found a null association (185). Evidence regarding TV viewing and F&V consumption in younger children is equally mixed, with a paucity of research investigating the effect of total screen time on F&V intake in this age group (185).

4.1.2 Socio-cultural environments

4.1.2.1 Eating as a family

In a meta-analysis of 17 studies, Hammons *et al*. (2011) found that there was a 12% reduction in obesity risk, and a 20% reduction in the odds of consuming unhealthy foods, in children and adolescents who had a family meal three times per week or more, compared to those having a family meal twice a week or less (186). However, failure to consider the heterogeneous nature of the studies involved (e.g. differences in study designs and self-reporting of anthropometric data) limits the validity of these findings. A further systematic review conducted in 2012, concluded there was an inconsistent, weak inverse association between frequency of family meals and risk of childhood overweight (187). However, this review included little research from the UK, few studies investigating the relationship in children under 12 years old (6 of 15 studies identified), and only four studies adjusting for the four variable groups considered important by the authors (age and sex, deprivation, physical activity, and diet). Hence, there is a need for high quality studies investigating the relationship between family meals and obesity in younger children, in the UK, and with adequate control for confounders.

Although the available evidence is generally suggestive of a positive effect of eating as a family on dietary consumption, this is not consistent. De Wit *et al*. (2014; n=2764) found that higher F&V consumption was more likely if joint family meals were more frequent (B=0.18 (95%CI: 0.13, 0.22)) in young people aged 10-17 years from four European countries (188). These findings are further supported by Fink *et al*. (2014; n=1992) who report an increase in the odds of vegetable consumption in younger children (aged 6-11 years; OR 1.87 (95%CI: 1.08, 3.14), and both fruit (OR 2.11 (95% CI: 1.40, 3.19)) and vegetable consumption (OR 1.81 (95%CI: 1.14, 2.88)) in adolescents who ate meals as a family more than twice a week (189). However, Sweetman *et al*. (2011; n=434) found no evidence of an association between eating as a family and vegetable intake in pre-school children (aged 2-5 years) in the UK (190).

4.1.2.2 Regular breakfast consumption

Multiple systematic reviews of the literature have concluded that there is moderate evidence to suggest that the frequency of breakfast consumption is inversely associated with weight status in children (94, 191-194). However, the most recent review by Blondin *et al*. (2016), warns of potential publication bias in the literature, short follow-up durations, and an inconsistent definition of breakfast, which hinders the validity and reliability of the review findings (191).

Few studies have looked at the relationship between frequency of breakfast consumption and other correlates of diet, however a review by Rampersaud *et al*. (2005) highlighted that generally children who report eating breakfast regularly have better nutritional profiles than their breakfast skipping peers (192). Two cross-sectional studies have investigated the association between frequency of breakfast and F&V consumption in adolescents, in Italy (n=3291; (195)) and Denmark (n=3913; (196)). Both studies highlight differential associations between age and sex groups, with stratified analysis indicating a significant association between frequency of breakfast intake and F&V consumption only in girls (OR ranging from 1.31 – 1.78, (95%CIs ranging from 1.02 – 2.47; (195, 196)). Therefore, future studies investigating this association must consider age and sex as moderating factors.

4.1.2.3 Frequency of consuming food prepared outside of the home e.g. fast food and going out for dinner

Eating food prepared outside of the home has increasingly become a concern in relation to the health of both adults and children, as they are typically EDNP and served in large portion sizes (197). In 2015, a USDA evidence review, concluded that there was moderate evidence in adults to indicate that consumption of fast foods was associated with increased risk of obesity (198). However, the evidence in children was inconsistent, with two of six studies reviewed finding a null association, and another finding an association only in girls. There was insufficient evidence in adults or children to indicate whether there was an association between other forms of food away from the home (e.g. restaurant meals) and obesity (198).

4.1.2.4 Parental self-efficacy in ability to provide healthy meals

Parental self-efficacy, or confidence, in their knowledge of, and ability to provide, healthy, nutritious food may be an important predictor of diet quality and weight status in children (199). A recent qualitative study with parents in the UK (n=61) found parents were critical of the food and cookery education they had received in school themselves and called for improved teaching of this in school (200). Social Cognitive Theory states that people who are confident in their ability to change are more likely to change a health behaviour (201) and adults reporting higher levels of self-efficacy and positive outcome expectations (e.g. people who are confident in their ability to prepare and cook a nutritious meal that they find tasty) are more likely to plan and monitor their healthy eating behaviours (202). Additionally, maternal self-efficacy has been linked to increased F&V intake and decreased intake of cake and cordial in Australian children (n=140; (203)). However, despite parental self-efficacy being an important target within various childhood obesity programmes, no studies were found exploring parental self-efficacy in relation to healthy food provision to children, and its association with childhood obesity.

4.2 Aims

This chapter explores the hypothesis that the food environment created within the home is associated with both dietary quality and weight status. Children living in households with a greater number of obesogenic practices are expected to have an increased likelihood of overweight and obesity, and a reduced daily intake of F&V. It is also hypothesised that there may be a stronger association between the home food environment and F&V intake in boys compared to girls.

Hence, the aim of this study is to investigate various elements of the home food environment both individually and in combination, and their association with the odds of overweight/obesity and F&V intake. Subgroup analysis will also explore differences in these relationships by sex as various studies in the literature have highlighted this as a potential moderator.

4.3 Methods

4.3.1 Characteristics of the home food environment

Questions regarding the HFE were included in the **W**est Midlands **A**cti**V**e lifestyles and healthy **E**ating in **S**chool children (WAVES) study baseline parental questionnaire (2011/2012). Children were given the questionnaire in school on the day of study measurements and asked to return it to school within five days or via a freepost envelope. Several aspects of the HFE were covered including:

- snacking, for example “Excluding fruit, to what extent can your child eat snacks without your permission? E.g. crisps, biscuits, chocolate, sweets (please tick one box) never/rarely/sometimes/frequently/always”;
- family meals, for example “How often does your family sit at a table to eat an evening meal together? Family means your child, their siblings, and at least one parent/guardian. (please tick one box) every day/4-6 days a week/1-3 days a week/less than once a week/never”;
- parent/carer confidence around shopping, preparing, and cooking healthy meals, for example “How confident do you feel about your ability to prepare meals that you know are healthy? (please tick one box) extremely confident/confident/not very confident/not at all confident”.

Questions were adapted from the Family Eating and Activity Habits Questionnaire (FEAHQ) or developed in consultation with the Nutrition Epidemiology Group at the University of Leeds (204). A full list of included HFE questions can be found in Appendix 4, Section 9.4.

Categorical data were collapsed *a priori* into either two or three groups for analysis. The aim was to create the most meaningful groups for each included question. The final groups were decided through consensus of four researchers.

A composite score was created to investigate the combined association between obesogenic HFE, with child weight status, and portions of F&V consumed. Participants could score a maximum of 16 from eight aspects of the HFE; higher scores indicate more obesogenic HFE behaviours. **Table 14** details the scoring criteria.

Table 14: Scoring system for the composite Home Food Environment score

Home Food Environment item	Score 0	1	2
Screen time	Less than 2 hours	2-4 hours	Over 4 hours
Frequency of breakfast	Every day	4-6 days per week	3 days per week or less
Frequency snacking without permission (non-F&V items)	Never/Rarely	Sometimes	Frequently/Always
Eat at a table with family for evening meal	Every day	4-6 days per week	3 days per week or less
Go out for a meal	Less than once per month	1-3 times per month	Once a week or more
Consume fast food	Less than once per month	1-3 times per month	Once a week or more
Parental confidence in preparing and cooking healthy meals	Extremely confident	Confident	Not very/not at all confident
Parental confidence in trying new foods	Extremely confident	Confident	Not very/not at all confident

4.3.2 Weight status

Dichotomised weight status based on the British 1990 (UK90) thresholds were used per methods defined in Chapter 2 (Section 2.3.1). Overweight/obese children were compared to all other children.

4.3.3 Dietary assessment

Dietary data was collected using a modified version of the Child and Diet Evaluation Tool (CADET; (113)). A detailed description of the methods used to assess dietary intake can be found in Chapter 2 (Section 2.4.1). Misreporting was assessed using the Goldberg methods, described in Chapter 2 (Section 2.4.4).

4.3.4 Fruit and vegetable intake

A detailed description of the methods used to calculate F&V portion sizes can be found in Chapter 2 (Section 2.4.2).

4.3.5 Other variables

Confounding variables included the individual level factors of ethnicity, sex of the child, height, average physical activity energy expenditure (kJ/kg/day), and the English Indices of Multiple Deprivation (IMD) 2010 score of the household. Detailed descriptions of the sources of these variables can be found in Chapter 2 (Section 2.5).

4.3.6 Statistical methods

Statistical analysis was performed using STATA 13 (StataCorp LP, Texas, US). For the composite HFE score, a standard 5% two-sided significance level was used. Eight factors of the HFE were also considered individually; therefore, their significance was assessed using a more conservative significance level of 1% to account for the type one error associated with multiple testing. Continuous descriptive characteristics were summarised using mean and standard deviation where normally distributed and median and inter-quartile range otherwise. Categorical variables were summarised as the number and percentage of respondents.

Multilevel logistic regression models were developed to investigate associations between both the composite HFE score, and its individual elements, with the odds of overweight/obesity. Similarly, multilevel linear regression models were developed to investigate the associations between both the composite HFE score, and its individual elements, with portions of F&V consumed. Model one only adjusted for school as a random effect to account for the clustered nature of the sample. Model two added ethnicity, sex of the child, IMD score (as a proxy for socioeconomic status), height, and physical activity energy expenditure as fixed effects. In instances where there were three categories being compared (i.e. frequency of breakfast consumption, snacking without permission, frequency of sitting together at a table for the evening meal, frequency of eating out, and frequency of fast food), separate multi-level linear regressions, using the HFE element as a continuous variable and adjusting for the Model 2 confounders, were conducted to assess the trend across the groups (p-for-trend).

4.3.7 Subgroup and sensitivity analysis

Subgroup analysis for boys and girls was conducted, using the further adjusted model (Model 2), excluding sex of the child as a covariate. Age was not considered as a modifier in this analysis due to the narrow age range of the study sample.

All analyses were repeated for F&V intake using only those children deemed plausible reporters via the Goldberg methods (n = 789) to assess the potential effect of misreporting of dietary intake on the outcomes.

Additionally, analysis of total sample models was repeated on an imputed dataset to assess the impact of missing data on the outcomes of the further adjusted models. Imputation was conducted allowing for clustering of the data within the procedure. The following items were included in the imputation processes: weight status at baseline, height at baseline, physical activity expenditure at baseline, WAVES study trial arm, ethnicity of child (White, South Asian, Black African-Caribbean and Mixed/Other ethnicities), deprivation score of household (IMD 2010), sex of the child, school free school meal entitlement proportion, school level ethnic mix (White, South Asian, Black African-Caribbean and Mixed/Other ethnicities). Ten sets of estimated parameters were then pooled and the mixed effect regression models repeated using the imputed data. Generation of imputed datasets was conducted in REALCOM-Impute (152) and analysis conducted was in STATA 13.

4.4 Results

4.4.1 Sample description

Of the 1467 children participating in the WAVES study, there were 944 (64.3%) whose parent/carer (subsequently referred to as parents) had completed the relevant questionnaire (**Figure 11**). Compared to children for whom a questionnaire was not returned, responders were more likely to be ranked in the least deprived quintiles (IMD quintiles 3-5; 31% of children who returned questionnaires vs. 15% of children who did not return a questionnaire) and to be from a White ethnicity (51% of children who returned a questionnaire vs. 31% of children who did not return a questionnaire). There was no clear difference in the average energy consumed or average physical activity energy expenditure (kJ/kg/day) in the children of returners, compared to non-returners. Of the parental questionnaires returned, 18 did not have a corresponding child BMIz available for analysis and 81 did not have a complete dietary record for the 24-hour period (**Figure 11**).

Table 15 highlights key demographic differences between the children by weight status. Parents of overweight/obese boys were significantly more likely to return a questionnaire than parents of overweight/obese girls. Black and mixed/other ethnicity children who returned a questionnaire, were more likely to be overweight/obese than White children who returned a questionnaire. Additionally, those in the least deprived quintile of deprivation (quintile 5) were less likely to be overweight or obese than those in the most deprived quintile of deprivation (quintile 1) of those who returned a questionnaire. Between 3-20% of the sample did not answer specific questions in relation to the HFE. For questionnaires that were returned individual question response rates ranged from 81% (screen time) to 97% (snacking without permission).

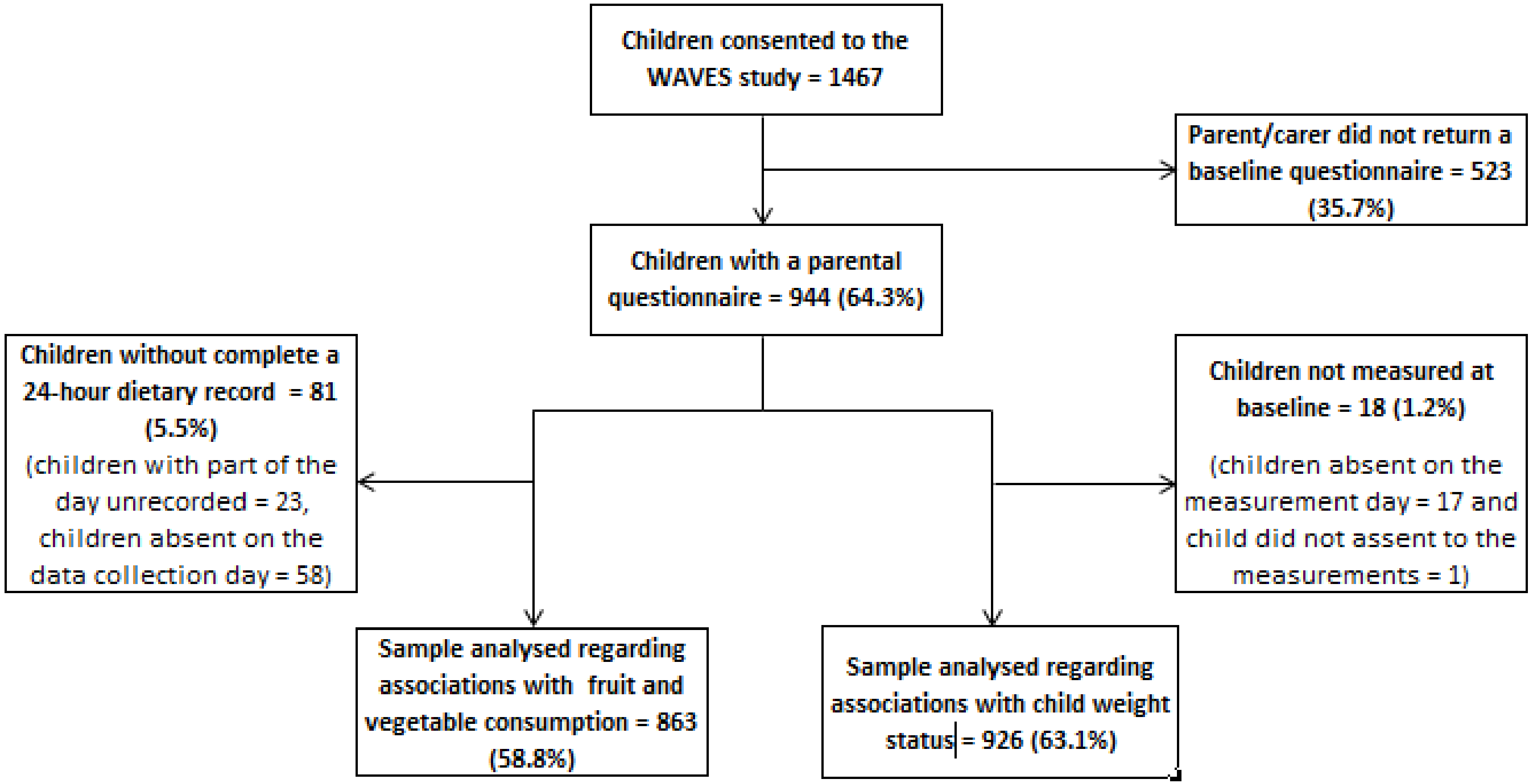


Figure 11: Flow diagram of participants from the overarching WAVES study for the Chapter 4 study sample

Table 15: Chapter 4 sample description, by weight status

	Not overweight/obese		Overweight		Obese		p-value
	(n = 740)		(n = 81)		(n = 105)		
Age of the child (years; mean (SD); N=926) [b]	6.3	(0.3)	6.3	(0.3)	6.3	(0.3)	0.956
Sex of the child (n (%); N=926) [c]							
Male	364	(77.3)	47	(10.0)	60	(12.7)	-
Female	376	(82.6)	34	(7.5)	45	(9.9)	0.019
Ethnicity (n (%); N = 924) [c]							
White	385	(82.4)	43	(9.2)	39	(8.4)	-
South Asian	208	(81.3)	22	(8.6)	26	(10.2)	0.522
Black	35	(64.8)	3	(5.6)	16	(29.6)	<0.001
Other/mixed ethnicity	111	(75.5)	13	(8.8)	23	(15.7)	0.039
Index of Multiple Deprivation 2010 (n (%); N = 914) [c]							
Quintile 1 (more deprived)	359	(76.6)	43	(9.2)	67	(14.3)	-
Quintile 2	138	(83.1)	15	(9.0)	13	(7.8)	0.059
Quintile 3	87	(84.5)	6	(5.8)	10	(9.7)	0.091
Quintile 4	71	(79.8)	7	(7.9)	11	(12.4)	0.472
Quintile 5 (less deprived)	75	(86.2)	9	(10.3)	3	(3.5)	0.012
Median energy intake (kcal; median (IQR); N = 855) [b]	1651.9	(507.1)	1688.9	(551.1)	1757.2	(517.6)	0.051
Average physical activity energy expenditure (kJ/kg/day; mean (SD); N=802) [b]	95.4	(25.1)	92.2	(20.4)	94.9	(21.5)	0.574
HFE score (mean (SD); N = 678) [b]	4.7	(2.4)	4.4	(2.1)	5.2	(2.8)	0.202

[a] Based on the UK 1990 growth reference data (UK90) and the population cut-off of the 85th (overweight) and 95th (obese) centile

[b] p-values generated using mixed effect linear regression models, fitting weight status as a continuous variable, and school attended as a random effect

[c] p-values generated using multinomial logistic regression models, fitting weight status as a continuous variable, and using robust standard errors to account for clustering

4.4.2 Associations between the composite score and individual elements of the home food environment with the odds of overweight/obesity

No significant associations were found between the HFE score and odds of overweight/obesity, either in the total sample, or by sex (**Table 16**). There was also no evidence of a trend in scores across weight status groups **Table 15**). Additionally, there was no evidence of a significant association between individual HFE elements and odds of overweight/obesity cross-sectionally (**Table 17**). However, boys consuming breakfast everyday were 73% less likely to be overweight/obese, after adjustment for relevant confounders (**Table 18**).

Results of the multiple imputation analysis were similar in terms of magnitude and significance of association.

Table 16: Multivariate logistic regression models to investigate associations between the home food environment score and odds of overweight/obesity

	Model 1[a]				Model 2[b]			
Predictor variable = Home Food Environment score [c]	n	OR	95% CI	p-value	n	OR	95% CI	p-value
Overweight/Obese	664	1.03	(0.95, 1.12)	0.485	570	1.02	(0.92, 1.12)	0.748
Overweight/Obese (boys only)	354	1.03	(0.93, 1.15)	0.534	302	1.07	(0.94, 1.21)	0.321
Overweight/Obese (girls only)	310	1.02	(0.90, 1.15)	0.783	268	0.96	(0.83, 1.11)	0.576

[a] Adjusted for clustering as a random effect only;

[b] Additionally adjusted for the demographic characteristics of sex (not included in sex subgroups), deprivation score, ethnicity, height, and physical activity energy expenditure (kJ/kg/day)

[c] See Table 14 for summary of HFE score

Table 17: Multivariate logistic regression models to investigate associations between various factors of the home food environment and child weight status

Outcome variable = odds of overweight/obesity[c]	Model 1[a] n	OR	99% CI	p-value	Model 2[b] n	OR	99% CI	p-value
Screen time (hours)	729	0.99	(0.80, 1.23)	0.881	628	0.93	(0.71, 1.23)	0.521
Breakfast (N = 865)								
3 days per week or less	66	(reference category)			51	(reference category)		
4-6 days per week	93	0.68	(0.26, 1.81)	0.316	78	0.63	(0.21, 1.93)	0.292
Every day	706	0.61	(0.29, 1.18)	0.089	564	0.55	(0.23, 1.32)	0.080
Snacking without permission (N = 884)								
Never / Rarely	571	(reference category)			474	(reference category)		
Sometimes	246	1.17	(0.72, 1.92)	0.400	194	1.18	(0.65, 2.17)	0.477
Frequently / Always	67	1.53	(0.70, 3.31)	0.160	45	1.61	(0.61, 4.24)	0.202
Frequency the family sit together at a table for the evening meal (N = 876)								
3 days per week or less	241	(reference category)			191	(reference category)		
4-6 days per week	248	0.73	(0.40, 1.35)	0.186	204	0.66	(0.33, 135)	0.136
Every day	387	1.01	(0.60, 1.70)	0.980	310	0.89	(0.47, 1.68)	0.628
Frequency the family go out for dinner (N = 877)								
Less than once per month	491	(reference category)			394	(reference category)		
1-3 times per month	290	0.68	(0.41, 1.13)	0.052	237	0.67	(0.36, 1.20)	0.073
Once a week or more	96	0.84	(0.40, 1.74)	0.534	77	0.89	(0.38, 2.08)	0.713
Frequency the family has fast food (N = 872)								
Less than once per month	317	(reference category)			253	(reference category)		
1-3 times per month	345	0.92	(0.56, 1.50)	0.645	281	0.93	(0.52, 1.65)	0.732
Once a week or more	210	0.68	(0.37, 1.25)	0.103	171	0.58	(0.28, 1.65)	0.058
Carer confidence in cooking and preparing healthy food (N = 869)								
Not at all confident / not very confident	184	(reference category)			152	(reference category)		
Confident / extremely confident	685	0.97	(0.57, 1.67)	0.893	551	1.06	(0.55, 2.02)	0.823
Carer confidence in trying new foods (N = 869)								
Not at all confident / not very confident	262	(reference category)			209	(reference category)		
Confident / extremely confident	607	0.89	(0.55, 1.43)	0.531	491	0.87	(0.49, 1.55)	0.541

[a] Adjusted for clustering as a random effect only;

[b] Additionally adjusted for the demographic characteristics of sex, deprivation score, ethnicity, physical activity energy expenditure and height;

[c] UK 1990 growth reference charts;

Table 18: Subgroup analysis using Model 2 multivariate logistic regression models to investigate differences in associations between various factors of the home food environment and child weight status by sex of the child

	Boys				Girls			
Outcome variable = odds of overweight/obesity[c]	n	OR	99% CI	p-value	n	OR	99% CI	p-value
Screen time (hours)	328	0.86	(0.57, 1.30)	0.343	300	1.01	(0.70, 1.46)	0.940
Breakfast (N = 865)								
3 days per week or less	31		(reference category)		26		(reference category)	
4-6 days per week	37	0.37	(0.08, 1.73)	0.097	45	1.66	(0.23, 12.11)	0.510
Every day	311	0.27	(0.08, 0.85)	0.003	289	0.58	(0.33, 10.17)	0.364
Snacking without permission (N = 884)								
Never / Rarely	261		(reference category)		237		(reference category)	
Sometimes	105	1.83	(0.79, 4.23)	0.400	102	0.72	(0.27, 1.91)	0.387
Frequently / Always	24	1.53	(0.33, 6.93)	0.480	28	1.54	(0.49, 6.58)	0.243
Frequency the family sit together at a table for the evening meal (N = 876)								
3 days per week or less	116		(reference category)		87		(reference category)	
4-6 days per week	116	0.57	(0.22, 1.48)	0.131	103	0.82	(0.26, 2.60)	0.661
Every day	155	0.80	(0.34, 1.92)	0.516	173	1.02	(0.36, 2.88)	0.957
Frequency the family go out for dinner (N = 877)								
Less than once per month	226		(reference category)		191		(reference category)	
1-3 times per month	131	0.61	(0.27, 1.38)	0.122	123	0.71	(0.28, 1.80)	0.338
Once a week or more	32	0.92	(0.25, 3.39)	0.873	50	0.94	(0.29, 3.10)	0.902
Frequency the family has fast food (N = 872)								
Less than once per month	144		(reference category)		125		(reference category)	
1-3 times per month	149	1.02	(0.46, 2.26)	0.953	149	0.73	(0.30, 1.80)	0.370
Once a week or more	95	0.54	(0.19, 1.57)	0.136	88	0.56	(0.19, 1.67)	0.175
Carer confidence in cooking and preparing healthy food (N = 869)								
Not at all confident / not very confident	91		(reference category)		69		(reference category)	
Confident / extremely confident	297	0.91	(0.38, 2.15)	0.776	290	1.32	(0.46, 3.77)	0.491
Carer confidence in trying new foods (N = 869)								
Not at all confident / not very confident	117		(reference category)		108		(reference category)	
Confident / extremely confident	269	0.60	(0.27, 1.30)	0.090	250	1.59	(0.61, 4.12)	0.209

[a] Adjusted for clustering as a random effect only;

[b] Additionally adjusted for the demographic characteristics of sex, deprivation score, ethnicity, physical activity energy expenditure, height, and clustering as a random effect;

[c] UK 1990 growth reference charts;

4.4.3 Associations between the composite score for the home food environment and portions of fruit and vegetables consumed

A significant and consistent negative association was found between HFE score and portions of F&V consumed, indicating that children in more obesogenic households consume less F&V (**Table 16**). A one-point increase in HFE score was shown to be associated with just under one third of a portion less F&V consumed in both the total sample and plausible reporters only. The association size between higher HFE scores and lower F&V consumption in boys was slightly greater than in girls (-0.32 (boys) vs. -0.22 (girls); **Table 16**).

Table 19: Multivariate linear regression models to investigate associations between the home food environment score and portions of fruit and vegetable intake

	Model 1[a]				Model 2[b]			
Predictor variable = Home Food Environment score [c]	n	B	95% CI	p-value	n	B	95% CI	p-value
F+V portions	642	-0.30	(-0.45, -0.15)	<0.001	541	-0.29	(-0.42, -0.15)	<0.001
F&V portions (plausible reporters only)	584	-0.30	(-0.41, -0.18)	<0.001	511	-0.29	(-0.41, -0.17)	<0.001
F&V portions (boys only)	337	-0.31	(-0.52, -0.10)	0.004	283	-0.32	(-0.51, -0.13)	0.001
F&V portions (plausible reporting boys only)	310	-0.34	(-0.50, -0.19)	<0.001	269	-0.36	(-0.53, -0.19)	<0.001
F&V portions (girls only)	304	-0.29	(-0.50, -0.07)	0.008	258	-0.22	(-0.41, -0.02)	0.028
F&V portions (plausible reporting girls only)	273	-0.25	(-0.42, -0.08)	0.003	242	-0.21	(-0.38, -0.03)	0.020

F&V = fruit and vegetables

[a] Adjusted for clustering as a random effect only;

[b] Additionally adjusted for the demographic characteristics of sex (not included in sex subgroups), deprivation score, ethnicity; physical activity energy expenditure (kJ/kg/day) and total energy intake (kJ);

[c] See Table 14 for summary of HFE score

4.4.4 Associations between individual aspects of the home food environment and fruit and vegetable consumption

A statistically significant negative association was found between screen time and portions of F&V consumed; an increase of one hour of screen time was associated with reduced consumption of F&V by just under half a portion (Model 2: B = -0.43, (99%CI: -0.79, -0.05), p=0.003; **Table 20**). There was a slight difference in the magnitude and significance of association between the sexes; however, this did not reach our conservative level of significance (**Table 22**).

A positive association was found between children who eat their evening meal at the table with other members of the family every day and intake of F&V, with intakes 1.38 portions higher than those who eat their evening meal at a table with family less than three times per week (Model 2: (99%CI: 0.39, 2.37) p <0.001; **Table 20**). The association size was attenuated slightly in the sensitivity analysis with plausible reporters only, but a difference of more than one portion remained between the two groups (Model 2: B=1.10 (99%CI: 0.21, 2.00) p=0.002; **Table 21**). The magnitude and significance of this association differed between the sex subgroups, with only boys showing a significant increase in portions of F&V consumed with the frequency of eating together at a table with family (**Table 22**). Whilst the 4-6 times per week category did not appear to be significantly different to the reference category at our conservative level of significance in the total sample, a significant trend was found across the groups (p-for-trend < 0.001, **Table 23**). Additionally, there was a differential trend between the sexes, with a significant trend found only in boys (**Table 23**).

Parental confidence in trying new foods was associated with almost a whole portion more F&V consumed by the children, when compared parents/carers who are not confident at trying new foods (B=0.90, 99% CI 0.02, 1.77, p=0.008). The magnitude of association and level of significance was similar in the plausible reporting children (**Table 21**); however, the association appeared to be stronger in boys than in girls (**Table 22**).

Other elements of the HFE showed trends towards higher (parental self-efficacy in cooking and preparing healthy food) and lower (frequent snacking without permission and family having fast food once a week or more) F&V consumption, however these associations failed to meet our conservative level of significance in the total sample (**Table 20**) and therefore spurious findings due to multiple testing cannot be ruled out.

Additionally, consuming breakfast everyday showed a stronger association with F&V intake in plausible reporters than in the main analysis (1.45 more portions in those having breakfast daily compared with those having breakfast 3 times per week or less; 99% CI 0.06, 2.86, p=0.007; **Table 21**), with a significant dose-response across the groups (p-for trend = 0.002; **Table 23**). Therefore, the non-significant result in the larger sample may reflect the greater heterogeneity of dietary data due to the potential inclusion of mis-reporters. There was some evidence of a differential association by sex of the child; however, this did not reach our conservative level of significance (p-for-trend (girls only) = 0.015; **Table 23**).

Results of the multiple imputation analysis were similar in terms of magnitude and significance of association.

Table 20: Multivariate linear regression models to investigate associations between various factors of the home food environment and portions of fruit and vegetable intake

Outcome variable = portions of fruit and vegetables	Model 1 [a]				Model 2 [b]			
	n	B	99% CI	p-value	n	B	99% CI	p-value
Screen time (hours)	702	-0.23	(-0.65, 0.19)	0.155	592	-0.43	(-0.79, -0.05)	0.003
Breakfast (N = 832)								
3 days per week or less	63	(reference category)			51	(reference category)		
4-6 days per week	91	0.06	(-1.92, 2.04)	0.940	78	0.01	(-1.88, 1.89)	0.992
Every day	678	1.00	(-0.60, 2.61)	0.106	564	0.93	(-0.62, 2.49)	0.122
Snacking without permission (N = 850)								
Never / Rarely	553	(reference category)			474	(reference category)		
Sometimes	235	-0.49	(-1.47, 0.49)	0.194	194	-0.47	(-1.42, 0.47)	0.198
Frequently / Always	62	-1.29	(-1.47, 0.38)	0.046	45	-1.30	(-2.99, 0.39)	0.048
Frequency the family sit together at a table for the evening meal (N = 845)								
3 days per week or less	231	(reference category)			191	(reference category)		
4-6 days per week	240	0.89	(-0.23, 2.01)	0.041	204	0.78	(-0.27, 1.84)	0.056
Every day	374	1.56	(0.53, 2.59)	<0.001	310	1.38	(0.39, 2.37)	<0.001
Frequency the family go out for dinner (N = 847)								
Less than once per month	475	(reference category)			394	(reference category)		
1-3 times per month	281	0.54	(-0.41, 1.49)	0.141	237	0.52	(-0.37, 1.41)	0.135
Once a week or more	91	0.18	(-1.24, 1.60)	0.749	77	-0.43	(-1.75, 0.90)	0.404
Frequency the family has fast food (N = 842)								
Less than once per month	309	(reference category)			253	(reference category)		
1-3 times per month	333	0.09	(-0.89, 1.07)	0.820	281	0.25	(-0.67, 1.17)	0.478
Once a week or more	200	-0.59	(-1.74, 0.55)	0.182	171	-0.76	(-1.83, 0.32)	0.070
Parental confidence in cooking and preparing healthy food (N = 837)								
Not at all / not very confident	179	(reference category)			152	(reference category)		
Confident / extremely confident	658	1.07	(0.05, 2.10)	0.007	551	0.94	(-0.04, 1.91)	0.013
Parental confidence in trying new foods (N = 836)								
Not at all / not very confident	253	(reference category)			209	(reference category)		
Confident / extremely confident	583	0.57	(-0.37, 1.51)	0.120	491	0.90	(0.02, 1.77)	0.008

[a] Adjusted for school attended (random effect);

[b] Additionally adjusted for the demographic characteristics of sex, deprivation score, ethnicity; physical activity energy expenditure (kJ/kg/day) and total energy intake (kJ);

Table 21: Multivariate linear regression models to investigate associations between various factors of the home food environment and portions of fruit and vegetable intake (plausible reporters only)

	Model 1 [a]				Model 2 [b]			
Outcome variable = portions of fruit and vegetables	n	B	99% CI	p-value	n	B	99% CI	p-value
Screen time (hours)	630	-0.50	(-0.80, -0.12)	<0.001	553	-0.43	(-0.79, -0.08)	0.002
Breakfast (N = 743)								
3 days per week or less	54		(reference category)		49		(reference category)	
4-6 days per week	76	0.69	(-0.97, 2.34)	0.285	68	0.54	(-1.18, 2.27)	0.420
Every day	613	1.35	(0.34, 2.68)	0.008	529	1.45	(0.06, 2.86)	0.007
Snacking without permission (N = 760)								
Never / Rarely	509		(reference category)		449		(reference category)	
Sometimes	199	-0.34	(-1.14, 0.45)	0.268	172	-0.20	(-1.07, 0.68)	0.566
Frequently / Always	52	-1.05	(-2.43,0.34)	0.049	42	-1.30	(-2.84, 0.24)	0.030
Frequency the family sit together at a table for the evening meal (N = 753)								
3 days per week or less	213		(reference category)		181		(reference category)	
4-6 days per week	213	0.92	(0.03,1.82)	0.008	190	0.86	(-0.10, 1.81)	0.021
Every day	327	1.11	(0.29, 1.93)	<0.001	285	1.10	(0.21, 2.00)	0.002
Frequency the family go out for dinner (N = 755)								
Less than once per month	420		(reference category)		364		(reference category)	
1-3 times per month	254	0.66	(-0.09, 1.42)	0.022	223	0.47	(-0.34, 1.28)	0.135
Once a week or more	81	-0.55	(-1.68, 0.58)	0.211	72	-0.63	(-1.83, 0.58)	0.180
Frequency the family has fast food (N = 749)								
Less than once per month	271		(reference category)		232		(reference category)	
1-3 times per month	301	0.46	(-0.32, 1.24)	0.127	266	0.37	(-0.46, 1.20)	0.253
Once a week or more	177	-0.81	(-1.72, 0.10)	0.021	157	-0.87	(-1.85, 0.11)	0.022
Parental confidence in cooking and preparing healthy food (N = 749)								
Not at all / not very confident	165		(reference category)		146		(reference category)	
Confident / extremely confident	584	0.76	(-0.05, 1.58)	0.016	510	0.65	(-0.23, 1.53)	0.056
Parental confidence in trying new foods (N = 750)								
Not at all / not very confident	218		(reference category)		192		(reference category)	
Confident / extremely confident	532	0.91	(0.15, 1.66)	0.002	462	0.94	(0.12, 1.75)	0.003

[a] Adjusted for school attended (random effect);

[b] Additionally adjusted for the demographic characteristics of sex, deprivation score, ethnicity; physical activity energy expenditure (kJ/kg/day) and total energy intake (kJ);

Table 22: Subgroup analysis using Model 2 multivariate linear regression models to investigate differences in associations between various factors of the home food environment and fruit and vegetable intake by child sex

Outcome variable = portions of fruit and vegetables	Boys [a]				Girls [a]			
	n	B	99% CI	p-value	n	B	99% CI	p-value
Screen time (hours; N=592)	305	-0.46	(-1.00, 0.07)	0.025	287	-0.26	(-0.76, 0.23)	0.170
Breakfast (N=693)								
3 days per week or less	27		(reference category)		24		(reference category)	
4-6 days per week	35	0.62	(-1.79, 3.03)	0.507	43	0.63	(-1.84, 3.10)	0.514
Every day	289	1.49	(-0.41, 3.40)	0.043	275	1.49	(-0.55, 3.53)	0.060
Snacking without permission (N=713)								
Never / Rarely	245		(reference category)		229		(reference category)	
Sometimes	99	-0.26	(-1.44, 0.92)	0.568	95	-0.16	(-1.44, 1.11)	0.744
Frequently / Always	18	-2.48	(-4.86, -0.10)	0.007	27	-0.58	(-2.61, 1.46)	0.465
Frequency the family sit together at a table for the evening meal (N=705)								
3 days per week or less	106		(reference category)		85		(reference category)	
4-6 days per week	109	1.53	(0.29, 2.77)	0.001	95	0.10	(-1.37, 1.57)	0.860
Every day	143	1.29	(0.10, 2.49)	0.005	167	0.78	(-0.55, 2.11)	0.133
Frequency the family go out for dinner (N=708)								
Less than once per month	214		(reference category)		180		(reference category)	
1-3 times per month	117	0.58	(-0.50, 1.67)	0.129	120	0.26	(-0.93, 1.46)	0.572
Once a week or more	30	-0.24	(-2.52, 1.15)	0.334	47	-0.49	(-2.12, 1.13)	0.436
Frequency the family has fast food (N=705)								
Less than once per month	134		(reference category)		119		(reference category)	
1-3 times per month	139	0.51	(-0.61, 1.62)	0.239	142	0.11	(-1.12, 1.35)	0.814
Once a week or more	87	-0.98	(-2.29, 0.33)	0.054	84	-0.77	(-2.22, 0.69)	0.176
Parental confidence in cooking and preparing healthy food (N=703)								
Not at all/not very confident	83		(reference category)		69		(reference category)	
Confident / extremely confident	276	1.00	(-0.15, 2.15)	0.025	275	0.16	(-1.17, 1.49)	0.757
Parental confidence in trying new foods (N=700)								
Not at all /not very confident	107		(reference category)		102		(reference category)	
Confident / extremely confident	250	1.14	(0.03, 2.25)	0.008	241	0.65	(-0.53., 1.84)	0.155

[a] Adjusted for the demographic characteristics of deprivation score, ethnicity, physical activity energy expenditure (kJ/kg/day), total energy intake (kJ); and school attended (random effect).

Table 23: P-for-trend analysis for portions of fruit and vegetables consumed in home food environment factors with more than two categories

	Total sample			Plausible reporters only			Boys only			Girls only		
	Median portions of F&V	IQR	p-for-trend [a]	Median portions of F&V	IQR	p-for-trend [a]	Median portions of F&V	IQR	p-for-trend [b]	Median portions of F&V	IQR	p-for-trend [b]
Breakfast			0.036			0.002			0.391			0.015
3 days per week or less	5.3	(4.8)		5.3	(4.8)		4.8	(5.6)		5.7	(4.4)	
4-6 days per week	6.2	(5.5)		5.9	(4.9)		6.0	(5.0)		6.2	(6.1)	
Every day	6.5	(5.1)		6.4	(4.8)		6.2	(4.9)		5.7	(4.6)	
Snacking without permission			0.033			0.064			0.168			0.196
Never / Rarely	6.5	(5.0)		6.4	(4.7)		6.3	(4.9)		6.7	(5.1)	
Sometimes	6.3	(5.1)		5.9	(4.9)		6.4	(4.9)		6.2	(5.2)	
Frequently / Always	5.3	(5.1)		5.3	(4.2)		4.4	(5.4)		6.2	(5.0)	
Frequency the family sit together at a table for the evening meal			<0.001			0.002			<0.001			0.095
3 days per week or less	5.7	(4.6)		5.6	(4.4)		4.7	(3.7)		6.4	(4.6)	
4-6 days per week	6.2	(5.3)		6.2	(5.4)		6.1	(6.1)		6.2	(5.3)	
Every day	6.7	(5.1)		6.6	(4.7)		6.7	(4.4)		6.7	(5.7)	
Frequency the family go out for dinner			0.955			0.738			0.526			0.863
Less than once per month	6.4	(4.9)		6.3	(4.5)		6.3	(4.9)		6.6	(5.0)	
1-3 times per month	6.5	(5.7)		6.5	(5.6)		6.4	(5.8)		6.6	(5.8)	
Once a week or more	5.7	(5.6)		5.4	(5.3)		5.0	(6.2)		6.2	(5.6)	
Frequency the family has fast food			0.126			0.060			0.342			0.266
Less than once per month	6.6	(5.1)		6.5	(4.8)		6.4	(4.9)		6.8	(5.1)	
1-3 times per month	6.6	(5.0)		6.7	(4.7)		6.6	(5.2)		6.6	(4.9)	
Once a week or more	5.3	(5.0)		5.2	(3.8)		5.2	(5.1)		5.6	(5.4)	

[a] Adjusted for school attended (random effect), sex of the child, deprivation level, ethnicity, physical activity energy expenditure (kJ/kg/day), and total energy intake (kJ); [b] Adjusted for school attended (random effect), deprivation level, ethnicity, physical activity energy expenditure (kJ/kg/day), and total energy intake (kJ)

4.5 Discussion

This study found no evidence of an association between any aspect of the HFE and child weight status in the total sample, however a differential association was found between sexes for frequency of breakfast consumption. A negative association between breakfast consumption and odds of overweight/obesity was found only in boys. However, HFE scores (a composite score of indicators of an obesogenic home food environment) were associated with reduced F&V consumption. Individually, decreased screen time, eating an evening meal at a table with family daily, and increased parental confidence in trying new foods were all found to be significantly associated with increased portions of F&V consumed in this sample of ethnically and socially diverse children from the West Midlands, UK. A significant positive effect of eating an evening meal at a table with family on portions of F&V consumed was found only in boys.

4.5.1 Weight status

The combined effect of elements of the HFE on weight status has not been well researched. However, some cross-sectional associations of multiple aspects of the HFE have shown promising results. For example, Anderson and Whittaker (2010) found that US pre-schoolers (n=8550) exposed to the three household routines of eating family meals together, obtaining adequate sleep, and limiting screen time, had a 40% lower prevalence of overweight/obesity than those following none of these routines (56). Whilst, the cross-sectional nature of this study hinders causal inferences, Anderson *et al.* (2010) highlight that these routines may present promising targets for future intervention (56).

Ihmels *et al*. (2009) also found that Family Nutrition and Physical Activity Tool (FNPA) scores explained a unique variance in BMI z-score increases at one-year follow-up in 6-7 year old children in the US (n=104) and that FNPA score correlation was strongest in the group with the highest baseline BMI z-score (205). Furthermore, whilst Yee *et al*. (2015; n=415; mean age 9.1 (SD1.6)) found that the odds of being overweight was not associated with FNPA score, the authors do report that the odds of a high fat mass in the higher risk (bottom tertile of FNPA scores) group were increased by 74% compared to those in the lower risk group (top tertile of FNPA score; (206)). These studies add weight to the argument that those children who are overweight/obese may be at higher risk of the influences of an obesogenic HFE (205).

Whilst, an association with weight status was not confirmed in the present study, there were several methodological differences between the studies presented above and the present study, which may account for this. Measurement tools used in Anderson et al. (2010), Ihmels et al. (2009) and Yee et al. (2015) all included a wider range of practices than those specifically related to the food environment, for example, the FNPA includes both measures of physical activity and sleep (207). Additionally, all of the studies were conducted in American populations and had different definitions of overweight/obesity.

Further refinement and validation of a HFE tools specifically related to the modifiable aspects of the food environment at home may be warranted. For example, Schrempft *et al*. (2015) found no evidence of an association between Home Environment Interview score with BMI in 4 year olds in the US (n=1096; (208)), however they did find that children in 'higher risk' food environments consumed less fruit and vegetables and more energy-dense snacks and sugar sweetened drinks (208). The impact of these dietary behaviours on weight status trajectories should not be overlooked and the relevance of the HFE in advocating these dietary behaviours not discounted. Future research should investigate the longitudinal association between composite HFE scores and weight status.

Some individual elements of the HFE, previously shown to be associated with weight status were not confirmed in this study sample. For example, a systematic review recently concluded that out-of-home eating (broadly defined to include fast food, take away foods, and restaurant meals) was positively associated with the risk of becoming overweight/obese in adults and children, and that relationship was particularly strong for fast food (209). However, it is important to note that the literature on the relationship between most of the HFE elements explored in this study with overweight and obesity are inconsistent. An example of this can be seen in a systematic review by Valdes *et al.* (2012), who concluded that there was only a weak and inconsistent association between risk of childhood overweight and frequency of family meals (187). Reasons for the inconsistency of the literature in this area may be due to a number of factors. These include study design, age of the children, the weight status thresholds used, and the sociodemographic profile of the participants. Additionally, differences in definition of the HFE element may affect the outcome, for example, a study conducted by Dialektakou and Vranas (2008) in Greece (n=811) demonstrated that the definition of breakfast consumption used may affect whether an association is ultimately found (210).

4.5.2 Fruit and vegetable consumption

The HFE composite score showed that there was an association between households with more obesogenic environments and lower F&V consumption in this sample. This reflects the findings of Jackson *et al*. (2015) who reported a positive association between favourable food environments and F&V intakes using the FNPA tool in rural Oregon, US (n=102; mean age 8.4 years (SD 2.0); (211)).

Screen time was consistently shown to be associated with a reduced consumption of F&V across all models with no moderating effect of sex. This finding lends support to a positive association in what has been shown to be a mixed evidence base (185), and reflects the findings of a recent large scale study of 6-9 year old children (n=10453) conducted in five European countries for the World Health Organisation, which found that each additional hour of screen time was associated with approximately 10% less F&V consumed (212).

In contrast to recent findings, this study found no significant difference between sexes in the association between frequency of breakfast consumption and F&V consumption, although there was a trend towards a stronger association in girls (albeit non-significant; (195, 196)). Over 80% of this sample reported consuming breakfast every day and therefore the difference in results may potentially reflect the younger age range studied, as skipping breakfast is usually positively associated with age, and is more pronounced in girls (213).

A systematic review conducted by Wang *et al*. (2011) found only a weak resemblance between the diets of children and the diets of their parents in the 15 studies selected for meta-analysis (214). However, many studies investigating the impact of parents and siblings on intake of F&V have shown that child and adolescent F&V intake is higher in households where parental intake is high (215, 216). The findings in the present study of a positive association between parental confidence in trying new foods and the family eating together at the table with consumption of F&V reflect these findings, however sex was also found to be a moderating effect on eating together at a table which has not been seen previously.

Some aspects of the HFE shown to be significantly associated with F&V consumption in previous studies showed no evidence of an association in the present study. For example, adolescents with free access to snack foods (through permissive parenting behaviours) have been shown to have lower F&V intakes, both in cross-sectional and longitudinal studies (177), but was not significantly associated in our sample of 5-6 years old children. Again, the difference in results may be due to the younger age group studied, the different method of capturing information about the HFE, a different demographic profile of the study population, or the difference in study design. Further research is required to elucidate whether an association exists between these elements of the HFE and F&V consumption in primary school aged children. The moderating effect of sex observed in the present study highlights the need to consider sex as a potential moderator in the analysis of the HFE.

4.6 Strengths and limitations

Overall, the HFE represents aspects of a child's life that may each be contributing in a small way towards overweight and obesity. However, there is currently no consensus over the elements that constitute the HFE and no gold standard for measurement of it. Hence, whilst there are tools available that have been developed to measure the HFE; they are often lengthy and measure more than just the home environment in relation to food (204, 205, 217-219). To keep participant burden to a minimum, the present study devised a simple score to give an indication of the households that may have more obesogenic features; however, the lack of validation of this method requires the associations found in this study to be interpreted cautiously.

This study calculated portions of F&V consumed based on the guidelines set out by the 5-a-day campaign in which the UK government set a target for the population to consume five portions of F&V daily. Whilst most F&V count continuously towards this recommendation, pulses (due to their low nutrient density) and fruit juice (due to its high free sugar content) are exceptions to the rule, counting as only one portion per day regardless of the number of portions actually consumed (122). Our calculation of F&V portions takes account of this recommendation. However, due to the differing needs for growth, the 5-a-day campaign does not set a portion size in grams for children but states, “As a rough guide, one portion is the amount they can fit in the palm of their hand.” (122) and the Northern Ireland Public Health Agency (NIPHA) have stated that a child portion of fruit and vegetables is “roughly half an adult portion” (123). Therefore, half of the adult portion reported by the UK 5-a-day campaign was used to constitute a portion of F&V. The F&V portions for these analyses were therefore based on a combination of both the guidance from the 5-a-day campaign and the NIPHA (122, 123).

Dietary data was collected prospectively using the CADET tool which uses average portion sizes specific to the child’s age and sex. This reduced the potential for recall bias and the need for weighing of food. The CADET provided an easy to administer and speedy tool requiring minimal training and with relatively low respondent burden. However, as the F&V intake used in this study is based on only one weekday record of consumption, it may not be reflective of habitual or weekend intake.

Misreporting of dietary data can lead to diminished estimates of associations with health outcomes (84). Sensitivity analyses using only plausible reporters as determined through the Goldberg calculations were conducted to check if the inclusion of potentially mis-reported dietary intakes affected the study outcomes. Additionally, multiple imputation analysis was conducted to check for the impact of missing covariate data on the reported associations. The consistency of outcomes between the main and sensitivity analyses strengthens the validity of the results as it confirms that the observed outcomes in the main analyses do not result from the inclusion of potentially misreported or missing data (85).

Both the CADET and the parental questionnaire required parent/carers to self-complete. However, to reduce the impact this may have on parents/carers with low English literacy levels (a consideration in this ethnically and socially diverse sample), participants were provided with a DVD containing verbal and visual instructions on how to complete the CADET booklet. Parents/carers were also offered documents in other languages upon request and schools were encouraged to offer language support where necessary.

The sample included children from diverse socioeconomic backgrounds, ruralities, and ethnicities, which strengthens the external validity of the findings. However, the use of non-validated instruments to measure the HFE, the limited geographical area sampled from, and the narrow age range of participants limits generalisability. Whilst generally seen as a strength, the diversity of the sample could also be seen as a limitation of this study as it increases the variability of the study sample. Lower socioeconomic status groups and some ethnic minority groups may have a higher prevalence of obesogenic home environments, therefore future work may wish to consider investigating subgroup associations between HFE and weight status (220).

4.7 Conclusion

This study, including a diverse sample of primary school-aged children from the West Midlands, UK, is suggestive of less obesogenic HFEs being associated with higher childhood intake of F&V. Evidence has shown that diets rich in fruits and vegetables can have wide reaching health implications leading to a reduction in morbidity and mortality from various chronic disease, e.g. cardiovascular disease and type 2 diabetes mellitus. However, the evidence on the association between fruit and vegetable intake and risk of obesity is inconclusive. Further work is needed to develop valid tools that identify households with multiple obesogenic practices and interventions that may help curb these behaviours amongst families to improve dietary habits and decrease lifetime disease risk. Brief, validated tools that assess the HFE as a whole are required to aid investigation of these factors in large-scale population research. Repeated assessments to investigate the impact of the HFE on weight status trajectories and the stability of household rules and routines in relation to food and the feeding environment over time are also required.

Chapter Five: Parent feeding practices and child eating behaviours - investigating the relationship cross-sectionally and over-time with child weight status and percentage of energy consumed from free sugars

Contributions: KLH developed the idea for the study with guidance from PA, MJP, and ERL. The WAVES study research team (including KLH) were responsible for collecting, inputting, and cleaning the data. The Nutrition Epidemiology Group at the University of Leeds was responsible for processing most of the dietary data, however, KLH and TG calculated the percentage of energy from free sugar and contributed to the dietary data processing programme modifications required for the WAVES study. KLH conducted the statistical analyses and wrote the chapter, guided by PA, MJP, and ERL.

5.1 Background

Excess weight in children is an important public health concern, with adverse physical and psychosocial consequences in childhood, and increased risk of morbidity and mortality in later life (221, 222). Understanding the multi-factorial aetiology of obesity will inform approaches aiming to reverse the upward trend in childhood obesity prevalence (223).

5.1.1 Parent/Carer Feeding Practices

A recent review of twin studies showed that common environmental factors, such as parent feeding practices, have a substantial effect on Body Mass Index (BMI) from childhood through to adolescence (224). Parents/carers (subsequently referred to as parents) influence children's eating patterns and ultimately their children's weight development through their feeding practices (techniques and behaviours used to influence a child's diet; (225)), the home food environment (availability, structure, and provision of food in the home), and their personal eating behaviour (226). There is also evidence of 'intergenerational ripples', whereby parents develop their feeding practices based on their own childhood feeding experience (227). Therefore, understanding the effect of parental feeding practices on children's diet and weight status could inform the development of interventions with potential impact beyond the current generation. This has been noted as a research priority to improve obesity prevention strategies in childhood (228).

Evidence from a variety of studies suggests that certain parent feeding practices are associated with child weight status. For example, restrictive feeding practices are associated with higher weight status (226, 229-233), whilst pressure to eat (PTE) is related to lower weight status (226, 232-235). However, these findings are inconsistent and sometimes conflicting (235-239), particularly in relation to other parent feeding practices (for example, using food as a reward; (232, 233, 236, 237)). Additionally, the majority of research fails to recognise the impact of the child in influencing the parental choice of feeding practice. For example, Shloim *et al.* (2015) noted in their systematic review, that where child characteristics were measured, the parental feeding practices employed were responsive to the child e.g. greater restriction was seen in larger children and greater pressure to eat in thinner children (69). Therefore, future research must consider the possibility of reverse causation, whereby the child's weight status and appetitive traits may be driving specific parental feeding practices rather than a consequence of them.

Evidence surrounding the effects of various parent feeding practices on children's dietary intake is sparse. Fruit and vegetable (F&V) intake is often the focus of research into the influence of parent feeding practices on their children's diet as high F&V consumption has been associated with lower all-cause and cardiovascular mortality risk (240). Various investigations have found that parental consumption of F&V (216, 241), modelling of healthy food intake (242, 243), and employing child-centred feeding practices (e.g. reasoning and praise; (244)) are associated with increased F&V consumption in children. However, the association between parent feeding practices and other dietary components has been scarcely researched.

Free sugar consumption refers to the intake of simple carbohydrates that are readily absorbed for use as energy. In a recent report, the Scientific Advisory Committee on Nutrition (SACN) advised that diets high in free sugars are associated with weight gain and tooth decay in children, therefore the recommendation for dietary free sugar intakes was reduced from 10% of total energy intake (TEI) to 5% TEI for the population over two years old in the UK (102). However, there is a paucity of research investigating the association between parental feeding practices, child eating behaviours, and free sugar consumption. In a review of the literature surrounding restriction and pressure to eat, Loth (2016) concluded that children exposed to high levels of these feeding practices are more likely to consume sugar-sweetened beverages (SSBs), and energy-dense, nutrient-poor (EDNP) foods than children exposed to lower levels (245). Additionally, two recent studies specifically focusing on SSB consumption (which substantially contribute to free sugar intakes) found that paternal intake of SSBs (241) and maternal use of restriction (246) were associated with increased child SSB consumption, whereas limit setting was associated with lower SSB consumption in children (246). Consumption of EDNP foods and/or SSBs are likely to lead to free sugars making a greater contribution to overall energy intake and diets that exceed the recommended maximum level of 5% TEI.

5.1.2 Child Eating Behaviours

Eating behaviours in children can also have an impact on a child's weight status. The 'externality theory' was first introduced in 1968 from clinical observations with obese adults, whereby obese subjects were more reactive to external cues and less responsive to internal cues regarding satiety and hunger (247). Extensions of this work in children have led to the investigation of several traits which may influence a child's risk of weight gain including food approaching behaviours, such as eating in the absence of hunger (248) and in response to emotions (249, 250); and food limiting behaviours such as food fussiness (58). A number of studies have shown a graded association between appetite and weight, rather than an atypical eating style that is only associated with the obese population (58) and therefore assessment of appetitive traits in relation to unfavourable dietary habits in children may identify those at-risk of obesity whilst they are still a healthy weight (251).

In addition, most previous studies have been conducted in predominantly white, middle-income populations (252) and research using samples that are more diverse has suggested associations between feeding practices and weight may not be as prevalent in children who are predominantly non-White and children from a low socioeconomic background (253). Given that feeding practices vary between different cultures and by socio-economic status, there is a need to explore the relationship between parent feeding practices, child eating behaviours, and child dietary intake and weight status in more diverse samples (230, 234, 254).

5.2 Aims

This study will investigate, cross-sectionally and longitudinally, the relationship between parent feeding practices and child eating behaviours in relation to child weight status and proportion of TEI from free sugar (%sugar) in a socially and ethnically diverse sample of UK children.

It is hypothesised that parental feeding practices that use food as a reward or to regulate emotion will be associated with greater likelihood of overweight /obesity and higher %sugar intake in children and practices which promote healthy eating or food environments will be associated with reduced likelihood of overweight /obesity and

%sugar intake in children. It is anticipated that these results will be independent of the baseline values of each outcome and current activity level.

5.3 Methods

Data collected, between 2011 and 2014, at the baseline (children aged 5-6 years), first (children aged 7-8 years) and second (children aged 8-9 years) follow-up for the **W**est Midlands **A**cti**V**e lifestyle and healthy **E**ating in **S**chool children (WAVES) study were used in these analyses. Written informed consent was obtained from parents and verbal assent from children was obtained prior to measurements commencing. For further information on the sampling strategy and consent process can be found in Chapter 2 (Section 2.2).

5.3.1 Validated questionnaires

Data on parent feeding practices and child eating behaviours were collected through a self-administered questionnaire booklet sent home for completion by the child's main parent (self-defined) at the first follow-up (F1) when the children were 7-8 years. Parents were requested to either return the questionnaire to their child's school within five days for collection by a researcher or via a freepost envelope directly to the research team.

Subscales of the Comprehensive Feeding Practices Questionnaire (CFPQ) were used to assess a wide range of parent feeding practices (255). The CFPQ was used to assess parent feeding practices in preference to the more widely used Child Feeding Questionnaire (CFQ) as it allowed for a wider range of feeding practices to be investigated. This questionnaire is based on and extends upon selected subscales of the two most widely used instruments, CFQ and Pre-schooler Feeding Questionnaire (PFQ) (239). The CFPQ has been shown to be valid in children up to twelve years old (239, 255, 256) and in varied cultural contexts (256-258). However, to keep respondent burden to a minimum, only selected subscales of the CFPQ were included in the parent questionnaire. These were emotion regulation; food as a reward; monitoring; modelling; pressure to eat (PTE); environment; child control; and restriction for weight control (RWC). **Table 24** shows the subscale descriptions and items included. Minor wording changes from the original questionnaire were applied to make the tool appropriate for a UK population e.g. replacing 'Soda' with 'Fizzy pop'.

To consider child eating behaviours, three food-approach subscales (food responsiveness, enjoyment of food, and emotional over eating) and three food-limiting subscales (satiety responsiveness, food fussiness, and emotional under eating) were included from the Child Eating Behaviour Questionnaire (CEBQ; **Table 25**; (249)). Composite scores were created for overall CEBQ food-approach and food-limiting subscales as per Blissett *et al.* (2013; (257)). Previous studies have shown this tool to be reliable and valid and to have good agreement with observed eating behaviour (58, 226, 249).

Both the CEBQ and CFPQ use Likert scales ranging from one (never) to five (always) for each item. For ease of interpretation, scores for all items in each subscale were summed and divided by the number of items creating a score range of 1-5 for each subscale. Subscale scores were not calculated if there were missing data from more than one (3-5 item scales) or two (6-8 item scales) item(s). Where subscale scores were calculated with missing data, the subscale was standardised using the completed number of items as the denominator.

Table 24: Subscales of the Comprehensive Feeding Practices Questionnaire used within Chapter 5 (255)

Subscale	Description	Items
Emotion Regulation (3 items)	Use of food to regulate child's emotional state	When this child gets fussy, is giving him/her something to eat or drink the first thing you do? Do you give this child something to eat or drink if s/he is bored even if you think s/he is not hungry? Do you give this child something to eat or drink if s/he is upset even if you think s/he is not hungry?
Food as a reward (3 items)	Food is used as a reward for good behaviour.	I offer sweets (candy, ice cream, cake, pastries) to my child as a reward for good behaviour. I withhold sweets/dessert from my child in response to bad behaviour. I offer my child his/her favourite foods in exchange for good behaviour.
Monitoring (4 items)	Keeping track of child's intake of less healthy foods.	How much do you keep track of the sweets (candy, ice cream, cake, pies, pastries) that your child eats? How much do you keep track of the snack food (potato chips, Doritos, cheese puffs) that your child eats? How much do you keep track of the high-fat foods that your child eats? How much do you keep track of the sugary drinks (soda/pop, Kool-Aid) this child drinks?
Modelling (4 items)	Actively demonstrating healthy eating for the child.	I model healthy eating for my child by eating healthy foods myself. I try to eat healthy foods in front of my child, even if they are not my favourite. I try to show enthusiasm about eating healthy foods. I show my child how much I enjoy eating healthy foods.
Pressure to eat (4 items)	Pressure the child to consume more food at meals.	My child should always eat all of the food on his/her plate. If my child says, ''I'm not hungry,'' I try to get him/her to eat anyway. If my child eats only a small helping, I try to get him/her to eat more. When he/she says he/she is finished eating, I try to get my child to eat one more (two more, etc.) bites of food.
Environment (4 items)	Make healthy foods available in the home.	Most of the food I keep in the house is healthy. I keep a lot of snack food (potato chips, Doritos, cheese puffs) in my house. ***(R)*** A variety of healthy foods are available to my child at each meal served at home. I keep a lot of sweets (candy, ice cream, cake, pies, pastries) in my house. ***(R)***
Child Control (5 items)	Allow the child control of his/her eating behaviours and parent–child feeding interactions.	Do you let your child eat whatever s/he wants? At dinner, do you let this child choose the foods s/he wants from what is served? If this child does not like what is being served, do you make something else? Do you allow this child to eat snacks whenever s/he wants? Do you allow this child to leave the table when s/he is full, even if your family is not done eating?
Restriction for weight control (8 items)	Control the child's food intake with the purpose of decreasing or maintaining the child's weight.	I have to be sure that my child does not eat too many high-fat foods. I encourage my child to eat less so he/she won't get fat. I give my child small helpings at meals to control his/her weight. If my child eats more than usual at one meal, I try to restrict his/her eating at the next meal. I restrict the food my child eats that might make him/her fat. There are certain foods my child shouldn't eat because they will make him/her fat. I don't allow my child to eat between meals because I don't want him/her to get fat. I often put my child on a diet to control his/her weight.

(R) = item is reverse scored

Table 25: Subscales of the Child Eating Behaviour Questionnaire used within Chapter 5 (249)

Subscale	Description	Items
Child Food-Approach Behaviours		
Food responsiveness (5 items)	Eating in response to environmental food cues	Given the choice, my child would eat most of the time Even if my child is full up s/he finds room to eat his/her favourite food If given the chance, my child would always have food in his/her mouth My child is always asking for food If allowed to, my child would eat too much
Enjoyment of food (4 items)	General interest in food and eating	My child loves food My child is interested in food My child looks forward to mealtimes My child enjoys eating
Emotional over-eating (4 items)	An increase in eating in response to negative emotions, such as anger and anxiety	My child eats more when worried My child eats more when annoyed My child eats more when anxious My child eats more when s/he has nothing else to do
Child Food-Limiting Behaviours		
Satiety responsiveness (5 items)	Reduction of food intake after eating to regulate energy intake (responding to internal fullness cues)	My child has a big appetite ***(R)*** My child gets full before his/her meal is finished My child gets full up easily My child cannot eat a meal if s/he has had a snack just before My child leaves food on his/her plate at the end of a meal
Food fussiness (6 items)	Refusal to consume some familiar foods as well as 'new' foods leading to the consumption of a poor variety of foods	My child refuses new foods at first My child is difficult to please with meals My child enjoys tasting new foods ***(R)*** My child is interested in tasting food s/he hasn’t tasted before ***(R)*** My child enjoys a wide variety of foods ***(R)*** My child decides that s/he doesn’t like a food, even without tasting it
Emotional under-eating (4 items)	A decrease in eating in response to negative emotions, such as anger and anxiety	My child eats less when angry My child eats less when s/he is tired My child eats more when she is happy My child eats less when upset

(R) = item is reverse scored

5.3.2 Weight status

Weight status was defined using the British 1990 (UK90) growth reference charts (111). Children were categorised as underweight, healthy weight, overweight, or obese using the age and sex specific 2nd, 85th, and 95th centile cut-offs, respectively (111). More detail on the calculation of weight status categories can be found in Chapter 2 (Section 2.3.1).

5.3.3 Dietary intake

The Child and Diet Evaluation Tool (CADET) was used to assess dietary intake over 24 hours on a school day. Free sugar consumption was expressed as the percentage of total energy intake from free sugar (%sugar). The %sugar was calculated as free sugar intake (g) multiplied by 16 kJ (the amount of energy in one gram (118)), divided by total energy intake (kJ), and multiplied by 100. Chapter 2 contains further detail regarding the dietary data collection and calculation of free sugar intake (Section 2.4).

5.3.4 Other variables

Further adjusted models included variables for child sex and height, household English Indices of Multiple Deprivation (IMD) 2010 score, parent age and ethnicity, child baseline BMI z-score (weight status models) or baseline %sugar intake (%sugar models), and current child physical activity energy expenditure (kJ/kg/day). Where parent ethnicity was missing, child ethnicity was used as a proxy. Detailed descriptions of these variables can be found in Chapter 2 (Sections 2.5).

5.3.5 Statistical methods

Statistical analysis was performed using STATA 13 (StataCorp LP, US) and an *a priori* significance level of 1% (two-sided) was used for all analyses to account for the potential type one error associated with multiple testing.

Parents and children participating in the WAVES study were included in the present study if a questionnaire booklet was returned and child weight status or 24-hour dietary information was available. Descriptive statistics were used to summarise participant characteristics by child weight status. The internal validity of all questionnaire subscales was assessed using Cronbach Alpha.

To account for the clustered nature of the sample, mixed-effects models were used to evaluate the relationship between CFPQ subscales/CEBQ composite scores, and overweight/obesity (mixed-effects logistic regression), and %sugar intake (mixed-effects linear regression). Four models are presented. Model 1 adjusts for the WAVES study trial arm allocation (fixed effect) and school attended (random effect) to account for the data being collected after delivery of the WAVES study intervention and the inherently clustered nature of this sample. Model 2 additionally includes sex and height of the child, deprivation score (IMD), and parent level factors (age and ethnicity). Model 3 adds baseline BMI z-score (weight status analyses) or baseline %sugar intake (%sugar analyses) to the models to investigate whether any associations exist independent of baseline values. The final model (Model 4) adds physical activity energy expenditure. This was added separately to the other model covariates as the level of missing data substantially reduced the number of participants included in the model.

5.3.6 Sensitivity analysis

All %sugar analyses were repeated using only those children deemed plausible reporters via the Goldberg methods (F1: n = 736; F2: n=677) to assess the potential effect of misreporting of dietary intake on the outcomes (Chapter 2, Section 2.4.4).

Due to the large amount of missing data for some covariates, (e.g. F2 physical activity energy expenditure (n=322)), the sample sizes included in the further-adjusted models were reduced. To consider the impact of this missing data on the relationships investigated, all further adjusted models were repeated on an imputed dataset. Generation of imputed datasets was conducted in REALCOM-Impute (152) to account for the clustered nature of the sample, imported into STATA using the Realcomimputeload command, and analysed in STATA 13. Generation of imputed datasets included the following variables: the relevant follow-up one or follow-up two outcome value (i.e. weight status or %sugar intake), the relevant baseline outcome value (i.e. BMI z-score or %sugar intake), deprivation score, age at follow-up one, physical activity energy expenditure at follow-up one, physical activity energy expenditure at follow-up two, energy intake at follow-up one, energy intake at follow-up two, height at follow-up one, height at follow-up two, age, sex, ethnicity, trial arm allocation, school level free school meal entitlement, and school level ethnic mix. The results of ten imputed datasets were pooled to produce imputation estimates (259).

5.4 Results

5.4.1 Sample description

There were between 737-833 parent-child dyads included in these analyses (50-57% of the WAVES study cohort, **Figure 12**). Compared to children whose parents did not return the relevant questionnaire, children of responders were less likely to be from the most deprived IMD quintile (50% for children with a returned questionnaire (returned) vs. 62% for children without a returned questionnaire (not returned)). In contrast, they were more likely to be from the least deprived IMD quintiles (Quintile 4: 11% (returned) vs. 5% (not returned) or Quintile 5 (most deprived; 10% (returned) vs. 5% (not returned)). They were also more likely to be of White ethnicity (50% (returned) vs. 39% (not returned)) and less likely to be of Black (6% (returned) vs. 11% (not returned)) or Other/Mixed ethnicity (14% (returned) vs. 20% (not returned)).

The demographic profiles of those included in each analysis were similar to that for the children whose parent returned the relevant questionnaire. With regard to weight status however, children included in the cross-sectional analyses were less likely to be overweight/obese (25% (included) vs. 30% (not included)), than those who were not included. For those included in the longitudinal analyses (where a weight status was available), overweight/obesity prevalence was similar to those who did not return a questionnaire (31% and 32% for the weight status and %sugar, respectively).

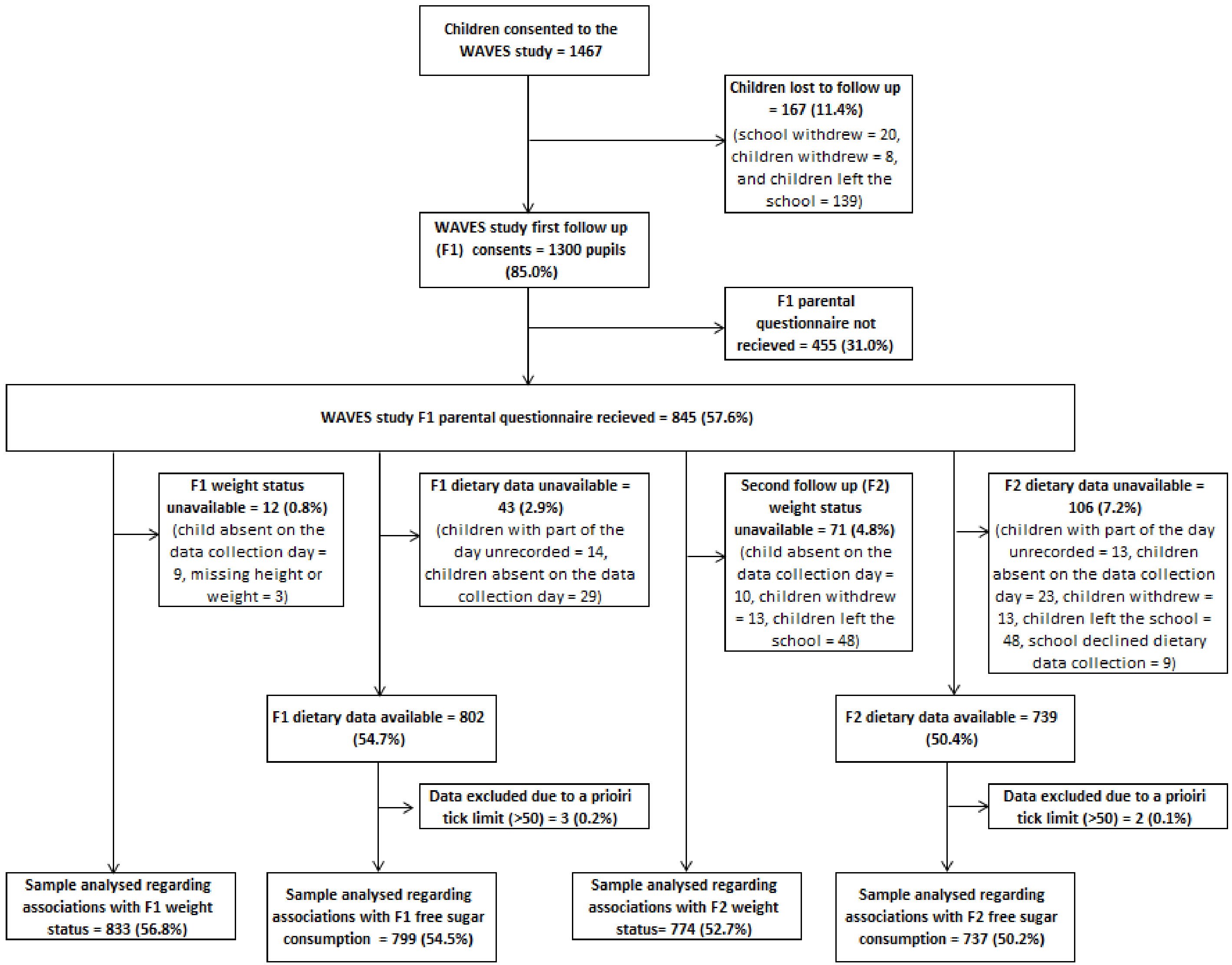


Figure 12: Flow diagram of participants from the overarching WAVES study for the Chapter 5 study sample

Child and parent characteristics at F1 are described by child weight status in **Table 26**. Overall, 80% of responders were mothers, 16% fathers, and 4% other relatives (e.g. grandmother, stepfather, or aunt). The mean parent age was 36.7 years (SD 6.7 years). Additionally, just over a quarter of children were overweight or obese (24.8%). More boys were overweight/obese than girls, and children of a Black ethnicity were more likely to be obese than White children, which are in line with England averages (30). National averages show a clear trend in overweight/obesity prevalence across deprivation groups. This trend was less clear within the study sample as Quintile 2 (more deprived) and 5 (least deprived), were the only subgroups to differ from the reference category (Quintile 1 – most deprived).

Table 26: Chapter 5 sample description, by weight status

	Weight status groups[a]						
	Not overweight/obese (n=626)		Overweight (n=86)		Obese (n=121)		p-value
Child Age (years) N=833, mean (SD)[b]	7.7	(0.3)	7.7	(0.3)	7.7	(0.3)	0.600
Sex of the child (N=833, n (%))[c]							
Males	310	(73.5)	43	(10.2)	69	(16.4)	(reference)
Females	316	(76.9)	43	(10.5)	52	(12.7)	0.013
Child Ethnicity (N=833, n (%))[c]							
White	320	(77.3)	44	(10.6)	50	(12.1)	(reference)
South Asian	190	(74.8)	27	(10.6)	37	(14.6)	0.332
Black	30	(60.0)	6	(12.0)	14	(28.0)	0.026
Other/Mixed	86	(74.8)	9	(7.8)	20	(17.4)	0.380
Average physical activity energy expenditure (kJ/kg/day; mean (SD); N=802)[b]	92.7	(25.5)	86.2	(21.9)	88.4	(22.8)	0.145
IMD quintiles (N=824, n (%))[c]							
Quintile 1 (more deprived)	298	(72.9)	44	(10.8)	67	(16.4)	(reference)
Quintile 2	120	(77.4)	13	(8.4)	22	(14.2)	0.040
Quintile 3	72	(78.3)	9	(9.8)	11	(12.0)	0.291
Quintile 4	66	(75.9)	9	(10.3)	12	(13.8)	0.318
Quintile 5 (less deprived)	62	(76.5)	10	(12.4)	9	(11.1)	0.049
Main carer relationship to child (N=828, n (%))[c]							
Mother	509	(76.7)	65	(9.8)	90	(13.6)	(reference)
Father	91	(69.5)	16	(12.2)	24	(18.3)	0.073
Other	22	(66.7)	5	(15.2)	6	(18.2)	0.195
Main carer age ((years) N=781, mean (SD))[b]	36.7	(6.6)	37.0	(6.9)	36.9	(6.3)	0.556

[a] Based on the UK 1990 growth reference data (UK90);
[b] p-values generated using mixed effect linear regression models, fitting weight status as a continuous variable, controlling for WAVES study trial arm allocation as a fixed effect, and school attended as a random effect
[c] p-values generated using multinomial logistic regression models, fitting weight status as a continuous variable, controlling for WAVES study trial arm allocation as a fixed effect, and using robust standard errors to account for clustering

Questionnaire subscale response rates ranged from 89% (parent feeding practice: modelling) to 93% (child eating behaviour: enjoyment of food). All questionnaire subscales had moderate to good internal consistency. Cronbach Alphas (α) for

CEBQ ranged from 0.7 (emotional over-eating) to 0.9 (enjoyment of food) and for CFPQ ranged from 0.6 (environment) to 0.9 (monitoring; (**Table 27**)).

Table 27: Internal consistency tests using Cronbach Alphas

	number of items	α
CFPQ subscale		
Monitoring	4	0.9
Child control	5	0.7
Emotion regulation	3	0.8
Environment	4	0.6
Pressure to eat	4	0.7
Restriction for weight control	8	0.8
Food as a reward	3	0.7
Modeling	4	0.8
CEBQ subscale		
Enjoyment of Food	4	0.9
Food Responsiveness	5	0.8
Emotional Over Eating	4	0.7
Satiety Responsiveness	5	0.7
Food Fussiness	6	0.9
Emotional Under Eating	4	0.7

5.4.2 Trends in mean scores

High median scores were seen in the parent feeding practices of monitoring and modelling across all weight status categories, indicating that parents in this sample believe these to be the feeding practices most frequently employ (**Table 28**). Clear trends across weight stats groups can be seen for the parent feeding practices of emotion regulation, pressure to eat, and restriction for weight control, with parents of obese children using more restriction and emotion regulation and less pressure to eat.

Table 28: Average subscale scores for parent feeding practices and child eating behaviours, by child weight status.

	Child weight status [a]								
	Not overweight/obese (n=626)		Overweight (n=86)		Obese (n=121)		Total (n=833)		p-for-trend [b]
Carer feeding practices									
Monitoring (N=761; median (IQR))	4.0	(1.5)	4.0	(1.5)	4.0	(1.0)	4.0	(1.5)	0.444
Child control (N=763; median (IQR))	2.4	(1.3)	2.2	(1.0)	2.3	(1.2)	2.4	(1.0)	0.409
Emotion regulation (N=763; median (IQR))	1.3	(1.0)	1.6	(1.2)	1.7	(1.0)	1.3	(1.0)	0.029
Environment (N=760; median (IQR))	3.7	(0.8)	3.5	(1.3)	3.5	(1.3)	3.6	(1.0)	0.389
Pressure to eat (N=743; median (IQR))	3.5	(1.3)	3.0	(1.0)	2.8	(1.5)	3.3	(1.3)	<0.001
Restriction for weight control (N=743; median (IQR))	2.3	(1.1)	2.6	(1.3)	3.1	(1.1)	2.4	(1.3)	<0.001
Food as a reward (N=758; median (IQR))	2.7	(1.7)	2.3	(2.0)	2.7	(1.8)	2.7	(1.7)	0.376
Modelling (N=742; median (IQR))	4.0	(1.3)	3.8	(1.3)	4.0	(1.5)	4.0	(1.5)	0.104
Child eating behaviours									
Food Approach composite score (N=755; mean (SD))[c]	2.6	(0.6)	2.6	(0.6)	2.9	(0.7)	2.6	(0.6)	<0.001
Food Limiting composite score (N=755; mean (SD))[d]	2.6	(0.6)	2.5	(0.5)	2.6	(0.5)	2.6	(0.6)	0.794

[a] Based on the UK 1990 growth reference data (UK90);
[b] Adjusted for cluster (random effect) and WAVES study trial arm;
[c] Standardised composite score for enjoyment of food, food responsiveness, and emotional overeating;
[d] Standardised composite score for satiety responsiveness, food fussiness, and emotional under-eating.

5.4.3 Weight status

Table 29 shows the associations between subscales of parent feeding practices, and child eating behaviours, in relation to the odds of overweight/obesity both cross-sectionally and longitudinally. In Models 1 and 2 at both time points, a clear association with weight status can be seen for the parental feeding practices of 'pressure to eat' (negative association) and 'restriction of weight control' (positive association) and the child 'food approach' eating behaviours (positive association). However, the addition of baseline BMI z-score (aged 5-6 year) in Model 3 shows a reduction in magnitude and loss of significance of these associations and, for child food approach eating behaviours, a change in direction of effect.

Greater use of the parental feeding practice of 'emotion regulation' was associated with a 69% (99% CI: 0-286%) greater risk of overweight/obesity at 8-9 years after adjustment for baseline BMI z-score, although the confidence interval was wide and included no effect at the lower interval. A higher score on the parental feeding practice of 'environment' was associated with a 41% (99% CI: 36-97%) lower risk of overweight/obesity after adjustment for baseline BMI z-score (Model 3), however the inclusion of physical activity energy expenditure in Model 4, reduced the number of included children significantly, and widened the confidence interval over the point of no effect (**Table 29**). All other Model 4 analyses were consistent with the Model 3 analyses.

The results of the multiple imputation sensitivity analysis were comparable to those reported with similar direction and magnitudes of association. However, the imputed data resulted in narrower confidence intervals and a change in significance for ‘emotion regulation’ longitudinally (MI Model 4: OR=0.54 (0.98, 1.02) p=0.013). Additionally, the non-significant result in Model 4 for ‘environment’ became significant in the imputation models suggesting that the difference in significance between Model 3 and Model 4 in the total sample may be the result of the missing data for physical activity energy expenditure (MI Model 4: OR=0.57 (0.36, 0.90) p=0.002.

Table 29: Multivariate mixed-effects logistic regression models exploring the relationships between Comprehensive Feeding Practices Questionnaire subscales and Child Eating Behaviour Questionnaire subscales with child weight status

	Model 1[a]				Model 2[b]				Model 3[c]				Model 4[d]			
	n	OR	99% CI	p-value	n	OR	99% CI	p-value	n	OR	99% CI	p-value	n	OR	99% CI	p-value
Outcome variable = odds of overweight/obesity at age 7-8 years																
CFPQ subscale																
Monitoring	761	0.95	(0.73, 1.22)	0.581	712	0.93	(0.69, 1.27)	0.562	679	0.95	(0.58, 1.58)	0.804	550	0.79	(0.45, 1.39)	0.283
Child control	763	1.09	(0.80, 1.47)	0.482	714	1.07	(0.74, 1.54)	0.652	681	1.12	(0.60, 2.11)	0.642	552	1.13	(0.54, 2.37)	0.680
Emotion regulation	763	1.26	(0.96, 1.65)	0.027	714	1.17	(0.84, 1.65)	0.222	682	1.15	(0.64, 2.04)	0.545	554	1.11	(0.56, 2.21)	0.700
Environment	760	0.90	(0.66, 1.21)	0.343	711	0.84	(0.60, 1.18)	0.182	678	0.66	(0.38, 1.13)	0.047	551	0.60	(0.32, 1.13)	0.037
Pressure to eat	743	0.59	(0.46, 0.76)	<0.001	698	0.60	(0.45, 0.79)	<0.001	665	0.95	(0.60, 1.51)	0.776	539	0.95	(0.56, 1.60)	0.807
Restriction for weight control	743	2.59	(1.93, 3.48)	<0.001	699	2.63	(1.87, 3.69)	<0.001	666	1.55	(0.88, 2.71)	0.045	541	1.44	(0.76, 2.73)	0.137
Food as a reward	758	0.91	(0.75, 1.12)	0.258	711	0.87	(0.69, 1.10)	0.117	678	0.88	(0.59, 1.29)	0.384	551	0.87	(0.55, 1.36)	0.407
Modelling	742	0.85	(0.66, 1.08)	0.085	698	0.82	(0.63, 1.08)	0.063	665	0.66	(0.40, 1.10)	0.036	540	0.58	(0.32, 1.06)	0.019
CEBQ composite scores																
Food approach behaviours[e]	755	1.98	(1.35, 2.89)	<0.001	707	2.06	(1.38, 3.07)	<0.001	671	0.88	(0.43, 1.79)	0.642	545	0.75	(0.33, 1.70)	0.366
Food limiting behaviours[f]	755	0.90	(0.62, 1.32)	0.480	707	0.85	(0.56, 1.27)	0.292	671	1.24	(0.59, 2.63)	0.442	545	1.18	(0.52, 2.69)	0.597

Table 29 continued overleaf

Table 29 continued	Model 1[a]				Model 2[b]				Model 3[c]				Model 4[d]			
	n	OR	99% CI	p-value	n	OR	99% CI	p-value	n	OR	99% CI	p-value	n	OR	99% CI	p-value
Outcome variable = odds of overweight/obesity at age 8-9 years																
CFPQ subscale																
Monitoring	710	0.96	(0.75, 1.24)	0.701	663	0.91	(0.68, 1.23)	0.432	631	0.85	(0.54, 1.35)	0.371	434	0.75	(0.42, 1.35)	0.208
Child control	712	1.11	(0.82, 1.52)	0.363	665	1.21	(0.83, 1.74)	0.192	633	1.42	(0.80 2.52)	0.119	436	1.30	(0.61, 2.75)	0.372
Emotion regulation	712	1.28	(0.98, 1.67)	0.015	665	1.34	(0.96, 1.86)	0.023	634	1.69	(1.00, 2.86)	0.010	436	2.45	(1.20, 5.01)	0.001
Environment	709	0.83	(0.62, 1.10)	0.091	630	0.78	(0.56, 1.07)	0.043	630	0.59	(0.36, 0.97)	0.005	435	0.55	(0.29, 1.04)	0.015
Pressure to eat	694	0.55	(0.43, 0.71)	<0.001	651	0.58	(0.44, 0.76)	<0.001	619	0.80	(0.53, 1.22)	0.176	430	0.85	(0.48, 1.49)	0.443
Restriction for weight control	694	2.12	(1.61, 2.78)	<0.001	652	2.12	(1.54, 2.93)	<0.001	620	1.26	(0.78, 2.05)	0.218	431	1.66	(0.86, 3.21)	0.048
Food as a reward	707	0.96	(0.79, 1.18)	0.615	662	0.89	(0.71, 1.12)	0.198	630	0.97	(0.68, 1.39)	0.842	435	1.21	(0.76, 1.93)	0.284
Modelling	693	0.87	(0.69, 1.11)	0.144	651	0.87	(0.66, 1.13)	0.169	619	0.72	(0.47, 1.12)	0.055	430	0.78	(0.45, 1.34)	0.237
CEBQ composite scores																
Food approach behaviours[e]	704	1.92	(1.31, 2.81)	<0.001	656	1.93	(1.27, 2.93)	<0.001	624	1.19	(0.63, 2.23)	0.486	429	1.42	(0.63, 3.18)	0.262
Food limiting behaviours[f]	704	0.99	(0.68, 1.43)	0.947	656	1.02	(0.67, 1.55)	0.926	624	1.33	(0.68, 2.60)	0.276	430	1.25	(0.53, 2.90)	0.504

[a] Adjusted for cluster (random effect) and WAVES study trial arm;
[b] Additionally adjusted for child sex, height, deprivation score (IMD), parent/carer age, and ethnicity
[c] Additionally adjusted for baseline BMI z-score
[d] Additionally adjusted for physical activity energy expenditure
[e] Standardised composite score for enjoyment of food, food responsiveness and emotional over-eating;
[f] Standardised composite score for satiety responsiveness, food fussiness and emotional under-eating.

5.4.4 Percentage of energy from free sugar

Only the parent feeding practice of ‘environment’ was significantly associated with %sugar consumption cross-sectionnally (**Table 30**). A one point increase in environment score (denoting a better food environment with good availability and access to healthy foods and low availability and access to unhealthy food) was associated with approximately 1% less energy consumed from free sugar (Model 4: B=-0.91 (99% CI: - 1.74, -0.07)). A similar result was seen amongst plausible reporters only (Model 4: B=-1.11 (99% CI: -1.93, -0.23); **Table 31**) and in the multiple imputation analysis (Model 4: B=-0.87 (99% CI: -1.59, -0.14)). At age 8-9 years, the trend towards lower %sugar intakes in children of parent who reported higher ‘environment’ scores was continued across all but Model 1 (**Table 30**). This was also confirmed in the sensitivity analysis with plausible reporters only (Model 4: B= -0.99 (99% CI: (-1.91, -0.06) p=0.006; **Table 31**) and with multiple imputation models (Model 4: B= -0.73 (-1.43, -0.08) p=0.004).

Child food limiting eating behaviours were significantly associated with higher %sugar intake cross-sectionally (B=1.41 (99% CI: 0.36, 2.47) p=0.001), but the association was not seen in multiple imputation analysis at the pre-stated level of significance (MI Model 4: B=0.78 (-0.15, 1.71) p=0.031), however a trend was seen in the same direction.

Table 30: Multivariate mixed-effects linear regression models exploring the relationships between Comprehensive Feeding Practices Questionnaire subscales and Child Eating Behaviour Questionnaire subscales with percentage of energy from free sugar consumed

	Model 1[a]				Model 2[b]				Model 3[c]			
	n	B	99% CI	p-value	n	B	99% CI	p-value	n	B	99% CI	p-value
Outcome variable = percentage of energy from NMES consumed at age 7-8 years												
CFPQ subscale												
Monitoring	729	0.31	(-0.35, 0.97)	0.232	680	-0.07	(-0.76, 0.61)	0.781	555	-0.09	(-0.83, 0.64)	0.704
Child control	731	-0.58	(-1.39, 0.22)	0.062	682	-0.17	(-1.02, 0.68)	0.607	557	-0.3	(-1.25, 0.65)	0.422
Emotion regulation	731	-0.10	(-0.84, 0.64)	0.726	682	0.35	(-0.43, 1.14)	0.247	559	0.53	(-0.36, 1.41)	0.126
Environment	728	-0.98	(-1.23, -0.23)	0.001	682	-1.16	(-1.90, -0.41)	<0.001	556	-1.13	(-1.95, -0.31)	<0.001
Pressure to eat	711	0.22	(-0.38, 0.83)	0.345	665	0.33	(-0.28, 0.93)	0.162	543	0.44	(-0.22, 1.11)	0.088
Restriction for weight control	710	-0.41	(-1.05, 0.24)	0.107	666	-0.02	(-0.69, 0.65)	0.941	545	0.13	(-0.59, 0.86)	0.638
Food as a reward	726	-0.08	(-0.61, 0.44)	0.680	678	0.20	(-0.34, 0.73)	0.334	555	0.09	(-0.51, 0.68)	0.704
Modelling	710	-0.13	(-0.75, 0.50)	0.601	665	-0.16	(-0.78, 0.46)	0.503	544	-0.12	(-0.81, 0.57)	0.651
CEBQ composite scores												
Food approach behaviours[d]	723	-0.38	(-1.32, 0.57)	0.306	675	-0.57	(-1.52, 0.38)	0.122	549	-0.55	(-1.59, 0.49)	0.173
Food limiting behaviours[e]	724	0.26	(-0.70, 1.22)	0.483	673	1.03	(0.06, 2.00)	0.006	550	1.41	(0.36, 2.47)	0.001

Table continued overleaf

Table **30 continued.**

	Model 1[a]				Model 2[b]				Model 3[c]			
	n	B	99% CI	p-value	n	B	99% CI	p-value	n	B	99% CI	p-value
Outcome variable = percentage of energy from NMES consumed at age 8-9 years												
CFPQ subscale												
Monitoring	681	0.53	(-0.12, 1.17)	0.035	635	0.29	(-0.39, 0.96)	0.275	446	0.42	(-0.41, 1.25)	0.191
Child control	683	-0.79	(-1.55, -0.03)	0.008	637	-0.30	(-1.13, 0.53)	0.354	448	-0.16	(-1.18, 0.87)	0.693
Emotion regulation	683	-0.35	(-1.06, 0.36)	0.203	637	0.001	(-0.78, 0.78)	0.999	447	0.21	(-0.74, 1.16)	0.574
Environment	680	-0.70	(-1.41, 0.02)	0.012	634	-0.92	(-1.64, -0.20)	0.001	447	-1.08	(-1.96, -0.20)	0.002
Pressure to eat	664	0.16	(0.43, 0.75)	0.477	623	0.37	(-0.24, 0.97)	0.118	442	0.72	(-0.01, 1.45)	0.011
Restriction for weight control	664	-0.34	(-0.97, 0.28)	0.159	624	0.02	(-0.65, 0.68)	0.947	443	-0.09	(-0.89, 0.72)	0.783
Food as a reward	678	0.29	(-0.21, 0.79)	0.136	634	0.53	(0.02, 1.05)	0.007	447	0.54	(-0.07, 1.16)	0.024
Modelling	663	-0.23	(-0.83, 0.37)	0.317	623	-0.29	(-0.89, 0.31)	0.212	442	0.08	(-0.64, 0.80)	0.771
CEBQ composite scores												
Food approach behaviours[d]	676	0.16	(-0.75, 1.06)	0.654	628	-0.09	(-1.02, 0.84)	0.805	440	0.12	(-1.01, 1.24)	0.791
Food limiting behaviours[e]	675	-0.11	(-1.04, 0.82)	0.760	628	0.51	(-0.45 1.47)	0.172	441	0.52	(-0.62, 1.65)	0.241

[a] Adjusted for cluster (random effect) and WAVES study trial arm;
[b] Additionally adjusted for child sex, height, deprivation score (IMD), parent/carer level factors of age and ethnicity
[c] Additionally adjusted for physical activity energy expenditure
[d] Standardised composite score for enjoyment of food, food responsiveness and emotional over-eating;
[e] Standardised composite score for satiety responsiveness, food fussiness and emotional under-eating.

Table 31: Multivariate mixed-effects linear regression models exploring the relationships between Comprehensive Feeding Practices Questionnaire subscales and Child Eating Behaviour Questionnaire subscales with percentage of energy from free sugar consumed (plausible reporters only)

	Model 1[a]				Model 2[b]				Model 3[c]			
	n	B	99% CI	p-value	n	B	99% CI	p-value	n	B	99% CI	p-value
Outcome variable = percentage of energy from NMES consumed at age 7-8 years												
CFPQ subscale												
Monitoring	671	0.18	(-0.51, 0.88)	0.503	630	-0.25	(-0.97, 0.48)	0.381	518	-0.32	(-1.10, 0.45)	0.279
Child control	673	-0.55	(-1.36, 0.27)	0.084	632	-0.11	(-0.99, 0.76)	0.739	520	-0.27	(-1.24, 0.70)	0.476
Emotion regulation	673	-0.04	(-0.81, 0.72)	0.882	632	0.42	(-0.40, 1.24)	0.187	521	0.56	(-0.36, 1.48)	0.114
Environment	670	-1.13	(-1.90, -0.36)	<0.001	629	-1.26	(-2.03, -0.49)	<0.001	519	-1.25	(-2.09, -0.41)	<0.001
Pressure to eat	654	0.39	(-1.24, 1.02)	0.108	616	0.44	(-0.19, 1.06)	0.073	507	0.55	(-0.13, 1.23)	0.038
Restriction for weight control	654	-0.43	(-1.10, 0.25)	0.106	617	-0.02	(-0.72, 0.68)	0.937	509	0.06	(-0.69, 0.80)	0.843
Food as a reward	669	-0.08	(-0.62, 0.46)	0.687	629	0.24	(-0.31, 0.79)	0.257	519	0.08	(-0.53, 0.69)	0.729
Modelling	653	-0.20	(-0.85, 0.45)	0.428	615	-0.23	(-0.88, 0.41)	0.354	507	-0.21	(-0.93, 0.51)	0.448
CEBQ composite scores												
Food approach behaviours[d]	668	-0.48	(-1.46, 0.50)	0.205	625	-0.61	(-1.60, 0.37)	0.108	514	-0.64	(-1.70, 0.43)	0.125
Food limiting behaviours[e]	671	0.35	(-0.64, 1.33)	0.365	628	1.11	(0.10, 2.12)	0.004	517	1.51	(0.41, 2.60)	<0.001

Table continued overleaf

Table 31 **continued.**

	Model 1[a]				Model 2[b]				Model 3[c]			
	n	B	99% CI	p-value	n	B	99% CI	p-value	n	B	99% CI	p-value
Outcome variable = percentage of energy from NMES consumed at age 8-9 years												
CFPQ subscale												
Monitoring	627	0.62	(-0.05 1.31)	0.018	586	0.34	(-0.37, 1.06)	0.215	415	0.46	(-0.40, 1.32)	0.167
Child control	628	-0.63	(-1.44, 0.19)	0.048	587	-0.02	(-0.92, 0.87)	0.949	416	0.110	(-0.94, 1.15)	0.789
Emotion regulation	627	-0.35	(-1.11, 0.41)	0.233	586	0.10	(-0.73, 0.94)	0.748	414	0.32	(-0.66, 1.31)	0.395
Environment	626	-0.68	(-1.44, -0.07)	0.020	585	-0.98	(-1.74, -0.22)	0.001	416	-1.11	(-2.02, -0.20)	0.002
Pressure to eat	614	0.16	(-0.45, 0.77)	0.488	577	0.36	(-0.26, 0.98)	0.135	412	0.64	(-0.10, 1.37)	0.026
Restriction for weight control	612	-0.36	(-1.03 0.30)	0.158	576	0.06	(-0.65, 0.76)	0.836	411	-0.09	(-0.92, 0.74)	0.783
Food as a reward	624	0.31	(-0.22, 0.84)	0.128	585	0.61	(0.07, 1.14)	0.004	416	0.66	(0.02, 1.30)	0.008
Modelling	611	-0.20	(-0.82, 0.43)	0.424	575	-0.26	(-0.89, 0.38)	0.300	410	-0.09	(-0.66, 0.83)	0.766
CEBQ composite scores												
Food approach behaviours[d]	621	0.38	(-0.58, 1.33)	0.311	578	0.07	(-0.90, 1.05)	0.848	408	0.38	(-0.79, 1.54)	0.406
Food limiting behaviours[e]	620	-0.18	(-1.15, 0.81)	0.642	578	0.58	(-0.43, 1.58)	0.140	409	0.65	(-0.83, 1.82)	0.156

[a] Adjusted for cluster (random effect) and WAVES study trial arm;

[b] Adjusted for cluster (random effect), WAVES study trial arm, child gender and height, deprivation score (IMD), parent/carer level factors of age and ethnicity

[c] Additionnally adjusted for child physical activity energy expenditure (kJ/kg/day);

[d] Standardised composite score for enjoyment of food, food responsiveness and emotional over-eating;

[e] Standardised composite score for satiety responsiveness, food fussiness and emotional under-eating.

5.5 Discussion

The aim of this study was to explore the relationships between parent feeding practices, and child eating behaviours, and child weight status and percentage of total energy intake from free sugar consumption (%sugar) in an ethnically diverse sample of UK children. The parental feeding practice of 'environment' was consistently associated with reduced % sugar, both cross-sectionally and longitudinally, and a lower odds of overweight/obesity longitudinally. The parent feeding practice of 'emotion regulation' was associated with increased odds of overweight/obesity longitudinally. Additionally, child food limiting eating behaviours were associated with higher %sugar intakes cross-sectionally.

5.5.1 Parent feeding practices

5.5.1.1 Restriction for weight control and pressure-to-eat

Restriction of food by parents has been shown to be associated with increased weight in several studies, both cross-sectionally and longitudinally (226, 230-233, 260-263). Clark *et al.* (2007) proposed a number of related mechanisms as to why restriction may be a counterproductive feeding practice (264). For example, restricted food becoming more desirable and so consumed in excess when outside of the parent's control (264). Only one study has looked at the likelihood of overweight/obesity in children whose parents use restrictive feeding practices and they found that there were 75% greater odds of excess weight where restrictive feeding practices were utilised (263). However, as this was a cross-sectional analysis, there was no adjustment for the child's previous size. Additionally, pressure-to-eat has been associated with lower weight status (69).

In the present study, after including baseline BMI z-score as a model covariate (Model 3), the significant associations between ‘restriction for weight control’ and ‘pressure-to-eat’ with the odds of adiposity were mitigated. This suggests that the use of these feeding practices may be in response to initial child weight status (262). One potential hypothesis for this may be reverse causation, such that parents of higher weight children are more likely to implement restrictive feeding practices and parents of lower weight children implement pressuring feeding practices, rather than those feeding practices being the cause of the child’s weight gain/reduction. The finding of the present study is reflective of that of Webber *et al.* (2010) who found no association between maternal restriction or pressure to eat with change in child adiposity longitudinally (71) and supports the theory of reverse causation.

5.5.1.2 Emotion regulation

Due to the wide spread use of Birch’s Child Feeding Practices questionnaire, the majority of the research in this area focuses on the feeding practices of ‘restriction’, ‘pressure-to-eat’ and ‘monitoring’. However, the use of the CFPQ in this study allowed exploration of a wider range of feeding practices and their associations with the odds of overweight/obesity both cross-sectionally and longitudinally. The feeding practice of ‘emotion regulation’ showed significantly increased odds of overweight/obesity longitudinally. Whilst few studies have investigated this construct longitudinally, one theory about how using food to regulate a child’s emotional state may lead to excess weight gain is that it teaches the child to rely on food to cope with emotional stress or difficult situations and therefore may encourage excess consumption over time (265). This theory may also account for why this association is not seen cross-sectionally in the present study, which echoes the limited previous research in this area (235, 266).

5.5.1.3 Environment

Within this context, the feeding practice of ‘environment’ refers to the variety and availability on healthy foods within the home. The present study found higher scores on this subscale were associated longitudinally with lower odds of overweight/obesity in children ages 8-9 years old. Qualitative research with parents and children report that availability and access to healthy foods in the home was a key strategy to improve the diet of children and maintain a healthy weight (267). In a report for the National Obesity Observatory, Rudolf (2009) advised that reducing the availability and access to EDNP foods and using techniques to increase the acceptance of healthy foods, including F&V, were key strategies to combating childhood obesity by reducing a child’s preference for such palatable, sweet foods (268). The proposed mechanism behind this parental feeding practice is that EDNP snack foods may be displaced by healthier, nutrient dense foods such as fruits and vegetables. This theory is further supported by the lower %sugar intakes seen in children whose parents report higher ‘environment’ subscale scores, both cross-sectionally and longitudinally, suggesting that high sugar foods and drinks are being displaced by lower sugar alternatives. This study provides evidence that supports the recommendation by Rudolf (2009) and should be considered in the development of future childhood obesity interventions.

5.5.1.4 Food as a reward

Parent use of food as a reward has been hypothesised to impact children's feeding behaviour by increasing the desire for the reward food (269-271). Foods used as a reward are often highly palatable ENDP snack foods, which tend to be high in free sugars and/or fat, resulting in a preference for these over healthier foods. In a study of 135 Dutch children (aged 6-7 years), Sleddens *et al.* (2010) found that parent use of instrumental feeding (e.g. using food as a reward) and emotional feeding (e.g. using food as a response to negative emotions) was associated with more frequent snacking occasions (272). This may, in part, explain the positive association found in the present study between parent use of food as a reward and subsequent %sugar intake.

5.5.2 Child eating behaviours

In a recent analysis of twins who were discordant for food fussiness (n= 2026; mean age 15.8 months (SD 0.9)), Harris *et al.* (2016) found that mothers used more pressure to eat and food as a reward with the fussier twin than their sibling (273). Given that in the present analysis, food as a reward was significantly associated with higher future %sugar intakes and pressure to eat showed a trend towards this association (Model 4: $p = 0.011$), children who are exhibiting food limiting behaviours may develop consumption patterns with higher %sugar intakes as a result of their parent's feeding practices. This is further supported by the finding that food-limiting eating behaviours were associated with increased % sugar consumption cross-sectionally. These findings highlight there may be a need to equip parents with a range of alternative feeding practices that do not result in higher %sugar intakes, particularly with those children who exhibit more food limiting eating behaviours. This potential moderating effect of food-limiting eating behaviours on the association with higher %sugar intake may warrant further investigation.

5.6 Strengths and limitations

Strengths of this study include the large, socially and ethnically diverse sample, objective BMI measurements, and availability of questionnaire responses from the main parent (including mothers, fathers, and other guardians/carers), which all enhance the external validity of the study results. However, the observational design of this study limits conclusions regarding causation. Nevertheless, this study provides preliminary evidence that is suggestive of a number of parental feeding practices that may be potential targets for interventions to improve child weight status and dietary intake.

Parent data were all self-reported, and child eating behaviour is based on parent/carer perception. Validation studies on both the CEBQ and CFPQ have reported that the responses correlate well with observed practices and behaviours and so these questionnaires allow a relatively quick and cost-effective method of collecting data on a large scale (249, 255). However, the use of specific subscales, rather than the questionnaires in their entirety, may have altered the reported psychometric properties of the questionnaires used. Investigations of the internal consistency of the included subscales found Cronbach alphas that were generally within an acceptable range (274).

Another potential limitation is the impact of missing data. Multiple imputation techniques were conducted to assess whether the missing covariate data influenced the outcome in the further-adjusted models. The results of the multiple imputation sensitivity analysis were generally similar to the results presented, with little difference in the magnitude of associations. Small differences in the width of the confidence intervals and significance of associations were seen for some factors (reported in text) which may reflect a loss of power due to missing data in the main analyses.

5.7 Conclusion

This study has allowed further exploration of a wide range of parent feeding practices and child eating behaviours and their relationships with child weight status and percentage of energy intake from sugar (%sugar). It has extended the current evidence by adding a measure of previous body size (baseline BMI z-score) to the regression models to assess whether the feeding practices and eating behaviours are associated with the odds of overweight/obesity and %sugar intake independent of child's previous size or %sugar intake. Parent feeding practices that are positively or adversely associated with weight status and/or %sugar intake were identified and future work could build upon these findings to investigate potential differences in subgroups of the population and develop parental interventions designed to shape children's dietary intake and weight status. Additionally, qualitative studies, investigating why parents adopt such feeding practices, would contribute to understanding the complex relationship between feeding practices, child eating behaviours, weight status and dietary intake.

Chapter Six: Dietary patterns – Identifying patterns of intake and investigating their cross-sectional and longitudinal relationship with child weight status

Contributions: KLH developed the idea for the study with guidance from PA, MJP, and ERL. The WAVES study research team (including KLH) were responsible for collecting, inputting, and cleaning the data. The Nutrition Epidemiology Group at the University of Leeds was responsible for processing most of the dietary data; however, KLH and TG calculated the percentage of energy from free sugar and contributed to the dietary data processing programme modifications required for the WAVES study. KLH conducted the statistical analyses and wrote the chapter, guided by PA, MJP, and ERL.

6.1 Background

The prevalence of excess weight in childhood is an increasing public health concern worldwide (275). In its simplest terms, obesity is the result of energy consumption outweighing energy expenditure; however, multiple determinants may contribute to this energy imbalance. Energy intake is particularly complex, as it is not only total energy intake that may influence the development of obesity and other chronic conditions, but also the types of food consumed, typically referred to as dietary patterns. Childhood patterns of dietary intake often continue into adolescence/adulthood suggesting that adherence to a healthful dietary pattern (DP) in childhood can positively influence diet preferences and practices in later life (108, 276, 277).

Traditional analyses in nutritional epidemiology investigate relationships between single nutrients or foods in relation to specific diseases or risk factors (105). However, this method does not consider the complex interactions between individual nutrients and other components of the diet and the wide variety of combinations in which food and nutrients are consumed (278). For example, recent discussions over the relative importance of fat and free sugar in the development of obesity have suggested that, whilst both are important, free sugar may have greater impact than fat (279). This contrasts with previous literature, which deemed dietary fat to be the major predictor of excess adiposity (280, 281). , fat and free sugars are often consumed together in highly palatable foods, such as chocolate and cakes, which can lead to excess energy consumption (282). Dietary fibre also has an important role in increasing the satiating effect of food and thus reducing the energy ultimately consumed (283) Children in the highest tertile of consumption of fibre in a nationally representative diet and nutrition survey in the US (NHANES; n = 4667) were found to have a 21% lower risk of overweight/obesity when compared to those in the lowest tertile (284). However, foods are rarely composed of solely fat, free sugar, or fibre, and so it is the combined effect of the various components of food in the diet and quantity in which they are consumed that may contribute to disease risk.

A ‘whole diet’ approach works on the assumption that macronutrients, micronutrients, and bioactive components inherent in foods act synergistically and therefore need to be explored together in relation to health and disease. Additionally, there is a tendency for diets to cluster around distinct food types, such as energy dense, nutrient poor (EDNP) foods (285). Exploring the quantity, variety, and combination of different foods in the diet offers a unique opportunity to identify DPs that may increase or decrease risk of obesity and related health outcomes. However, methods of identifying these DPs vary, making it difficult to compare findings of studies exploring associations between DPs and adiposity (108, 286, 287).

Dietary pattern analysis attempts to simplify the numerous components of the diet into either a simple set of factors describing various diets, or a score that reflects adherence to dietary guidelines. A systematic review by Kant *et al*. (2004) found two principal methods of dietary pattern analysis (107). Firstly, *a priori* patterns of intake following set dietary guidelines, prevailing hypotheses, or patterns of eating (such as the Mediterranean diet), are used to create a score or index, that rank compliance to a predefined healthful pattern of consumption. These dietary indices are generated from public health guidance and current nutrition knowledge. However, they are often country specific, and can be based upon recommendations that do not have scientific consensus, leading to indices that measure different definitions of a 'healthful' diet (278).

Current evidence on predefined dietary patterns in children is limited and inconsistent. A recent evidence review by the National Institute for Health and Care Excellence (NICE) concluded that, due to the wide variety of *a priori* DPs, and ways of analysing these, drawing firm conclusions about their associations with weight is difficult (66). Jennings *et al.* (2011) have investigated three predefined DP tools: the Diet Quality Index (DQI); Healthy Diet Indicator (HDI); and Mediterranean Diet Score (MDS); and their association with weight status in British children aged 9-10 years old (n=1700). DQI and HDI were significantly associated with weight status (and moderately correlated with each other). MDS was not associated with weight status in this sample of children and was only weakly correlated with DQI and HDI scores overall (151). However, MDS has been shown to be associated with weight-related outcomes in other studies of children and adults (288, 289).

The second method of deriving dietary patterns is a data-driven approach that identifies patterns of food and drink intake in a population using exploratory statistical techniques such as factor analysis or cluster analysis (290). Factor analysis reduces dietary data into patterns based on the inter-correlations between items, whereas cluster analysis reduces dietary data into patterns based upon individual differences in mean intakes (291). Whilst these methods remove the need to define a 'healthful' pattern of consumption, the patterns identified reflect actual dietary behaviour of the population sampled and therefore do not take into consideration empirical nutrition knowledge to date (290). Accordingly, the identified patterns are not necessarily those that are most closely associated with the outcome in question and may not be replicable between studies (105, 290). A recent systematic review of *a posteriori* pattern identification methods (factor and cluster analysis) in adults concluded that there was only limited and inconsistent evidence of an association between a diet high in fruit, vegetables, whole grains and reduced-fat dairy products and favourable body weight status, compared to diets high in red and processed meat, sugar-sweetened food and drinks, and refined grains (286).

A relatively new method of defining dietary patterns utilises a mix of *a priori* and *a posteriori* methods (106). Reduced Rank Regression (RRR) uses a combination of existing knowledge and exploratory statistics to define dietary patterns associated with disease risk (106). Here, similar data reduction techniques are used to produce summary variables (also known as factors or patterns) from a larger set of initial food groups (also known as predictor variables). However, where RRR differs from other *a posteriori* statistical techniques, is that the resultant factors/patterns are linear combinations of predictor variables which aim to explain as much of the variation as possible in the chosen response variables, rather than the variance in the predictor variables directly (287). These response variables are usually key nutrients or biomarkers, believed from empirical evidence to be associated with the disease in question. Studies comparing patterns produced by *a posteriori* methods, such as principal component analysis, to those produced by RRR, have shown that patterns derived from RRR are more likely to be associated with health outcomes (106, 292, 293). However, there are concerns in the literature about the reproducibility of RRR findings (278). Two reviews of prospectively derived DPs and adiposity have concluded that the disparate nature of studies in this area make comparison of results difficult and have called for studies using similar response variables in those that have used RRR to aid comparison between study samples (108, 286).

Additionally, studies using RRR in diverse populations with varying dietary exposures are required (287). It is known that dietary intake and food purchase decisions vary across different socio-demographic groups (294). For example, data from the UK Living Costs and Food Survey (2011) found increases in fruit and vegetables and unprocessed meat and fish purchases, and a decrease in processed meat purchases, across increasing income deciles (295). Additionally, analysis of early childhood risk factors for obesity in the US (n=1116) has shown that in children as young as 2-3 years old, there are ethnic differences in dietary intake. Compared to non- Hispanic White children, Black and Hispanic children were more likely to have consumed sugar-sweetened beverages and take-away food, by ages two and three years, respectively (296). Hence, there is a need to investigate the associations between DPs and adiposity in an ethnically and socioeconomically diverse population of children.

Dietary patterns that can be shown to be associated with disease risk may be used to inform the development of food-based dietary guidelines. The European Food Safety Authority (2010) have stated that in order to communicate nutrition and healthy eating messages to the public food-based dietary guidelines may be more relevant than nutrient-based guidelines (297). However, it is important that empirical knowledge to date is incorporated into any recommendations.

6.2 Aims

The aim of this chapter is to identify dietary patterns, using two different methods, which may be associated with child weight status. First, an *a priori* DP determined through an adaption of the original DQI will be created (109). Second, RRR will be used to identify patterns that explain the maximum variation in the key response variables of dietary energy density (DED), fibre density (FD), percentage intake from free sugar (%sugar) and percentage of energy intake from fat (%fat) in an ethnically diverse sample of UK children. Associations between each DP and child weight status will then be explored in the total sample and by the following subgroups: sex of the child (male/female), ethnicity (White, South Asian, Black, and Mixed/Other ethnicities), and deprivation level (IMD quintile 1&2/IMD quintiles 3-5).

6.3 Methods

This study uses data collected between 2011 and 2014 as part of the **W**est Midlands **A**cti**V**e lifestyle and healthy **E**ating in **S**chool children (WAVES) study. Further information on the WAVES study sampling strategy is provided in Chapter 2 (Section 2.2).

6.3.1 Weight status

Weight status was defined using the age- and sex-specific British 1990 (UK90) growth reference charts (111). Children were categorised as underweight, healthy weight, overweight, or obese using the age and sex specific 2nd, 85th, and 95th centile cut-offs, respectively (111). More detail on the calculation of BMIz and generation of weight status groups can be found in Chapter 2 (Section 2.3.1).

6.3.2 Dietary assessments

A modified version of the Child and Diet Evaluation Tool (CADET) was used to assess the diet of a sample of 5-6 year old children over a 24-hour period (113). Techniques devised by Goldberg *et al.* (1991) were used to determine the plausibility of the reported data (117). A detailed description of CADET and Goldberg methods can be found in Chapter 2 (Section 2.4).

6.3.3 Identification of dietary patterns

Two methods of dietary pattern analysis were conducted. All resultant patterns were converted into z-scores prior to analysis to allow comparison between the patterns and their association with child weight status.

6.3.3.1 Diet Quality Index

The *a priori* score produced for each child in Chapter Three, using a modified version of a DQI devised by Patterson *et al*. (1994; (109)) will be compared to the results of the RRR factors. Adaptations were made to align the DQI with UK Dietary Reference Values (DRVs) for children aged 4-6 years (Chapter 3, Section 3.3.2). Children received a score of 0-2 for each component of the DQI, and total scores ranging from 0-16. Lower scores indicate greater compliance with UK DRVs and therefore a greater dietary quality.

To aid comparison of association sizes between the different patterns, raw scores were standardised into z-scores by subtracting the mean from each individual's score and dividing by the standard deviation. This created a scale for each score with a mean of 0 and a standard deviation of 1.

6.3.3.2 Reduced Rank Regression

RRR was used to develop dietary pattern scores using the methods defined in Hoffman *et al.* (2004; (106)). RRR creates linear combinations of food intakes that explain the maximum variation in response variables (believed to be associated with the outcome of interest) and assigns them as factors (subsequently referred to as patterns; (106)). The maximum number of patterns that can be produced is equal to the number of response variables chosen. DED, FD, %sugar, and %fat intake were chosen as response variables as these have been shown to be associated with increased weight (55, 95, 104, 284, 298-301) and have been used previously in the literature (282). Using response variables that have been previously reported in the literature will aid comparison of the resultant dietary patterns to those produced in other population samples (108). DED was calculated as total food energy (kJ) divided by total food weight (g), excluding beverages (92). FD was calculated as total fibre intake (g, non-starch polysaccharide, defined by the Englyst method) divided by total energy intake (MJ). The %sugar was calculated as free sugar intake (g) multiplied by 16 kJ (energy provided by 1 gram of sugar), (118) divided by total energy intake (kJ) and multiplied by 100. The %fat was calculated as total fat intake (g) multiplied by 37kJ (energy provided by 1 gram of fat), (118) divided by total energy intake (kJ) and multiplied by 100.

The 115 CADET food groups were aggregated into 38 food groups based on those used by Schulze *et al*. (2001) and were used as predictor variables in the RRR analysis. Fewer food groups improves the prediction stability, reduces the potential multicollinearity of the food groups and eases the interpretation of the resultant patterns (**Table 32**; (302, 303)). Within each pattern, the food groups were assigned a factor loading; this factor loading is the correlation of each food group with the overall dietary pattern. The pattern score produced is the sum of the products of intake of each food group with the corresponding factor loading. Higher DP scores reflect greater compliance with the dietary pattern identified. DP identification was conducted on only those children whose dietary reports were deemed plausible via the Goldberg methods (n=1085) to reduce the impact of misreporting on the resultant patterns. All dietary reports were then assigned a pattern score and corresponding z-score for the identified DPs (n=1186).

6.3.4 Other variables

Models also included variables for sex, ethnicity, physical activity energy expenditure of the child (kJ/kg/day), and household English Indices of Multiple Deprivation (IMD) 2010 score. Detailed descriptions of these variables can be found in Chapter 2 (Section 2.5).

6.3.5 Statistical analysis

Identification of RRR dietary patterns was performed using the Statistical Analysis Systems (SAS) for Windows, release 9.4 (SAS Institute Inc., Cary, NC, USA). All other analysis was performed using STATA 13 (StataCorp, Texas, USA). A two-sided significance level of 5% was used for all analysis.

Data were summarised using mean and standard deviation for continuous variables and number and percentage for categorical variables. Participant characteristics were considered by weight status groups, and macronutrient intakes across tertiles of DP scores were explored. Trends were assessed using mixed-effect linear regression, modelling DP z-score tertiles as continuous variables and including school attended as a random effect. Pairwise correlation coefficients were calculated to assess the strength of the association between the identified dietary patterns and response variables. Mixed-effect logistic regression models were developed to examine the relationship between the DPs at baseline (age 5-6 years) and child weight status cross-sectionally (aged 5-6 years) and longitudinally (aged 7-8 years and 8-9 years). Model one adjusted for school attended (random effect) and, in longitudinal models, WAVES study trial arm allocation (fixed effect). Model two further adjusted for ethnicity, IMD score, sex of the child, and child physical activity energy expenditure (kJ/kg/day) as fixed effects.

6.3.6 Sensitivity and subgroup analysis

Subgroup analysis was performed to assess the differences in DP associations with weight status between sexes (male vs. female), four ethnic groups (White, South Asian, Black, and Mixed/Other ethnicities) and amongst those most deprived (IMD quintiles 1-2) compared to those least deprived (IMD quintiles 3-5).

Total sample models were repeated using only those children deemed plausible reporters via the Goldberg methods (n=1085) to investigate the impact of misreporting on the reported associations and on an imputed dataset to investigate the impact of missing covariate information. Generation of imputed datasets was conducted in REALCOM-Impute (152) to account for the clustered nature of the sample, imported into STATA using the Realcomimputeload command, and analysed in STATA 13. The following variables were used to create the imputation values: dichotomised weight status at the relevant time point, baseline BMI z-score, deprivation score, physical activity energy expenditure, height, age, sex, ethnicity, trial arm allocation, school level free school meal entitlement, and school level ethnic mix. Ten sets of estimated parameters were pooled and mixed effect regression models repeated on the imputed dataset.

Table 32: Predictor variables: Food groups created from the Child and Diet Evaluation Tool

Food group	Description
Brassica vegetables	cabbage, broccoli, Brussel sprouts, cauliflower
Legumes	peas, sweetcorn, baked beans, lentils, dhal, other beans
Non-fried potatoes	boiled, mashed and jacket potatoes
Sauces	ketchup, brown sauce, mayonnaise, salad cream, gravy
Poultry	sliced or plain, nuggets, dippers, Kiev, in a creamy sauce e.g. Korma
Red meat	sliced, roast, steak, chops, stew, mince, curry, keema, offal
Desserts & cakes	ice lolly, jelly, ice cream, frozen dessert e.g. Vienetta, cream, custard, mousse, milk puddings e.g. rice pudding, cakes, buns, sponge puddings, sweet pies, tarts and crumbles
Confectionary	chocolate biscuits, other biscuits, sweets, toffees, mints, chocolate bars and
Sweet spread	jam, honey, chocolate spread
Fruit juice	pure fruit juice and smoothies
Tea & Coffee	tea and coffee
Fibre-rich cereal	hi-fibre cereals e.g. Weetabix, Shreddies, Branflakes and muesli, porridge and Ready Brek
Sugary cereal	sugar-coated cereals e.g. Frosties, Sugar Puffs and other cereals e.g. Cornflakes, Rice Krispies etc.
Pasta & Rice	boiled rice, fried rice, noodles, pasta and cous cous
Pizza & Quiche	quiche – meat, fish and vegetable, and pizza
Vegetarian foods	vegetable pies/pasties, samosa, pakora, bhajee, Quorn, veggie mince, vege sausages etc., mixed vegetable curry, paneer curry
Fruit	fruit salad, fresh/frozen/tinned fruit, dried fruit
Water	tap water, unflavoured mineral water
Fish	fish fingers, white fish, oily fish, shellfish
Nuts & Seeds	nuts, seeds e.g. sunflower or sesame
Crisps & Crackers	crisps, savoury snacks such as Mini cheddars, crackers and crispbreads etc.
Fried potatoes	chips, roast, potato faces etc.
Eggs	scrambled, omelette, fried, poached and boiled
Soup	soup
Processed meat	bacon, ham, sausages, beef burger, hamburger, donor kebab, sausage roll, meat pie, pasty, fried dumplings, corned beef, luncheon meats, salami, pepperoni
Butter & Margarine	butter and margarine
Non-brassica Vegetables	tomatoes, radishes, carrots, peppers, courgettes, spinach, parsnips, leeks, cucumber, coleslaw, celery, other salad vegetables, mixed vegetables, stir-fried vegetables, other vegetables
Breads	sandwich bread, roll, toast, crumpet, garlic bread, naan, paratha, chapatti, pitta, wrap, roti
Milk	milk, milky drinks, lassi, drinking chocolate, milk on cereal
Yoghurts & Fromage frais	yoghurt, fromage frais
Cheese	hard cheese e.g. cheddar and red Leicester, cheese spread, cheese string, cottage cheese
Sugary drinks	fizzy drink (pop/cola), squash, and fruit drinks e.g. Ribena
Low-Calorie drinks	diet and low-calorie drinks including fizzy low-calorie
Sweet snack foods	cereal bar, muesli bar, flapjack, croissant, sweet waffles and pop tarts
Savoury spread	e.g. Marmite, pate
Pancake/Yorkshire pudding	pancakes and Yorkshire puddings

6.4 Results

6.4.1 Sample characteristics

Of the 1467 consented children, there were 1204 children (82.1%) with 24-hour dietary records eligible for inclusion in this study. The response rate was higher in White children (91.0%) than South Asian children (82.6%), Black children (84.3%), or children of a Mixed/Other ethnicity (84.2%). Additionally, response was higher in the least deprived groups (92.1% in least deprived vs. 83.1% in most deprived quintile). Eighteen dietary records were excluded due to exceeding the *a priori* cut-off of >50 ticks, therefore 1186 dietary records were included in the analyses.

The flow of participants through the study is shown in **Figure 13**. Reasons for missing information included the child being absent; parent or child request for exclusion from a particular measurement; or the measurement was invalid for another reason, for example, the child had a plaster cast. There was no difference between those included and those excluded from this study in terms of proportion of the sexes, ethnicity, or deprivation status.

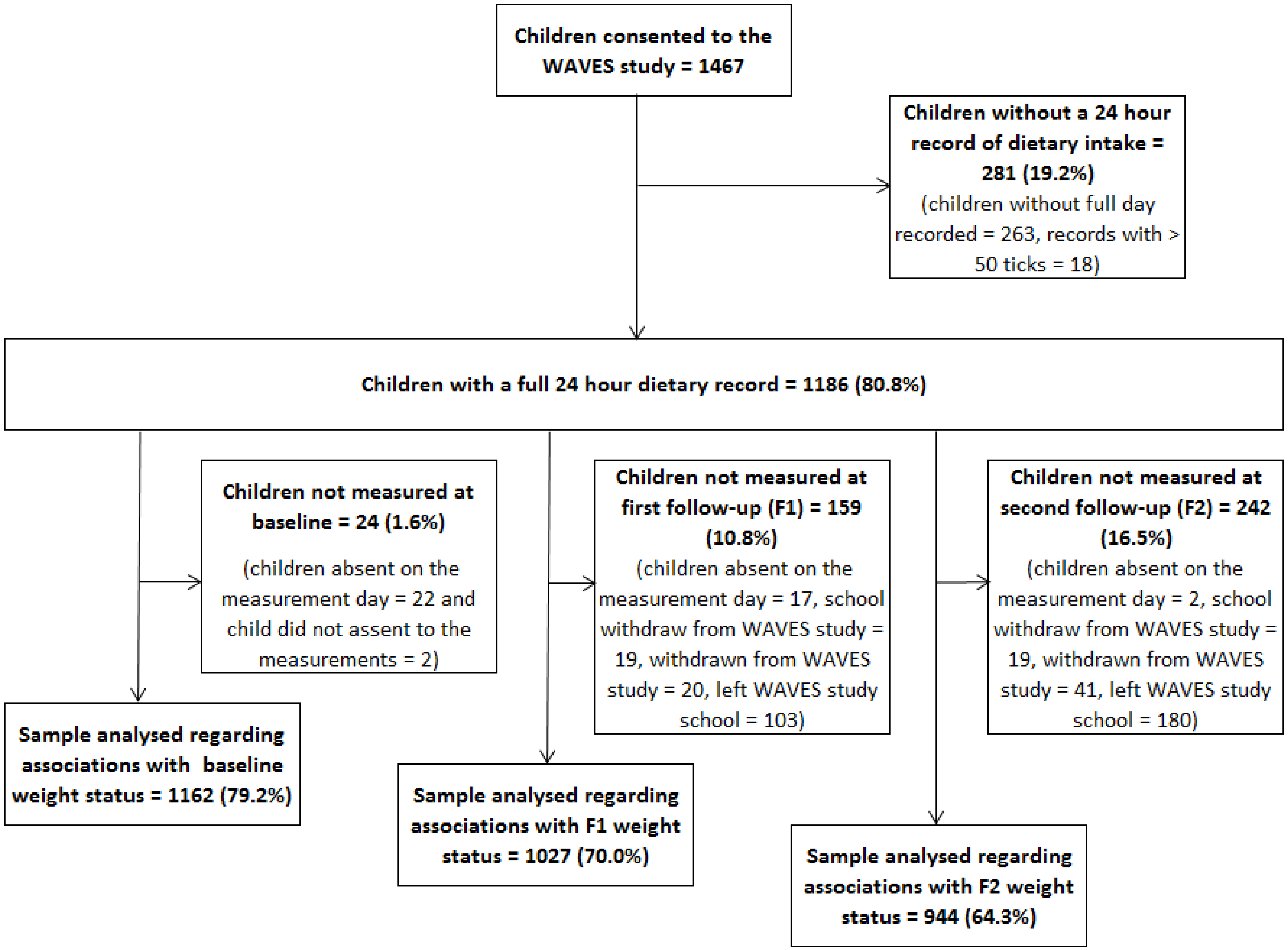


Figure 13: Flow of participants from the overarching WAVES study for the Chapter 6 study sample

Descriptive statistics for the sample by child weight status are shown in **Table 33**. Compared to males, there were more healthy weight females and less obese females in this sample; however, the proportion of overweight males and females was similar. There was also a larger proportion of Black children who were overweight/obese compared to White children. A clear trend of increasing mean deprivation (IMD) scores was seen across weight status groups (p=0.007), however this pattern was less clear when the sample was grouped by quintiles of English deprivation scores. Only children in quintile groups 5 (least deprived) and group 2 (greater deprivation) had weight status distributions that were significantly different from the reference category (Quintile 1 (most deprived)).

Table 33: Chapter 6 sample description, by child weight status

	Child weight status [a]						
	Not overweight/ obese (n=917)		Overweight (n=106)		Obese (n=139)		p-value
Age (N=1162; mean (SD))[b]	6.3	(0.3)	6.3	(0.3)	6.3	(0.3)	0.807
Sex (N= 1162; n (%))[c]							
Male	457	(76.7)	56	(9.4)	83	(13.9)	-
Female	460	(81.3)	50	(8.8)	56	(9.9)	0.019
Child Ethnicity (%, N=1155; n (%))[c]							
White	441	(81.2)	50	(9.2)	52	(9.6)	-
South Asian	276	(80.5)	29	(8.5)	38	(11.1)	0.595
Black	52	(61.9)	9	(10.7)	23	(27.4)	<0.001
Other/Mixed	143	(77.3)	16	(8.7)	26	(14.1)	0.183
IMD score (N=1145; mean (SD))[b]	34.5	(17.9)	35.2	(18.1)	38.7	(17.7)	0.007
IMD quintiles (N=1145; n (%))[c]							
Quintile 1 (more deprived)	468	(76.7)	55	(9.0)	87	(14.3)	-
2	184	(81.4)	21	(9.3)	13	(10.9)	0.040
3	97	(81.5)	9	(7.6)	13	(10.9)	0.192
4	78	(80.4)	7	(7.2)	12	(12.4)	0.418
Quintile 5 (less deprived)	77	(82.8)	11	(11.8)	5	(5.4)	0.011
Average expenditure for physical activity (N=967; mean (SD))[b]	96.1	(24.6)	92.7	(21.1)	92.7	(21.8)	0.051
Misreporting status (N=1162; n (%))[c]							
Under reporters	7	(70.0)	0	(0.0)	0	(0.0)	0.312
Plausible reporters	851	(78.4)	103	(9.5)	131	(12.1)	-
Over reporters	59	(88.1)	3	(4.5)	5	(7.5)	0.106

[a] Based on the UK 1990 growth reference data (UK90);

[b] p-values generated using mixed effect linear regression models, fitting weight status as a continuous variable, and school attended as a random effect

[c] p-values generated using multinomial logistic regression models, fitting weight status as a continuous variable, and using robust standard errors to account for clustering

6.4.2 The dietary patterns

Four uncorrelated factors (patterns) that together explained 73% of the variation in response variables (DED, FD, %sugar, and %fat) were identified using RRR. These are characterised as the following:

- Pattern one (explaining 34% of the variation) – a low fibre density but high %sugar and energy density diet
- Pattern two (explaining 25% of the variation) – a reduced %sugar but higher fat and energy density diet
- Pattern three (explaining 8% of the variation) – a high energy density diet
- Pattern four (explaining 6% of the variation) – a diet with only moderate changes in the four response variables

The remaining 27% of the variation in response variables remains unexplained by any of the above dietary patterns.

The subsequent results will only refer to dietary pattern one (DP1) and dietary pattern two (DP2) from the RRR, as together they explained over half of the variation in response variables.

For all DPs, lower scores generally signify better diet quality. In the DQI score, lower scores reflect dietary intakes that are more compliant with the UK dietary recommendations for children aged 4-6 years. In DP1, lower scores reflect dietary intakes with a lower energy density and %sugar but with a higher fibre density. DP2 lower scores indicate diets that are higher in fibre and %sugar and lower in fat and energy density.

6.5 Dietary pattern scores and the diet

Figure 14a and 14b shows the response variable correlations with DQI score, DP1 and DP2. However, it is important to consider these correlations in conjunction with the mean figures across the tertiles of each dietary pattern (**Table 34**). This is because although some of the correlations seem strong; this does not necessarily mean the highest or lowest tertiles represent diets that are high or low in that particular nutrient. For example, whilst DP1 score was highly correlated with %sugar (r=0.7), all tertiles of DP1 score had %sugar intakes above the recommended maximum intake (100).

There was no clear trend between total energy intake (TEI; kJ) and tertiles of DP1 score (p=0.613; (**Table 34**)). However, DP2 (p<0.001) and DQI (p=0.001) score showed positive trends across tertiles with TEI. Only tertile 3 of DQI score had an average intake of total fat above that of the dietary recommendation (less than 33% TEI; (100)) and this was only marginally above the recommendation (34.2% of total daily energy). However, the %sugar recommendation of less than 5% TEI was not met by any of the tertiles for any dietary pattern score (102). In fact, proportions of energy from free sugar far exceeded even the previous recommendation of no more than 10% TEI in all tertiles of all DPs (100). Due to these considerations, none of the identified DPs could be referred to as high fat or low free sugar.

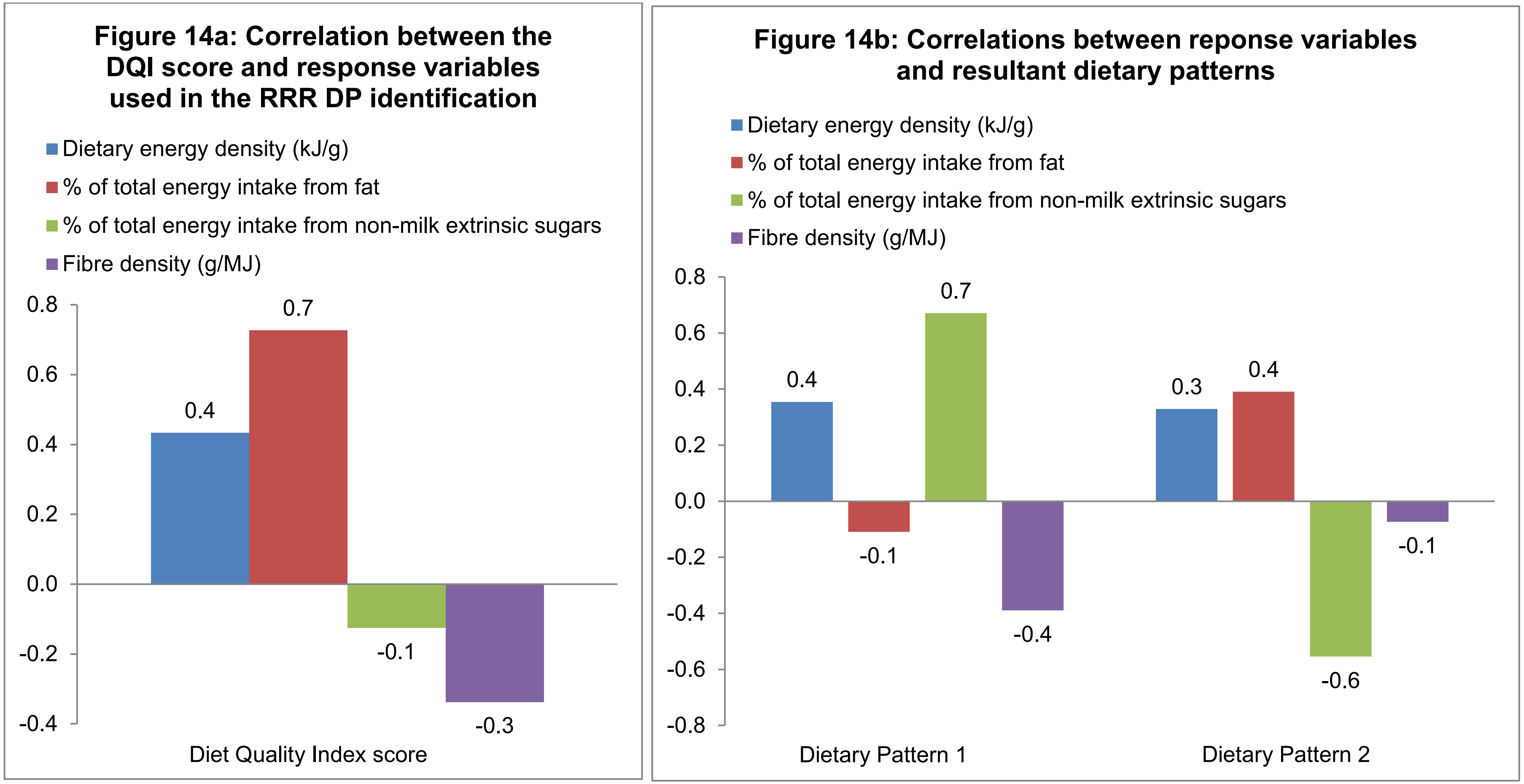


Figure 14a and b: Pearson correlations coefficients between diet quality index score, dietary pattern 1, and dietary pattern 2, and four key dietary components (response variables)

Table 34: Macronutrient characteristics by tertile of each dietary pattern score

	T1			T2			T3			Total			p-for-trend[1]
	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD	
DQI score (N= 1181)	***405***	***6.3***	***(0.8)***	***435***	***8.5***	***(0.5)***	***341***	***10.5***	***(0.8)***	***1181***	***8.4***	***(1.8)***	
Energy intake (kJ)		6791.5	(1840.9)		7304.2	(2071.9)		7384.2	(1530.4)		7149.2	(2060.9)	< 0.001
Dietary energy density (kJ/g)		6.3	(1.2)		6.9	(1.2)		7.7	(1.3)		6.9	(1.3)	< 0.001
Fat (%TEI)		25.8	(3.7)		30.6	(3.4)		34.2	(3.4)		30.0	(4.8)	< 0.001
Saturated fat (%TEI)		9.7	(2.1)		12.1	(2.2)		14.0	(2.1)		11.8	(2.7)	< 0.001
Protein (%TEI)		13.5	(2.8)		14.0	(2.6)		14.4	(2.6)		14.0	(2.7)	< 0.001
Carbohydrate (%TEI)		60.7	(4.5)		55.5	(3.9)		51.5	(4.2)		56.1	(5.6)	< 0.001
NMES (%TEI)		18.2	(6.2)		16.8	(5.5)		16.4	(4.9)		17.2	(5.6)	< 0.001
Fibre density (g/MJ)		1.8	(0.5)		1.7	(0.4)		1.5	(0.3)		1.7	(0.4)	< 0.001
F1DP z-score (N= 1186)	***395***	***-1.1***	***(0.6)***	***395***	***0.0***	***(0.6)***	***396***	***1.1***	***(0.6)***	***1186***	***0.0***	***(1.0)***	
Energy intake (kJ)		7302.4	(2486.6)		6919.5	(1891.8)		7201.4	(1737.9)		7141.1	(2068.5)	0.613
Dietary energy density (kJ/g)		6.3	(1.1)		7.0	(1.2)		7.6	(1.4)		6.9	(1.3)	< 0.001
Fat (%TEI)		30.2	(4.9)		30.1	(4.7)		29.6	(4.4)		30.0	(4.8)	0.356
Saturated fat (%TEI)		11.8	(4.9)		12.0	(2.8)		11.7	(2.6)		11.8	(2.7)	0.888
Protein (%TEI)		14.8	(2.8)		14.1	(2.6)		13.0	(2.4)		14.0	(2.7)	< 0.001
Carbohydrate (%TEI)		55.0	(5.4)		55.8	(5.8)		57.5	(5.2)		56.1	(5.6)	< 0.001
NMES (%TEI)		13.3	(4.5)		16.9	(4.9)		21.3	(4.6)		17.2	(5.7)	< 0.001
Fibre density (g/MJ)		1.9	(0.4)		1.6	(0.4)		1.5	(0.3)		1.7	(0.4)	< 0.001
F2DP z-score (N= 1186)	***395***	***-1.1***	***(0.6)***	***395***	***0.1***	***(0.3)***	***396***	***1.1***	***(0.4)***	***1186***	***-0.1***	***(0.5)***	
Energy intake (kJ)		7528.7	(2000.8)		6938.0	(1881.6)		6957.2	(2255.2)		7141.1	(2068.5)	0.001
Dietary energy density (kJ/g)		7.1	(1.4)		6.9	(1.4)		6.8	(1.3)		6.9	(1.3)	0.004
Fat (%TEI)		28.6	(4.2)		29.9	(5.0)		31.4	(4.9)		30.0	(4.8)	< 0.001
Saturated fat (%TEI)		11.3	(2.5)		11.9	(2.8)		12.3	(2.7)		11.8	(2.7)	< 0.001
Protein (%TEI)		12.8	(2.3)		14.0	(2.6)		15.0	(2.7)		14.0	(2.7)	< 0.001
Carbohydrate (%TEI)		58.6	(4.7)		56.1	(5.6)		53.7	(5.3)		56.1	(5.6)	< 0.001
NMES (%TEI)		21.6	(4.3)		17.1	(4.4)		12.7	(4.3)		17.2	(5.7)	< 0.001
Fibre density (g/MJ)		1.6	(0.3)		1.7	(0.4)		1.8	(0.5)		1.7	(0.4)	< 0.001

[1] test for trend by mixed-effects linear regression, controlled for clustering;
DQI = Diet Quality Index; %TEI = percentage of total energy intake; NMES = non-milk extrinsic sugar; F1DP = Factor 1 dietary pattern; F2DP = Factor 2 dietary pattern

Table 35 highlights the strongest food group correlations with the DQI and the two DPs tested. Diets high in foods with positive associations and low in foods with negative associations will have higher scores for each DP. DQI score and DP1 showed positive correlations with a mixture of high fat and high free sugar foods, such as processed meat and confectionery, and negative correlations with fruits and vegetables indicating that children who follow these patterns may be eating an overall EDNP diet. DP2, however, showed positive correlations with high fat foods and mainly negative correlations with foods high in added sugar, indicating that children following this pattern may be consuming less energy from sugary foods and drinks, but more energy from high fat foods.

Table 35: Highest and lowest food group correlations with each of the identified dietary patterns

Diet Quality Index		Dietary Pattern 1		Dietary Pattern 2	
Food group	r	Food group	r	Food group	r
Top 5 positive correlations					
Processed meat	0.24	Sugary drinks	0.35	Water	0.27
Cheese	0.23	Confectionary	0.34	Cheese	0.26
Sweet snack foods	0.14	Crisps & Crackers	0.19	Fried potatoes	0.24
Sauces	0.14	Processed meat	0.15	Butter & Margarine	0.20
Butter & Margarine	0.14	Cheese	0.15	Crisps & Crackers	0.20
Bottom 5 negative correlations					
Fruit	-0.35	Fruit	-0.45	Sugary drinks	-0.44
Pasta & Rice	-0.20	Legumes	-0.33	Fruit juice	-0.32
Mixed vegetables	-0.14	Water	-0.24	Yoghurts & Fromage frais	-0.22
Fruit juice	-0.13	Brassica vegetables	-0.19	Fruit	-0.19
Red and Orange vegetables	-0.10	Red and Orange vegetables	-0.19	Sugary cereal	-0.15

6.5.1 Dietary pattern scores and weight status

None of the identified DPs showed significant associations with weight status. This was seen both cross-sectionally and longitudinally (**Table 36**). Sensitivity analysis on plausible reporters (**Table 37**) and multiple imputation analysis found very similar results. Additionally, all effect sizes were very small, and therefore not clinically significant, as well as being statistically non-significant (304). There were also no differences found between the sexes, levels of deprivation, or ethnicities (results not presented).

Table 36: Multivariate logistic regression models to investigate associations between three dietary patterns and the odds of overweight/obesity at three time points

	Model 1[a]				Model 2[b]			
	n	OR	95% CI	p-value	n	OR	95% CI	p-value
Outcome variable: Odds of overweight/obesity at 5-6 years old[c]								
DQI z-score	1158	1.03	(0.90, 1.19)	0.671	947	1.03	(0.87, 1.22)	0.718
DP1 z-score	1162	0.91	(0.79, 1.05)	0.211	950	0.92	(0.78, 1.09)	0.327
DP2 z-score	1162	1.06	(0.92, 1.22)	0.396	950	1.08	(0.91, 1.28)	0.384
Outcome variable: Odds of overweight/obesity at 7-8 years old[c, d]								
DQI z-score	1025	1.01	(0.88, 1.16)	0.900	831	1.05	(0.89, 1.24)	0.557
DP1 z-score	1027	1.01	(0.88, 1.17)	0.824	834	1.02	(0.86, 1.20)	0.830
DP2 z-score	1027	0.96	(0.84, 1.11)	0.597	834	0.99	(0.84, 1.18)	0.920
Outcome variable: Odds of overweight/obesity at 8-9 years old[c, d]								
DQI z-score	938	0.90	(0.78, 1.04)	0.156	767	0.93	(0.79, 1.10)	0.396
DP1 z-score	940	0.95	(0.83, 1.09)	0.478	770	0.92	(0.79, 1.09)	0.337
DP2 z-score	940	1.00	(0.87, 1.16)	0.945	770	1.05	(0.89, 1.24)	0.567

DQI = Dietary Quality Index; DP1 = Dietary pattern 1 from the reduced rank regression; DP2 = Dietary pattern 2 from the reduced rank regression;
[a] Adjusted for clustering
[b] Adjusted for sex, deprivation score, ethnicity, physical activity energy expenditure (kJ/kg/day)
[c] UK 1990 growth reference charts
[d] Additionally adjusted for WAVES study trial arm allocation

Table 37: Multivariate logistic regression models to investigate associations between three dietary patterns and the odds of overweight/obesity at three time points (plausible reporters only)

	Model 1[a]				Model 2[b]			
	n	OR	95% CI	p-value	n	OR	95% CI	p-value
Outcome variable: Odds of overweight/obesity at 5-6 years old[c]								
DQI z-score	1085	1.06	(0.92, 1.23)	0.405	886	1.07	(0.90, 1.26)	0.460
DP1 z-score	1085	0.94	(0.81, 1.09)	0.419	886	0.96	(0.81, 1.15)	0.693
DP2 z-score	1085	1.04	(0.90, 1.21)	0.579	886	1.04	(0.87, 1.25)	0.630
Outcome variable: Odds of overweight/obesity at 7-8 years old[c, d]								
DQI z-score	940	1.03	(0.89, 1.19)	0.674	777	1.07	(0.91, 1.28)	0.382
DP1 z-score	940	1.06	(0.92, 1.24)	0.406	777	1.07	(0.90, 1.28)	0.432
DP2 z-score	940	0.93	(0.81, 1.08)	0.352	777	0.95	(0.80, 1.13)	0.568
Outcome variable: Odds of overweight/obesity at 8-9 years old[c, d]								
DQI z-score	857	0.92	(0.80, 1.07)	0.276	716	0.95	(0.80, 1.12)	0.537
DP1 z-score	857	1.02	(0.88, 1.18)	0.822	716	0.98	(0.83, 1.17)	0.855
DP2 z-score	857	0.95	(0.82, 1.10)	0.516	716	0.99	(0.83, 1.18)	0.919

DQI = Dietary Quality Index; DP1 = Dietary pattern 1 from the reduced rank regression; DP2 = Dietary pattern 2 from the reduced rank regression;

[a] Adjusted for clustering

[b] Adjusted for sex, deprivation score, ethnicity, physical activity energy expenditure (kJ/kg/day)

[c] UK 1990 growth reference charts

[d] Additionally adjusted for WAVES study trial arm allocation

6.6 Discussion

6.6.1 Principal findings

This study investigated three dietary patterns (one through an *a priori* DQI and two identified through reduced rank regression) that described nutritional intake in a young, demographically diverse sample of UK children, using two methods of pattern detection. There was no evidence of an association between the identified patterns and the likelihood of overweight/obesity at three time points.

6.6.2 Comparisons with other studies

A lack of clarity over the definition of the response variables to be used in dietary RRR analysis limits the studies available for comparison to the present study. Response variables should be intermediates between the predictor variables (in this case foods) and the outcome of interest (in this case child weight status; (106)). This allows *a priori* knowledge regarding known associations to be included in the generation of the dietary patterns and produce dietary patterns that are behaviourally meaningful as a result. However, some studies have used their outcome measures as the response variables (305-307) forcing the resultant factors to be correlated with the outcome of interest, undermining the value of this approach, and returning to solely *a posteriori* methods of dietary pattern analysis (308).

One study was identified that looked at cross-sectional associations between RRR-derived DPs and adiposity in children. The Growth, Exercise and Nutrition Epidemiological Study in pre-Schoolers (GENESIS; n=2317; using the response variables of simple carbohydrates, total fat and fibre intake) found that a dietary pattern characterised by high consumption of sweets and low consumption of fruit, vegetables, legumes and total grains was significantly positively associated with prevalence of childhood obesity (OR = 1.11, CI: 1.00-1.28 for each unit increase in DP; (292)). However, whilst the proposed association is in a positive direction, the confidence interval of the odds ratio reaches the point of no significance and therefore, the confidence of the proposed effect may be questionable. Additionally, demographic information on the participants in this study was lacking, with limited or no description of age, sex, ethnicity, or deprivation level.

Two longitudinal analyses of RRR-derived DPs of British children have been conducted on sub-samples from the Avon Longitudinal Study of Parents and Children (ALSPAC) study (309, 310). Results of these studies have reported longitudinal associations between energy dense, high fat, high sugar, and low fibre DPs, similar to the DPs found in the present study, with fat mass, fat mass index, and odds of adiposity between the ages of 5-9 years (n=521 and n=682) and 7-13 years (n=6772; (309, 310)). Ambrosini *et al*. (2014; n=7027) have also shown that the observed DP tracks moderately between the ages of 7-13 years old in the ALSPAC cohort (311). However, the ALSPAC sample has been noted as less representative of those less affluent and those from non-White backgrounds (312) and there were differences between the dietary assessment and anthropometry methods used, therefore the differing results regarding the association with weight status from the present study may reflect these differences. Despite this, our finding of a null association in the current sample is surprising given the apparent establishment of EDNP dietary patterns in preschool aged children in the UK (312, 313) and therefore warrants further exploration.

Tucker (2010) highlighted the issue of replication of RRR derived DPs and suggested that DPs identified may be population-specific (278). As noted previously, there were notable differences between the ALSPAC studies and the present study in terms of dietary data collection (282, 310), therefore it was not possible to utilise the exact score generated by the ALSPAC cohort in the present study. However, the same intermediary variables as the Ambrosini *et al.* (2016) study were used to assess the robustness of the patterns identified in these demographically different UK cohorts (282).

DP1, explaining over a third of the variation in both cohorts, was fairly similar with positive loadings for high-sugar and high-fat foods such as sweets, chocolate, crisps and cheese and negative loadings with foods such as fruits, vegetables, and water. However, the correlations between the dietary pattern and the intermediary nutrients differed between the two studies. For example, the correlation with dietary energy density was much stronger in ALSPAC (r=0.7 (ALSPAC) compared to r=0.4 (WAVES)) and percentage of fat intake was weakly correlated in differing directions (r=0.3 (ALSPAC; (282)) compared to r=-0.1 (WAVES). This may be a result of the different dietary data collection methods between the two studies and the different food composition tables used. Accordingly, higher scores in the ALSPAC cohort correlate with higher intakes of fat, free sugar, and energy density and lower intakes of fibre; typically regarded as an obesogenic dietary pattern. However, in the WAVES DP1 energy consumed from fat was below the recommendation in all tertiles and higher DP1 scores correlated with only marginally lower intakes. DP2 was also fairly similar between the two studies, albeit in opposite directions, with the ALSPAC pattern being high in sugary foods/drinks and low in high-fat foods and the WAVES DP2 the reverse of this pattern. Despite these minor differences, the patterns extracted were fairly similar between the two studies regardless of the differences in data collection method and sample demographics. However, the population-specific issue highlighted by Tucker (2010; (278)) is evident in both the ALSPAC and WAVES cohorts. Both describe very high intakes of free sugar (reporting mean intakes of approximately 17% of energy intake – over three times the maximum recommendation) and therefore the resultant patterns cannot be described as 'low' in free sugar, even where a strong correlation between a DP and sugar intakes were identified. This impacts the interpretability and usefulness of the patterns identified.

Differences in outcome measures chosen may explain the differences in results between the present study and the ALSPAC study (2016). The present study used overweight/obesity risk as defined by body mass index z-scores derived from the British 1990 growth reference charts, whereas the ALSPAC study utilised a dichotomous outcome based upon fat mass index scores obtained using dual energy x-ray absorptiometry (282). Fat mass normalised for height, as used in the ALSPAC study, may present an estimation of body composition which may more reliably detect excess adiposity in pre-pubertal children (314), however there is currently no reference data for fat mass indices in the UK and hence, a pragmatic threshold of >80th percentile of fat mass index z-score was utilised to represent excess adiposity (282).

When considered in combination with other methods of prospectively deriving DPs, such as factor analysis and principle component analysis, an overall DP that is energy dense, high fat, and low fibre, has been shown to predispose children to later childhood and adolescent overweight and obesity (108). The individual food components that make up these DPs varied between each study. Again, this may be due to methodological differences between the studies, such as the number or type of food groups included (108). However, there are also studies that have found no relationship between dietary patterns and adiposity. For example, a “healthful” pattern (consisting of higher intakes of wholegrain bread, vegetables, rice and other grains and low sugar-sweetened beverage consumption) and a “pancake and potatoes” pattern (consisting of higher intakes of vegetable oil, flour, potatoes and eggs), derived from Principal Component Analysis, were not found to be associated with baseline BMI or fat mass, or change in BMI or fat mass, in 6-11 year old children in Germany (307).

A recent study comparing three diet quality indices with weight status in 9-10 year old children in the Sport, Physical Activity, and Eating Behaviour: Environmental Determinants in Young People (SPEEDY) study found that poorer quality DQI scores had significant positive associations with weight (kg), BMI (kg/m^2), BMI z-score, waist circumference, waist to height ratio, and percentage body fat (151). This finding is in contrast to the present study where no significant associations were found between DQI score and weight status. However, there were several methodological differences (e.g. the use of a 4-day food diary to collect dietary data) and sample differences (e.g. age, ethnicity, deprivation level) between the two studies which may contribute to the difference in these results.

Findings from studies using other *a priori* tools to assess diet quality in children are broadly in agreement with the SPEEDY study (315, 316); however, some found associations only in obese subgroups (317, 318). This inconsistency may be due to the variety of tools available and the different definitions of what constitutes ‘good’ dietary quality, drawing into question the usefulness of analyses using diet quality indices over individual dietary components (single nutrients or foods) when there is no universal consensus over the definition of a ‘healthful’ diet (319).

6.7 Strengths and limitations

6.7.1 Dietary data

Dietary data was collected prospectively using the CADET tool and average portion sizes were used specific to the child’s age and sex. This reduced the potential for recall bias and the need for weighing of food. The CADET provided an easy to administer and speedy tool requiring minimal training and with relatively low respondent burden. Whilst the dietary intake in these analyses is based only on one weekday record of consumption and so may not be reflective of habitual or weekend intake, Cole *et al*. (1997) has noted that one-day assessments may be the best form of dietary assessment method for large-scale group comparisons, as it allows the number of participants to be maximised (320).

The sample population used in this study was largely deprived (72% of children are from the lowest two quintiles of deprivation score) and non-White (47% of children are from a White ethnicity). However, varying response rates in different subgroups were observed. This may reflect two important considerations. Firstly, the CADET was written, therefore if English literacy was an issue, completing the record correctly may have been problematic. However, in an attempt to reduce the impact of this, participants were provided with a DVD containing verbal instructions on how to complete the CADET booklet. This was also available online. Secondly, the CADET was developed to capture foods typically consumed in the UK. Whilst there was an attempt to represent some foods that may be consumed in other cultures, this was limited, and therefore it may have been difficult to accurately complete the record if a non-western diet was consumed.

Previous versions of the CADET have been validated in this age group (113). However, the validation study was not completed against the gold-standard in dietary data collection, i.e. doubly labelled water, and the study sample was mainly white British. Additionally, adaptations to the CADET to align it to the latest version of the UK nutrient databank and smooth anomalous portion sizes (Chapter 2, Section 2.4), may have undermined the validation of this tool.

6.7.2 Misreporting

Misreporting can lead to attenuated estimates of associations between dietary intakes and health outcomes (84). In the present study, some records could potentially have been misreported and, in instances where a prospective report was not returned, where possible, a recall was conducted with the child to complete the 24-hour record. To ensure these considerations did not introduce bias to the study by including implausible intakes, sensitivity analyses were conducted using only plausible reporters as determined through the Goldberg calculations. The consistency of outcomes between the main and restricted analyses strengthens the validity of the results as it suggests that the observed outcomes in the main analyses do not result from the inclusion of potentially misreported data (85).

6.7.3 Identification of patterns

The DQI used UK recommendations that are specific to the age group in question. However, as the DQI was adapted specifically for use in this study, comparisons between this DQI and other *a priori* methods of deriving dietary patterns are problematic.

Similar response variables to previous studies were used in the reduced rank regression analysis to assist in comparing findings to other studies in this area, as has been called for by two recent reviews (108, 286). However, some limitations of RRR as a method of dietary pattern identification have been identified. Tucker (2010) argues that use of nutrients or biomarkers known to be associated with the outcome in question, as intermediary variables, generates DPs that are essentially a proxy for the intermediary variable itself (278). Thus, if the intermediary variables are good predictors of the disease in question, then the DPs generated will also predict the outcome. However, in dietary research, translating the nutrient recommendations into patterns of food intake that can be developed into food based dietary guidelines that are associated with reduced risk of overweight/obesity in children may be beneficial in helping the public understand the basic requirements of a child's diet. Additionally, the reproducibility of the DPs identified has been questioned as they may be population specific (282). However, the present study identified similar DPs to the ALSPAC study using the same intermediary variables (282).

6.8 Conclusions

Dietary pattern analysis has allowed investigation of the combined effects of several elements of the diet. By comparing a predefined method (DQI) and a prospective method (RRR), assessments have been made of both a ‘healthy’ DP and two ‘less healthy’ DPs. Neither method produced patterns with significant associations with weight status cross-sectionally or longitudinally in our cohort. However, given the young age of our sample and the predominance of significant longitudinal associations in the literature, further work may wish to consider tracking changes in DPs over time and investigating their relationship with adiposity or weight status in diverse samples of children.

Chapter Seven: Conclusions

Treatment of established obesity is notoriously difficult, needing substantial and sustained changes in behaviour to produce and maintain weight loss (52). Therefore, taking steps to try to prevent excessive weight gain is critical to, and may be more successful in, reducing the prevalence of childhood obesity over time (321). In addition to its role in weight gain, poor dietary intakes contribute to increased risk of chronic diseases, such as type 2 diabetes and cardiovascular disease, at an earlier age (322). Hence, improving the diets of children may have positive consequences beyond obesity and help reduce the burden of disease on society over time.

However, to be able to take effective preventative action, we must first understand the potentially modifiable determinants of poor dietary choices. The aim of this thesis was to investigate some of the social, environmental, and individual dietary characteristics that may be contributing to poor diet quality and childhood overweight. This was undertaken in a socially and ethnically diverse population of 5-9 year old children from the UK through the analysis of data from the **W**est Midlands **A**cti**V**e lifestyle and healthy **E**ating in **S**chool children (WAVES) study, which provided the opportunity for cross-sectional and longitudinal analysis. Following a brief review of the main findings, Chapter 7 will summarise the contributions from this thesis to the evidence base and how they will help to inform and guide future dietary intervention development for children.

7.1 Thesis summary and main findings

Collectively, this thesis looked at dietary intake and a variety of environmental aspects and behaviours related to diet, acting at differing levels within the Ecological Systems Theory, that may be contributing to overweight and obesity in children.

Chapter 3 investigated the nutritional differences between having a home-packed lunch (HPL) and a school-provided lunch (SPL) and the impact of school meals on dietary quality (as measured through a diet quality index (DQI)) and child weight status. Generally, lunchtime nutrient consumption was more favourable in children having a school-provided, rather than home-packed, lunch. However, subgroup analysis suggested that consuming a HPL was associated with improved overall daily diet quality in girls and more affluent children. No clear relationship between lunch type and child weight status was evident in the sample overall, and a reduced likelihood of overweight/obesity was highlighted in more deprived children and South Asian children.

Chapter 4 explored cross-sectional relationships between multiple aspects of the home food environment (HFE), and child weight status and a measure of diet quality, namely portions of fruit and vegetables (F&V) consumed. Each aspect of the HFE was considered individually and as part of a composite score. Separately, increased screen time, infrequent consumption of an evening meal with family at a table (compared to daily) and lower parental confidence in trying new foods were all found to be significantly associated with decreased portions of F&V consumed. Additionally, higher composite scores (indicating a more obesogenic environment) were associated with lower intakes of F&V. No evidence of an association between any aspect of the HFE and child weight status was found in the total sample, however a potential differential effect of eating breakfast everyday (compared to three days a week or less) was found in boys.

Chapter 5 investigated the association between parental feeding practices and child eating behaviours, with child weight status and percentage of energy intake from free sugar (%sugar). Parental use of food as a reward and children exhibiting food limiting eating behaviours were both associated with increased %sugar intake longitudinally, whereas the feeding practice of environment (availability and access to healthy food) was associated with decreased %sugar intake both cross-sectionnally and longitudinally. Parental use of food for emotion regulation was associated with increased odds of child overweight/obesity longitudinally and the environment feeding practices was associated with decreased odds of overweight/obesity longitudinally. Neither pressure-to-eat nor restriction for weight control were found to be associated with %sugar intake or weight status after controlling for previous weight status.

Chapter 6 used a DQI to assess compliance with UK dietary recommendations and Reduced Rank Regression (RRR) to identify patterns in dietary consumption. RRR identified two patterns that explained over half of the variation in dietary energy density, fibre density, percentage of energy from fat and percentage on energy from free sugar. Neither of the RRR dietary pattern scores, nor the DQI score, showed an association with child weight status.

7.2 Contribution to the evidence base

Multiple factors influence dietary behaviour throughout the course of childhood. In this thesis, evidence is presented of the impact of some aspects of the microenvironment on dietary behaviour within the context of childhood obesity.

Overall, daily diet quality in this sample of 5-6 year olds was relatively low and was dominated by particularly high intakes of free sugar and sodium, and low intakes of fibre (Chapter Three, Section 3.4.1, **Table 10**). This highlights the urgent need for strategies to improve the quality of the diets of children in the UK.

Whilst, dietary pattern associations with weight status were not seen in this population, either cross-sectionally or longitudinally, diets high in energy dense, nutrient poor (EDNP) foods have shown associations with weight status and adiposity elsewhere (323). One explanation for this contrast in findings may have been due to the lack of variation in the diets of the children assessed, as evidenced by the lack of dietary pattern that could be described as high fat or low sugar in Chapter Six. Margetts *et al*. (1997) noted that lack of variation in the diets of a community might influence their associations with the outcome measure (324).

7.2.1 The role of parent/carers

Parents are the providers of food and controllers of availability and access to it in the home. Recently, it has been argued that dietary related research into obesity needs to focus not only on what foods are consumed but also on how and within what context they are consumed, particularly within a paediatric setting where children have limited autonomy regarding their environment (45, 325). However, whilst children have limited autonomy, it is important to be aware that they will also influence their own surroundings. For example, Rollins *et al*. (2015) suggested that the explanation for the lack of longitudinal evidence of associations between restriction and maladaptive eating behaviours (other than eating in the absence of hunger), was reverse causation, whereby parents use restriction in response to perceived child eating behaviours (326). This theory is also reflective of qualitative research with UK mothers of 3-5 year old children (n=12), which found that they tend to adapt their feeding techniques in response to a child’s eating behaviour (327). This reverse causation theory could also be extended to parental feeding practices being influenced by the child’s size, i.e. parents of larger children being more likely to restrict and those of smaller children more likely to pressurise. The lack of consideration of this in the existing research base may explain the prevalence of significant associations between the parent feeding practices of restriction or pressure-to-eat and child weight status, BMI z-score, and adiposity. The present research provides evidence that supports the reverse causation theory as when a measure of previous child weight was included in the models investigating the likelihood of overweight/obesity in the presence of these feeding practices, no association was found (Chapter Five, Section 5.4.3, **Table 29**).

This is also set within a context of the general parenting and feeding styles of the parents/carers. A parenting style is the general framework of rules and actions within which parents and children interact; feeding styles are the application of this framework to food and mealtimes (69). Both may influence the specific feeding practices a parent utilises with their child. In general, indulgent and uninvolved parenting and feeding styles have been shown to be negatively associated with the parental feeding practice of monitoring (328) and positively associated with unfavourable weight status in children (69). Whereas, more authoritative parenting feeding styles have been positively associated with parental monitoring of children’s intake (328) and generally more favourable child outcomes (active lifestyles, healthier dietary intake and lower weight status; (69, 329)). This highlights the need to emphasise positive structures and practices around food for parents to employ, to not only help regulate child weight gain, but also encourage a preference for and consumption of a healthier diet.

To create change and avoid maladaptive feeding practices being developed, interventions addressing parental feeding practices may be best placed with uniparous parents when children are in their infancy/pre-school age (312). A recent systematic review looking at the effectiveness of interventions within the first two years of life aimed at reducing childhood obesity in children from birth-7 years old, showed that the most effective interventions involved behaviour change theory, and had components looking at the diet and parental feeding practices (330). One such study conducted in Australia found that first-time mothers (n=698) reported using more responsive feeding practices and less controlling feeding practices (such as restriction and pressure to eat; (331)). Additionally, there were marked differences in the eating behaviours of their children with greater satiety responsiveness and preference for fruits, and lower emotional overeating, food fussiness, and preference for EDNP foods, compared to control children approximately 20 months later (332). Although there was no significant association with prevalence of overweight after 20 months, the authors note that the 4.9% lower prevalence seen in the intervention group, could be meaningful on a population level and suggest that these feeding practices equip children with attributes to help them negotiate their obesogenic environment (331). Early intervention may also help to combat the age-related increase in poor dietary patterns. Additionally, a recent review of the published evidence from the Avon Longitudinal Study of Parents and Children (ALSPAC) cohort in the UK suggested that the critical period of dietary change is between the ages of 1.5-3 years old (312).

In addition to parental feeding practices, other aspects of the home environment will influence dietary intake in children. Kime (2009) discussed generational changes in the home environment with three generations of families: grandparents, parents, and children. Typically, parents described less order regarding food than the previous generation, with families rarely eating together, eating at different times and locations, consuming different meals, and having a greater reliance on convenience food (325). Hence, the authors suggest the ordering of eating may act as an intermediary variable in determining *'what'* children eat (325). This theory was further explored in Chapter 4, where associations between aspects of the HFE, with marker of dietary quality (F&V consumption) and child weight status were explored. Free access to snack foods, eating as a family, eating food prepared outside of the home, parental self-efficacy in providing healthy meals and trying new foods, screen time and breakfast consumption were all discussed individually and were found to have varying influences on F&V consumption. Of particular relevance, was a differential association found between sex subgroups on the effect of eating as a family at a table on F&V consumption, with a significant effect found only in boys (Chapter Four, Section 4.4.4, **Table 20**). This may present a potentially simple but effective method of encouraging F&V intake in boys who typically consume less F&V than girls (150). However, this must be interpreted cautiously, as the effect of such a change is largely dependent on a host of other factors, including provision of F&V and parental feeding practices, such as modelling and pressure to eat. Hence, although individual characteristics of the HFE are likely to be associated with dietary intake, looking more broadly at the impact of various HFE elements together may be a more effective approach to positively influencing children's dietary intake.

Some studies have attempted to combine HFE elements in a score to look at associations with adiposity; however, all have defined the HFE differently. Schrempft *et al*. (2015), using a HFE score that measured availability of certain foods (e.g. number of F&V or EDNP foods in the household), visibility and accessibility of those foods, and multiple measures of the parental feeding practices, found no evidence of an association with BMI z-score in UK 4 year olds (n=1096; (208)). Anderson and Whittaker (2010; n=8550) used a simple score to assess whether three household routines (eating as a family > 5 times/week, obtaining ≥ 10.5 hours sleep/night, and limiting screen viewing to < 2 hours/day) were associated with odds of obesity in US pre-schoolers and found an approximately 40% reduction in the odds of overweight if all three routines were followed (56). Finally, two studies from the US both found positive associations between family nutrition and physical activity survey score and overweight (n=704 (age rage 6-7 years); (205)) or over-fatness (n=450 (age range 6-13 years); (206)). However, each composite measure of the HFE is different, with some including measures of sleep and physical activity, in addition to those more directly relevant to dietary intake. Therefore, whilst it is agreed that creating a home environment where healthy choices and habits become normal is important in encouraging a healthy lifestyle and weight in children, it appears there is no consensus in the literature about what constitutes a healthy HFE or how to measure it. A first step to helping parents/carers to create a healthy HFE may be defining what its components are.

The National Institute of Health and Care Excellence (NICE) recommend that studies assessing the associations with overweight and obesity outcomes should use validated methods to estimate body fatness (such as BMI; (333)). However despite the identified studies all using validated methods of defining overweight and obesity, including weight status defined by US Centre for Disease Control thresholds (56) or International Obesity Task Force thresholds (205, 206), BMI z-score based on UK reference data (208), and over-fatness based on US growth reference curves for body fat percentage (206), the differing outcome measures and reference populations make comparison and synthesis of the literature surrounding the effect of the HFE on weight status difficult. Hence, future research needs to carefully consider the most appropriate outcome measures to ensure comparison between studies is possible. This should include using a secondary outcome measure that is not dependant on BMI, for example waist circumference, as per the NICE guidance (333).

Additionally, it must be considered that whilst in this thesis and generally in the literature, the relationships between the HFE, parental feeding practices, and child eating behaviours, have been examined individually in relation to dietary intake and adiposity, in reality these factors may all interact, and modifying one aspect could have unpredictable effects on other aspect. Therefore, future work exploring these concepts may wish to examine them concurrently.

7.2.2 The role of school food

Children spend a large amount of their week in school and lunch typically provides around a third of a child's energy intake for a school day (156). Therefore, the school food environment offers a unique opportunity to encourage consumption of a healthy diet and consequently have an impact on obesity prevalence. As such, food provision and service is often the focus of health policies and obesity interventions in schools. In addition, a recent review of qualitative studies, various stakeholders (parents, school staff, school governors, school nurses and students) also believed that schools have a key role in providing and promoting healthy choices in school food settings (334).

In the UK, national policy has evolved to modify school lunch provision by the introduction of stringent school food standards, to which schools are required to comply. Chapter Three detailed typical SPL and HPLs consumed by 5-6 year old children in the West Midlands, UK. In line with previous literature (142, 153-156), the nutrient profile of SPLs consumed was, on average, healthier than HPLs and contained less EDNP foods. Despite this, overall daily diet quality was better in some children consuming a HPL (Chapter 3, Section 3.4.3), particularly among girls and those in the most affluent quintiles of IMD score. One theoretical explanation may be that some parents believe, as SPL provides a nutritious meal, there is less of a requirement for the food provided at home to be nutritious, resulting in a lower overall daily diet quality. However, this finding is in contrast with previous literature that has concluded that daily dietary quality is poorer in those consuming HPL (64, 142). Previous studies did not consider the association in different subgroups of their sample; therefore, further research is needed to assess whether the subgroup differences observed in this study exist in other study populations.

The school has a vital role to play in obesity prevention, not only in the provision of nutritious food at lunchtime, but also in creating a positive school food environment. In an extension of the topics discussed within this thesis regarding parent feeding practices and the HFE, schools must also use a variety of techniques to foster healthful eating behaviours (335) and be wary of overly restrictive food policies which may have unintended consequences, for example 'black market' food exchanges in UK secondary schools in response to increasing food regulation (336). Whilst, the exact components of each school policy should be designed with the individual school population in mind, effective school food policy designs have used a combination of school food standards, nutrition education, and exposure to healthy foods e.g. through a school fruit and vegetable schemes, to encourage healthier food choice and preferences (337). Support from parents and pupils is key to successful implementation of any school food policy (338).

7.3 Strengths and limitations

The strengths and limitations have been discussed previously within each chapter's discussion; however, there are some important strengths and limitations to consider overall.

Firstly, this thesis has attempted to address some aspects of the obesogenic environments relevant to children to determine their impact in relation to dietary quality and excess weight. However, it is important to note that factors of the obesogenic environment are likely to have limited impact on dietary and weight-related outcomes individually. It is more probable that different aspects influence, enhance, or counteract one another in a complex system, such as that described in the Foresight report (8, 208). This thesis has attempted to take account of this by grouping behaviours (e.g. eating behaviours), environmental influences (e.g. the composite HFE score), or dietary determinants (e.g. via diet quality indices and statistical techniques to develop dietary patterns) prior to assessing their association with dietary quality and weight status. However, whilst this is useful to give an overall picture of their combined association, the oversimplification could mean that the more nuanced and complex relationships and interrelationships may not be captured.

7.3.1 Location

Data for all studies included in this thesis were from the WAVES study and therefore from one geographical area of the UK, the West Midlands. The West Midlands region is diverse in many ways. It contains one of the largest cities in the UK, Birmingham, with a population of 3,840 people per square km, but also some of the most rural and sparsely populated areas of the country, for example Stratford-upon-Avon (122 people per square km; (339)). It has some of the highest proportions of children aged under 16 years, and non-White populations outside of London, and some of the most and least deprived areas of England (340). The WAVES sampling strategy used a balancing algorithm to take into account several important school level factors in generating a random sample of schools for invitation: percentage of pupils eligible for free school meals (undertaken prior to the recent changes to eligibility), percentage of South Asian pupils (Indian, Bangladeshi and Pakistani children); percentage of

Black pupils (African and Caribbean children); and school size (110). However, whilst the diverse nature of the West Midlands population and the purposeful oversampling of schools with high proportions of South Asian and Black children the WAVES study, may have maximised the external validity of the study findings, it also adds an element of heterogeneity to the sample which may reduce the power to detect true effect estimates (341).

7.3.2 Dietary assessment

The use of the Child and Diet Evaluation Tool (CADET) for dietary data collection was a pragmatic decision made due to the tool's reported ease-of-use, reliability, low-respondent burden, and cost-effectiveness in studying large samples. The CADET has also reported favourable comparisons to results from semi-weighed food records (113). However, the tool required updates for use in the WAVES study to reflect the release of the most recent UK nutrient databank and to smooth some anomalies in portion sizes (detailed in Chapter 2, Section 2.4). This may have undermined the previous validation of this tool and so repeat validation of the WAVES study version of CADET may be warranted.

Foods commonly consumed in the UK were grouped into the 115 items that make up the CADET. This aimed to keep respondent burden to a minimum. However, some foods in the UK vary distinctly on one characteristic e.g. the fibre content of bread or the fat content of milk. An attempt to account for this was taken in the development of the tool (e.g. conducting a weighted average of the nutrient content of different types according to frequency of consumption in the NDNS 1997). However, the lack of detail may alter the nutrient output for some consumers: for example, children who consume wholemeal bread/pasta will have higher fibre intakes than the CADET is able to record. Additionally, half portions could not be recorded; therefore, if a child consumed at least half of a portion of food, they were assigned a full portion.

A further limitation of the tool is the high proportion of fruit and vegetable (F&V) items in the tick list. CADET was originally developed as a tool to assess F&V consumption (113) and as such, fruit (13 items), and vegetables and legumes (22 items), constitute 20% of the items in the CADET. The original CADET validation study states fruit and vegetables were overestimated by 45g on average (113). This value is approximately one standard portion used in these analyses; therefore, the total estimated amount of F&V consumed must be interpreted with caution. Additionally, the use of half an adult portion (40g (fresh/frozen/tinned) and 15g (dried fruit)) to denote a child's portion of fruit and vegetables, in the absence of UK government recommendations, is not a standard approach. Jones *et al*. (2010) used an age-adjusted equivalent of the adult recommendations (which equate to 45g/MJ of energy or 400g (5 x 80g portions)), which for an average 5 year old would equate to 53.5g per portion (342). However, this does not take into account the limitations set on fruit juice and pulses nor the smaller portion size for dried fruit. Nevertheless, whilst the absolute values for F&V consumption obtained from CADET may be overestimated, this is unlikely to affect the differences in consumption in the subgroups studied in this thesis.

Finally, due to the nature of the CADET tool, for each measurement period, only one, 24 hour, school-day food and drink consumption was recorded for each child. This may not be reflective of habitual consumption or consumption on a non-school day, e.g. analysis of 9497 2-9 year old children from seven European countries found that, although total energy intake did not differ, the proportion of energy from sugar was higher on weekends compared to weekdays (343). However, it has been noted that for group comparisons such as those performed in this thesis, one-day assessments may be the best form of dietary assessment method as it allows the number of participants to be maximised (320).

7.3.3 Physical activity data

Whilst the use of an objective measure of physical activity was a strength of these studies, compliance in wearing the Actiheart could have been better. Only 71% of the WAVES study cohort had a valid objective measure of physical activity energy expenditure (kJ/kg/day) and therefore, including this as a confounder in regression models reduced the number of children available for analysis. However, to assess the impact of this loss of data, multiple imputation analysis was conducted and compared to the analysis of complete cases.

7.3.4 Goldberg equations

Limitations of the Goldberg method have been described in detail elsewhere (84, 126). In brief, the Goldberg calculations offer an inexpensive alternative to the gold standard method of doubly-labelled water, however they have limited sensitivity, highlighting only those at the extreme ends of reporting. They also lack the ability to differentiate between under/over-consumers and under/over reporters (126). Ideally, they require an objectively measure PAL to determine energy expenditure, however as this was not feasible in these studies, age and sex specific values for light activity were applied (131).

7.3.5 Sample size and missing data

Responder bias could be introduced by low response rates to questionnaires in a study, such that the data available is not representative of the whole study population, which could result in misleading outcomes (344). Kelley *et al*. (2003) state that while it is unwise to set acceptable limits for response rates, as circumstances differ between studies and populations of interest, a typical response rate for a postal questionnaire is around 65% (344). The WAVES study employed several techniques to encourage questionnaire completion. These included collection of the questionnaires directly from the child's school, periodic reminders via telephone to the school and letters addressed to the parents, a final reminder posted to schools with a duplicate questionnaire and business-reply envelope, and an incentive that families returning a completed questionnaire would be included in a prize draw to receive £100 of shopping vouchers. All of which have been shown to improve response rates (345). To enhance the completeness of dietary intake data, child recalls were performed, where possible, with children who had not returned a completed tick-list or the tick-list was deemed misrepresentative of the child's dietary intake, e.g. it had been completed as a FFQ rather than an actual record of consumption. The response rate for the parental questionnaire was approximately 64% and complete dietary records were obtained for approximately 81% of the WAVES study cohort at baseline. However, it is important to consider that the WAVES study baseline cohort included only 60% of those pupils eligible to participate in the study and losses to follow-up led to only 48% of those children eligible at baseline still taking part by the second round of follow-up measurements (Chapter Two, Section 2.2, **Figure 5**). Whilst, no notable difference in pupil level demographic characteristics were identified between those who participated in the WAVES study and the those who did not participate or those who were lost-to-follow up (346), the findings generated from the data may be less generalisable as a result of this missing data.

The sample size calculation for the WAVES study was conducted specifically to enable detection of a 0.25 change in BMI z-score post-intervention (110). The studies involved in Chapter 3-6 may therefore not have been sufficiently powered to detect changes in dietary quality or weight status with the resultant sample sizes available. However, the sample sizes were still reasonably large and the samples studied relatively representative of the WAVES study sample.

7.4 Future research directions

The studies conducted within this thesis found few significant associations with child weight status. This is common in dietary research and may highlight a particular challenge around dietary data collection and definitions of 'healthy'. This is particularly evident in exploring the HFE and therefore future work may consider reviewing the empirical evidence to date to determine what constructs determine a healthy HFE in the context of obesity prevention. Additionally, the development of simple, cost-effective, and accurate dietary assessment tools must be prioritised.

Recent government changes to the school food standards for England were implemented in January 2015, with the removal of nutrient based standards and a revision of the food based standards to make them easier to understand and cheaper to implement due to the removal of the need for nutrient analysis software (134, 347). Monitoring the effects of such a policy change is imperative to ensure the positive changes to school food provision made in recent years are not undone. Future research may wish to repeat the dietary assessment undertaken in the WAVES study in a sample of primary schools and compare the dietary intakes with the data presented within this thesis to determine the effects of the changes for school food standards and food policies within schools.

7.5 Conclusion

Increasing obesity prevalence may be attributable to a complex network of genetic, psychosocial, economic, dietary, life cycle and environmental and behavioural factors as described in the Foresight report (8). This thesis has examined the dietary intake and behaviours of a sample of children from the West Midlands, UK. Overall, the nutritional quality of food consumed by these children was poor, with high intakes of free sugar and sodium and low intakes of fibre. However, the findings of this thesis suggest small, consistent changes throughout the environments within which children make their food choices may help to improve dietary quality through reducing free sugar intake or increasing fruit and vegetable intakes. Children must be consistently offered the opportunity to make healthy dietary choices, both within and outside of the home and school environments. Though most aspects of the food environment of children examined as part of these studies showed a null or unclear association with weight status, one parent feeding practices was associated with a reduction (providing availability and access to healthy food), and another an increase (using food to regulate negative emotions), in the likelihood of overweight and obesity longitudinally. Coordinated efforts to effect changes, not only to ‘what’ foods children consume but how and in what context they consume them, may have lasting impacts in obesity prevention and various other chronic diseases such as type 2 diabetes and cardiovascular disease. Future studies may wish to test the potential impact of encouraging selected parental feeding practices and affecting changes to the home food environment within interventions to prevent and manage childhood overweight/obesity. However, consensus around what is meant by a healthy diet and food environment may be a starting point for future work.

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Appendices

9.1 Appendix 1: Standard operating procedures – height and weight

<u>SOP Height:</u>

1. Ask the child to remove their shoes, socks and any hair ornaments, jewellery, buns, or braids from the top of the head.

2. Ask the child to stand upright with their heels touching the back of the platform. Ensure they are positioned facing forwards with their heels and buttocks in contact with the vertical board.

3. Move indicator so that it is touching top of head, but not pressing down.

4. If the child has a hair style which stands well above the top of their head, (or is wearing a joora or turban) record this on the back of the recording sheet to the nearest mm. If the respondent is wearing a joora, or other religious headwear, explain to them what you want to do first and be guided by the child. **Never touch religious headwear without obtaining consent from the child first.**

5. Make sure the child's head is facing forward (not tilted up or down) with eyes looking straight ahead. As a rule of thumb, the eyes should be roughly level with the top of the ears.

6. Explain to the child what you are going to do in Step 7.

7. Cup the child's head in your hands, placing the heels of your palms either side of the chin, with your thumbs just in front of the ears, and your fingers going round towards the back of the neck.

8. Ask child to breathe in.

9. Firmly but gently, lift the child's head upwards towards the head plate, ensuring their heels are kept on the floor and taking care not to alter the level of the head (i.e. Step 5).

10. Release the pressure and allow the child to stand relaxed. If the measurement has been done correctly, the child should be able to step off the measure without ducking their head.

11. Record the reading to the nearest mm.

12. Take a repeat measurement (the child must step off the measure between readings), go from step 5.

13. If the two measurements disagree by more than 4mm, take a third measurement.

P.T.O.

Notes:

a) Record on the back of the recording sheet, anything that may affect or interfere with the measurement (for example, refusal to remove shoes, hairstyles and accessories, or posture problems, e.g. bow legs, arthritis)

b) If you were unable to obtain the height for whatever reason, write the reason in the comments section on the back of the recording sheet.

ENSURE THAT YOU USE THE ANTIBACTERIAL HAND GEL PROVIDED IN BETWEEN EACH CHILD MEASURED AND THAT THE PLATFORM OF THE MEASURE IS CLEANED USING ANTIBACTERIAL SPRAY

P.T.O.

SOP: Weight

1. The Tanita scales should be set up on a flat surface ensuring that the spirit level indicator is level.

2. Ask the child to remove shoes, socks and any heavy items of clothing e.g. jumper or cardigan. Also, ask them to remove any heavy items of jewellery and check that their pockets are empty. (NB. If the child does not want to remove socks/tights, note this on the back of the recording sheet).

3. Record if the child has been to the toilet prior to coming into the measurement room. (Children should have been asked to go to the toilet before entering the measurement room).

4. **Children are not to step on scales until instructed.** Enter 0.0 for clothes weight. Press enter.

5. Ask child to step on scales. The child's weight should be evenly distributed on both feet. Ask the child to stand upright, hands by their sides and head level with eyes looking straight ahead. Check that the child's heels and feet cover both metal pads. If feet are unable to cover electrodes, change to weight only mode.

6. Press male or female.

7. Press standard.

8. Enter the age in years.

9. Enter height in whole centimetres, rounding up or down, as appropriate. If rounding would result in 2 different whole centimetre values (e.g. if one measurement was 66.4 and the other was 66.5), use the higher of the two values.

10. Ask the child to stand perfectly still - "Be a statue."

11. Once the green light stops flashing, the Tanita will print the results. From this printout, record the weight, to the nearest gram, on the recording sheet.

12. Check the Impedance – if it is less than 350.0 Ω, take the weight again.

13. On the top of the printout, write the child's ID number and date of birth. Staple the printout to the recording sheet.

14. If an error message occurs, check the table overleaf and adjust if required. If error messages occur repeatedly press "weight only" button, to obtain weight.

Note the following in the comments sections of the measurement recording sheet:

- If you successfully obtained the weight but the child had a cast, amputation or medical prostheses.
- If you successfully obtained the weight but the child retained heavy clothing or items on his/her person for cultural reasons.
- If the child refuses to remove their shoes in order to step on the scale.
- If you were unable to obtain the weight for whatever reason state why.

9.2 Appendix 2: The Child and Diet Evaluation Tool (CADET)

9.2.1 School food collection sheets

Morning break School Collection Sheet

Date		School										
Researcher			Food names									
Notes												
Child ID Code	Child Name	Food code ➡										

Packed Lunch School Collection Sheet

School:			Class:		Date:		
Child ID Code	Child First Name	Child Last Name	Food				Food Code

School Meal Collection Sheet

School:											
Class:											
Date:											
ID code	First name	Last name									

Afternoon break School Collection Sheet

Class:		Please write the corresponding code of each food item the child consumed in the columns below. E.g. Apple =M2				
School:						
Date:						
Fieldworker:			Food Code	Food Code	Food Code	Food Code
Child ID:	Child First Name	Child Last Name				

9.2.2 Home food collection booklet

Child ID (for office use only)

Home Food Diary

This diary belongs to: ____________________

Child's gender (please circle) Male Female

Date of birth DD/MM/YY

Contact number
(For use by Study Team in case anything needs to be checked)

____

Dear Parent/Caregiver,

Please make sure that -

- You watch the Tommy Tomato DVD with your child and fill in the Home Food Diary tonight.
- After breakfast in the morning, complete what your child had to eat and / or drink.
- Return the diary and the DVD to school tomorrow, so that they can be collected by the researchers.

WAVES

UNIVERSITY OF BIRMINGHAM

Dear Parent or Carer,

As part of the WAVES study we need to record everything your child eats and drinks for 24 hours. Today at school a researcher recorded everything your child had whilst at school.

All you need to do is to tick the food and drink your child eats outside of school, from when they left school today to when they leave home tomorrow morning. If your child ate or drank something whilst being looked after by someone else after school (including all after school clubs), ask your child or your child's carer what they ate and tick the foods and drinks they consumed.

HOW TO FILL IN THE HOME FOOD DIARY

Please look through the diary so that you know where to find each food.
Starting with the column headed "**Before tea (after school)**" tick all the food and drink that your child eats and drinks after finishing school today until their evening meal.

In the columns headed "**Evening meal/tea**", tick all the foods and drinks your child had for their evening meal.

In the column headed "**After tea/during night**" tick all the foods and drinks your child had after their evening meal and during the night.

In the column headed "**Breakfast/before school**", tick all the items of food and drink your child had at home before going to school the following morning (if your child eats breakfast anywhere else, this will be filled in at school).

If they do not have anything to eat or drink at a mealtime, please tick "**nothing to eat**" and/or "**nothing to drink**" on page 9.

Make sure you ask your child if she/he ate or drank anything between leaving school and getting home including all after school clubs.

If you cannot find the exact food or drink listed. Please tick the item you think is the closest match e.g.

> Spaghetti Bolognese is: **pasta with meat/fish (and sauce)**
> Popadom is: **crisps/savoury snack**

There are some additional questions that we would like you to complete at the end of the diary (page 9). When the diary is completed, please make sure it is placed in your child's bag and sent back to school.

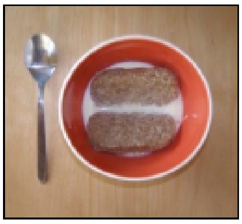
Before you start, please look at the examples of how to fill in the home food diary .

We have also provided a short (5 minutes) DVD that shows you what to do.

Here are some **EXAMPLES** of how to fill in the Home Food Diary

Tommy had a cereal bar and 2 chocolate biscuits when he got home from school so his mum ticked these foods in the column **'Before tea/(after school)'**

B **EXAMPLE 1: Snack Food**	Before tea /after school	Evening meal/tea	After tea/ during night	Breakfast/ before school
1 Crisps, savoury snacks (cheddars)	☐	☐	☐	☐
2 Crackers, crispbread etc	☐	☐	☐	☐
3 Cereal bar muesli bar, flapjack	☑	☐	☐	☐
4 Chocolate biscuit	☑	☐	☐	☐



The following morning Tommy had a bowl of weetabix with milk for breakfast so his mum ticked these foods in the column **'Breakfast/before school**

P **EXAMPLE 2: Cereals**	Before tea (after school)	Evening meal/tea	After tea/ during night	Breakfast/ before school
1 Sugar-coated e.g. Frosties, Sugar Puffs	☐	☐	☐	☐
2 Hi-fibre e.g. Branflakes, Weetabix, Shreddies, muesli	☐	☐	☐	☑
3 Other e.g. Cornflakes, Rice Krispies etc	☐	☐	☐	☐
4 Milk on cereal	☐	☐	☐	☑
5 Sugar on cereal	☐	☐	☐	☐

2

A **Drinks**	Before tea /after school	Evening meal/tea	After tea/ during night	Breakfast/ before school
1 Milk, milky drink, lassi	☐	☐	☐	☐
2 Tea, coffee	☐	☐	☐	☐
3 Drinking chocolate etc	☐	☐	☐	☐
4 Fizzy drink (pop/cola), squash, fruit drink (e.g. Ribena)	☐	☐	☐	☐
5 Diet, low calorie drink (including fizzy low calorie)	☐	☐	☐	☐
6 Fruit juice (pure)/smoothies	☐	☐	☐	☐
7 Water	☐	☐	☐	☐

B **Snack Food**	Before tea /after school	Evening meal/tea	After tea/ during night	Breakfast/ before school
1 Crisps, savoury snacks (cheddars)	☐	☐	☐	☐
2 Crackers, crispbread etc	☐	☐	☐	☐
3 Cereal bar, muesli bar, flapjack	☐	☐	☐	☐
4 Chocolate biscuit	☐	☐	☐	☐
5 Other biscuit	☐	☐	☐	☐
6 Croissant, waffles, pop tarts	☐	☐	☐	☐
7 Yoghurt, fromage frais	☐	☐	☐	☐
8 Nuts	☐	☐	☐	☐

C **Sandwich, bread**	Before tea /after school	Evening meal/tea	After tea/ during night	Breakfast/ before school
1 Sandwich (tick filling separately). Bread, roll, toast crumpet	☐	☐	☐	☐
2 Croissant, sweet waffles, pop tarts	☐	☐	☐	☐

3 Garlic bread, naan, paratha	☐	☐	☐	☐
4 Chapatti, pitta bread, wrap, roti etc	☐	☐	☐	☐
5 Cracker, crispbread etc	☐	☐	☐	☐
D **Spreads, Sauces, Soup**	Before tea /after school	Evening meal/tea	After tea/ during night	Breakfast/ before school
1 Margarine, butter	☐	☐	☐	☐
2 Tomato Ketchup, brown sauce	☐	☐	☐	☐
3 Mayonnaise, salad cream	☐	☐	☐	☐
4 Sweet spread e.g. jams, honey	☐	☐	☐	☐
5 Savoury spread e.g. marmite, pate	☐	☐	☐	☐
6 Gravy	☐	☐	☐	☐
7 Soup	☐	☐	☐	☐
E **Cheese, Eggs**	Before tea /after school	Evening meal/tea	After tea/ during night	Breakfast/ before school
1 Hard cheese, e.g. Cheddar, Red Leicester	☐	☐	☐	☐
2 Cheese spread, triangle, string	☐	☐	☐	☐
3 Cottage cheese	☐	☐	☐	☐
4 Quiche - meat, fish or vegetable	☐	☐	☐	☐
5 Scrambled egg, omelette, fried egg	☐	☐	☐	☐
6 Poached, boiled egg	☐	☐	☐	☐
F **Chicken, Turkey**	Before tea /after school	Evening meal/tea	After tea/ during night	Breakfast/ before school
1 ......sliced or plain	☐	☐	☐	☐

4

2	……nuggets, dippers, kiev, etc	☐	☐	☐	☐
3	……in a creamy sauce, curry e.g. korma or tikka masala	☐	☐	☐	☐
G	**Other Meats e.g.**	Before tea /after school	Evening meal/tea	After tea/ during night	Breakfast/ before school
1	……sliced roast, steak, chops	☐	☐	☐	☐
2	……stew casserole, mince, curry or keema	☐	☐	☐	☐
3	……beef burger, hamburger, doner, kebab	☐	☐	☐	☐
4	Bacon	☐	☐	☐	☐
5	Ham	☐	☐	☐	☐
6	Sausages	☐	☐	☐	☐
7	Sausage roll, meat pie, pasty, fried dumplings	☐	☐	☐	☐
8	Corned beef, luncheon meats, salami, pepperoni	☐	☐	☐	☐
9	Offal e.g. liver, kidney	☐	☐	☐	☐
H	**Fish**	Before tea /after school	Evening meal/tea	After tea/ during night	Breakfast/ before school
1	Fish fingers	☐	☐	☐	☐
2	Fried fish in batter (as in fish and chips)	☐	☐	☐	☐
3	White fish (not fried) e.g. cod, haddock, plaice	☐	☐	☐	☐
4	Tuna or other oily fish (including can or fresh)	☐	☐	☐	☐
5	Shellfish e.g. prawns, mussels	☐	☐	☐	☐
I	**Vegetarian**	Before tea /after school	Evening meal/tea	After tea/ during night	Breakfast/ before school
1	Vegetable pie, pasty	☐	☐	☐	☐

2	Samosa, pakora bhajee	☐	☐	☐	☐
3	Quorn, veggie mince, sausages etc	☐	☐	☐	☐
4	Mixed vegetable curry	☐	☐	☐	☐
5	Paneer (cheese curry)	☐	☐	☐	☐

J	Pizza, Pasta, Rice etc	Before tea /after school	Evening meal/tea	After tea/ during night	Breakfast/ before school
1	Pizza	☐	☐	☐	☐
2	Boiled rice	☐	☐	☐	☐
3	Fried rice	☐	☐	☐	☐
4	Noodles	☐	☐	☐	☐
5	Pasta-plain, cous cous	☐	☐	☐	☐
6	Pasta with tomato sauce (no meat)	☐	☐	☐	☐
7	Pasta with cheese sauce	☐	☐	☐	☐
8	Pasta with meat/fish (and sauce)	☐	☐	☐	☐
9	Yorkshire pudding, pancake	☐	☐	☐	☐

K	Vegetables & Beans	Before tea /after school	Evening meal/tea	After tea/ during night	Breakfast/ before school
1	Mixed vegetables	☐	☐	☐	☐
2	Tomatoes	☐	☐	☐	☐
3	Cucumber	☐	☐	☐	☐
4	Coleslaw	☐	☐	☐	☐
5	Other salad vegetables e.g. lettuces	☐	☐	☐	☐
6	Stir-fried vegetables	☐	☐	☐	☐
7	Broccoli, brussel sprouts, cabbage	☐	☐	☐	☐

K	Vegetables & Beans	Before tea /after school	Evening meal/tea	After tea/ during night	Breakfast/ before school
8	Courgettes	☐	☐	☐	☐
9	Spinach	☐	☐	☐	☐
10	Parsnips	☐	☐	☐	☐
11	Radish	☐	☐	☐	☐
12	Leeks	☐	☐	☐	☐
13	Carrots	☐	☐	☐	☐
14	Cauliflower	☐	☐	☐	☐
15	Peas, sweetcorn	☐	☐	☐	☐
16	Celery	☐	☐	☐	☐
17	Peppers, red, green, yellow etc	☐	☐	☐	☐
18	Other vegetable	☐	☐	☐	☐
19	Baked beans	☐	☐	☐	☐
20	Lentils, dahl	☐	☐	☐	☐
21	Other beans	☐	☐	☐	☐
22	Seeds e.g. sunflower, sesame	☐	☐	☐	☐

L	Potato	Before tea (after school)	Evening meal/tea	After tea/ during night	Breakfast/ before school
1	Boiled, mashed, jacket	☐	☐	☐	☐
2	Chips, roast, potato faces etc	☐	☐	☐	☐

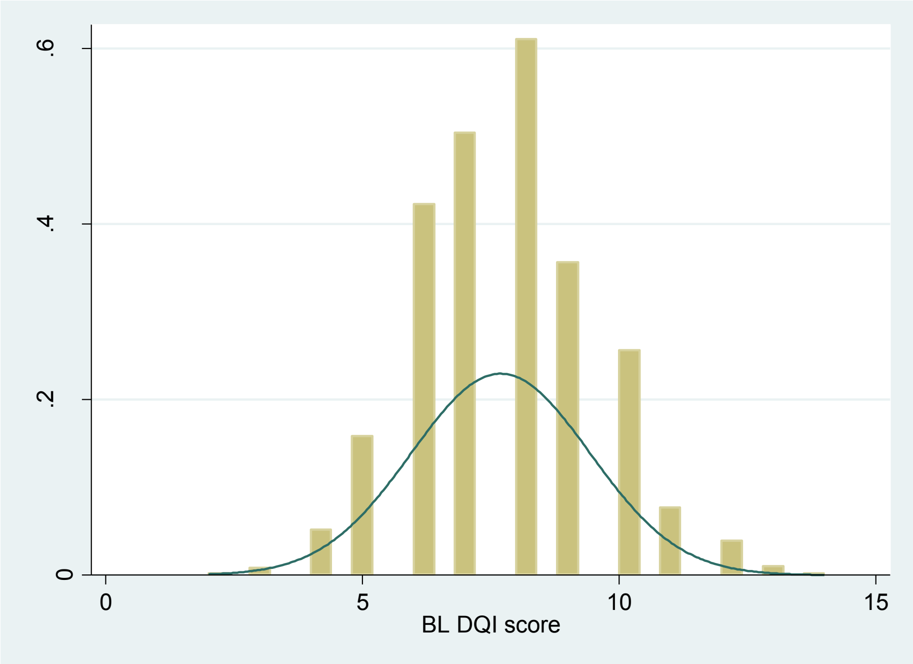
M	Fruit	Before tea (after school)	Evening meal/tea	After tea/ during night	Breakfast/ before school
1	Fruit salad (tinned or fresh)	☐	☐	☐	☐
2	Apple	☐	☐	☐	☐

M	Fruit	Before tea (after school)	Evening meal/tea	After tea/ during night	Breakfast/ before school
3	Pear	☐	☐	☐	☐
4	Banana	☐	☐	☐	☐
5	Orange, satsuma etc	☐	☐	☐	☐
6	Grapes	☐	☐	☐	☐
7	Melon, watermelon	☐	☐	☐	☐
8	Pineapple	☐	☐	☐	☐
9	Strawberry, raspberry etc	☐	☐	☐	☐
10	Peach, nectarine, plum, apricot, mango	☐	☐	☐	☐
11	Kiwi	☐	☐	☐	☐
12	Other fresh fruit	☐	☐	☐	☐
13	Dried fruit	☐	☐	☐	☐
N	Desserts, Puddings, & Cakes etc	Before tea (after school)	Evening meal/tea	After tea/ during night	Breakfast/ before school
1	Jelly, ice lolly	☐	☐	☐	☐
2	Ice cream, frozen dessert (e.g. Vienetta)	☐	☐	☐	☐
3	Cream, custard	☐	☐	☐	☐
4	Mousse, milk puddings, e.g. rice pudding	☐	☐	☐	☐
5	Cakes, buns, sponge pudding	☐	☐	☐	☐
6	Sweet pies, tarts, crumbles	☐	☐	☐	☐
O	Sweets	Before tea (after school)	Evening meal/tea	After tea/ during night	Breakfast/ before school
1	Sweets, toffees, mints	☐	☐	☐	☐
2	Chocolate bars, e.g. Mars, Galaxy	☐	☐	☐	☐

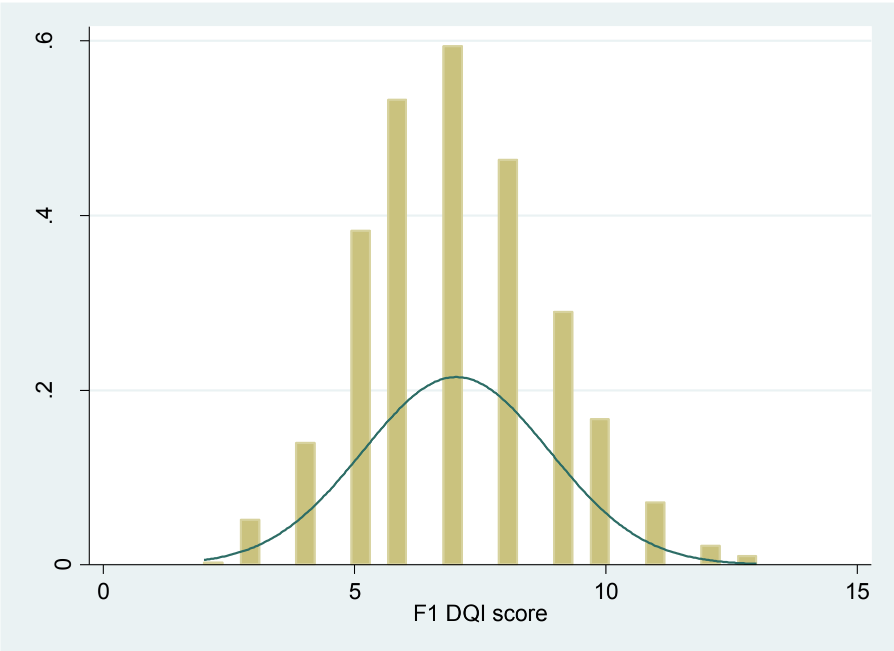
P	Cereals	Before tea (after school)	Evening meal/tea	After tea/ during night	Breakfast/ before school
1	Sugar-coated e.g. Frosties, Sugar Puffs	☐	☐	☐	☐
2	Hi-fibre e.g. Branflakes, Weetabix, Shreddies, muesli	☐	☐	☐	☐
3	Other e.g. Cornflakes, Rice Krispies etc	☐	☐	☐	☐
4	Porridge, Ready Brek	☐	☐	☐	☐
5	Milk on cereal	☐	☐	☐	☐
6	Sugar on cereal	☐	☐	☐	☐
Q	NOTHING TO EAT	☐	☐	☐	☐
R	NOTHING TO DRINK	☐	☐	☐	☐
S	OTHER FOOD NOT ON THE LIST (please list below)				
	______________________	☐	☐	☐	☐
	______________________	☐	☐	☐	☐

9.3 Appendix 3: Distribution of Diet Quality Index scores

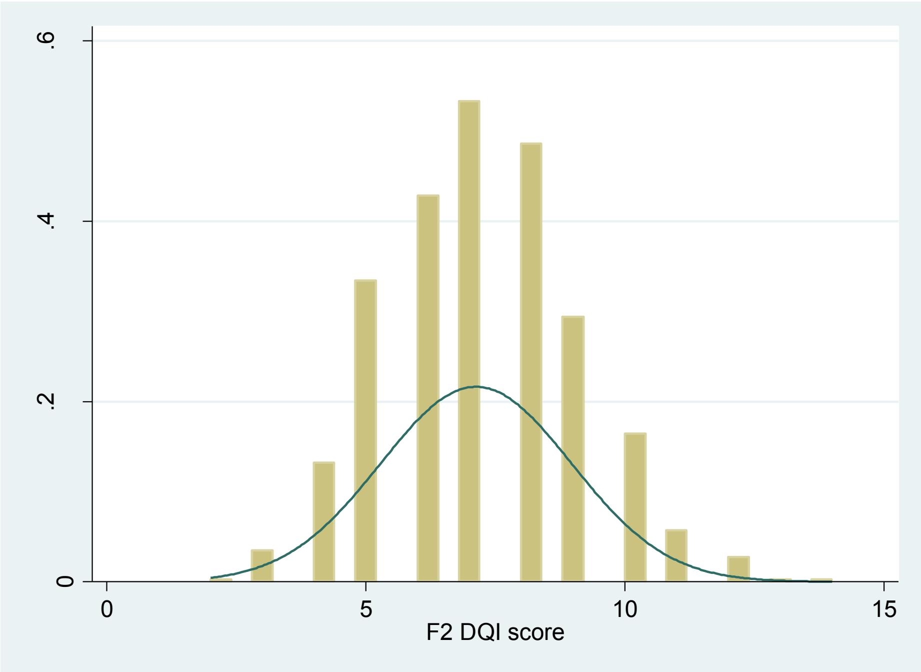
9.3.1 Baseline DQI score:



9.3.2 F1 DQI score:



9.3.3 F2 DQI score:



9.4 Appendix 4: WAVES study baseline parental questionnaire

Waves

UNIVERSITY OF BIRMINGHAM

ID LABEL

Parent Questionnaire

Thank you for agreeing for your child to be included in the WAVES study. **It is important that we receive a completed parent questionnaire for as many children as possible.** We would be most grateful if you could take the time to complete this questionnaire in relation to your Year 1 child, it should take around 30 minutes to complete.

If the questionnaire is completed and returned to your child's school, you will be entered into a **free prize draw** for shopping vouchers up to a maximum value of £100.

Completing the questionnaire

- This questionnaire should be completed by the **main caregiver** for the child in Year 1 taking part in the WAVES study.
- Please answer the questions in relation to your child in Year 1.
- Please answer all the questions by either putting a ✓ or writing in the boxes provided.
- Please try to answer all of the questions.

Confidentiality

All information about you and your child will be kept in the strictest of confidence. Your responses will only be seen by members of the research team.

Why we are collecting this information

The WAVES study is testing out a programme of activities that is designed to help children keep their weight at a healthy level. We know from other research that many factors may be involved in helping children maintain a healthy weight, but we don't fully understand these and past studies don't always agree with each other. To help us increase our overall understanding it is important that we collect a variety of background information in relation to both the child and their family. Some questions may seem sensitive and if you feel uncomfortable with any of them, you do not have to answer them.

Contact us

If you have any questions or require more information relating to this questionnaire or the WAVES study, please contact a member of the research team on: **0121 414 3921**

Please return within the next 10 days

Everyone who returns a completed questionnaire will be entered into a free prize draw for the chance to win shopping vouchers of up to £100.

We would like to start by asking for some information on your child in Year 1 and your relationship to this child. We would also like to know if you would be prepared to help us in the future.

Child's full name ....

Child's gender: ☐ Male
(please tick one box) ☐ Female

Child's date of birth: day ☐☐ month ☐☐ year ☐☐☐☐
(please complete in the boxes provided)

Your relationship to this child (please tick one box)

☐ Mother
☐ Father
☐ Other (please describe your relationship to the child)

....

We would like to invite some parents and their child for more detailed measures at the University over the next year. Would you be willing to be contacted for this?
(please tick one box)

☐ Yes (please provide your contact details in the box provided below)
☐ No

Contact details

Name: ....

Telephone number: ....

Address: ....

Postcode: ....

Email : ....

In the first section we ask for some information about your household and your child's activities

1 How many children under the age of 16 are there in your household?
(please write the total number, including the child for whom you are completing this questionnaire, in the box provided)
number ☐☐

2 How many people aged 16 years or above live in the same household as your child?
(please write the total number, including yourself, in the box provided)
number ☐☐

3 **In this question we are interested in the range of activities your child does when they are not physically active. Please tell us how long in total, outside of school time, your child spends doing each of the following activities.**

i) **First think about a typical school weekday (Monday to Friday) and include both before and after school?** (please complete this in the first column with **i) MON to FRI** at the top)

ii) **Now think about a typical weekend day (Saturday or Sunday).** (please complete this in the second column with **ii) SAT or SUN** at the top)

	i) MON to FRI Average time spent each day on a typical school weekday including both before and after school		**ii) SAT or SUN** Average time spent each day on a typical weekend day	
	Hours	**Minutes**	**Hours**	**Minutes**
Sleeping (include night and day time naps)				
Watching TV, videos or DVD's				
Using a computer (excluding homework), playing electronic games (eg Playstation / Nintendo DS)				
Craft, colouring, drawing				
Sitting listening to music				
Playing a musical instrument				
Reading, homework				

4 **If your child attends any organised clubs which involve physical activity in or out of school please provide details in the boxes below.**

(Clubs could include team games (eg football, netball), group activities (eg dance, athletics, cycling, martial arts), individual sports (eg swimming, tennis) or non-sporting physically active clubs (eg gardening)).

(please complete **both** the total time spent each week **and the** number of visits each week)

	Total time spent at the club each week		**Number of visits to club each week**
Name of club	**Hours**	**Minutes**	**Number**

5 **In the last month has your child, outside of school lesson time, taken part in any of the activities below?**

(please put a tick in the box next to each activity that your child has done IN THE LAST MONTH)

- ☐ Football (including five-a side)
- ☐ Netball
- ☐ Hockey
- ☐ Rounders
- ☐ Cricket
- ☐ Tennis
- ☐ Badminton
- ☐ Golf
- ☐ Bowling
- ☐ Swimming
- ☐ Running or athletics
- ☐ Gymnastics
- ☐ Trampolining
- ☐ Playground equipment (eg climbing frame)
- ☐ Ballet, dance, tap or aerobics
- ☐ Martial arts (eg karate or judo)
- ☐ Ice skating, ice hockey or snow sports
- ☐ Roller skating / blading or skate boarding
- ☐ Walking for leisure
- ☐ Cycling or scooting
- ☐ Horse riding or pony trekking
- ☐ Other game skills (eg hopscotch, skipping, throwing & catching)
- ☐ Other physical activity (please describe) ____________________

6 **How long, on average, would it take for your child to walk to school?** Minutes ☐
(please write the time it would take in minutes in the box provided)

7 **In a typical week, how many times per week (0 to 5 days) does your child walk, scooter or cycle to / from school?**

(Please think about each school term separately. For each term place one tick in the 1st row of boxes to indicate the number of times your child walks, scooters or cycles to school and another tick in the 2nd row of boxes to indicate the number of times for **returning** home (6 ticks in total)).

	Autumn term						Spring term						Summer term					
	0	1	2	3	4	5	0	1	2	3	4	5	0	1	2	3	4	5
Going to school																		
Returning home																		

In the second section we ask about your child's sleeping patterns

8 **What is your child's bedtime on:**

i) **a typical school week day?** ☐☐ : ☐☐ pm

(please complete the times in the boxes provided)

ii) **a typical weekend / holiday day?** ☐☐ : ☐☐ pm

9 **Please think about your child's sleeping in the <u>last week</u> and complete the following,** if the last week was an unusual week for your child, please think about a recent typical week.

(please tick one box in each row)

	Usually (5 - 7 times)	Sometimes (2 - 4 times)	Rarely/Never (0 - 1 times)
Child goes to bed at about the same time at night	☐	☐	☐
Child falls asleep within 20 minutes after going to bed	☐	☐	☐
Child falls asleep alone in own bed	☐	☐	☐
Child falls asleep in parent's or sibling's bed	☐	☐	☐
Child needs parent in the room to fall asleep	☐	☐	☐
Child struggles at bedtime (eg cries, refuses to stay in bed)	☐	☐	☐
Child is afraid of sleeping alone	☐	☐	☐
Child sleeps too little	☐	☐	☐
Child sleeps too much	☐	☐	☐
Child sleeps the right amount	☐	☐	☐
Child sleeps about the same amount each night	☐	☐	☐
Child moves to someone else's bed during the night (eg parent, sibling)	☐	☐	☐
Child wakes once during the night	☐	☐	☐
Child wakes more than once during the night	☐	☐	☐
Child wakes by him/herself	☐	☐	☐
Adults or siblings wake up child	☐	☐	☐
Child wakes up in a negative mood	☐	☐	☐
Child has difficulty getting out of bed in the morning	☐	☐	☐
Child takes a long time to become alert in the morning	☐	☐	☐
Child naps during the day	☐	☐	☐
Child seems tired	☐	☐	☐

10 **What time does your child usually wake up in the morning on:**

i) **a typical school week day?** ☐☐ : ☐☐ am

(please complete in the boxes provided)

ii) **a typical weekend / holiday day?** ☐☐ : ☐☐ am

In the third section we ask for some information about your child and their usual eating habit's

11 During an average week, how often (0 to 7 days) does your child usually have breakfast of more than just a glass of milk or juice?
(please complete the number of days in the box provided)

☐ days a week

12 In an average week, how often does your child eat / drink each of the following?
(please tick one box on each row and if once a day or more please also specify number each day)

	Never	Less than once a week	1 – 3 days a week	4 – 6 days a week	once a day or more	
A serving of fruit eg 1 medium apple or other fresh fruit, 3 heaped tablespoons fruit salad, 1 heaped tablespoon raisins or other dried fruit, small glass of 100% fruit juice DO NOT include other fruit drinks	☐	☐	☐	☐	☐	Number each day ☐
A serving of vegetables eg 1 medium carrot or other fresh vegetable 1 small bowl green salad, 3 heaped tablespoons raw or cooked vegetables, 3 heaped tablespoons of beans or pulses DO NOT include any form of potato or deep fried vegetables	☐	☐	☐	☐	☐	Number each day ☐
A glass of low fat or semi-skimmed milk	☐	☐	☐	☐	☐	Number each day ☐
A glass of whole or full fat milk	☐	☐	☐	☐	☐	Number each day ☐
Soft drinks that contain sugar eg coke, fruit cordials/squashes, fruit shoot, lemonade	☐	☐	☐	☐	☐	Number each day ☐

13 What time does your child usually have their evening meal?
(please complete time in the boxes provided)

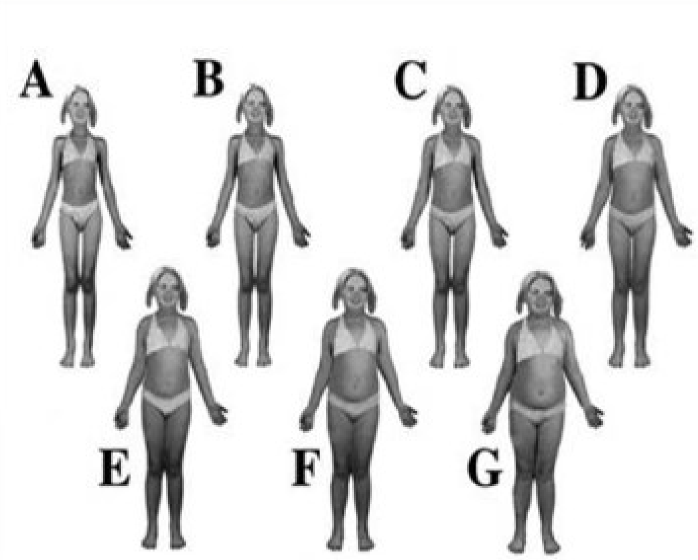
☐☐ : ☐☐ pm

14 Please look at the pictures below to answer the following four questions.
(for each question please tick the box under the letter for the picture closest to your choice)

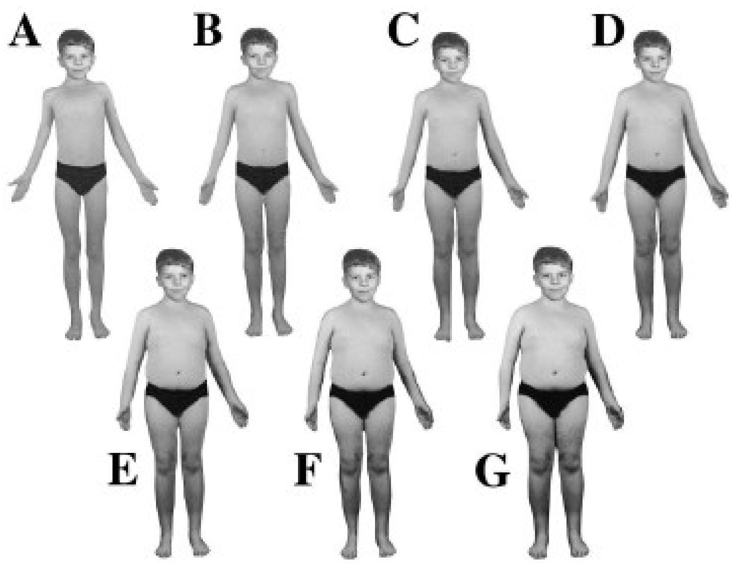
(please tick one box on each row)

		A	B	C	D	E	F	G
i)	Which picture looks most like your child?	☐	☐	☐	☐	☐	☐	☐
ii)	Which picture shows the way you want your child to look?	☐	☐	☐	☐	☐	☐	☐
iii)	Which picture shows the way you think is best for boys to look?	☐	☐	☐	☐	☐	☐	☐
iv)	Which picture shows the way you think is best for girls to look?	☐	☐	☐	☐	☐	☐	☐

Girls



Boys



15 **Do you think your child is?** (please tick one box only)

☐ Underweight ☐ Normal weight ☐ Overweight

16 **Would you say your child's health in general is?** (please tick one box only)

☐ Very good ☐ Good ☐ Fair ☐ Poor

17 **When your child was a baby, how long were they breast fed for AND for how long were they <u>exclusively</u> breast fed for?** (Exclusive = just breast milk, no food, formula milk, water or other drinks)

(please tick one box on each row)

	Not at all	Less than one month	1 to 2 months	3 to 5 months	6 to 11 months	12 months or longer
Breastfed	☐	☐	☐	☐	☐	☐
Exclusively breastfed	☐	☐	☐	☐	☐	☐

18 **What was your child's birth weight?** (please complete in either pounds and ounces **or** kilograms)

lb ☐ oz ☐ OR kg ☐ • ☐

In the fourth section we ask for some information about you and your family

19 **Are you?** (please tick one box) ☐ Male ☐ Female

20 **How old are you?** (please complete your current age in the box provided)

Years ☐

21 **In a typical week (7 days) how many times on average do you do the following kinds of exercise for more than 30 minutes during your leisure time? Write zero if in a typical week you would not normally do the specified level of exercise for more than 30 minutes.**

(Please count the number of times in a typical week you undertake each level of exercise for more than 30 minutes and write the number in the appropriate box. Each separate session should only be counted once even if the duration of the session is greater than 30 minutes.)

		Times per week
Strenuous exercise	(heart beats rapidly, sweating eg jogging, vigorous swimming, netball, aerobics, circuits)	☐
Moderate exercise	(not exhausting, but tiring eg fast walking, tennis, cycling, easy swimming, dancing)	☐
Mild exercise	(minimal effort eg yoga, archery, bowling, golf, easy walking)	☐

22 **What is your current height without shoes?** (please complete in either feet and inches **or** in centimetres)

feet [ ] inches [ ] OR centimetres [ ]

23 **What is your current weight without shoes?** (please complete in either stones and pounds **or** in kilograms)

stones [ ] pounds [ ] OR kg [ ] • [ ]

24 **On an average day, how many hours do you watch television or use a computer?** (please include both time spent during work and during leisure time and write the total time in the box provided)

hours [ ][ ] minutes [ ][ ]

25 **On average, how long do you sleep each night** (please write the total time in the boxes provided)

hours [ ][ ] minutes [ ][ ]

26 **Do you ever have difficulty falling asleep, staying asleep, or do you feel poorly rested in the morning?** (please tick one box)

[ ] Never [ ] Sometimes [ ] Almost always

27 **Do you smoke?** (please tick one box)

[ ] Yes [ ] No

If Yes, how many cigarettes do you smoke in an average day? (please write number in an average day in the box provided)

number [ ]

28 **Has a doctor ever told you that you have high blood pressure?** (please tick one box)

[ ] Yes [ ] No

29 **In an average week, how often do you eat / drink each of the following?** (please tick one box on each row and if once a day or more please also specify number each day)

	Never	Less than once a week	1 – 3 days a week	4 – 6 days a week	once a day or more	
A serving of fruit eg 1 medium apple or other fresh fruit, 3 heaped tablespoons fruit salad, 1 heaped tablespoon raisins or other dried fruit, small glass of 100% fruit juice DO NOT include other fruit drinks	[ ]	[ ]	[ ]	[ ]	[ ]	Number each day [ ]
A serving of vegetables eg 1 medium carrot or other fresh vegetable 1 small bowl green salad, 3 heaped tablespoons raw or cooked vegetables, 3 heaped tablespoons of beans or pulses DO NOT include any form of potato or deep fried vegetables	[ ]	[ ]	[ ]	[ ]	[ ]	Number each day [ ]
Soft drinks that contain sugar eg coke, fruit cordials/squashes, fruit shoot, lemonade	[ ]	[ ]	[ ]	[ ]	[ ]	Number each day [ ]

30 **Do you have a spouse or partner living in the same house as you?** ☐ Yes ☐ No
(please tick one box)

(if you have answered No to Question 30 please go to Question 41 on page 11, otherwise please continue with the next question)

31 **How old is your spouse / partner?** **years** ☐
(please complete their current age in the box provided)

32 **In a typical week (7 days) how many times on average does your spouse / partner do the following kinds of exercise for more than 30 minutes during their leisure time? Write zero if in a typical week they would not normally do the specified level of exercise for more than 30 minutes.**

(Please count the number of times in a typical week they undertake each level of exercise for more than 30 minutes and write the number in the appropriate box. Each separate session should only be counted once even if the duration of the session is greater than 30 minutes.)

		Times per week
Strenuous exercise	(heart beats rapidly, sweating eg jogging, vigorous swimming, netball, aerobics, circuits)	☐
Moderate exercise	(not exhausting, but tiring eg fast walking, tennis, cycling, easy swimming, dancing)	☐
Mild exercise	(minimal effort eg yoga, archery, bowling, golf, easy walking)	☐

33 **What is the current height of your spouse / partner without shoes?**
(please complete in either feet and inches **or** in centimetres)

feet ☐ **inches** ☐ OR **centimetres** ☐

34 **What is the current weight of your spouse / partner without shoes?**
(please complete in either stones and pounds **or** in kilograms)

stones ☐ **pounds** ☐ OR **kg** ☐ • ☐

35 **On an average day, how many hours does your spouse / partner watch television or use a computer?** (please include both time spent during work and during leisure time and write the total time in the boxes provided) **hours** ☐☐ **minutes** ☐☐

36 **On average, how long does your spouse / partner sleep each night?** **hours** ☐☐ **minutes** ☐☐
(please write the total time in the boxes provided)

37 Does your spouse / partner ever have difficulty falling asleep, staying asleep, or do they feel poorly rested in the morning? (please tick one box)

☐ Never ☐ Sometimes ☐ Almost always

38 Does your spouse / partner smoke? ☐ Yes ☐ No
(please tick one box)

If Yes, how many cigarettes do they smoke in an average day? number ☐
(please write number in an average day in the box provided)

39 Has a doctor ever told your spouse / partner that they have high blood pressure? (please tick one box) ☐ Yes ☐ No

40 In an average week, how often does your spouse / partner eat / drink each of the following?
(please tick one box on each row and if once a day or more please also specify number each day)

	Never	Less than once a week	1 – 3 days a week	4 – 6 days a week	once a day or more	
A serving of fruit eg 1 medium apple or other fresh fruit, 3 heaped tablespoons fruit salad, 1 heaped tablespoon raisins or other dried fruit, small glass of 100% fruit juice DO NOT include other fruit drinks	☐	☐	☐	☐	☐	Number each day ☐
A serving of vegetables eg 1 medium carrot or other fresh vegetable 1 small bowl green salad, 3 heaped tablespoons raw or cooked vegetables, 3 heaped tablespoons of beans or pulses DO NOT include any form of potato or deep fried vegetables	☐	☐	☐	☐	☐	Number each day ☐
Soft drinks that contain sugar eg coke, fruit cordials/squashes, fruit shoot, lemonade	☐	☐	☐	☐	☐	Number each day ☐

In the fifth section we ask for some information about your family's eating habits

41 In general, how often does your family:
(please tick one box in each row)

	Less than once a year	1 – 4 times a year	5 – 11 times a year	1 – 3 times a month	1 – 2 times a week	More than twice a week
Go out for a meal? (include breakfast, lunch and dinner)	☐	☐	☐	☐	☐	☐
Have take away food from a fast food shop?	☐	☐	☐	☐	☐	☐

42 How often in a normal week does your child eat an evening meal that is:

(please write the number of times in a normal week for each type of meal, the total of the 3 numbers should not be greater than 7)

		Times per week
i)	prepared from basic ingredients? (eg Shepherd's pie starting from raw mince and potatoes or chicken and vegetable curry starting with raw chicken and vegetables)	☐
ii)	prepared using some ready-made ingredients? (eg using a ready-made sauce or shop bought fish fingers with oven chips and peas)	☐
iii)	a complete ready meal? (eg shop bought pizza or oven ready pasta bake or curry)	☐

43 How often does your family sit at a table to eat an evening meal together? Family means your child, their siblings and at least one parent / guardian. (please tick one box)

☐ everyday ☐ 4 – 6 days a week ☐ 1 – 3 days a week ☐ less than once a week ☐ never

44 How often do either you or your spouse / partner cook with your child?
(please tick one box)

☐ everyday ☐ 1 – 3 times a month
☐ 4 – 6 days a week ☐ less than once a month
☐ 1 – 3 days a week ☐ never

45 How often are you responsible for preparing your child's evening meal?
(please write the number of times in a normal week in the box provided)

Times per week ☐

46 How confident do you feel about:
(please tick one box in each row)

		Extremely confident	Confident	Not very confident	Not at all confident
i)	being able to cook from basic ingredients? (eg using fresh vegetables and without using ready-made sauces)	☐	☐	☐	☐
ii)	your knowledge of what to eat to have a healthy diet?	☐	☐	☐	☐
iii)	preparing and cooking new foods and recipes?	☐	☐	☐	☐
iv)	shopping for healthy foods?	☐	☐	☐	☐
v)	your ability to prepare meals that you know are healthy?	☐	☐	☐	☐
vi)	tasting foods that you have not eaten before?	☐	☐	☐	☐

47 **Which of the following food / drink items are usually found in your home?**
(please tick all that apply)

- ☐ crisps
- ☐ salted nuts
- ☐ unsalted nuts
- ☐ seeds
- ☐ fresh fruit
- ☐ dried fruit
- ☐ chocolate / chocolate bars
- ☐ sweets (eg toffees or boiled sweets)
- ☐ cake
- ☐ biscuits
- ☐ ice cream
- ☐ soft drinks that contain sugar (eg coke, fruit cordials / squashes, fruit shoot, lemonade)

☐ Other (please specify) ....

48 **Excluding fruit, to what extent can your child eat snacks without your permission? eg crisps, biscuits, chocolate, sweets** (please tick one box)

☐ never ☐ rarely ☐ sometimes ☐ frequently ☐ always

49 **How frequently does your child buy their own snacks? eg crisps, biscuits, chocolate, sweets**
(please tick one box)

☐ never ☐ rarely ☐ sometimes ☐ frequently ☐ always

50 **How frequently when your child asks for a snack do they claim to be hungry?**
(please tick one box)

☐ never ☐ rarely ☐ sometimes ☐ frequently ☐ always

51 **In general when your child eats a snack, which of the following statements most often applies?**
(please tick **one** box only)

☐ they asked for it ☐ it was offered by you / another adult

Please go to section 6 on the next page

In the sixth section we ask for some information about your knowledge of leisure facilities in your local area and your family's leisure time

52 **For each of the leisure facilities listed below please indicate which of the options applies to your family?** (please tick one box in each row)

	Available in local area and used by your family	Available in local area but not used by your family	Not available in your local area	Unsure whether available in local area
swimming pool	☐	☐	☐	☐
gym with exercise & weights machines	☐	☐	☐	☐
sports hall	☐	☐	☐	☐
exercise class / dance studio	☐	☐	☐	☐
outdoor tennis court	☐	☐	☐	☐
outdoor football pitch	☐	☐	☐	☐
outdoor netball court	☐	☐	☐	☐
children's playground	☐	☐	☐	☐
park or green space	☐	☐	☐	☐
route for walking	☐	☐	☐	☐
route for cycling	☐	☐	☐	☐

53 **Do you, as a family, take part in any sports, exercise or other physically active pastimes? eg swimming, gardening, cycling** (please tick one box)

☐ Yes ☐ No

If Yes: i) **How frequently does your family do such activities?** (please tick one box)

☐ 5 – 7 times a week ☐ 1 – 3 times a month
☐ 2 – 4 times a week ☐ less than once a month
☐ once a week ☐ never

ii) **Which types of activity does your family take part in?**
(please describe any activities you do as a family in the box below)

54 **For each of the items listed below please indicate how many of the item you have in your household?**

(please write the number in the box provided writing zero if there are no such items in your household)

	Number available in your home
television set	☐
video / DVD player	☐
computer **without** internet access	☐
computer **with** internet access	☐
Video game player (eg Playstation, Xbox)	☐
Active video game player (eg Nintendo wii, Xbox kinect)	☐
car	☐
bicycle	☐
smartphone or similar hand held device	☐
other mobile phone	☐

In the final section we ask for some information about you and your household

55 **What is the main language spoken in your home?** (please tick one box)

☐ English

☐ other (please describe) ....

56 **How well can you speak English?**
(please tick one box)

☐ very well ☐ well ☐ not well ☐ Not at all

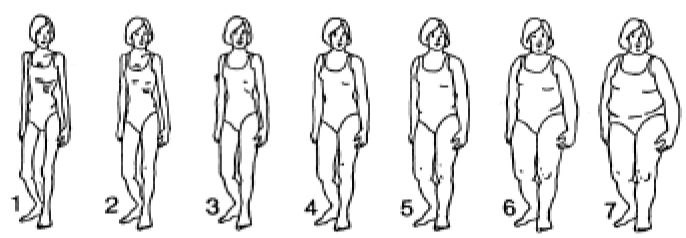
Please go to Question 57 on the next page

57 **Please look at the drawings of adults below to answer the following four questions.**
(for each question please tick the box under the number for the picture closest to your choice)

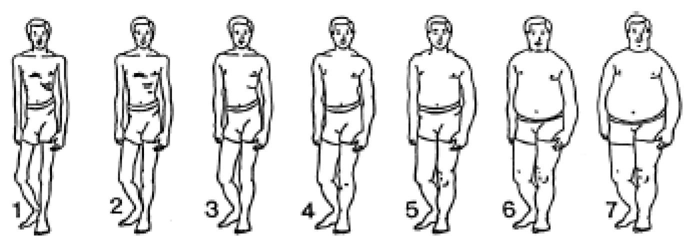
(please tick one box on each row)

		1	2	3	4	5	6	7
i)	Which picture looks most like you?	☐	☐	☐	☐	☐	☐	☐
ii)	Which picture shows the way you want to look?	☐	☐	☐	☐	☐	☐	☐
iii)	Which picture shows the way you think is best for a man to look?	☐	☐	☐	☐	☐	☐	☐
iv)	Which picture shows the way you think is best for a woman to look?	☐	☐	☐	☐	☐	☐	☐

Females



Males



58 **Please indicate below the religion of yourself, your spouse / partner and your child, we are interested in this information even if the individual is not currently practising?** (please tick one box in each column)

yourself	your spouse / partner	your child	
	☐		Do not have a spouse / partner
☐	☐	☐	Prefer not to answer
☐	☐	☐	No religion
☐	☐	☐	Christian (including Church of England, Catholic, Protestant and all other Christian denominations)
☐	☐	☐	Buddhist
☐	☐	☐	Hindu
☐	☐	☐	Jewish
☐	☐	☐	Muslim
☐	☐	☐	Sikh
☐	☐	☐	Any other religion (please describe)...

59 **Please indicate the current employment status for both yourself and your spouse / partner.** (please tick one box in each column)

yourself	your spouse / partner	
	☐	do not have spouse / partner
☐	☐	working full-time
☐	☐	working part-time
☐	☐	unemployed and looking for work
☐	☐	student
☐	☐	looking after family home (not seeking paid work)
☐	☐	long-term sick or disabled
☐	☐	retired from paid work
☐	☐	not in paid work for some other reason

Please answer the following question if you or your spouse / partner are currently working full or part-time.

60 **How would you describe the current occupation of yourself and your spouse / partner?** (please tick one box in each column)

yourself	your spouse / partner		
	☐	do not have spouse / partner	
☐	☐	manual	eg farm worker, postman, cleaner, general labourer, bricklayer
☐	☐	non- manual	eg office-based work, shop assistant, teachers, doctors

61 **Please indicate below the ethnic group of yourself, your spouse / partner and your child?** (please tick ***one box in each column*** by choosing one section from A to F for each individual and placing a tick in the box that best describes their ethnic group or background)

yourself	your spouse / partner	your child	
			A Do not wish to provide ethnic group / no spouse / partner
	☐		Do not have spouse / partner
☐	☐	☐	Prefer not to answer
			B White
☐	☐	☐	English / Welsh / Scottish / Northern Irish / British
☐	☐	☐	Irish
☐	☐	☐	Gypsy or Irish Traveller
☐	☐	☐	Any other White background
			(please describe) ....
			C Mixed / multiple ethnic groups
☐	☐	☐	White and Black Caribbean
☐	☐	☐	White and Black African
☐	☐	☐	White and Asian
☐	☐	☐	Any other Mixed / multiple ethnic background
			(please describe) ....
			D Asian / Asian British
☐	☐	☐	Indian
☐	☐	☐	Pakistani
☐	☐	☐	Bangladeshi
☐	☐	☐	Chinese
☐	☐	☐	Any other Asian background
			(please describe) ....
			E Black / African / Caribbean / Black British
☐	☐	☐	African
☐	☐	☐	Caribbean
☐	☐	☐	Any other Black / African / Caribbean background
			(please describe) ....
			F Other ethnic group
☐	☐	☐	Arab
☐	☐	☐	Any other ethnic group
			(please describe) ....

62 Please indicate the highest level of qualification obtained by both yourself and your spouse / partner, for both individuals please start at the top and tick the first box that applies. (please tick one box in each column)

yourself	your spouse / partner	
	☐	do not have a spouse / partner
☐	☐	**Degree or equivalent, and above** eg Higher degree and postgraduate qualifications First degree (including B.Ed.) Postgraduate Diplomas and Certificates (including PGCE) Professional qualifications at degree level e.g. graduate member of professional institute, chartered accountant or surveyor NVQ or SVQ level 4 or 5
☐	☐	**Other higher education below degree level** eg Diplomas in higher education & other higher education qualifications HNC, HND, Higher level BTEC Teaching qualifications for schools or further education (below Degree level standard) Nursing, or other medical qualifications not covered above (below Degree level standard) RSA higher diploma
☐	☐	**A'levels, vocational level 3 & equivalent** eg A level or equivalent AS level SCE Higher, Scottish Certificate Sixth Year Studies or equivalent NVQ or SVQ level 3 GNVQ Advanced or GSVQ level 3 OND, ONC, BTEC National, SCOTVEC National Certificate City & Guilds advanced craft, Part III (& other names) RSA advanced diploma
☐	☐	**Trade apprenticeships / some school qualifications** (usually obtained aged 16 yrs) eg GCSE/O Level grade A*-C, vocational level 2 & equivalents NVQ or SVQ level 2 GNVQ intermediate or GSVQ level 2 RSA Diploma City & Guilds Craft or Part II (& other names) BTEC, SCOTVEC first or general diploma etc. O level or GCSE grade A-C, SCE Standard or Ordinary grades 1-3
☐	☐	**Qualifications at level 1 and below** eg NVQ or SVQ level 1 GNVQ Foundation level, GSVQ level 1 GCSE or O level below grade C, SCE Standard or Ordinary below grade 3 CSE below grade 1 BTEC, SCOTVEC first or general certificate SCOTVEC modules RSA Stage I, II, or III City and Guilds part 1 Junior certificate YT Certificate/ YTP
☐	☐	**Other qualification: level unknown** eg Other vocational or professional or foreign qualifications
☐	☐	**No qualifications**

That is the end of the questionnaire.
Thank you very much for taking the time to complete this.

Please now return the questionnaire in the envelope provided to your child's school to be entered in the free prize draw for a chance to win up to £100 in shopping vouchers!