SCHOOL FOOD TRUST

Eat Better Do Better

The link between child nutrition and health: an overview of research in the UK

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Key Findings

Background

There is a long held belief that children's diets and their immediate and long-term health are linked. In addition to support from some empirically sound scientific evidence, anecdotal evidence suggests that when children are fed a nutritionally balanced diet they find it easier to concentrate in the classroom and their behaviour improves.

The School Food Trust ('the Trust') has been conducting research in the area of child nutrition and health, with a focus on school meals, to help build an evidence base to support the notion that if children eat better, they do better.

More generally, evidence focusing on the nutrition and health of school-aged children in the UK, particularly that focusing on school meals, also appears to be limited. Other than published reviews focusing on specific topics, the evidence has not previously been combined.

Aim and methods

This inventory identifies and summarizes recent and on-going research being conducted in the UK relevant to the remit of the Trust. Details of research were sourced through personal contact with key researchers in the field of child health and nutrition and through a journal search.

Findings

i. Diet and food choice

- Children's intakes of fruit and vegetables do not reach the recommended guidelines, irrespective of the type of lunch (school or packed) eaten, with one in every seven children reporting never eating fruit and girls eating more fruit than boys. Fruit and vegetable schemes in schools have led to an increased intake although this is not sustained once the promotion ends.
- Primary school children's knowledge of fruit and vegetables is generally poor but their knowledge of fruit is greater than that of vegetables. Although the term 'healthy eating' is well known by children, it is not well understood and is often confused with a low calorie diet. Teenagers' understanding of a 'balanced diet' and eating foods in moderation is also weak.
- Parents, particularly mothers, play an important role in the development of a child's dietary habits.
- Children's food preferences are related to their exposure to food. Early experience with a wide range of foods maximises the probability of a healthy diet. Familiarity accounts for over half of children's food preferences.
- Children in Scotland, particularly boys, are at high risk of having diets furthest away from dietary guidelines. The diets of children and young people of ethnic minorities are also showing trends towards less healthy eating as a result of choosing unhealthy elements of a UK diet.
- Children in Northern Ireland tend to have a lower daily consumption of fruit and vegetable compared with children in the other UK countries.

ii. School based research and school food

- Not being able to eat with friends, long queuing times and the lack of access to their preferred types of foods are the main reasons given by pupils for leaving the school premises at lunchtime. The 'local shop' is a popular outlet for pupils' purchases of snacks on their way to and from school, and is more likely to be used than vending machines on the school premises.
- Using a whole school approach and implementing School Food Groups formed of pupils, teachers, catering staff, and health professionals that had specific targets of increasing the school meal take up and increasing the availability of healthier foods, provided by the

school caterers have not been associated with long-term changes in school-based eating.
- Reducing stigma associated with taking free school meals (FSMs) in secondary schools may help to increase take up.
- There is limited evidence to conclude that the introduction of breakfast clubs has a positive influence on nutrient intake, behaviour or academic attainment.
- While a whole school approach may result in a short-term modest improvement in fruit intake and increased knowledge about fruit and vegetables, there is no evidence that the impact is sustainable.

iii. Food related research associated with health and cognitive function
- The prevalence of childhood obesity is increasing. Evidence suggests that it is easier to change attitudes and knowledge towards obesity prevention than actually effecting a change in physical attributes such as body mass index (BMI), body fat or waist circumference.
- Dietary intake in adolescence is a clinically weak but statistically significant predictor of dietary intake in adulthood. Tracking of diet through to adulthood is influenced by moving to a different geographic location and changes in socio-economic status.
- There is evidence to suggest that education and intervention during early adolescence on certain aspects of diet may be justified as part of a coronary heart disease (CHD) prevention strategy.
- Low fruit intake, excessive energy intake and high childhood BMI have been associated with increased risks of cancer and cancer mortality in adulthood.
- Frequent exposure of carbonated, sugared drinks, sports drinks and herbal or lemon tea and foods such as tomato ketchup and other foods with a high non-milk extrinsic sugar (NMES) content are positively associated with an increased risk of dental caries, especially if these are consumed close to bed-time. There is a higher prevalence of dental caries in those children from lower socio-economic backgrounds.
- Tap water, with its higher fluoride levels, may be more beneficial in preventing caries than bottled water. Water consumption has remained fairly constant in the past 20 years but the shift towards bottled water, means that intakes of tap water have decreased with an associated decrease in fluoride intake.
- Peanuts, tree-nuts, gluten, wheat, eggs, shellfish, milk and additives are among the most commonly reported foods causing hypersensitivity reactions in children. The incidence of severe allergic reactions, requiring hospitalisation, with fatal or near fatal outcomes is low and these reactions are almost always associated with a history of moderate or severe asthma. There is a common misconception about the severity of allergy. Many children claiming to be allergic to food items do not avoid these in their daily diet.
- More research is needed to provide evidence of the relationship between a healthy diet and subsequent physical and mental well-being. Developing collaborative research programmes and working with partners will strengthen messages about the need for healthy eating and tackling obesity.

Conclusion

Although the term ‘healthy eating’ is familiar to children, it is neither well understood nor applied in practice. More research is needed to demonstrate the best ways in which to encourage children to adopt healthier eating practices at school and throughout the day and to counteract pressures from advertising and elsewhere that encourage the consumption of foods high in fat, salt and sugar and that may promote over-eating and weight gain. The introduction of standards or guidelines throughout the UK, have been designed to improve the overall nutritional quality of school food - however changing perceptions of school meals and marketing them as an attractive and healthy lunchtime option continues to be a challenge. Limited research activities investigating the impact of diet and nutrition on health, behaviour, and academic achievement highlights the need for continuing research activities to build a robust evidence base that supports the case for change.

Executive Summary

Food choices are driven primarily by a child's familiarity with food and secondly by taste. Perceptions of which foods should be eaten in moderation and an understanding of balancing a diet appear to be weak. Where there is a wide variety of choice, children naturally choose the foods they like the most and even if more healthy foods are offered, a balanced meal may not always be chosen. Children and young people tend to leave the healthier elements of a meal while eating the less healthy items. Foods high in sugar and low in fibre, iron and vitamin A are frequently chosen and children's understandings of the dangers of a high salt diet are also generally poor. Scottish children, and especially boys, have the highest likelihood of having a diet furthest from healthy eating guidelines and minority groups, particularly South Asian populations, have shown to be lacking in vitamin D and tend to eat more unhealthy foods and fewer vegetables than white Europeans.

Overall, children's knowledge of the positive benefits of fruit is greater than their knowledge of vegetables, and children tend to prefer fruit compared with vegetables. It is also easier to increase a child's consumption of fruit than it is vegetables. Apples and oranges are generally the most popular fruits although preference for both fruit and vegetables have been shown to vary with age and sex with fruit intakes being higher among teenage girls than teenage boys and higher in England than in Scotland. Children participating in school fruit and vegetable schemes tend to have greater nutritional knowledge about fruit and vegetables than those not participating in schemes. Such schemes may be associated with a lower intake of fruit and vegetables in the home if parents rely on schools to provide children with their daily portions. Although schemes can increase fruit and vegetable intake in the short term this increase tends not to be maintained once the intervention is withdrawn. Although children consider parents to be their main source of nutritional education many parents think that the responsibility of nutrition education is that of the teachers. Mothers appear to play one of the main and hence most important roles in the development of a child's dietary behaviour and they can have a positive impact on increasing fruit and vegetable intake.

Children in the UK do not eat the recommended amounts of fruit and vegetables and as many as one in seven children never eat fruit. Boys tend to prefer foods high in sugar and fat rather than fruit and vegetables as the former are considered to be more 'satisfying' and filling. Food preferences appear to be related to exposure and the earlier and broader the experiences with food, the healthier a child's diet is likely to be.

Although work has been conducted assessing the level of take up of school meals and Free School Meals (FSM), little work has been done to determine effective ways of increasing take up rates. For secondary school pupils, barriers preventing them from taking a school meal include not being able to eat with friends (including those in other year groups), lack of availability of their preferred foods, and long queuing times. Secondary school children may be more likely to take FSM if there is greater anonymity. As a result of this, many children opt to take a packed lunch to school instead, although research has shown that packed lunches usually compare unfavourably with dietary guidelines. Although standards for school meals have been introduced, there is still scope for improvement, as poor quality food has previously been another factor deterring children taking a school lunch, along with lack of cleanliness and poor dining environments.

There is insufficient evidence about the impact of breakfast clubs on nutrient intakes, behaviour or academic performance. One study by the Trust has shown higher academic attainment in schools with breakfast clubs, but a methodological weakness in the study's design prevents causality to be concluded with certainty. After-school clubs can provide a setting where healthy recipes and food preparation skills can be learnt. Evidence presented in a systematic review on the influence of nutrition on mental health supports the introduction of funded school breakfast clubs and draws a link between children's behaviour

and iron deficiency. A review looking at breakfast and its effects on mental performance in children and adolescents is also due for completion.

It is well established that the prevalence of childhood obesity has risen in recent times and is still rising. Food intake in adolescents is a weak but statistically significant predictor of food intake in adulthood, allowing for dietary changes being influenced by sex, geographic location and socio-economic status. To date, school based interventions have proved unsuccessful at reducing levels of obesity and although a whole school approach, including the modification of school meals, can be successful in making changes at a school level, it has little impact on the dietary habits of individuals.

Studies have consistently shown that diets high in sugar, especially NMES, are positively associated with increased dental caries although this is confounded by socio-economic status. Particular food items that have been identified as being implicated in the increased incidence of dental caries in adolescents include sugar rich foods and carbonated, sugar sweetened drinks. The health benefits of dried fruit and fruit juice, and their promotion as replacements for high fat and NMES snacks and drinks, must be balanced against their effect on developing teeth.

Calorie restricted diets, popular among female adolescents, can result in reduced intakes of calcium (which can lead to reduced bone mass density in adulthood), zinc, iron and folic acid. Iron intakes are of particular concern as these have been found to be less than half the requirements within certain groups, especially those who are vegetarian or non-Caucasian. Reduced intakes of vitamins A and B may also result in poor visual acuity.

The most common foods linked to food hypersensitivity among young children and teenagers are dairy products and milk, peanuts and eggs, additives and colourings and, to a lesser extent, wheat and fish. Schools need to adopt policies to address the rising incidence of food-related allergies.

Work in progress or planned for the near future appears to be concentrating on further evaluations of the effectiveness of schemes promoting fruit and vegetables in schools; and assessing the intakes of those children who are not eligible for FSM but who are near to the threshold of eligibility. The effects of education on various dietary aspects, such as fat and sugar, and whether this education has a positive impact on dietary behaviour will also be investigated, together with new methods of nutrition education. Aspects of the dining environment and how these influence food choices are being studied to provide insights into reasons for poor take up of school meals. Gaining an understanding of the issues around the provision of school meals and the implementation of the new legislation from the perspective of caterers is also important. Exploring perceived barriers to implementing the standards may provide suitable solutions.

There is sufficient evidence related to health benefits gained from eating a healthy diet to warrant further research. On-going longitudinal studies will provide further evidence, particularly in relation to obesity. Proposed studies aim to identify early life risk factors or current lifestyle factors which may predict body fatness in young children. Dietary intakes combined with levels of physical activity are also being studied to help in the prevention or intervention of obesity. Developing further collaborative research programmes and working with partners will strengthen messages about the need for healthy eating and its impact on obesity.

1 Introduction

There is a body of evidence which links children's diets to their immediate and long-term health. Additionally, to support from some empirically sound scientific evidence, anecdotal evidence suggests that when children are fed a nutritionally balanced diet they find it easier to concentrate in the classroom and their behaviour improves. Although this has yet to be verified by robust scientific research, it is anticipated that two current studies being carried out by the Trust will link diet with educational and social achievement.

As well as much research concerning diet and health of children having been published in scientific peer reviewed journals, evidence exists in a number of other sources such as reports published on Local Authority websites, or in Government reports. Although there have been some attempts at synthesising the existing literature linking children's nutrition and health, this tends to have focussed on particular aspects of health such as obesity. To date, we are unaware of any overall review, or any central inventory of information on nutrition and health of school aged children in the UK, particularly in relation to school meals. In the apparent absence of any readily available comprehensive overview, the Trust saw a need to compile an inventory of existing, current, and planned research with an emphasis on understanding the nature and extent of any associations between nutrition, health, behaviour and attainment in children and young people, and to identify any gaps in knowledge.

1.1 Background

The last two decades have seen a profound shift in food culture, particularly the increased consumption of highly processed and fast foods.[1] These tend to be energy dense due to their high levels of refined carbohydrates and fats (including saturated fat) and they frequently have a high salt and low fibre content.

Poor nutrition during infancy, childhood and adolescence tends to be associated with poorer rates of childhood growth and development. In developed countries, associations with lower cognitive abilities, increased lethargy, reduced attention span and reduced intellectual success have also been shown.[2] Poor eating patterns with excess energy intakes, coupled with reduced physical activity levels have also seen a rise in obesity (a condition where weight gain has reached the stage at which it poses a serious threat to health[3]) and other health related problems such as iron deficiency anaemia and dental caries.

Since the 1980s, typical body compositions have changed, with a worldwide increase in average body fatness and rates of overweight and obesity. This change is most notable in high income countries and in industrial and urban environments in many if not most countries.[4] The prevalence of obesity and overweight is increasing in both adult and childhood populations throughout the world,[5] [6] leading to reference by the World Health Organisation (WHO) of a 'global epidemic'.[7] Obesity in childhood can lead to a wide range of serious complications and chronic disease which will ultimately increase the risk of premature illness and death.[8] Treatment for childhood overweight and obesity remains largely ineffective and the epidemic continues. An overweight adolescent has a 70% chance of becoming an overweight or obese adult.[3] This can be attributed to limited nutrition knowledge, unhealthy eating habits, and low physical activity levels.

School health programmes can help children and adolescents attain their full educational and health potential by providing them with the skills and social support they require to learn the basic fundamentals and importance of a healthy diet. The food and drink choices that children make at school are helpful in modeling healthier choices made outside of the school environment and for the future. School is therefore an important setting for children to learn about and practice positive dietary habits.[9] The re-introduction of standards for school food, and significant Government investment in the school meal agenda in recent years has

therefore been warranted.[10] [11] [12] The wider educational benefits of improved school food in terms of readiness to learn, pupil mood, behaviour, and thus learning and attainment, are also of key interest. There is, however, little robust research in this area.

1.2 Policy context

The increasing prevalence of childhood obesity has resulted in a significant policy response from Governments with the implementation of school based initiatives such as increased physical activity programmes, removal of vending machines, the ban on soft drinks (whether naturally or artificially sweetened) and modification of school lunch systems, including the introduction of measures to reduce queuing times and provision of an improved dining experience.[13] Other issues such as the use of sustainable and locally produced seasonal ingredients are also being addressed. A response has also taken place in industry, with attempts to improve nutritional labelling on food products and the development of healthier alternative foods and drinks being made available to children. Although research relating to food policies is not being included in this overview, it is important that these issues and their effects on the provision of school food and the dietary habits of children and adolescents continue to be explored.

2 Aims and objectives

The Trust has been conducting a number of research activities in the area of child nutrition and health, with a focus on school meals, to add to the evidence investigating the notion that if children eat better, they do better. To date, we are unaware of any catalogue, overview or central holding of information on nutrition and health of school aged children in the UK, particularly in relation to school meals.

The aim of this review is to determine what research, with relevance to the remit of the Trust, has been or is being conducted in the UK, and what is being planned for the near future. Its purpose is to provide an overview rather than a critical evaluation of the research. The main objectives of this project were therefore:

- To determine if a comprehensive review of research on child nutrition and all aspects of health has been conducted by any national or academic institution or Government body.

- If not, to collate and document information on recently completed, ongoing and planned research work on nutrition and health of school aged children in the UK.

- To identify gaps in knowledge in relation to the remit of the School Food Trust.

This report summarises the main findings and planned research on school children in the following areas:

- food consumption and nutrient intake
- school meals and other school food
- factors affecting food choice (e.g., spending on food to and from school).
- nutritional status (including aspects of obesity)
- food related factors (including aspects of environment) affecting learning and cognitive function

A brief history of the school meals systems in the individual countries in the UK can be found in Appendix 1. *School food in the UK*

3 Methods

The criteria used to identify research on children's nutrition and health, relevant to the remit of the Trust is given in Appendix 2. *Research inclusion and exclusion criteria*Due to constraints in both time and resources, a full systematic search was not undertaken, which may impact on the external validity of the conclusions.

There are two main aspects to this report: a summary of findings from a search of the grey literature (including web-based research funded by supporters' donations), and a summary of findings from a comprehensive search of published journal articles. For the purpose of this report, the term 'grey literature' will refer to any literature which has been found via internet searches or through communication with sourced contacts, including research published as Government reports. It also includes web-based research funded by supporters' donations, the results of which are published on publicly accessible web sites. Published literature is defined here as research published in peer-reviewed journals, located through standard database searches.

3.1 Grey literature search

- A list was prepared of the health professionals or those working in relevant areas who were likely to be able to provide information for this review. Contact details of those identified were obtained through internet searches, using the search engine Google,[14] or through the UCAS directory to identify university research departments.[15]
- The grey literature search commenced on October 2007 and was completed in Spring 2008.
- Initially, letters were sent to key persons to identify whether any work similar to this proposed review had been conducted by any national or academic institution or Government body.
- Letters were then sent to all remaining contacts requesting information on research activities relevant to this review. These letters were followed up by e-mail, with a PDF copy of the original letter attached. These were then followed up with a phone call where necessary. All correspondence and contact details were recorded in an Excel® spreadsheet.
- A 'call out - request for information' was posted on the Nutrition Society's 'Reproduction and Child Health theme news' website[16] on 7th November 2007. A request for information was circulated via the British Dietetic Associations Community Nutrition Group listings and via the schools nutrition network email on the 15th November 2007 and a final request for information was circulated via the Faculty of Public Health's listed members on the 22nd November 2007.
- Permission was obtained from all those involved via e-mail to report information supplied by them in this review.

Details of all research work identified were stored in a spreadsheet along with contact details of key personnel involved in each study. Studies involving the food industry (either through funding, use of products or design of the study) have been excluded, as have MSc or MA projects. Relevant works from research degrees (usually PhDs) were included.

3.1.1 Outcome of grey literature search

A total of 100 key persons were identified from various national or academic institutions or Government bodies and were contacted with a request for information. Of these, 36 provided information on research activities; five further relevant research studies were found through internet searches. Half of the remaining contacts were unable to provide any information on relevant research activities and the remaining 32 contacts did not respond. Further details of the individual studies can be found in Appendix 3 *Findings from grey literature search*

3.2 Journal-based literature search

- Electronic searches on the following databases were conducted during the third and fourth week in October 2007:
  - MEDLINE ® (1996 to October week 2 2007) via the Ovid interface.
  - PsychINFO ® (2000 to October week 2 2007) via the Ovid interface.
  - EMBASE ® (1996 to October week 2 2007) via the Ovid interface.
- The search strategy consisted of two separate searches in each of the above databases using a specifically developed search strategy (see Appendix 2. *Research inclusion and exclusion criteria* for search terms).
- In addition to electronic database searches, additional articles of relevance that were otherwise identified (e.g. from reference lists of identified articles) were added to the article database and were tagged as 'found'.

3.2.1 Selection of studies

Articles were initially screened for relevance based on the title. In cases of uncertainty, the abstract was read. Full versions of all potentially included studies were obtained and read for final selection. Details of selected articles were saved to a spreadsheet. A second selection process then took place (inclusion and exclusion criteria as described in Appendix 2. *Research inclusion and exclusion criteria*), leaving the remaining articles for inclusion in this overview. Details of the articles were then added to the spreadsheet and divided into those which are Government reports, diet and food choice and those with health outcomes. Full text versions of the articles were then obtained and saved.

4 Results

The findings summarized in this section are based on information from both the grey literature search (see Appendix 3 *Findings from grey literature search*) and the journal-based literature search (see Appendix 4. *Findings from electronic literature search*).

The level of detail on each research activity identified from the grey literature search varies according to how much information was supplied or published and (for unpublished research) how far advanced the study is. This report includes information that was supplied by respondents and, that located through a search of academic articles.

The report has several limitations. Since it includes unpublished research, the information is current only at the time of writing, and includes only information from responding contacts. Inevitably, areas of research work being undertaken by non-responding contacts will not have been included. As this report in not based on a systematic journal search, the results may reflect publication and response bias due to the exclusion of unpublished but completed research.

4.1 Food related research not directly associated with health outcomes

4.1.1 Diet and food choice

Evidence has been extracted from surveys, focus groups and interviews, reflecting population averages.

a. General dietary behaviour, food choice, healthy eating and health education

What is known (29 studies): Early eating behaviour may set the trend for subsequent academic attainment with evidence from the Avon Longitudinal Study of Parents and Children (ALSPAC) suggesting that early eating patterns have implications for attainment that appear to persist over time, regardless of subsequent changes in diet. Results from

analysis of longitudinal data showed that a "junk food" dietary pattern at age three had a negative association with the level of school attainment. There was no evidence that eating packed lunches or eating school meals affected children's attainment, once the impact of junk food dietary pattern at age 3 was accounted for in the model.[17]

Even though the energy intakes of 7-8 year olds might be close to the estimated average requirement for both boys and girls, it has been suggested that the proportion of energy derived from fat and saturated fat is high in relation to the UK's dietary reference values (DRV). Targeting high intakes of total and saturated fat should therefore be the health priorities in this age-group.[18]

Pupils who eat packed lunches typically consume sufficient energy, too much saturated fat, salt and sugar, and less than the recommended amount of fruit or vegetables from this meal. Fewer than half the lunchboxes contained a piece of fruit, and when they did, apples were the most common, followed by bananas.[19] More generally, although individual dietary patterns shown at age 12 are unlikely to predict energy and nutrient intake at age 15,[20] [21] the predictive value of intake improves with age. Food intake in adolescence is a significant, but not strong, predictor of intake in adulthood, with dietary changes being influenced by variables including gender, location and socio-economic status.[22] [23] Evidence from a systematic review has shown schools to be a key setting for the implementation of food and health policy.[24] For such a policy to have maximum effect, the provision and promotion of healthy food and drinks in schools should be part of a whole-school, health promoting approach.

An evaluation of nutrient intake from school meals of children in secondary schools found choices made by the children appeared to be the main factor in determining nutritional intake and meals chosen did not conform to the Eatwell plate[25] (formerly the Balance of Good Health model).[26] Scottish children and young people (especially boys) were particularly at risk of having a diet furthest from current dietary guidelines, with intake of all foods being strongly socially patterned.[63] [27] [28] Further evidence from Scotland of the need for dietary change at family level comes from a study suggesting a strong link between the diets of younger children and their mothers.[29] Mothers were an important factor in the development of children's dietary patterns. Children's confectionary consumption was predicted by the mother's liking for confectionary and the children's concern for health in choosing what to eat, while children's fruit intake included the child's liking for commonly eaten vegetables, and the mother's belief in the importance of disease prevention.[53]

School meals have been highlighted as being the least healthy and most monotonous part of a pupil's daily diet, and pupils recognise that their diets could be improved. Differences between primary and secondary aged pupils exist, with secondary school pupils citing a desire to eat outside of school and being more negative in their views of school lunches, especially regarding the introduction of healthier menus, compared with primary school pupils. Primary pupils considered initiatives such as breakfast and fruit schemes to be successful and were positive regarding school lunch provision and healthy options.[36] However, a survey investigating various aspects of school food in secondary school pupils suggested that over a third of 11-15 year olds were actually happy with their school meals. The physical and social environment exerts an important influence on pupils' take up and experience of school meals. Effective management and co-ordination by school staff during lunchtime has a positive impact on pupils' experience of lunch and on the general atmosphere in school canteens. Active encouragement by teaching and catering staff, as well as practical steps to make healthy foods easily accessible and attractive to pupils, can increase take up.[30]

Children of all ages tend to prefer foods that they rate as unhealthy, making it necessary for school-based food education to focus on helping children make balanced food choices. The

'one size fits all' approach does not seem to work well in any setting, and tailoring is necessary, particularly for different subgroups.[72] An intervention study showed the success of involving pupil participation in the process of initiating change to promote healthy eating in secondary schools.[31] A survey in post-primary schools in Northern Ireland found that although there are strengths in the provision of health education in schools, many schools need to strengthen the liaison between the senior managers in schools and the canteen staff to promote more consistent messages about healthy eating. Schools also need to provide more healthy choices in the vending machines on the school premises.[32]

Encouraging young teenagers to view healthy eating as an attractive and achievable behaviour will be a major challenge for health promotion specialists, particularly since 'healthy eating' has largely negative connotations.[33] This is compounded by many young girls' acceptance of dieting as a healthy activity, and there is evidence that major nutritional deficiencies exist among adolescent dieters.[34] A critical review provides further evidence that some teenagers are more motivated by ill health or factors such as desire to lose weight or body image than by prophylactic health promotion or disease prevention.[35] Primary pupils thought peer influence had little impact on their own dietary practices within school whereas secondary felt that friends would often follow the same pattern of behaviour at lunchtime.[36] Both primary and secondary aged school children appear to have a clear perception of the healthiness or otherwise of the foods when asked to rank photographs of different items. However, their understanding of the relationship between foods or nutrients and health was weak, as was the idea of moderation or balance in the items they would be likely to choose.[37] [38]

The Low Income Diet and Nutrition Survey (LIDNS) showed no significant association between mean food consumption and education level of the parents among boys. Girls whose parents had less education consumed lower amounts of fruit juice, biscuits, cakes and pastries, and greater amounts of soft drinks (not diet) than those with more education. Sixty percent of parents or carers said they would like to change their children's diet with the most commonly required changes including increasing consumption of vegetables or salads, fruit or fruit juice, and reducing consumption of sugary foods and drinks.[39]

Minority groups warrant particular attention. Despite having an increased risk of developing type II diabetes and CVD, South Asian pupils tend to eat more negative or unhealthy food items than white Europeans.[40] Less healthy aspects of a Western diet, high in sugar and salt, have been incorporated into the diets of girls and young women from Somalia, Zimbabwe, or South Asia (Pakistani/Bangladeshi) with a trend towards eating fewer vegetables in the UK than would be eaten in their country of origin. Ways of encouraging healthy lifestyles among these minority groups need to be developed.[41]

Progress made in the implementation of standards and general approaches to promoting healthy eating in schools needs to be monitored and evaluated to assess their effectiveness. Monitoring has highlighted examples of good practice and shown the need to ensure that commitments to sustaining the good policies, practices and lessons learned are encouraged, supported and widely disseminated across schools. In Northern Ireland, whilst a majority of schools are making good, or very good, progress towards achieving the food-based nutritional standards, there remain a number of important areas in menu planning where these standards are not being met. Also, a significant minority of schools, whilst seeking to meet the nutritional standards for school meals at lunch times, did not apply similar principles at break time, or where breakfasts were provided.[42] In Scotland, the monitoring the Hungry for Success initiative has provided a baseline picture of school meal provision across a range of case study schools. Among other findings, the research highlighted the importance of the role of the education authority in leading implementation.[43]

What unpublished studies will add (6 studies):
1) The determinants of and age variations in social patterning of health related behaviours in teenagers in the west of Scotland. This study will further explore how perceptions of the future impact on current health, health behaviours and lifestyles.[44]

2) The association between aspects of health, behaviour, diet and activity will be studied by the Institute for Public Policy Research with possible Trust collaboration. No dates or further details are available.[45]

3) Two studies planned by the University of Nottingham will examine:
- Association between weight loss desires and dietary practices among young people[46]
- Health locus of control, health value and diet among young people

No dates or further details are available.[47]

4) The National Diet and Nutrition Survey (NDNS) is a rolling programme which aims to provide annual data about the nation's dietary intake and nutritional status. It will estimate the proportion of individuals with poor nutritional status, estimate the proportions achieving recommended dietary intakes, examine the differences in diet between population sub-groups (including school children) and provide a database that allows the calculation of likely dietary intakes of food additives or chemicals. The current phase of the NDNS is planned to run until 2013.[48]

5) UK Household Longitudinal Study (UKHLS) will provide valuable new evidence about the people of the UK, their lives, experiences, behaviours and beliefs, and will enable an unprecedented understanding of diversity within the population. Interviews from all household members aged 10 and above will be conducted with collections of health indicators and biomarkers.[49]

b. Nutritional knowledge

What is known (4 studies): Among primary school children there was a general basic awareness and understanding of the current recommendations for a balanced diet although the message may have become somewhat confused at times. Overall knowledge of fruit and vegetables at this age is not as good as might be expected. Children preferred, and were better able to recognise, fruit compared with vegetables. Cabbage was the least well identified vegetable and melon the least well recognised fruit.[50] In a study comparing nutritional knowledge among English and Korean primary aged children, knowledge was similar although food preferences between the two cultures showed some differences.[51] English children were less aware of the dangers of excess salt compared with Korean children. In both countries primary school children tend to identify parents as the main source of nutritional information. Parents, in turn, want schools to provide more nutritional information to children. The term 'healthy eating' is well-known by children but may not be well understood.[51] [52] The nutritional knowledge of mothers is important in predicting children's fruit intake.[53]

What unpublished studies will add (2 studies):
1) A cluster randomised trial in Cambridgeshire primary schools is assessing the effectiveness of a novel educational intervention designed to improve nutrition knowledge using the 'Top Grub' healthy eating resource. The aim is to assess whether changes in nutritional knowledge can help children make healthy choices and results will be available in 2008.[54]

2) A study designed to assess the impact of an education programme about fat and sugar aimed at school children and their subsequent nutritional knowledge and habitual diet will be completed in 2010 at the earliest.[55]

c. Fruit and vegetable consumption

What is known (10 studies): A systematic review of barriers and facilitators relevant to children's healthy eating produced a relatively solid evidence-base for informing policy and practice for the promotion of fruit and vegetables to children aged 4 to 10. The results of the meta-analysis suggest that it is easier to increase children's consumption of fruit than vegetables.[56]

Most 7 year old children do not eat sufficient fruit and vegetables[57] and irrespective of whether a school or packed lunch is eaten they only consume about half the recommended amount.[58] LIDNS found mean fruit and vegetable consumption in children to be 1.6 (adult) portions for boys and 2.0 (adult) portions for girls. This pattern was similar in girls and women.[59]

By the age of 12 there is a difference between sexes with girls eating significantly more fruit per day than boys, whereas boys reported eating significantly more calcium and vegetables than girls.[60] Even the highest self-reported intake of fruit is not as high as the recommended levels. Among 14 year olds the most commonly eaten fruit was apples and more than two-thirds reported regularly eating oranges, bananas and grapes but even those reporting relatively high intakes did not reach the recommended levels. Only 10% of the group had more than 8 intakes of fruit each week with 2% reporting eating fruit more than 22 times per week. One in every seven reported never eating fruit. In general, girls had a greater intake of fruits than did boys.[61] LIDNS identified a third of boys (32%) and a fifth of girls (18%) who did not consume any portions of fruit during four 24h recall days. This was higher in those aged 11-18 compared with those aged 2-10 years.[59]

Intake of leafy green vegetables is particularly low, even among teenagers from families in high socio-economic groups.[62] There may be regional variations as intake of fruit in English school children is higher than that of Scottish children, although the low intakes are associated with teenage smoking.[63] LIDNS found children in Northern Ireland to have the lowest daily consumption of combined fruit and vegetable portions compared with children in the other countries (although these differences were not always significant).[59]

School fruit and vegetable schemes have shown to be successful for a limited period of time. The Free Fruit in Schools Initiative was perceived by both local authority professionals and school staff members as being very successful and should be allowed to continue.[64] The National School Fruit Scheme (NSFS) were also successful, showing an increased consumption of fruit and vegetables for up to three months. This rate of consumption has been seen to still be significantly sustained at seven month although with a small reduction. After two years and with the end of the scheme, intake of fruit and vegetables was shown to return to baseline intakes.[65] However, research by the University of Liverpool suggested that children in schools participating in the NSFS ate more fruit at school but families tended to compensate by eating fewer portions of fruit at home whilst the school was in the scheme.[206] Children's consumption and knowledge of fruit and vegetables has also been shown to increase when the promotion has been focussed on low-income groups. This was also accompanied by a modest reduction in consumption of high fat snacks. [66]

A report published on the Department of Health (DH) concluded similar findings after the School Fruit and Vegetable Scheme had been running throughout England for two years. Consumption of fruit and vegetables by children in Years 1, 2, and 3 had increased significantly from 3.65 portions per day in 2004 to 4.41 portions per day in 2006 with nearly half of pupils reaching the '5 A Day' goal (44% compared with 32% in 2004). This change

was mainly due to a large increase in consumption of vegetables (from 1.61 to 2.14); the increase in fruit, although significant, was much smaller (1.65 to 1.82 portions). However, this increase was not sustained when children's participation in the scheme came to an end. There was also a small decrease in the quantity of snacks consumed, but this was not statistically significant. There were no significant differences between boys and girls or between white UK and minority ethnic pupils. There were very different patterns of eating between children who had school dinners and those who took a packed lunch to school. Children who had packed lunches consumed more fruit and fruit juice than those who had school dinners, but ate a lot less vegetables and a lot more snacks and desserts. Overall, children who had a packed lunch ate less fruit and vegetables than children on school dinners, but the additional fruit helped to compensate for the lack of vegetables. There was a drop in sugar intake among pupils taking school dinners. Interestingly this group decreased their intake of snacks and desserts over the same period.[67]

What unpublished studies will add (2 studies):
1) A study led by Professor Janet Cade and funded by the NPRI aims to assess the fruit and vegetable intake of those children who were previously eligible for a FSM and are now not eligible for a FSM. No dates are available.[68]

2) The Food Dude Healthy Eating Programme is an on-going well established programme to promote increased fruit and vegetable consumption in 4-11 year old children which is continually being evaluated. Further outputs in addition to two previous publications are expected.[69]

d. Food preference

What is known (4 studies): Food preference in very young children is related to food exposure. The earlier and broader the experience with food, the healthier the child's diet is likely to be.[70] Familiarity accounts for more than half of children's food preferences although a twin study produced some evidence that as well as influenced by environmental factors, food tastes and preferences may have a genetic basis.[71] Novel foods are often rejected by young children, resulting in lower dietary quality and variety, as well as lower intakes of fruit and vegetables although mothers can be taught effective methods of increasing children's acceptance of vegetables. The pattern of food preference changes with age, and varies with sex as children become older. Although fruits are among the most popular food items of school-aged children, vegetables are among the least popular foods with a difference in preference between males and females. Junior aged children liked fruit more than infant aged or secondary aged children, whereas vegetables were liked more by infant aged children than by junior or secondary aged children. A liking for dairy foods, fish, and starchy staples all decreased with age, in contrast with that for processed meat which increased with age. A liking for fatty or sugary food peaked in junior aged children. Males tended to prefer fatty or sugary food whereas girls liked fruit and vegetables more than boys[72] which may be explained by boys being more likely than girls to choose a dish based on how filling it was.[40] In general, evidence from food preference studies suggests that children's food preferences overall, and particularly boys, are not consistent with a healthy diet. Food preferences, not surprisingly, show some cultural differences, with marked variations in favourite foods between English and Korean children.[51]

What unpublished studies will add: No relevant research identified.

4.1.2 School based research and school food

a. Nutritional level of school dinners and packed lunches

What is known (8 studies): In 2005 it was suggested that school meals needed substantial improvements to meet revised nutritional guidelines for school meals, and that the

introduction of guidelines in England in 2001 had not improved food choices.[9] [73] This was confirmed in two studies which found that school meals in both primary and secondary schools were unlikely to meet CWT guidelines,[74] [75] [76] even when the meals were free and aimed to provide adequate nutritional intake.[77] In general, children tend to eat the food they like and leave the rest and hence the choice or provision of a healthy, balanced meal by an individual does not guarantee its consumption nor adequate nutrition. Since the current standards apply only to average provision for school lunches, it is possible for individuals to choose less healthy meals, particularly in secondary schools where pupils tend to have a wide choice of food items.

A Trust study conducted, following the introduction of food-based standards for school lunch, in primary schools showed after nutrient analysis of food eaten at lunch time in a sample of 136 pupils aged 8-10, a greater proportion of children having a school lunch compared to a packed lunch met the 2008 nutrient standards for carbohydrate, NMES, total fat, fibre, sodium, vitamin A and vitamin C. More children taking a packed lunch met the nutrient standard for calcium.[78] Improving the dining room environment and the nutritional content of school lunches has mixed effects on subsequent classroom behaviour, with improved on-task behaviour when pupils were interacting with a teacher, but increased off-task behaviour when pupils were engaged in pupil-to-pupil behaviour.[79] Further to this, another study also found packed lunches as well as school lunches of seven year old children to compare unfavourably with dietary guidelines.[58] Only about half of the recommended amount of fruit and vegetables were eaten by children irrespective of type of lunch.

The use of smart card technology has contributed to the improved monitoring of nutritional intake and school meal choice.[80] [81] [82] Even in this group of boys from an affluent, well-educated demographic group and attending an independent school, the choice of desserts and beverages for school lunch mirrored those of children in less affluent groups, with buns and cookies being over ten times more popular than yogurt and fresh fruit. Meals containing higher than the recommended maximum amounts for sugar and lower then the recommended minimum amounts of fibre, iron, and vitamin A were likely to be chosen, although protein and vitamin C contents of meals were well above the minimum requirements. Nutrient requirements were met 41% of the time and it was estimated that over any given 20 school days (one month) a reduction of 200 g fat and over 800 g added sugar could be achieved by pupils making healthier drink and dessert choices at lunch time.

What unpublished studies will add (3 studies):

1) Data have been collected in the Scottish Children's Diet Survey[83] through food frequency questionnaires (FFQ). Sub-samples have completed a four-day food diary to calibrate the results of the FFQ. A separate sub-sample completed a questionnaire on food intake in the previous 24 hours. A total of 1700 interviews were conducted and 196 food diaries and 429 24-hour recalls completed. Secondary analysis is being conducted in three parts:

i. Secondary analysis of the FFQ in 1,391 children. Analysis aims to identify dietary patterns and investigate associations with overweight and obesity; compare intakes with population targets and identify and describe children whose intakes are below the targets.

ii. Meal and snacking patterns: Secondary analysis of 4-day food diaries in around 180 children. The analysis will aim to describe the proportion of children who eat meals and snacks; assess differences in nutrient intake between consumers of meals and snacks; explore differences in meal and snack patterns and in nutrient intake between term-time and holidays and between and school days and weekends in term time; investigate the relationship between snack consumption and dental health.

iii. School meals versus packed lunches: Secondary analysis of the 24 hour recall data in around 180 children. The analysis will aim to describe the foods consumed and the nutrient intake at lunchtime for the children taking school lunches and the children taking packed lunches. Comparison will be made to the new nutrient school lunches standards by type of school lunch.

2) The School Lunch and Behaviour Study in secondary schools aims to determine whether a) secondary school food provision at lunchtime meet the new food-based standards and b) changes to the school dining room environment improve pupils' concentration and behaviour in the learning period after lunch.[84]

3) A cluster randomised controlled trial of a Smart Lunch Box, designed to improve the content of primary school children's packed lunches in the UK is being conducted in Leeds aims to assess the nutritional content of children's packed lunches and assess their food choices.[85]

b. Barriers to school meal take up or change of dietary practices in schools

What is known (4 studies): Results from a qualitative study in Scotland gave insights into the influence of the secondary school environment as a context for understanding young teenagers' eating habits and food practices. Of particular interest were that a) restrictions of not being able to eat with friends from other year groups and b) not always being able to access the type of preferred food were described as frustrating and in some case were unacceptable, resulting in pupils leaving the school premises to buy food elsewhere. The main finding was that the dislike of queuing, their ability to budget for food at school, and the desire to maximise time spent with friends all influence food choice at lunch-time.[86] The implementation of School Food Groups that had specific targets of increasing the school meal take up and increasing the availability of healthier foods (particularly fresh fruit, vegetables and salad, high-fibre bread, non-fried potato, and non-cream cakes) provided by the school caterers was not associated with long-term changes in school-based eating. Although this whole school approach suggested that it was successful in making some positive changes at an early stage, these were not sustained two years from the baseline measure, despite continuation of some elements of the complex intervention throughout the two years, indicating the difficulties associated with achieving sustained dietary changes in secondary school pupils.[87] Further consultation with secondary school children about the food provided at school found that pupils were in favour of school meals being promoted to everyone, and for schemes to make the take up of free school meals more anonymous and less embarrassing for those who receive them.[88]

Consultation with primary school children about the food provided at school found that barriers to children taking a school meal are poor quality of food and limited choice, lack of cleanliness and a poor dining environment. The participants also identified some positive aspects of school meal provision, including the promotion of healthy eating and that it could encourage younger children to develop better eating habits.[89]

What unpublished studies will add: Opinion research by the Trust has identified a variety of factors associated with avoidance of school food, such as noisy dining environments, queuing, and lack of preferred foods. These and other findings will be summarized in a report on the Trust website in the near future.

c. The introduction of breakfast clubs, food clubs, and food groups in schools

What is known (5 studies): There is insufficient evidence to provide any clear-cut conclusions about the impact of breakfast clubs on nutrition, behaviour or academic attainment. Breakfast club participation may be associated with poorer nutrient intake[90] but may also show decreased unauthorised school absences.[91] A study undertaken by the Trust showed improvement in academic attainment in schools that had introduced breakfast clubs, although design weakness cast doubt on a clear causal link.[92]

There are also key economic differences between clubs based in primary schools and those based in secondary schools in both funding levels and cost structures. For example, for

breakfast clubs funded by the Department of Health's pilot study for the expansion of clubs, the mean level of year 1 funding provided to clubs based in secondary schools was higher than for clubs based in primary schools (£3158 vs. £2847). Although the estimated total costs of implementing and running breakfast clubs for the duration of the pilot initiative (year 1 and year 2) were similar irrespective of phase of education (£9494 in primary schools compared with £9728 in secondary schools), higher levels of attendance at secondary school-based clubs suggest that the unit cost per child was likely to have been greatest for clubs based in primary schools.[93]

The introduction of an after school 'Food Club' is an appropriate method for the development of food preparation skills in teenage pupils, but the choice of recipes needs careful consideration, particularly to encourage boys to engage with the clubs. Although the newly acquired skills may be used at home, it was also apparent that many teenagers did not have this opportunity, and were unlikely to be able to influence food choices in families.[52]

A whole school approach using School Food Groups formed of pupils, teachers, catering staff, and health professionals and in which target setting was used, was not effective in improving school-based eating. Any early positive changes were not sustained, indicating the difficulties associated with achieving long-term dietary changes in secondary school pupils.[87]

What unpublished studies will add: The Trust, through the 'Let's Get Cooking' programme, will be evaluating in 2008-2009 the impact of the introduction of cooking clubs on cooking skills and consumption of healthier foods.

d. School meal take up (free and paid for) and choice

What is known (7 studies):

The first annual survey of take up of school meals in England (2006) produced baseline data for the tracking of school meal data following the formation of the Trust, set up to address the problems associated with school meal provision.[94] The second annual survey of take up of school meals in England (2007) provided evidence of changes from baseline levels. There was some evidence that the level of take up in primary schools had stabilised. In secondary schools, however, the results showed a decrease in the take up of school meals nationally.[95] However, results from the third annual survey indicates there has been a 2.3 percentage point increase in take up amongst primary school pupils, whilst secondary schools have stemmed the decline with only a 0.5 percentage point decline since last year.[96]

Prior to the introduction of the food-based standards for school meals the profile of foods on offer at lunch time in both primary and secondary schools was not consistent with the Balance of Good Health. This was compounded by the poor choice of pupils from these available foods.[97] [98] Provision of healthy free meals to primary aged children in one area of England was shown to have a positive impact on a number of behaviours. [99]

A telephone survey sought young peoples' opinions of school meals, providing insights into factors that influence young people's meal choices.[100] Irregular use of the dining room was most likely to be associated with a dislike of the food, including poor quality or inadequate daily variation. An equal number of pupils reported that food was not healthy enough, was too healthy, or was too boring. Other reasons for not using the dining room were concerned with its environment such as having nowhere to sit, or the decoration being unpleasant. The length of the queue was also a deterrent, as was the noise and the crowded atmosphere. Pupils were also deterred by the cost of food or by social issues such as their friends not eating there, a desire to have a break from school, a preference for sitting outside, or being unable to eat packed lunches there. The single most frequently given reason that would entice non-users back into the dining room was reducing the cost of food or the provision of better or healthier food. Improved organisation was also a suggestion, with shorter queues

being particularly important. Improved structure, more space, and more opportunity for socialising were also given as reasons.

What unpublished studies will add (2 studies):
1) A survey aims to establish the reasons for the poor take up of free school meals within Leeds schools. This project, which started in September 2007, is part of the Leeds School Meals Strategy. The findings are not available at present but will be written up into a final report and shared locally, regionally and nationally.[101]

2) A Free School Lunch Trial in primary schools (years 1-3) is being conducted in 5 Scottish LAs in Scotland. The final report of the evaluation will be submitted to the Scottish Government in Summer 2008 and will include take up figures and results of a promotion of FSM to parents.[102]

e. Education and national programmes and peer-led programmes

What is known (4 studies): While a whole school approach to increasing intakes of fruit and vegetables may result in a short-term modest improvement in fruit intake and increased knowledge about fruit and vegetables there is no evidence that this persists over time.[103] A peer modelling and reward based programme in primary schools resulted in at least a short-term increase in fruit and vegetable consumption both in and out of school as well as increasing a liking for fruit and vegetables.[104] [105] More recently the same programme has been evaluated in Ireland where school meals are not provided and children take a packed lunch to school.[218] Provision of fruit and vegetables in school, supplemented by a peer modelling and reward based programme, led to an increased consumption of fruit and vegetables during the intervention phase which was sustained, at least partly, at one year.

The National School Fruit Scheme (NSFS) aimed to provide one free piece of fruit each school day to children aged 4-6 years. Initial improvements in fruit intake during the scheme did not persist when children were no longer eligible for the scheme. For increased fruit consumption to have lasting effects, additional interventions will be needed.[106] [107]

What unpublished studies will add: No relevant research identified.

f. Vending machines in schools

What is known (1 study): Evidence from a study using a lifestyle questionnaire showed no association between schoolchildren's consumption of confectionary purchased from vending machines and 'poor' dietary practice or 'undesirable' lifestyle habits.[108] When outside school, the local shop was the most popular purchasing outlet. Throughout the day, both in and out of school, fizzy drinks were most frequently consumed while during the evening fruit was popular, particularly among girls.

What unpublished studies will add: The Trust has commissioned a study to monitor changes in vending in secondary schools in England. A report is due in Summer 2009.

g. Catering/Standards

What is known: No relevant research identified.

What unpublished studies will add (2 studies):
1) Calderdale Caterers' Perspectives on Implementing the School Meal Standards will explore Calderdale caterers' knowledge and understanding of the SMRP recommendations, the barriers to implementation, and the proposed solutions, and will inform local practice. No web link is available.
2) The Trust will be undertaking a study of food provision and consumption in primary schools in England. The provision of food, the quality of the provision, and the extent to

which it is compliant with the standards will be evaluated. Field work will take place between January and March, 2009, and a report is due in Summer 2009.

4.2 Food related research associated with health and cognitive outcomes

a. Asthma/lung function

What is known (2 studies): The consumption by children of at least 4.5 portions of fresh fruit each day has a beneficial effect on lung function but is not associated with wheezing except for a higher prevalence of wheeze among those who never ate fresh fruit compared with those who did eat fresh fruit.[109] Eating bananas or drinking apple juice made from concentrates, but not apple intake or other types of apple juice, may have a protective effect against wheeze.[110]

What unpublished studies will add: No relevant research identified.

b. Body weight and obesity

What is known (15 studies): The Liverpool SportsLinx Project highlighted the trend in increasing rates of obesity as well as evidence that many children fail to eat the recommended 5 a day and have a high intake of sugary and fatty foods.[111]

A small study of 60 children aged 5-16 recruited from a dental surgery in the Chelsea area of London suggested that just over one quarter (26%) of boys and 32% of girls have been estimated as being overweight with 11% of boys and 5% of girls being obese.[112] More robust estimates come from the Government's National Child Measurement Programme (NCMP) based on high-level analysis of the prevalence of obese and overweight children, in reception (aged 4 to 5 years) and year 6 (aged 10 to 11 years), measured in the school year 2006/07. In total, 876,416 valid measurements were received for children in the Reception year and Year 6 in English primary schools. This represents approximately 80 per cent of those eligible. In reception, almost one in four of the children measured was either overweight or obese. In year 6, this rate was nearly one in three. Of particular interest is that obesity prevalence is significantly higher than the national average in the North East, West Midlands and London Strategic Health Authorities (SHAs) for both school years, while it is significantly below the national average in the South East Coast, South Central, South West and East of England SHAs for children in both school years as well as for year 6 children in the East Midlands SHA. Obesity prevalence is higher in urban areas than in rural areas, and there is a strong positive relationship between deprivation and obesity prevalence for children in reception and Year 6.[113]

Taking prevalence of both overweight and obesity together, out of 34 countries, Wales was 3rd in rank, England was 7th, Scotland was 11th, and Ireland was 14th. Wales (at 21.5%) was one of only four countries to have a combined prevalence of over 20%. Looking at the prevalence of obesity only, England, at 5.1%, was ranked 3rd behind Malta and USA. [114]

In the UK (and USA) it appears to be easier to change attitudes and knowledge towards obesity prevention rather than changing actual physical attributes such as body mass index (BMI), body fat, or waist circumference.[115] A family-focused lifestyle intervention for overweight children and young people in Liverpool showed changes in the participating children's attitudes and enthusiasm for physical activity, their willingness to try new foods and their confidence and social skills.[116] More generally, school based interventions aimed at reducing obesity do not have high success rates,[117] although a school based education programme aimed at reducing the consumption of carbonated drinks showed a slight short-term reduction in the number of overweight and obese children.[118] However, the three-year

follow-up showed similar rates of increase in obesity in both the intervention and control groups.[119] The results of a survey to measure the intake of non-milk extrinsic sugars in children in Scotland provide clear evidence that the intake of NMES is considerably higher than the Scottish Dietary Target in the study population and in all sub-groups. The foods contributing to NMES vary significantly with socio-economic status but are mainly due to high consumption of soft drinks, confectionary, biscuits and cakes.[120] A whole school approach, including modification of school meals, was successful in producing changes at the school level but had little effect on children's behaviour.[121] The feasibility of the evaluation of the MEND programme in improving child health and reducing obesity was undertaken in 2002 and has generated various publications showing significant improvements in health outcomes.[122] Interim reports on the evaluation of the MEND programme (the world's largest childhood obesity intervention programme) are expected to become available before 2010. Results from pilot studies and presented at three conferences[123] suggest that the programme is effective in improving various physical (including decreased waist circumference, BMI, systolic blood pressure, and sedentary activities, and increased physical activity) and mental health (including global self esteem score) outcomes. The APPLES study aimed to develop, implement and rigorously evaluate interventions aimed at both obesity prevention and treatment in children has confirmed the continuing rise in childhood obesity and has contributed to raising the awareness that its increasing prevalence is a public health issue.[124] Results from a further programme developed to address the needs of obese children from disadvantaged communities suggests that effective care can be delivered cost effectively by health trainers supervised by health professionals, to reduce the incidence of overweight and obesity and improve quality of life.[125]

What unpublished studies will add (10 studies):

1) A follow-on from the Gateshead Millennium Study (GMS) is a two-stage study that started in 2006 looking at factors that identify potentially modifiable risk factors in early life or current lifestyle that can also predict body fatness at age 6-7 years. Stage 2 will involve key subgroups of parents invited to focus groups and interviews to explore perceptions and attributions for adiposity.[126]

2) A project recording the dietary intake and physical activity recorded with the use of a Smart phone is planned.[127]

3) Children may learn to adjust their intake in response to a disguised energy load; therefore the role of learning in short term compensation must be further examined.[128]

4) A PhD studentship aims to examine the association between multiple obesogenic factors and childhood obesity.[129]

5) A qualitative study starting in Spring 2008 will gather data on thoughts and perceptions of presently obese and previously obese young adults. No web link is available.[210]

6) The SPEEDY study (Sport, Physical activity and Eating behaviour: Environmental Determinants in Youth) aims to assess physical activity and dietary behaviour in children, and to study a wide range of determinants of these behaviours in order to inform future health intervention. The study will also look at the perceptions of both parents and children concerning the children's physical activity and diet.[130]

7) An intervention designed to reduce the obesity prevalence in a population of South East Asian children living in Birmingham is planned.[131]

8) A report looking at the effects of snacking on childhood obesity funded by the Food Standards Agency and led by the University of Ulster has been handed to the FSA (December 2007). No web link is available.[213]

9) A study looking at the prevalence of young people's concerns about their bodyweight has been funded and led by the University of Nottingham has been completed.[132]

10) Results on the evaluation of the MEND programme (the world's largest childhood obesity intervention programme) are expected to become available by 2010 [209]

c. Cancer and all cause mortality

What is known (4 studies): Analyses of a longitudinal study (Boyd Orr's survey of family diet and health in Britain between 1937 and 1939 and followed up through the National Health Service central register 2003 shows evidence of a relationship between (i) lower fruit intake in childhood and increased risk of incident cancer in adulthood,[133] (ii) higher energy intakes in childhood and cancer mortality in adulthood,[134] and (iii) higher childhood BMI and subsequent increased cancer risk.[135] There is little evidence from the same study of any effect of food supplementation on all-cause mortality.[136] The difference in diet and social environment in the 1930s compared with today limits the external validity of the findings.

What unpublished studies will add: No relevant research identified.

d. Cardiovascular disease, coronary heart disease and hypertension

What is known (8 studies): Data from the Boyd Orr survey of family diet and health in Britain between 1937 and 1939 showed a protective (dose-response relationship) effect of vegetable intake against stroke.[137] Evidence from the 1946 British Birth Cohort Study showed a beneficial effect of vitamin E for both the risk of hypertension and for high waist circumference.[138] The most recent study contributing to this set of outcomes gives some unexpected results, but provides some limited evidence that education and intervention during early adolescence on certain aspects of diet may be justified as part of a preventative strategy for CHD. [139]

The School Heart Health Study (Ten Towns Study) was established in 1990 to examine the `heart health' of children living in areas of England and Wales with widely differing rates of adult heart disease. Three surveys were done, one in 1990 in infant schools, one in 1994 in junior schools and one in 1998-9 in secondary schools. Results suggested that blood cholesterol levels in childhood may be an important marker of heart disease risk, because it may affect the structure and function of the arteries, even at this early stage. It is already known that dietary patterns and overweight affect cholesterol level in young people, as in adults.[140]

More recent evidence from a meta-analysis of randomised controlled trials of salt reduction in children showed that a modest reduction in salt intake caused an immediate fall in blood pressure which, if continued, may well lessen the subsequent rise in blood pressure with age. This would result in major reductions in cardiovascular disease in later life. These results in conjunction with other evidence provide strong support for a reduction in salt intake in children.[141] Further support of the relationship between salt intake and blood pressure in children and adolescents comes from analysis of the National Diet and Nutrition Survey for young people. The average salt intake, which did not include salt added in cooking or at the table, was 4.770.2 g/day at the age of 4 years which increased with age to 6.870.2 g/day at 18 years. An increase of 1 g/day in salt intake was related to an increase of 0.4mm Hg in systolic pressure and 0.6mm Hg in pulse pressure. [142] Further analysis of the National Diet and Nutrition Survey for young people in Great Britain showed a significant association between salt intake and total fluid, as well as sugar-sweetened soft drink consumption and demonstrate that salt is a major determinant of fluid and sugar-sweetened soft drink consumption during childhood. Halving the salt intake in children in the UK would reduce their consumption of sugar-sweetened soft drinks per week per child. A reduction in salt

intake could therefore play a role in helping to reduce childhood obesity through its effect on sugar sweetened soft drink consumption. This would have a beneficial effect on preventing cardiovascular disease independent of and additive to the effect of salt reduction on blood pressure. [143]
Prior to the introduction of the 2007 Food Based Standards, a survey of just over 1100 pupils showed that, after adjustment for town, school, age, and sex, several markers associated with chronic disease risk (including anthropomorphic markers of adiposity) were potentially more favourable in pupils who ate school dinners rather than a meal from home (a packed lunch), although serum folate concentrations were also lower in the school dinner group. [144]

What unpublished studies will add (1 study):
1) The Young Hearts (YH) Project is an ongoing study of biological and behavioural risk factors for cardiovascular disease in a representative sample of young people from Northern Ireland, a region of high coronary mortality.[145]

e. Cognition

What is known (3 studies):
A systematic review provided evidence of the effect of nutrition, diet and dietary change on learning, education and performance of children of relevance to UK schools, designed to assess the strength of evidence surrounding the effect of nutrition on the behaviour, learning and performance of school-aged children in the UK and the developed world.[146] The review highlighted that due to the small number of studies available and the great variation in their designs, there is insufficient quality evidence to reach firm conclusions on the effect of nutrition and dietary changes on learning, education or performance for all schoolchildren. There is also insufficient evidence to reach a firm conclusion on the effect of omega 3 fatty acids on the education or learning of the general population. However, there is some evidence of benefits for some children with learning difficulties.

Findings presented in the Report of an inquiry held by the Associate Parliamentary Food and Health Forum[147] suggested that the evidence supports the introduction of funded School Breakfast Clubs, and particularly those serving a low glycaemic index breakfast. They also strongly recommend that all children entitled to free school lunches should be entitled also to a free school breakfast, whose content should, like school lunches, be subject to quantified nutritional standards. This is particularly important because poor school performance may contribute to a life-cycle of under achievement. In addition, a PhD study shows evidence of the impact of four types of breakfast (high or low Glycaemic Index and Glycaemic Load). It demonstrates that performance on memory tasks are improved 90-120 minutes following the consumption of low GI, high GL breakfasts, whereas attention and vigilance tasks are improved following consumption of high GI, high GL meals. These findings take into account changes in mood associated following the different breakfast types.[148]

Authors of the report[147] also presented evidence linking children's behaviour and iron deficiency. While this is particularly important in pre-school aged children, there is also evidence that iron deficiency anaemia in school age children (5-18 years) is associated with poorer cognition and school performance. However, these adverse effects of iron deficiency appear to be more transitory than with younger children. In addition, the National Diet and Nutrition Survey[149] indicates that there is a deficient iron intake in some children, especially teenage girls. If this is a failure to properly regulate iron absorption rather than a deficient intake, the bioavailability of iron from cereals and vegetables can be enhanced by a concurrent consumption of vitamin C, in for example fruit juices. Breakfast clubs would provide a good opportunity to serve both these foods.

The low intake of zinc by the majority of children is of concern, and warrants further research, particularly since it has a close relationship with serotonin receptors, both of which, in low concentrations, have been shown to be associated with violence.[150] [151] [152]

Of less relevance to the general population of school pupils, but none the less of importance is the preliminary evidence supporting the benefits of omega-3 fatty acids in childhood depression and in young people at high risk of psychosis. This, together with evidence from other sources on the effects of dietary change and supplementation on the behaviour of children and young people, suggests that the risk of developing certain mental health problems may be preventable at least in part by improving the diet of children and young people. The incidence of disciplinary incidents and reported violence was reduced among groups of young offenders whose diets were supplemented with the recommended daily intake of vitamins, minerals and essential fatty acids.[153] Preliminary results from similar trials in Holland show a reduction in incident reports in those receiving supplementation compared to those taking a placebo where the number of reported incidents increased.[154]

What unpublished studies will add (5 studies):
1) A systematic review of breakfast and its effects on mental performance in children and adolescents is due for completion in 2008.[214]

2) Children aged 11-12 years who are regular breakfast eaters will be asked to complete some computer tests during two separate morning sessions with the aim of investigating the importance of breakfast on mental performance and appetite in children. No web link is available for either of these linked activities.[215]

3) The Food for Life programme, which aims to transform the quality of school meals by enabling local authorities, caterers and schools to provide a much greater proportion of food that is nutritionally valuable, fresh, unprocessed, locally produced and of organic origin, will be evaluated in terms of it impact on school meal take up and the effects of this on attention, behaviour and possibly attainment.[155]

4) Two studies by Food for the Brain studies have shown a consistent improvement in all measured areas rated independently by teachers and parents and an improvement in SAT scores following dietary improvements and essential fatty acid, vitamin and mineral supplementation and exercise.[156] [157] A third project aims to evaluate and quantify the effect of three elements, (no change to diet or lifestyle, change to diet or lifestyle change only, and taking supplements only) on behaviour and academic performance.[158]

5) Evaluation of the 'Lottery funded 'Let's Get Cooking' programme will provide evidence of the impact of a national scheme aimed at improving children and young people's attitude to healthy eating by teaching basic cooking skills.[159]

f. Dental

What is known (9 studies; 4 further articles providing comments): The availability of fresh tap water may be more beneficial for the prevention of dental caries than bottled water, due to its higher levels of fluoride.[160] This would also be a cheaper alternative for schools. There is strong evidence that the consumption of carbonated sugar-sweetened drinks, as well as sports drinks, and herbal or lemon tea is associated with increased caries experience[61] [161] [162] [163] as is the consumption of foods and drinks containing NMES, particularly prior to bed-time.[162] [164] The findings of positive associations between sugar and caries, and negative associations between dairy produce and caries, could be explained by the replacement of sugar by diary products, rather than a real protective effect of dairy produce.[165]

It has, however, been suggested that the prevalence of dental caries is more strongly associated with the frequency of exposure to sweet food and drink rather than the amount of sugar ingested.[166] There is also the view that much of the identified association between diet and dental decay can be at least partly explained by levels of social deprivation. At the very least the whole picture surrounding this association is complex, but there is strong evidence to suggest that social deprivation is a high risk factor for both increased sugar intake[112] and the development of caries in children and teenagers.[167] Although acidic fruits increase the likelihood of caries, fruit other than apples or citrus fruit (most likely in children and teenagers to be bananas) reduces the likelihood of dental erosion by 52%.[161]

There are some mixed messages surrounding the suitability of dried fruit, a food recommended by the Trust as one alternative to sweets and biscuits, although the guidance acknowledges that schools may choose to serve dried fruit only as part of a meal. In contrast, the advice on the prevention of childhood tooth decay from The British Dental Health Foundation includes:

"If you want to give your child a snack, try to stick to cheese, vegetables and fruit, but not dried fruit."[168]

The range and amount of fruit intake has also been found to be associated with dental erosion as has intake of tomato ketchup and yogurt.[61] Other foods found to be associated with increased tooth wear include brown and, or other sauces, vinegar, salt and vinegar crisps, and curry and, or spicy food.[163] One estimate suggested that 10% of 14 year-olds eat a vegetarian diet but found no evidence of an association between the prevalence or severity of erosion with type of diet.[169] The apparent association between access to a school vending machine and tooth decay offers support for the shift to healthier vending.[112]

It is generally accepted that teeth are necessary for the maintenance of good health, with inter-dependence between teeth and diet. A good diet is essential in the development and maintenance of healthy teeth, but healthy teeth are also important in facilitating the consumption of a varied and healthy diet throughout life.

What unpublished studies will add: Work on further research is currently being investigated and this section will be updated where appropriate.

g. Food hypersensitivity and food allergies

What is known (4 studies contributing 5 papers): In general there is a lack of information of food hypersensitivity (FHS) among young children and teenagers [170] [171] [172] and studies have concentrated on estimating the prevalence of sensitisation of food allergens rather than identifying any causal relationship between diet and the development of hypersensitivity. Among six-year-olds living on the Isle of Wight, the prevalence of reported adverse reactions to one or more food items was almost 12%.[171] Of these, two-thirds were avoiding one or more foods, although not necessarily the one to which an adverse reaction was reported. Dairy products and milk and were most frequently reported as causing a problem (by 31% and 40% respectively of those reporting a problem) followed by peanuts and eggs (both 16%), additives and colourings (14%), tree nuts (12%), wheat (11%), strawberry (6%), sesame (5%), and fish (2%). The rate of sensitisation fell to 7.7% when tested using a skin prick test (SPT), and this fell further to 3.6% when children with a history of grass pollen allergy who were sensitised to both grass and wheat were removed. There was considerable mis-match between the food reported to be a problem and that (if any) found to be cause a positive SPT. Milk, peanuts, and wheat were the key food allergens in those with positive challenges. Similar results were found in a slightly older population in the same area.[172] The most common foods implicated in FHS in the 11year age-group were peanuts, tree-nuts, egg, milk, shellfish, gluten, green beans, cheese, kiwi, tomato and additives. In the group of

15 year-olds, the foods implicated were peanuts, tree-nuts, gluten, wheat, shellfish, egg, milk, and additives. This is consistent with previous evidence suggesting that peanut, tree nut and shellfish allergy are often reported in older children and young adults. The prevalence of peanut allergy at 1% and 0.8% in the 11 and 15 year-old groups respectively was similar to that in a group of 3 to 4 year olds in the same geographic region.[173]

The prevalence of sensitisation to aeroallergens and food allergens was estimated in the Avon Longitudinal Study of Parents and Children (ALSPAC) using skin tests.[170] Of the foods tested, the most common sensitisation was to peanut (1.4%) and mixed tree nuts (1.0%).

The fourth study[174] [175] was concerned with the management of clinical allergy. Using a prospective survey of children's hospital admissions for food-allergic reactions, the incidence of severe food-allergic reaction was estimated to be very low, and accounted for 0.89 hospital admissions per 100 000 children of whom two-thirds were male. The main allergens were peanut (21%), tree nuts (16%), cow's milk (10%), and egg (7%), similar to the pattern described in the previous studies. Of 229 reported admissions over two years, three were fatal, with a further six classified as near fatal. All nine (except one who was too young to have been diagnosed) had a strong history of asthma. The study concluded that the deaths and near deaths were more likely to be a consequence of the control and management of asthma than of the food allergy itself.

Overall, the perceived sensitivity to foods is higher than that estimated by objective methods, and the rate of severe reaction is very low. The implication for school meals is that although the risk is minimal, it is a real risk, although it is expected that any pupil with a true allergy will have made themselves known to the school staff that will be aware of any action that should be taken in the event of a medical emergency.

What unpublished studies will add: Work on further research is currently being investigated and this section will be updated where appropriate.

h. Growth, development, and bone mineral density (BMD)

What is known (5 studies): While children aged 7-11 eating a meat-free or vegetarian diet (liberally defined) have at least as satisfactory growth rate as those eating an omnivorous diet,[176] there is a relationship between some aspects of diet and BMD, which might be particularly important for females in later life. [60] [62] [177] [178]

What unpublished studies will add: (4 studies):

1) The Southampton Woman's Survey is a longitudinal study examining the maternal pre-conception and intrauterine factors that influence the growth and development of the foetus and child, and the subsequent health of the child. Dietary data has been collected for about 200 children who have been born to these women and are aged 6 years so far along with information on growth and allergies. These children will be followed up at intervals until adulthood.[179]

2) The Avon Longitudinal Study of Parents and Children (ALSPAC). The study was established to investigate the complex genetic and environmental pathways that predispose to the development of conditions including asthma, food allergies, autism, hyperactivity, and dental decay.[180]

3) The Millennium Cohort Study (MCS) is a longitudinal UK-wide study that examines the social, economic and health-related circumstances of the new century's children and their families. Dietary data have been collected for more than 2000 children to date. Dietary data are collected at 6 months, 12 months, 3 years, and 6 years. The follow-up of children at the age of 8 years is starting this Autumn. Detailed information is being collected about these children, including data on growth, illnesses and atopic disease, cognitive function, DXA-

assessed bone status and body composition, respiratory function and cardiovascular function. There are no plans to follow these children until adulthood.[181]

4) The Born-in-Bradford research project is a unique multi-ethnic birth cohort study in Bradford. From October 2006, all babies born in Bradford will be recruited into the cohort One of the main aims is to investigate the factors that influence birth weight and childhood growth. [182]

i. Micro-nutrient intake and deficiencies

Evidence has been extracted from dietary, clinical and biochemical evidence.

What is known (12 studies): Compared with a typical diet eaten in 1950, today's diets are less compliant with current healthy eating guidelines,[183] with, for example, 21% of a sample of Glaswegian primary school children having a diet lacking in meat, fruit, vegetables, and milk.[184] More generally many children would benefit from a reduction in the amount of sodium and an increase in fruit and vegetable consumption.[57] Some minority groups are at particular risk with vitamin D deficiency occurring in up to 45% of school-children and over 70% of adolescents. [185]

Dietary restraint in adolescent girls can lower the intake of some nutrients and a weight reducing diet is associated with low levels of calcium, zinc, and, in particular, iron.[186] Over half of a more general sample of children and young people had dietary iron intakes below the reference nutrient intake (RNI), with 12% of intakes below the lower RNI.[187] Levels were lowest in 11-18 year-old girls, particularly those who were vegetarian or non-Caucasians.

Fortification of flour is an important source of both calcium and folic acid without which estimates suggest that at least one-tenth of children would fall below the lower RNI for calcium. [188] Under normal circumstances, average calcium and phosphorous intakes for 16-18 year olds eating a non-restricted varied diet have been estimated to be above the UK RNI with only 3% having calcium levels below the lower RNI.[62] As well as maintaining adequate intakes of calcium, the inclusion in school meals of bread and other flour products might be an important source of folic acid which can help to lower the UK's high rates of neural tube defects as well as prevent cardiovascular disease.[189] Increasing bread consumption would also increase the currently low intake of whole-grain foods which can offer protection against the risk of CVD, some cancers, and type II diabetes.[190]

Despite the recommendation to reduce the intake of total and saturated fat, these food may be an important source of vitamin K in some groups. Fats in cakes and biscuits and, particularly in boys' diets, potato products such as chips and crisps, provide considerable amounts of vitamin K and if levels of green vegetables are low, the removal of these fats could lead to vitamin K deficiency.[183]

Although water consumption in 11-12 year old children has remained fairly constant over the past 20 years, the intake of tap water has decreased which may have implications for estimating fluoride intake in fluoridated areas.[22]

What unpublished studies will add: Work on further research is currently being investigated and this section will be updated where appropriate.

j. Visual acuity

What is known (1 study): There is a suggestion that a diet lacking in vitamins A and B may result in visual acuity screening failure [184] although further work in a more general population and geographical area is required.

What unpublished studies will add: No relevant research identified.

5 Further evidence or research needed

A variety of research activities at the Trust are currently being undertaken to address questions to help build on the evidence for the benefits of improving school food: schools' compliance with the school food standards; children's consumption of the improved food; factors influencing the change in the provision and consumption of school food; the impact of changes in school food on academic performance, learning, behaviour, health and vitality; the economic case for investing in better school food.

This work will contribute to: increasing take up; changing attitudes and behaviour in relation to school food; and the embedding of systems which sustain the changes and develop a whole education approach to food. This remit is based on the outcomes set by the Department of Children, Schools and Families (DCSF) in December 2007:

- Maximising the take up of school meals.
- Maximising compliance with the new school food standards.
- Raising awareness of the new healthier school meals and the contribution they can make to children's well-being, including reducing obesity in the short and longer term as part of an overall balanced diet, in order to change behaviour among children, parents and other stakeholders.

5.1.1 Diet and food choice

Food and nutrition education is vital if children are to understand the concept of a 'healthy diet'. Further evidence regarding the impact of healthy eating education on positive dietary habits would be beneficial in developing and informing effective education programmes. Evaluation of these programmes and monitoring of their long term effects also requires careful consideration if programmes are to have sustainable results, e.g. in prolonging increased consumption of fruit and vegetables. Schools must be supported when implementing a whole school approach to healthy eating, and improving education and the curriculum through work which links with the National Healthy Schools Programme, Healthy Schools and the FSA will help in the communication of consistent key messages on healthy eating and specific aspects of healthy eating, such as the importance of eating fruit and vegetables. It is important to assess whether children and their families understand the benefits to current and future health of eating a healthy and balanced diet. With efforts to improve the nutritional knowledge of children and their families and to improve cooking skills in both schools and in the home it is important to monitor to their effectiveness on children's food choices both in and out of school. By raising awareness of healthy school meals, the important contribution they can make to a child's well-being can also be highlighted. It is particularly important that those who are choosing not to eat school lunches, particularly those who are eligible for free school meals, are reached. Increasing our understanding of reasons for not taking school meals would help to develop an appropriate targeted approach.

The Trust will be undertaking research activities to understand how changes in food provision affect performance and behaviour at both the school and individual level through randomised controlled trials and cross-sectional studies. Monitoring take up of school meals and free school meals and identifying and defining areas where targeted support is needed to assist with increasing take up is a key deliverable.

5.1.2 School based research and school food

Since many factors play a role in influencing children's food choices, it is important to gain a comprehensive understanding of the impact of specific changes made to the school food service system have on the take up of school meals. These changes include improved dining facilities, improved skills in the workforce, and the introduction of school-based nutritional standards. Take up levels in secondary school are a particular concern and a greater understanding of barriers to take up within secondary schools will facilitate appropriate targeted support. It is also important to understand issues the workforce may face in implementing and adhering to the food-based standards as well as the problems they anticipate in adopting the nutrient-based standards. Schools and local authorites should also be monitored to assess whether or not they are complying with the standards, with detailed examination data provided via the Trust's web-based School Food Checklist providing some useful information. Failure to meet standards may have adverse effects on the nutritional content of the meals served which in turn may negatively impact on take up levels and ultimately behaviour and academic performance.

5.1.3 Food related research associated with health and cognitive function

Tackling childhood obesity, which in turn can reduce the prevalence of adult obesity and co-morbidities, is a high priority and is in line with the National Healthy Schools Programme and the 'Healthy Weights, Healthy Lives' Cross-Government Strategy for England, launched in January 2008 as the first step in a sustained programme to support people to maintain a healthy weight. Ensuring that children, schools, LAs, catering staff, parents and carers understand the long term benefits of a healthy and balanced diet on both present and future health outcomes is crucial. Communicating that healthy eating, in conjunction with adequate physical activity levels, can curb the rising prevalence of obesity is of key importance. Further work into the possible positive effects of diet on cognition, and hence attainment and long term learning potential would also help to strengthen the importance of the healthy eating messages.

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7 Glossary

FSM(s)	Free School Meal(s)
BMI	Body Mass Index
CHD	Coronary Heart Disease
NMES	Non-milk Extrinsic Sugar
UK	United Kingdom
WHO	World Health Organisation
ALSPAC	Avon Longitudinal Study of Parents and Children
DRV	Dietary Reference Value
LIDNS	Low Income Diet and Nutrition Survey
CVD	Cardiovascular Disease
NDNS	National Diet and Nutrition Survey
UKHLS	UK Household Longitudinal Study
NSFS	National School Fruit Scheme
DH	Department of Health
CWT	Caroline Walker Trust
FFQ	Food Frequency Questionnaire
SMRP	School Meals Review Panel
NCMP	National Child Measurement Programme
SHA	Strategic Health Authorities
USA	United States of America
MEND	Mind, Exercise, Nutrition…Do it
GMS	Gateshead Millennium Study
SPEEDY	Sport, Physical Activity and Eating Behaviour: Environmental Determinants of Youth
FSA	Food Standards Agency
YH	Young Hearts
GI	Glycaemic Index
GL	Glycaemic Load
SAT	Scholastic Aptitude Test
FHS	Food Hypersensitivity
SPT	Skin Prick Test
BMD	Bone Mineral Density
RNI	Reference Nutrient Intake
DCSF	Department for Children, Schools and Families
LA(s)	Local Authoritie(s)
LACA	Local Authority Caterers Association
NI	Northern Ireland
ELB(s)	Education and Library Board(s)
kcal	Calorie
COMA	Committee on Medical Aspects of Food and Nutrition Policy
LRNI	Lower Reference Nutrient Intake
SE	Socio-economic
RDA	Recommended Dietary Allowance
mg	milligram
MJ	Mega joule
CRV	Calculated Reference Value
OR	Odds Ratio
CI	Confidence Interval
NHS	National Health Service
KS	Key Stage
NSP	Non-Starch Polysaccharide
CADET	Child and Diet Evaluation Tool
LSQ	Lifestyle Questionnaire
FEV	Forced Expiratory Volume
DXA	Duel-Energy X-ray Absorptiometry
SD	Standard Deviation
TWI	Tooth Wear Index
DMFT	Decayed, Missing or Filled Teeth
APPLES	Active Programme Promotiong Lifestyles in Schools
VA	Visual Acuity

8 Appendices

Appendix 1. School food in the UK

In recent years, various initiatives in England, Scotland, Wales and Northern Ireland have been implemented to improve the food and drink served in schools with the aim of improving child health and reducing health related and social inequalities. This links with the Government's Every Child Matters: Change for Children [191]. The aims of this strategy are for every child, whatever their background or their circumstances, to have the support they need to be healthy, stay safe, enjoy and achieve, make a positive contribution, and achieve economic well-being.

England

The School Food Trust (the Trust) was established by the Department of Education and Skills in September 2005 to promote the education and health of children and young people by improving the quality of food supplied and consumed in schools. In October 2005, the Government appointed School Meals Review Panel published its report 'Turning the Tables'.[9] The report proposed radical changes to the quality and nutritional value of food served and consumed in school and has resulted in improved standards for school food.

The new school food standards cover all food sold or served in schools: breakfast, lunch, and after-school meals. Tuck shops, vending, mid-morning break and after-school clubs are also covered by the standards. Interim food-based standards for school lunches were introduced in September 2006, and in September 2007 food-based standards for food other than lunch were introduced. Nutrient-based standards for school lunches will be introduced in primary schools in September 2008 and in secondary schools, special needs schools, and pupil referral units (PRUs) in September 2009. These are based on the 2005 Caroline Walker Trust (CWT) guidelines for school meals.[192] Schools can adopt the nutrient-based standards before these dates.

Scotland

In 2002 the Scottish Ministers established an Expert Panel on School Meals to develop standards for the nutritional content of school meals and improve their general presentation and take up. These were the first school meal nutrient standards to be introduced in the UK since 1980. February 2003 saw the publication of the report 'Hungry for Success'.[193] The detailed food and nutrient standards, based on the 1992 CWT guidelines[194], were implemented in primary schools in December 2004 and in secondary schools by December 2006.

In October 2006 the panel made initial proposals for alterations to the standards. On 25th June 2008 The Nutritional Requirements for Food and Drink in Schools (Scotland) Regulations 2008[195] were passed by the Scottish Parliament and the regulations will commence in primary schools on 4th August 2008 with secondary schools following a year later (3rd August 2009). The introduction has been delayed for a year in secondary schools to give those schools that need it more time to make a phased transition to the new regulations. However, schools which feel able to make the changes effectively from August 2008 are encouraged to do so and in the mean time the implementation of Hungry for Success should continue. Guidance is currently being prepared to help those who are involved in providing food and drinks in schools to implement the regulations with publication due in the summer of 2008.

Wales

In 2001, the Education (Nutritional Standards for School Lunches) Wales Regulations[196] were issued to all schools and Local Authorities (LAs) setting out minimum dietary standards on portion sizes, type, and frequency of the main food groups. In July 2005, the Welsh Assembly established an independent Food in Schools Working Group. The group issued the consultation document, 'Appetite for Life',[197] in June 2006 which recommended accepting the CWT 2005 nutrient guidelines to apply to all food served at lunch time.

The Appetite for Life Action Plan[198] was launched on 22 November 2007, setting out the strategic direction and actions required to improve the nutritional standards of food and drink provided in schools in Wales. Its development was informed by: responses to the consultation exercise (which included children and young people's views); lessons learnt from other parts of the UK; and detailed discussions with the Local Authority Caterers Association (LACA).

At present, regulations will not be made to introduce the proposed food and nutritional standards within the Appetite for Life Action Plan. From September 2008, a two year action research project will be applied in four Welsh councils to develop and test the guidelines for implementing the food and nutritional standards proposed within the Appetite for Life Action Plan, and to inform wider application across all maintained schools in Wales.

Northern Ireland (NI)

In Northern Ireland in 1995 the Chest, Heart and Stroke Association published a report on the menus offered at secondary schools.[199] This led to the content of school meals being reviewed by the Department of Health and Health Promotion Agency. In December 2001 the Department of Education released the consultation document "Catering for Healthier Lifestyles – Compulsory Nutritional Standards for School Meals" which set out new compulsory nutritional standards for school meals.[200] The responses indicated that there was widespread support for the principles underpinning the revised nutritional standards. However, service providers (Education and Library Boards (ELBs) pointed out that removing certain foods from school menus, or restricting their availability, could have potentially negative effects on the school meals service as a whole and the secondary sector in particular. A decision was made to consult further with service providers before introducing the standards.

Following agreement with the five ELBs a small working group was convened to take forward the introduction of a pilot scheme to test the reaction to the revised nutritional standards. The pilot ran from March 2004 to March 2005. The results of the pilot pointed to a need to allow time for pupils to adjust to new, healthier menus. Therefore, the Department, in conjunction with the ELBs and other school authorities, began to introduce the standards to schools during the autumn 2005 term. A programme was devised that allowed for the introduction of the standards to small groups of schools, building up over a period of two tears to include all schools. The aim of this programme was to permit ELBs to manage the process strategically, and to allow them to intervene at the earliest opportunity should pupils react unexpectedly to the introduction of the standards. By the autumn term of 2007, all schools under ELB control had implemented the standards successfully.

In 2006 the Department consulted on proposals for new, updated, nutritional standards for school meals and extended the initiative to include other food in schools (vending machines, tuck shops, etc). [201] The Department proposed that these new standards for school meals and other food in schools would reflect the work being done in England and Scotland by following their food-based standards and the CWT 2005 nutrient recommendations. During

2006-2007 the Education and Training Inspectorate evaluated the nutritional quality of the school meals against the standards set out in Catering for Healthier Lifestyles. [202] Following the consultation exercise, the Department updated and finalised the food-based standards which were issued to schools in June 2007 and came into effect from September 2007.[203] The standards were further updated in February 2008 to clarify some aspects and provide additional guidance for schools. [204] Since September 2007 the Education and Training Inspectorate has been evaluating these new standards.

Nutrient-based standards may be introduced to schools at a later stage – the Department is keeping this position under review.

Appendix 2. Research inclusion and exclusion criteria

The criteria for considering studies for this review are as follows:

Types of research studies and participants

Research work on school aged children, i.e., those aged four to eighteen years, residing in the UK has been included.

Research work and articles included

This overview of research comprises:

- research work with health behaviours and outcomes, directly related to, or influenced by, nutrition or the provision of school meals.
- research where educational, health and nutrition promotion and where other school and family strategies were used to attempt to achieve, or identify how best to achieve, positive health outcomes and behaviours, where positive health outcomes and behaviours are defined as those concerned with optimal physical health, well being and psychological health (including self-esteem, self perception of health, healthy eating, and body weight)
- intervention studies involving diet and lifestyle in the community, school or clinic-based studies along with around the
- research involving the provision and take up of school meals and free school meals.

The review was limited to work that has been published since 1997. This also applies to the start date for unpublished research activities with the exception of some longitudinal studies that may have begun prior to 1997 and that are still producing findings that are relevant to this review. This time-frame represents the ten years and includes the two terms in which a Labour Government has been in power. Also, during this time in 1997, just four months after the general election, a process of devolution was started for Scotland which led to a Scottish Parliament based in Edinburgh being formed in 1999.

Research work excluded

Research work on children below four years of age has generally been excluded; this also applies to research on adults over the age of eighteen years. Any research work conducted, being conducted or planned to be conducted outside the UK has also been excluded.

Research work with health behaviours and outcomes not directly related to, or influenced by, nutrition or the provision of school meals has been excluded. This applies to eating disorders and alcohol consumption as numerous social and psychosocial factors can influence these behaviours. The main focus of the review was on physical health, and studies concerned with mental health have therefore been excluded.

Search terms

Search terms were based around the following categories: population, setting, exposure and health outcomes. An overview is given below, all searches done through journal abstracts and titles.

1. Population: child$, adolescent$, infant$, teenager$.
2. Setting: location, school, primary, secondary, England, Scotland, Wales, Northern Ireland, UK.
3. Exposure: Food, nutri$, micro-nutri$, micronutri$, vitamin$, diet$, energy, calori$, mineral, eat$, dinner$, lunch$, meal, meal time, health$, weight$, obes$, BMI, malnutrition$, overweight, underweight, low weight, grow$, develop$.
4. Health outcomes: attention$, hyperactivity, ADHD, cognitive function, allergy$, intoleran$, physical$, dental, tooth.
5. Other: attainment, concentration, confidence$, self esteem, attitude$, knowledge$, learn$, behaviour$, active$.

Appendix 3 Findings from grey literature search

Government Evaluations

Subject	Title	Investigators	Funding	Start Date	End Date	Publication	Link
Food in schools, choice and consumption	Paper 1: Healthy Food Provision and Promotion in Primary School: What impact is it having on food choices?[30]	Glasgow Centre for Population Health, Direct and Care Services (DACS) and the Education Department of Glasgow County Council	Glasgow City Council	May 2006	May 2006	Report published on GCPH website March 2007	www.yorkconsulting.co.uk/uploads/3_Healthy_Food_Promotion_and_Provision.pdf
	Free School Lunch Trial[102]	Glasgow City Council, West Dunbartonshire Council, Fife Council, East Ayrshire Council and Scottish Borders Council.	Scottish Government	October 2007	March 2008	Interim report on baseline take up figures will be submitted to the Scottish Government by 30 November 2007. Final report will be submitted to the Scottish Government on 29 July 2008	www.scotland.gov.uk/Topics/Education/Schools/HLivi/schoolmeals
	A critical review of the psychosocial basis of food choice and identification of tools to effect positive food choice: a summary[35]	British Nutrition Foundation	Food Standards Agency	February 2003	2004	Report published March 2004	www.britishnutrition.org.uk/upload/Food%20choice%20information(9).doc
	Consultation with Primary School Children on Food at School[89]	Scottish Out of School Care Network on behalf of the Scottish Executive	Scottish Government	June 2006	July 2006	Report published on the Scottish Government Website 25 September 2006	www.scotland.gov.uk/Resource/Doc/923/0039901.pdf
	Report of a survey of health education in post-primary schools in Northern Ireland[32]	Education and Training Inspectorate	Education and Training Inspectorate	October 2002	November 2002	Report Published on the Northern Ireland Department of Education Website November 2002	www.etini.gov.uk/denihealthedsurvey.pdf
	School lunchbox survey[19]	Community Nutrition Group (CNG) of the British Dietetics Association	Food Standards Agency	April 2003	2003	Report published on FSA website	www.food.gov.uk/multimedia/faq/school_lunches_survey/
	Mintel Report: UK school meals[205]	Mintel	Mintel‡	Unknown	2007	Report Published August 2007	http://reports.mintel.com/sinatra/reports/display/id=219253#about
Introduction of standards	Baseline research of implementation of recommendations of expert panel on school meals - Hungry for Success[43]	Scottish Executive Education Department and TNS System Three Social Research	Scottish Government	September 2004	2006	Report published on the Scottish Government Website January 2006	www.scotland.gov.uk/Resource/Doc/89259/0021349.pdf
	Cambridgeshire Secondary School Meals Pilot Project[31]	Cambridgeshire Catering Services (CCS), Personal, Social and Health Education Service (PSHE), E. Cambridgeshire and Fenland PCT Nutrition and Dietetic Department	Food Standards Agency	January 2005	May 2005	Report published on FSA website	www.food.gov.uk/multimedia/pdfs/cambridgepilot.pdf
	Progress made in the implementation of Catering for Healthier Lifestyles and general approaches to promoting healthy eating in schools in Northern Ireland[42]	The Education and Training Inspectorate	Department of Education Northern Ireland	January 2007	June 2007	Report Published November 2007 on the Education and Training Inspectorate Website	www.etini.gov.uk/for_healthier_lifestyles.pdf
	Paper 2: Healthy food provision and promotion in primary and secondary school: Impacts in school and beyond[36]	Scottish Centre for Social Research (led by Andy MacGregor)	Glasgow City Council	2007	2007	Report Published November 2007	www.gcph.co.uk/index.php?option=com_content&task=view&id=51&Itemid=100
	School meals in primary schools in England[97]	King's College London and TNS Social Research	Food Standards Agency and Department for Education and Skills	2006	June 2006	Report Published by the Department for Education and Skills	www.dfes.gov.uk/research/data/uploadfiles/RB753.pdf
	Schools Health and Nutrition: Young People Consultation Feedback[88]	Young Scotland and the Scottish Executive Education Department	Scottish Government	May 2006	July 2006	Report published on the Scottish Government Website 13 October 2006	www.scotland.gov.uk/Resource/Doc/151566/0040730.pdf
Health promotion	Healthy Food Provision and Promotion in Schools: A Literature Review[24]	Glasgow Centre for Population Health	Glasgow Centre for Population Health	Unknown	2003	Report published on GCPH website March 2006	www.gcph.co.uk/index.php?option=com_docman&task=doc_download&gid=163.
Fruit and vegetable consumption	Evaluation of Free Fruit in Schools Initiative[64]	Scottish Centre for Social Research	Scottish Government	February 2005	2005	Report published on the Scottish Government Website 29 December 2005	www.scotland.gov.uk/Resource/Doc/47121/0020887.pdf
	Children and healthy eating: a systematic review of barriers and facilitators[56]	Evidence for Policy and Practice Information and Co-coordinating Centre	Department of Health	Possibly 2001*	2003	Report published October 2003	http://eppi.ioe.ac.uk/cms/Default.aspx?tabid=246

* Date not confirmed ‡ Funding may involve these institutions, organisations or Government bodies plus possible others † Principle investigators may involve others

Diet and food choice

Subject	Title	Investigators	Funding	Start Date	End Date	Publication	Link
Fruit and vegetable consumption	The consumption of fruit and vegetables in those not eligible for FSM[68]	Professor Janet Cade	NPRI‡	Not available	Not available	Not available	http://lubswww2.leeds.ac.uk/cdr/index.php?id=53
	The Food Dude Healthy Eating Programme[69]	Bangor Food and Activity Research Unit (BFARU) at the University of Wales Bangor	Food Standards Agency (Wales)	1992	Ongoing and August 2007	Programme Summary Published August 2007	www.fooddudes.co.uk/documents/overview_of_fd_programme.pdf
	Evaluation of the Big Lottery Fund's national school fruit and vegetable scheme[65]	Joan Ransley, Janet Cade, Darren Greenwood from University of Leeds; Sandie Schagen, Sarah Blenkinsop, Ian Schagen, Emma Scott, David Teeman, Gabrielle White from NFER.	Big Lottery Fund	2004	2006	Ransley, J *et al* (2006) Does the School Fruit and Vegetable Scheme improve children's diet? A non randomised controlled trial. Journal of Epidemiology & Community Health.2007;61:699–703	http://webdir.leeds.ac.uk/CALPAGE/3/newhtml/med/epid.htm
	Assessing fruit intake in schools with and without the National Schools Fruit Scheme (NSFS)[206]	Professor Marion Hetherington	University of Liverpool	September 2001	April 2002	Not published. Report sent to Liverpool County Council and the schools	None
	Evaluation of the Sustain Grab 5! school fruit and vegetable project[66]	British Heart Foundation Health Promotion Research Group of the University of Oxford	Community Fund (previously the National Lotteries Charities Board)	2001	2002	Evaluation Report Published May 2003	www.sustainweb.org/pdf/g5_eval.pdf
	The Further Evaluation of the School Fruit and Vegetable Scheme[67]	The National Foundation for Educational Research (NFER), nutritionists from the University of Leeds (Inc Prof Janet Cade)	Department of Health	October 2006	May 2007	September 2007 DoH Website	www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_078170
Nutritional knowledge	Providing information on fat and sugar to children at school and the effects of this on their nutrition knowledge and habitual diet.[55]	PhD student and the Rowette Research Institute	Unknown	2007*	Not available	Not available	www.rowett.ac.uk/divisions/phnq/d_jackson.html
	Cluster randomised control trial of primary school based intervention to assess effectiveness of a novel educational intervention designed to improve nutrition knowledge.[54]	Cambridge PSHE Service, Health Enterprise East, MRC Epidemiology Unit	Health Enterprise East (NHS)	Summer 2007	Results due early 2008	Not available	https://secure2.symphonyem.co.uk/MissionPossible/WEB-INF/resources/HEECaseStudyTopGrub.pdf
School dinners and packed lunches	Nutritional content of school meals versus packed lunches (title not confirmed)[83]	Dr Geraldine McNeill and Dr Bridget Holmes	KCL and Scottish Centre for Social Research (not confirmed)	Not available	Not available	Results should be available Spring 2008	www.rowett.ac.uk/divisions/phnq/qm_group.html
	Secondary school lunch and behaviour[84]	School Food Trust	School Food Trust	2007	2008	Not available	www.schoolfoodtrust.org.uk/research
	A cluster randomised controlled trial of a Smart Lunch Box, designed to improve the content of primary school children's packed lunches in the UK [85]	University of Leeds and Food Standards Agency†	University of Leeds and Food Standards Agency	Not available	Not available	Not available	http://lubswww2.leeds.ac.uk/cdr/index.php?id=53
	School lunch and behaviour: systematic observation of classroom behaviour following a school dining room intervention[79]	School Food Trust	School Food Trust	January 2007	May 2007	Full paper due 2008	www.schoolfoodtrust.org.uk/surveysandmonitoring
	Parents' Attitudes to School Food[207]	BMRB Omnibus (British Market Research Bureau)	School Food Trust	2005	August 2006	Report Published on School Food Trust Website August 2006	www.schoolfoodtrust.org.uk/documents/parentssurvey2006
	Children's lunchtime choices following the introduction of food-based standards for school lunch; observations from six primary schools in Sheffield[78]	School Food Trust	School Food Trust	February 2007	March 2007	Report Published on School Food Trust Website September 2007	www.schoolfoodtrust.org.uk/UploadDocs/Contents/Documents/childrens_lunchtime_choices.pdf

* Date not confirmed ‡ Funding may involve these institutions, organisations or Government bodies plus possible others † Principle investigators may involve others

Diet and food choice (continued)

Subject	Title	Investigators	Funding	Start Date	End Date	Publication	Link
Behaviour and health practices	Unknown[45]	IPPR and Trust TBC	Possibility of Trust collaboration	Not available	Not available	Not available	www.ippr.org/research/teams/?id=100&tid=100
	Association between weight loss desires and dietary practices among young people[46]	University of Nottingham†	University of Nottingham‡	Not available	January 2008	Report expected to be made available end of Summer 2008	www.nottingham.ac.uk/biosciences/nutribio/research/group_research_themes.php
	Health locus of control, health value and diet among young people[47]	University of Nottingham†	University of Nottingham‡	Not available	January 2008	Report expected to be made available end of Summer 2008	www.nottingham.ac.uk/biosciences/nutribio/research/group_research_themes.php
	West of Scotland 11 to 16 study; Teenage Health[44]	Patrick West, Helen Sweeting	MRC	October 1994	March 1999	Various articles published - see journal database	www.sphsu.mrc.ac.uk/studies/11to16/index.php?Page=30&mitem30=1
	UK Household Longitudinal Study (UKHLS)[49]	UKHLS is based at, and will be led by the Institute for Social and Economic Research (ISER) at the University of Essex, together with colleagues from the University of Warwick and the Institute of Education.	Economic and Social Research Council. (ESRC)	January 2009	Not available	Not available	www.iser.essex.ac.uk/ukhls/
	National Diet and Nutrition Survey (NDNS)[48]	National Centre for Social Research and the Department of Epidemiology and Public Health at University College London.	Food Standards Agency	2006	2013	Not available	Website in progress
	An evaluation of nutrient intake from school meals of children in secondary schools in Knowsley MBC before and after a programme of intervention.[26]	Justin Waters, Operations Manager, Knowsley MBC and Professor Alan Hackett, Reader in Community Nutrition, Liverpool John Moores University	Food Standards Agency	February 2005	June 2005	Report Published September 2005, FSA Website	www.food.gov.uk/multimedia/pdfs/knowsleypilot.pdf
Take up and FSMs	A survey to establish the reasons for the poor take up of free school meals within Leeds schools (title not confirmed)[101]	The Faculty of Health, Leeds Metropolitan University	Leeds School Meals Strategy Group	September 2007	2008	Results should be available in 2008	www.educationleeds.co.uk/schoolmeals/infopage.aspx?pageno=639
	Eat Well Do Well – Evaluation[99]	University of Hull under the direction of Professor Derek Colquhoun from the Institute for Learning and has been supported by an International Advisory Group and a Parent Advisory Group.	University of Hull	April 2004	Summer 2007	Preliminary results presented 16-11-07. Final Report due to be published January 2008	http://web4.hullcc.gov.uk/akshull/images/att2306.doc
	First annual survey of take up of school meals in England[94]	PriceWaterhouseCoopers (PWC) was commissioned by the School Food Trust. The Local Authority Caterers Association (LACA) was a collaborating partner.	School Food Trust	March 2006	May 2006	Report Published on School Food Trust Website March 2006	www.schoolfoodtrust.org.uk/documents/annualsurvey1
	Second annual survey of take up of school meals in England[95]	Association for Public Service Excellence (APSE) was commissioned by the School Food Trust	School Food Trust	March 2007	September 2007	Report Published on School Food Trust Website September 2007	www.schoolfoodtrust.org.uk/documents/annualsurvey2
	Young peoples' opinions of school meals: a telephone survey[100]	BMRB Omnibus (British Market Research Bureau)	School Food Trust	2007	2007	Report Published on School Food Trust Website December 2007	www.schoolfoodtrust.org.uk/documents/youngpeoplesopinionsurvey
	School meals in secondary schools in England[98]	King's College London and the National Centre for Social Research	Food Standards Agency and Department for Education and Skills	October 2003	November 2003	Report Published by the Department for Education and Skills 2004	www.food.gov.uk/multimedia/pdfs/secondaryschoolmeals.pdf
	Calderdale Caterers' Perspectives on Implementing the School Meal Standards[208]	Carol Weir, Public Health Specialist , Rotherham PCT, Health Promotion	Rotherham Primary Care Trust‡	Not available	2007	Final report should be written up by the end of 2007	None

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Health outcomes

Subject	Title	Investigators	Funding	Start Date	End Date	Publication	Link
Body weight and obesity	Gateshead Millennium Study (GMS)[126]	Newcastle University - Dr Ashley Adamson, Dr Kathryn Parkinson, Professor Ann Le Couteur, Dr Mark Pearce, Dr Paul McArdle. University of Glasgow - Profs Charlotte Wright and John Reilly. University of Durham - Dr Robert Drewett and Gateshead NHS Health Trust - Dr Anne Dale	Henry Smith Charity, SPARKS, NHS R&D Northern Region and the National Prevention Research Initiative (MRC)	1999	Stage one ongoing 2006 to 2007. Time for study plan is to continue indefinitely	Not available	www.ncl.ac.uk/gms/index.htm
	Dietary intake and physical activity recorded with the use of a Smart phone (title not confirmed)[127]	Professor Janet Cade and Dr Alison Marshall	University of Leeds‡	Not available Funding has been received	Not available	Not available	http://lubswww2.leeds.ac.uk/cdr/index.php?id=53
	Changes in the prevalence of young people's concerns about their bodyweight over the past decade[132]	University of Nottingham†	University of Nottingham‡	Not available	January 2008	Report expected to be made available end of Summer 2008	www.nottingham.ac.uk/biosciences/nutribio/research/group_research_themes.php
	MEND Evaluation[209]	MEND†	MEND‡	In progress	2010	Not available although interim reports will be released	www.mendprogramme.org/the_research
	Identifying the pre-obese phenotype in nursery and young school children[128]	Vanessa Mitchell, PhD student and Professor Marion Hetherington	Funded by GCU institutional award since 2005	2005	Possibly 2008*	Not available	www.gcal.ac.uk/sls/Psychology/staff/vmitchell.html
	Measuring the Obesogenic Environment of Childhood Obesity[129]	Professor Janet Cade and Dr Joan Ransley of the Nutritional Epidemiology Group and Professor Graham Clarke of the School of Geography	MRC/ESRC	2006	Possibly 2008/2009*	Not available	http://lubswww2.leeds.ac.uk/cdr/index.php?id=53
	Unknown[210]	Department of Health Epidemiology, University of Oxford	Department of Health - Funding not yet granted	Spring 2008	Spring/Summer 2009	Not available	None
	The SPEEDY study (Sport, Physical activity and Eating behaviour: Environmental Determinants in Youth)[130]	MRC Epidemiology Unit and the University of East Anglia	MRC Epidemiology Unit and the University of East Anglia	Summer 2006	Not available	Not available	www.preventivemedicine.nrp.org.uk/cms.php?categoryid=41#cassidy
	An intervention designed to reduce the obesity prevalence in a population of South East Asian children living in Birmingham (title not confirmed)[131]	Peymane Adab, University of Birmingham in collaboration with the University of Leeds	NPRI‡	Not available	Not available	Not available	www.phintranet.bham.ac.uk/directory/homepage.htm?id=63
	A family-focused lifestyle intervention for overweight children and young people in Liverpool [116]	Liverpool John Moores University in partnership with Liverpool North, Central and South PCTs, Liverpool Community Dietetics Department, Liverpool City Council, Alder Hey Children's Hospital, and the University of Salford	Neighbourhood Renewal Fund	Pilot 2005. Main Intervention 2006 (academic terms)	Pilot 2006. Main intervention 2007 (academic terms)	Aim peer-reviewed journal	www.ljmu.ac.uk/ecl/psd/reach/CPSportsLinx.htm
	The APPLES study[124]	Dr P Sahota, Dr Rachael Dixey, Leeds Metropolitan University with collaborators from Leeds University and Leeds PCT	Leeds Met University, Leeds University & PCT	1996	2001	Various publications	www.leedsmet.ac.uk/health/dietetics/research/obesity/prevention.htm
	MEND feasibility trial[122]	MEND†	MEND‡	2002	2003	Various publications	www.mendprogramme.org/the_research/feasibility_study
	MEND Pilot Study[211]	MEND†	MEND‡	2005	2006	Various publications	www.mendprogramme.org/the_research/large_pilot_study
	MEND RCT[212]	MEND†	MEND‡	April 2005	January 2007	Various publications	www.mendprogramme.org/the_research/rct

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Health outcomes (continued)

Subject	Title	Investigators	Funding	Start Date	End Date	Publication	Link
Body weight and obesity continued	The management of children who are already obese[125]	The programme is run through the NHS and University of Leeds (Professor Mary Rudolf)	Neighbourhood Renewal Fund	January 2004	November 2005	NHS 'Watch It' Website	www.watch-it.org.uk/?professionals.research.papercbpoca
	Liverpool SportsLinx Project. Report on the Health and Fitness of Liverpool Primary and Secondary School Children[111]	Liverpool City Council Education, Libraries and Sports Services, Liverpool John Moores University, Sure Start, Liverpool Healthy Schools and Leap for Health Living Centre.	Liverpool City Council Sports, New Opportunities Fund Out of School Hours Learning, Liverpool Children's Fund, Neighbourhood Renewal Fund	1996	2004	Report published by the City of Liverpool	www.ljmu.ac.uk/ecl/psd/reach/CPSportsLinx.htm
	Snacking in relation to childhood obesity (title not confirmed)[213]	University of Ulster	Food Standards Agency	Not available	Not available	Report being handed to FSA December 2007 to be finalised. Results should be released soon after	None
	Survey to measure the intake of non-milk extrinsic sugars in children in Scotland[120]	Geraldine McNeill, Christine Sheehy. Also Jennie MacDiarmid, Lindsey Masson, Leone Craig, Bridget Holmes, Michael Nelson. The survey was carried out by a consortium of four organisations: The Scottish Centre for Social Research (part of the National Centre for Social Research); the Departments of Environmental and Occupational Medicine and the Department of Public Health, University of Aberdeen; the Rowett Research Institute, Aberdeen and the Division of Nutritional Sciences, King's College, London.	Food Standards Agency Scotland (FSAS)	November 2005	2007	Final report due end 2007	www.rowett.ac.uk/divisions/phnq/gm_group.html
	Prevalence of young people's concerns about their bodyweight[132]	University of Nottingham†	University of Nottingham‡	Not available	2007	Report completed and is under review	www.nottingham.ac.uk/biosciences/nutribio/research/group_research_themes.php
Cognition	Systematic review of breakfast and its effects on mental performance in children and adolescents[214]	Alexa Hoyand (3rd year PhD student) Leeds University and unknown others	Leeds University‡	Not available	End 2007 or 2008	Not available	None
	Food for Life Evaluation[155]	Soil Association, University of West England and The University of Cardiff	National Lottery	In progress	Not available	Not available	www.foodforlife.org.uk/
	The importance of breakfast on mental performance and appetite in children (title not confirmed)[215]	Alexa Hoyland (3rd year PhD student) Leeds University	ESRC	2004	2008*	Not available	None
	Third Schools Project[158]	Food for the Brain	Not available	January 2008	July 2008	Not available	www.foodforthebrain.org/content.asp?id_Content=1
	Cricket Green School Results[156]	Food for the Brain	Personal and corporate donations	May 2006	December 2006	Unpublished data, not peer reviewed	www.foodforthebrain.org/content.asp?id_Content=1669
	Chineham Park Primary School Project[157]	Food for the Brain	Not available	2006	Not available	Unpublished data, not peer reviewed	www.foodforthebrain.org/content.asp?id_Content=1669
	Glycaemic potency of breakfast and cognitive function and mood in school children[148]	King's College and The School Food Trust	King's College and The School Food Trust	2005	July 2007	Interim results due December 2007	www.schoolfoodtrust.org.uk/collaborativeprojects

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Health outcomes (continued)

Subject	Title	Investigators	Funding	Start Date	End Date	Publication	Link
Cognition continued	The impact of primary school breakfast clubs in deprived areas of London[92]	School Food Trust	School Food Trust	March 2007	April 2007	Report due to be published on Trust website Autumn 2007	www.schoolfoodtrust.org.uk/researchprojects
	A systematic review of the effect of nutrition, diet and dietary change on learning, education and performance of children of relevance to UK schools[146]	University of Teesside	Food Standards Agency	14th November 2005	30th April 2006	Report published on FSA website August 2006	www.food.gov.uk/multimedia/pdfs/systemreview.pdf
Growth and development	Southampton Woman's Survey[179]	MRC Epidemiology Resource Centre and University of Southampton	Medical Research Council, University of Southampton, Dunhill Medical Trust, British Heart Foundation, Food Standards Agency, British Lung Foundation	1998	Ongoing	Various to date	www.mrc.soton.ac.uk/index.asp?page=4
	The Avon Longitudinal Study of Parents and Children (ALSPAC)[180]	University of Bristol	Medical Research Council, the Wellcome Trust and the University of Bristol	1991	Ongoing	Various journal publications to date	www.alspac.bris.ac.uk/
	Millennium Cohort Study (MCS)[181]	A consortium headed by the Centre for Longitudinal Studies	Economic and Social Research Council and a consortium of Government Departments	June 2001	Ongoing	Various journal publications to date	www.cls.ioe.ac.uk/studies.asp?section=000100020001
	Born-in-Bradford Cohort[182]	NHS	NHS	2006	Ongoing	Not available	http://www.borninbradford.nhs.uk/index.php?page=professionals
Cardio-vascular	Young Hearts Northern Ireland Study[145]	Queen's University Belfast plus possible others	Wellcome Trust and the British Heart Foundation	1989	Ongoing	Various journal publications to date	www.qub.ac.uk/research-centres/CentreforClinicalandPopulationSciences/CentrePublications/MurrayLiam/
	Ten Towns Heart Health Study[140]	Professor Peter Whincup Department of Community Health Sciences, St George's, University of London	Wellcome Trust	1990	2002	Various publications possible	www.tentowns.ac.uk/

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Appendix 4. Findings from electronic literature search

The following review of literature is that of published work.

Diet and food choice

1. Food choice and healthy eating

A review of research investigating the relationship between the exposure to foods and healthy eating suggested that the earlier and broader the experience with food, the healthier the child's diet.[70] The general conclusions from the review were that familiarity accounts for more than half of the preference in children's food preferences and novel foods are often rejected. Food neophobia emerges at about two years of age and is associated with lower dietary quality and variety, as well as with lower intakes of fruit and vegetables. Laboratory based research has shown that repeated exposure to unfamiliar tastes can reduce neophobia and increase liking and consumption of new foods. Mothers who have been taught exposure techniques report that they are effective in increasing acceptance of vegetables. The techniques were also popular and tended to be continued after the end of the study period.

Evidence from a study of 214 (103 monozygotic, 111 dizygotic) same-sex old twins aged 4-5 years provides further support of an association between having tried food and a liking for that food.[71] Principal components analysis showed that children tended to like or dislike foods in the four emergent factors (vegetables, desserts, meat and fish, and fruit) independently of preference patterns in the other factor categories. Factor loadings were unrelated to average liking or frequency of exposure and the distribution of factor loadings refutes an assumption that simple sensory properties such as sweetness, saltiness, or fattiness predict food preferences. The mechanism of development may involve more complex multimodal sensory synthesis, which could have both biological and learnt elements. The contribution of genetic and environmental influences requires further investigation.

A cross-sectional survey of children in Years 1-11 registered in three primary and three secondary schools in the London Borough of Hammersmith and Fulham examined age and sex differences in the food preferences of British school children.[72] The primary schools were all mixed-sex, as was one of the secondary school. The other two schools were each single sex (one boys only, and one girls only). All primary school pupils (n=840) and pupils from two secondary school classes from each year (n=750) were invited to participate. All participants completed the Food Preference Questionnaire in school except those of the youngest age group (4-7 y) who completed them at home with parental help. The final questionnaire contained 115 food items including single foods (e.g. apples), mixed food (e.g. lasagne), and condiments (e.g. jam). In common with previous questionnaires, drinks were excluded. To maximise participation, children were asked only for their age and gender. An average of 98 of the 115 listed foods had been tried, and there a strong association between frequency with which foods were tried and degree to which it was liked. Not surprisingly there was a marked increase in the number of foods tried across the four derived age groups (infant, junior, lower secondary, and mid-secondary). However, the number of foods liked as a function of those tried decreased with age. There were no gender differences for the three main outcomes, but there was evidence of an age by gender interaction in the number of foods disliked, with younger boys disliking more foods than younger girls, and older girls disliking more foods than older boys. Of the ten most highly rated items, two were fruits (strawberries and grapes) whereas the ten lowest rated items included six vegetables. Girls liked fruit and vegetables more than boys did, with boys liking fatty and sugary foods, meat, processed meat products, and eggs more than girls did. In general, although ratings for fruit were high, children's food preferences overall are not consistent with a healthy diet. It was suggested that interventions should focus on increasing the familiarity, availability and accessibility of healthy foods. Particular attention should be given to boys whose food preferences tend to be less healthy than those of girls.

Data collected in 1986/87 from a sub-sample of the 1970 longitudinal birth cohort compared dietary intakes of Scottish teenagers with teenagers from elsewhere in Britain.[63] After adjusting for potential confounders (including smoking habits, alcohol intake, family size, and housing tenure) there was evidence that the diets of Scottish teenagers differed from those of other teenagers, with Scottish teenagers having a diet that was further removed from current dietary recommendations than other teenagers. However, the apparently lower intakes of fruit in Scotland appeared to be associated with a higher incidence of teenage smoking rather than with living in Scotland.

Data collected during three consecutive national surveys conducted in Scotland in 1990, 1994, and 1998 provided evidence of an increase across time in fruit and vegetable consumption among Scottish schoolchildren aged 11, 13, and 15 y. This increase was particularly evident among girls who, unlike boys, also increased their intake of both raw vegetables and salads, and cooked vegetables. Boys increased their consumption of crisps during the time period, and both sexes increased intakes of chips, sausages, pies and burgers, sweets or chocolates, and low-fat milk. Intake of full-fat milk and total milk decreased in both groups. Intake of all food items tested was strongly socially patterned in the expected directions (e.g. intake of raw vegetables and salads decreased while intake of chips increased from high to low socio-economic groups). The findings emphasised the need for continued health promotion efforts to improve the diets of Scottish schoolchildren, particularly those in lower socio-economic groups.

In a comparison of food intake of 36 Scottish children aged 5½ to 8½ with that of their mothers it was found that compared with their mothers, children had a higher median density of snack foods (i.e. the snacks eaten by children were more calorie dense than those eaten by their mothers – [weight of food giving 1000 kcal]), and lower median densities of meat and meat products, fish, potatoes, and vegetables.[29] There was evidence of correlations between children and mothers for median densities of bread, fruit, potatoes, chips, chocolate confectionary, which suggests that there is a need for change at family level if current dietary guidelines are to be implemented.

Using data collected in 1994-95, which may therefore not reflect current dietary habits, the relationship between 'less healthy eating' and 'unhealthy snacking' at age 11, and family life was investigated in 2,586 children living in and around Glasgow.[28] The analysis adjusted for potential socio-economic confounders, and although 56.8% were classified as 'less healthy eaters' and 32.3% as 'unhealthy snackers'. In the fully adjusted models there was strong evidence of reduced odds for 'less healthy eating' in families where the mother was in part-time employment, or was sick/disabled. Higher maternal qualifications were also associated with lower rates of 'less healthy eating' and unhealthy 'snackers'. Boys more than girls were more likely to be less healthy eaters and unhealthy snackers. Neither family structure nor the frequency with which family meals were eaten were associated with unhealthy eating or snacking behaviours, suggesting that it may be necessary to look beyond the family in order to make improvements to children's diets.

A survey of 221 children aged 8-11 who attended a school on the South Coast assessed the attitudes and knowledge of fruit and vegetables.[50] The school had a high turn-over of pupils, with many single parent families living in bed-sits and relying on social services for financial and other support. The school provided no cooked food, but encouraged a healthy snack to be taken in and eaten, while discouraging fizzy drinks. Overall it was found that fruit was more popular and better recognised than vegetables, with melon being the least well identified. Recognition of vegetables increased with age: cabbage was least well identified and tended to be confused with lettuce. Most (75%) children were familiar with the term 'healthy eating', citing the school as the most common source of the information. There was a general basic awareness and understanding of the current recommendations for a balanced diet although the message may have become somewhat confused at times.

A small study of 92 families, including 48 girls and 44 boys, examined the relative influences on children's fruit and vegetable consumption of a number of variables including mothers' beliefs, attitudes, and knowledge and mother-child correlations in knowledge, beliefs, and attitudes.[53] Independent predictors of children's fruit intake included mothers' nutritional knowledge, mothers' frequency of fruit intake, and mothers' belief that increasing fruit and vegetables could reduce their children's risk of developing cancer. Independent predictors of children's fruit intake included the child's liking for commonly eaten vegetables, and the mother's belief in the importance of disease prevention. Children's confectionary consumption was predicted by the mother's liking for confectionary and the children's concern for health in choosing what to eat. The results may have limited external validity particularly since the proportion of obese mothers was considerably lower than that of the UK population, although the mean BMI of the children was the same as UK national data.

Although South Asians in the UK have an increased risk of developing type 2 diabetes and CVD, information about the dietary habits of young people is limited. To address this, a food intake questionnaire (of the food eaten the previous day) was used to survey the eating habits of 3,418 pupils aged 11-15 years in five inner-city Leicester schools with predominantly South Asian populations.[40] Of these 3,018 could be categorised as either South Asian (86%) or white European (14%). Overall one-quarter of pupils left home without breakfast. Some bought food on the way to school but by the time they reached school 20% had still eaten nothing. The diets of pupils overall were poor, and particularly so in the South Asian group. There was strong evidence that White European pupils reported eating a higher proportion of food items from positive food groups (i.e. those considered to be positive markers/foods that would generally be recommended) than South Asian pupils, with equally strong evidence that South Asian pupils ate more negative food items than white Europeans. The results suggest that ways of encouraging healthy lifestyles, particularly among populations with a high risk of developing type 2 diabetes and CVD, need to be developed.

A qualitative study used focus groups to elicit the factors that affect food choices made by girls and young women, from minority ethnic groups, living in the UK[41] The participants, belonging to an ethnic minority from Somalia, Zimbabwe, or South Asia (Pakistani/Bangladeshi), and living in Dundee, Greater London, Southall, South of England or Hampshire were aged from 12 to 35 years. All the groups used Western foods, although these tended to be at quite a low level. There was a tendency to adopt the less healthy aspects of Western diet including fried fish, pizza, chips, and fatty snack food. The main reasons for this seemed to be related to time saving (their traditional dishes took considerable time to prepare and cook) and the suitability of the food. Those who could eat only Halal meat felt that eating fish from 'outside' was acceptable. The younger girls who often ate at a popular fast-food outlet on the way home from school or at weekends chose fish rather than meat, although some appeared not to worry about dietary restrictions when away from their families. The cost of vegetables, particularly those used in traditional cooking, was a barrier to some, particularly those in the older age groups who cooked at home. All respondents made a connection between health and food, but this was influenced by cultural background and knowledge. For some, knowledge did not necessarily translate into dietary choices. The Pakistani/Bangladeshi women, for example, acknowledged that frying food is not healthy but when describing meals, frying and the use oil was frequent. Cooking was an activity that appealed to most of the groups and expressed an interest in learning how to cook healthy versions of their traditional foods. The main finding was that it was the less healthy aspects of a Western diet, high in sugar and salt, that had been incorporated into these women's diets, and that there was a trend towards eating fewer vegetables in the UK than would be eaten in their country of origin.

A cross-cultural study[51] looking at food choice, nutrition education, and parental influence in British (n= 97) and Korean (n=74) primary school children aged 10-11 years and their parents (British n= 47; Korean n=77) found considerable differences in both favourite snacks and favourite foods reported by the children in each country. Some of these differences reflected exposure to different foods, although favourite snacks reported by Korean children were crisps

and fruit. British children reported this to be chocolate and sweet. The favourite foods of Korean children were meat or chicken, followed by burgers, and dumplings with British children expressing a particular liking for pizza. Knowledge about healthy eating issues were similar, although attitudes towards salt differed with twice as many Korean children as British children believing that salt should not be added at the table. This is probably due to the high salt content of Korean food. The recommended salt intakes differ between the two countries: the British COMA report recommends a sodium intake of 1.6 g/day (4.0 g salt /day) compared with the Korean Nutrition society guidance that sodium should be less than 3.5g/day (8.8 g salt/day). Korean children were more likely than British children to consider excess salt intake to be harmful. Both groups of children identified parents as the main source of nutritional information which suggests that parents should be well informed. Parents wanted schools to provide more nutritional information to children.

Focus groups were used to elicit children's view on food and nutrition. A total of 106 11-12 year old boys and girls from 11 post-primary (secondary) schools in Northern Ireland and England each took part in two focus groups, and included a 'brainstorming' session based on a word association activity. The 11 schools represented a range of demographic backgrounds and socio-economic backgrounds (seven schools were mixed, two all-boys and two all-girls). At this age, most of the children reported eating breakfast, at least during the week. Their diet differed at weekends when they admitted eating less healthily. Pupils consistently highlighted the meals eaten at lunchtime in the school dining room as being the least healthy and most monotonous part of their daily diet. The term healthy eating had largely negative connotations, but almost all pupils considered that they could improve their diet. The greatest barrier to healthy eating was taste and they even presumed that they would not like healthy foods not previously tasted. Appearance was also an important factor with junk food being more appealing in appearance. A telling comment from a boy on the importance of value and taste was:

"Sometimes you can get like bad fruit but you never get bad chocolate".

The children were influenced by role models, and mentioned both appearance and type of foods promoted by celebrities. The deep concerns about body weight or image, particularly among girls from all-girls schools was a concern. The main conclusions from a large amount of data revealed a number of barriers to, and motivation for, healthy eating. Encouraging this age group to view healthy eating as an attractive and achievable behaviour will be a major challenge for health promotion specialists.

The effect of dieting on the nutritional intake of adolescent girls in the NW of England was investigated using a purpose designed self-complete questionnaire.[46] The mean age of the 569 girls was 12.8 years ranging from 11 to 15 years. Approximately one third (35.3%) of girls reported having dieted (defined as changing the way they ate to lose weight). The mean BMI of dieters was higher than that of the non dieters (20.7 compared with 18.3). In contrast with previous evidence, this study found no difference in rates of dieting behaviour between independent and comprehensive schools. Two-thirds of girls considered that dieting was a healthy activity, which might suggest that many girls hold misconceptions about dieting and healthy eating. This is of concern as previous studies have found evidence that major nutritional deficiencies exist among adolescent dieters. Nutritional advice and education should be reviewed and modified to address these issues.

Conclusions

- Food preference in very young children is related to food exposure. The development of food neophobia at around two years of age can affect the acceptance of new foods after this age. A twin study produced some evidence that as well as influenced by environmental factors, food tastes and preferences may have a genetic basis. The pattern of food preference changes with age, and varied with sex as children become older.

- Knowledge of fruit and vegetables in primary school children is not as good as might be expected, although the evidence comes from disadvantaged families. One explanation is that this low knowledge might be due to a lower than average exposure to these food.
- Scottish children and young people seem to be particularly at risk of having a diet further from current dietary guidelines, with intakes of all foods being strongly socially patterned. Boys were more likely to have a less healthy diet than girls, although this is probably not peculiar to Scottish children and young people. Further evidence from Scotland of the need for dietary change at family level comes from a study of the diets of younger children and their mothers.
- Parental, particularly maternal, attitudes to diet and nutrition are predictors of children's eating habits.
- The diets of South Asian adolescents in inner-city Leicester need to be improved to address the increased risk of CVD and type 2 diabetes in this population.
- Girls and young women from minority ethnic groups are adopting the less healthy aspects of a Western diet into their lifestyles, and are eating fewer vegetables than they would eat in their home countries.
- Preference for unhealthy foods is not confined to British children; primary children living in Korea also expressed a preference for some unhealthy foods and knowledge about healthy eating issues were similar in both groups of children.
- The number of barriers to healthy eating identified in young teenagers indicated that making healthy eating attractive to this age group could be a major challenge.
- The attitudes of adolescent girls towards dieting are misguided, and the prevalence of the activity could contribute to nutritional deficiencies in this group. Health education messages targeted at this group should be modified to emphasise the benefits to health and weight of healthy eating without the need for dieting.
- The term 'healthy eating' is well-known but may not be well understood. At least two studies mentioned that it was associated with mixed or confused messages.

2. Nutrient intake and nutrient deficiencies (12 included papers; 10 studies)

There is much general literature on nutrient intake in children, but evidence of intake or deficiencies is more limited. Studies of the relationships between diet and oral health provide some evidence of the nutritional profiles of selected groups of children, as do studies of bone-density and visual acuity. However, these rarely give full details of nutritional profiles since they tend to concentrate on the specific aspect of diet of interest.

It was suggested in a recent review that the prevalence of primary Vitamin D deficiency in children[185] is not known, but that it is particularly prevalent among non-European minorities. Observational studies have shown that, in these minority groups, vitamin D deficiency can occur in up to 45% of school-children and over 70% of adolescents. About 80% of the body's vitamin D comes from the action of UVB sunlight on 7-dehydrocholesterol in the skin, with the remaining 20% coming from diet. While cultural habits and dress may be barriers to adequate vitamin D levels, the improvement in diet can help to address some of the problems. Since this population may be eligible for, but not actually in receipt of, FSMs, efforts to increase the take up of FSMs could help to reduce the rate of vitamin D deficiency.

By comparing data collected via 3-day diet diaries in 1980 and again in 2000 provided some evidence that food intake changed considerably in a direction more in line with current dietary recommendations. [22] Of the original 405 participants, 198 completed all aspects of the survey. Intakes of foods containing fat and, or sugar and milk and dairy foods decreased over time, while intakes of fruits and vegetables increased. Intakes of bread, other cereals, potatoes, fruits and vegetables, and meat, fish and alternatives showed moderate tracking (defined as the maintenance of rank over time) from adolescence to adulthood. Respondents who had moved away from the area had a greater increase in intake of fruit and vegetables than those who

remained in the locality. Those who had moved down the socio-economic gradient had increased their intake of bread, other cereals, and potatoes. The main conclusion was that food intake in adolescence is a significant but not strong predictor of intake in adulthood, with dietary changes being influenced by variables including gender, location and socio-economic status. However, the high drop-out rate may have biased the results since it is possible that the respondents were self-selected and over-represented healthy-eating, although the diet profiles of responders and non-responders at age 11 did not differ.

Further evidence of the effect of social and regional transitions on the modification of dietary patterns comes from a follow-up study of 3,187 participants in the 1946 British Birth Cohort. [23] Participants who remained in the non-manual social classes consumed significantly more foods correlated with the factor 'health aware' than those who remained in the manual social class. Those who made a transition from manual social class in childhood to non-manual social class at 43 years partly adopted the dietary patterns of the non-manual social classes. There were clear differences between regions with respect to the intake of foods associated with the factor 'traditional' but these seem to be less likely to change, although the numbers moving between regions were smaller than those moving between social groups.

Evidence from the ALSPAC study suggests that the dietary intakes of 814 7 year olds who completed at least one day of a three day diet diary were adequate for most nutrients, although most children were not eating sufficient fruit and vegetables. Overall it was concluded that a reduction in the amount of sodium would be advantageous as would an increase in fruit and vegetable consumption, particularly in boys. Although this study considered the possibility of various biases, including the under or over-reporting of food items, it is possible that the response rate of 53% of those invited to submit a diary introduced biases otherwise unaccounted for.

It is widely accepted that the intake of dietary calcium in adolescence and adulthood is a critical factor in the development of peak bone mass. The maximisation of this mass is the main approach in the prevention of osteoporosis, a condition which in 1992 had an estimated annual cost to the NHS of £600 million. The nutritional profiles of 379 Northumbrian 12 year old children showed that the most important sources of calcium were milk (25%), beverages (12%), puddings (10%) and bread (9%).[188] The fortification of flour accounted for 13% of the total calcium intake. When the contribution of fortification was removed, the proportion of participants with an intake of calcium below the lower reference nutrient intake (LRNI) more than quadrupled to 10% of girls and 12% of boys. At the time of this survey (1990) the contribution to calcium by milk was lower than previously found, suggesting that an increased intake of milk should be encouraged. It was also suggested that calcium fortification of flour is also an important source of calcium, and the increased consumption of imported and unfortified products could result in a further reduction in calcium intake unless dietary habits are modified.

The same study provided evidence of the importance of folic acid fortification in flour and modelled the improvement in folic acid levels under various flour fortification levels. Despite the role of folic acid in the prevention of neural tube defects having been well documented, in 1991 the UK had one of the highest rates of this problem in the world. As well as having a role in the prevention of neural tube defects, folic acid helps in the prevention of cardiovascular disease. The level of fortification required to ensure that 97.5% of girls received 400 µg/day (the recommended supplementary intake estimated to reduce neural tube intake by 50%) is 10,430 µg/kg.[189] This would result in an additional folic acid intake of 831 µg/d and 866 µg/d for girls and boys respectively. Fortification at a level of 2,400 µg/kg would result in intakes of folic acid from this source of approximately 200 µg/d, which is estimated to be associated with a 35% reduction in the incidence of neural tube defects. The inclusion of bread and other flour products in school meals might be an important source of folic acid in some sectors of the population.

Evidence of low levels of calcium, iron, and zinc comes from a study investigating the association between dietary restraint and nutrient intake in 64 adolescent girls.[186] The 14-15 year old girls were recruited from two all-girl schools (one independent and one state grant maintained) in central London. This was one of the few studies that included a power calculation. The final sample of 46 was only half of the recommended number for the stated primary outcome which suggests that the study was under-powered. The sample was classified according to levels of dietary restraint (defined as the conscious control of eating in order to lose weight or avoid weight gain) measured by a combination of two validated questionnaires (the Dutch Eating Behaviour Questionnaire and the Three Factor Eating Questionnaire). Almost a third (31%) of participants was classified as overweight (above the 75th BMI percentile) and 9% were classified as obese (above the 98th BMI percentile). Mean BMI significantly increased with increasing levels of dietary restraint. An adequate intake of all micronutrients was found in the whole sample in excess of the Reference Nutrient intake (RNI) except for calcium, iron, and zinc. The intake of fat, mono-unsaturated fat, poly-unsaturated fat, and sugar significantly decreased across the three groups of dietary restraint. Nearly one quarter of participants had iron intakes below the LRNI and only one subject had a mean daily iron intake above the RNI. Significant numbers were iron deficient to some extent, with 8% having iron-deficiency anaemia, while 13% were iron deficient with depleted iron stores, and 31% had borderline depletion of iron stores. There was evidence that intakes of beverages, meat and meat products, and sugars and preserves were inversely related to dietary restraint. Intakes of cereals and cereal products (bread), fruit, and milk and milk products (cheese) increased with increasing dietary restraint. There was an association between dietary restraint and socio-economic (SE) group, with higher SE groups more likely to be associated with either high or low dietary restraint. The middle dietary restraint group was associated with lower SE status. However, the analysis is based on small numbers. One of the main conclusions was that low iron levels were widespread rather than being associated with dietary restraint. The study, although small, provides further evidence of levels of overweight and obesity among adolescent females.

A comparison of the food and nutrient intake of a national sample (n=4599) of 4 year old children in the 1950s compared with that of a group (n=493) in the 1990s[183] showed that the relative austerity of post-war food supplies resulted in food and nutrient intakes in 1950 which may have been beneficial to the health of young children, despite fat intake being higher than present-day recommendations. In summary, the 1950 diet, compared with that of the early 1990s, contained more bread and vegetables, and less sugar and soft drinks giving it a higher starch and fibre content and making it more in line with current healthy eating guidelines. Energy intake was higher in 1950 (1445 kcal, compared with 1228 kcal in 1992/93); the daily recommended dietary allowance (RDA) is 1500 kcal, and the RNI is 1490 kcal. In 1950 red meat was an important source of iron, whereas by 1992 most iron in this age group came from fortified breakfast cereal. The main source of vitamin C in 1950 was vegetables, compared with soft drinks in 1992.

Data from the same source highlighted a decrease in the intake of vitamin K_1 (also known as phylloquinone, and the major dietary form of vitamin K) in 4 year olds in the 1990s compared with the 1950s.[216] Food sources of this vitamin changed substantially during this time, with fats and oils contributing more, and green vegetables less. However, in both surveys vegetables were the main source at both times, contributing 60% and 48% respectively. Since vitamin K_1 is necessary for optimal development and maintenance of bone and also of the cardiovascular system, the lower levels may have implications for health risks in later adulthood.

A study using 455 12 year olds involved in the Young Hearts Project, Northern Ireland tracked energy and nutrient intakes, assessed by diet history, over three years. [20 21] The body weight and BMI of boys and girls increased significantly over the three year period. Tracking varied between nutrients and between sexes. The tracking of reported energy intake was poor for boys (kappa = 0.18) and fair for girls (kappa = 0.24), and for energy intake derived from fat was poor in both sexes (k = 0.17 boys; k = 0.09 girls). Energy intake/kg bodyweight was most likely

to track at a level approaching moderate (k = 0.37 boys; k = 0.40 girls). No macro- or micro-nutrient in either boys or girls tracked at a kappa above 0.31 (calcium mg/MJ and total folate µg/MJ, both in boys). Overall the poor to fair tracking observed in the cohort suggests that individual dietary patterns shown at age 12 are unlikely to predict energy and nutrient intake three years later at age 15.

A study conducted 16 years ago compared the energy and nutrient intake of 136 Caucasian children, aged 7-8 years and living in Edinburgh, with the UK's dietary reference values (DRV).[18] The sample was representative of the social class distribution for Edinburgh, and mean heights and weights were close to the 50th percentile. Mean BMI for both sexes was in excess of standards for this age-group. Mean energy intakes were close to the estimated average requirement for both boys and girls, while mean percentages of food energy derived from fat and saturated fat were high in relation to the DRV. Food energy derived from total carbohydrate was close to the DRV, but intakes of starch were low and of total sugars high. Although it might appear that a simple solution would be to alter the balance of these two components, the observed inverse relationship between fat and sugar suggests that decreasing sugar might lead to an increase in fat intake. Although non-starch polysaccharide (NSP) levels were only half of the calculated reference values (CRV), it was suggested that the level may be set too high. Mean intakes of most micro-nutrients were above the RNI and it was concluded that targeting high intakes of total and saturated fat should be the health priorities in this age-group.

The prevalence of dietary, socio-demographic, and lifestyle risk factors for low iron intake and poor iron status were examined in 1699 young people aged 4-18 years.[187] This number represented the 80% of the participants in the National Diet and Nutrition Survey (NDNS) for whom complete weighed dietary records were obtained. A total of 179 participants were subsequently excluded because they reported being unwell with changed eating habits, giving a total of 1520 valid dietary records. This appears to be one of the valid sources of nutritional profiles for a wide age range and includes an investigation of the extent, and possible impact, of under-reporting in the dietary record using the method based on estimated basal metabolic rate (BMR). Likely under-reporting of food consumption by this method was estimated to occur in 39% of the young people, and it was considered that likely under-reporting was not associated with any particular food. In addition the under-reporters did not differ in terms of socio-demographic variables or lifestyle characteristics. Only 3% (42/1520) reported taking iron-containing supplements during the 7-day period of dietary assessment, although as these provided no haem iron and negligible amounts of non-haem iron, iron-containing supplement users were included in the analyses. In total 54% of 4-18 year olds had dietary iron intakes below the RNI, with 12 % of intakes below the LRNI. Adequacy of dietary iron intake was significantly higher in boys than in girls in each age group. Dietary iron intakes were most adequate in the youngest age-group (4-6 years) of both boys and girls and lowest in 11-18 year old girls. In a model adjusted for 13 socio-demographic and lifestyle factors, this group of girls were seven times more likely to report low dietary iron intakes than boys (OR = 7.16; 95% CI 4.52 to 11.34). After excluding likely under-reporters adequacy of dietary iron intake remained lowest in 11-18 year-old girls, with 15% reporting low dietary intake in this age group compared with no age equivalent boys. Blood was obtained from 1,193 participants indicating low haemoglobin levels (based on age-specific norms) were in 9% of children. Adolescent girls who were vegetarian or non-Caucasians had significantly poorer iron status than Caucasians or meat-eaters, independent of other risk factors. The risk of poor iron status may be reduced by consuming meat (particularly red lean meat) or enhancers of non-haem iron absorption (e.g. fruit or fruit juice rich in vitamin C) in vegetarians.

Despite reported inverse associations between whole-grain food consumption and risk of CVD, some cancers, and type 2 diabetes, there have been few reports of whole grain intake in young people. Evidence from 1583 participants involved in the 1997 NDNS suggests that the main sources of whole-grain intake were breakfast cereals (56%) and bread (25%).[190] Intake of whole-grain was found to be associated with social class, with lower intakes among young

people whose head of household had a manual occupation. There was no evidence of any association between whole-grain intake with sex, age, region, or season. Although there is some debate about the quantity of whole grains required for good health, it seems that whole-grain intake in British young people is low.

A cross-sectional observational study using 11-12 year old children attending seven schools in Northumbria that had been used in a similar study conducted 20 years previously,[22] investigated any changes in the daily intake of water.[217] The data collected by a three-day diet diary with an interview of the fourth day, in the latter study were compared with that collected in the earlier study. Two-thirds (64%; n=424) of eligible children completed all aspects of the study. The mean water intake of 1,130 g/day was approximately the same as that recorded 20 years previously, with the contributions from drinks (65%) and food (35%) also being similar at both time points. The sources of water in drinks had changed considerably, with a marked increase in the consumption of soft drinks (particularly carbonated drinks) and a decrease in hot drinks and milk. Although the intake of water has not changed over time, levels are lower than intakes reported in other countries. From a public health perspective, the intake of tap water had decreased which may have implications for estimating fluoride intake in fluoridated areas.

Conclusion

Several studies have contributed to the evidence on nutritional profiles and nutritional deficiencies in UK children. However, the studies vary in quality and size, with the limiting factor most likely to be a difficulty in measuring nutritional intake. The difference in methods used, including self-report questionnaires, structured interviews, and diet diaries, as well as the difference in populations used makes comparisons difficult. These difficulties are compounded by the use of differing methods of measuring relative intake, with some studies using RNIs, and others using RDAs or CRVs. The time-lag to publication means that some of the included studies are based on data collected up to 16 years ago which may not reflect current dietary intakes. The evidence presented here is somewhat mixed, but a general conclusion is that the present diets of school-aged children are likely to be too high in fat and sugar although confounding by unmeasured social factors cannot be excluded. The difficulty of predicting future dietary intake is also highlighted using evidence from a tracking study. Even small nutritional deficiencies can present a considerable financial burden to the NHS, as well as having an impact on well-being, either in the short-term such as that caused by an increase in neural tube defects, or in the longer term by conditions such as osteoporosis which may be linked to inadequate intakes of calcium during bone growth. Evidence, based on two tracking studies, on the ability to predict future intake is inconsistent but since both studies suffer from some weaknesses, further evidence is required to provide more robust conclusions.

Food related research not related to health outcomes

1. School based research and school food

The effect on nutritional intake of attending a breakfast club was investigated in a small study involving three schools and 111 children (59 attendees and 52 controls).[90] One school was a primary in a large city in northern England with a FSM eligibility of 44%. Two were secondary schools in a mid-sized town in southern England with FSM eligibilities of 22% and 24%. All three schools had received funding for breakfast club provision under the Department of Health scheme. All participants completed a 3-day weighed food diary which showed that children who attended a breakfast club had significantly greater intakes of fat, saturated fat, and sodium than control subjects suggesting that breakfast club participation in these schools was associated with poorer nutrient intake.

A much larger cluster randomised trial assessing the effect of breakfast clubs suggested a mixed picture of both benefit and apparent detriment.[91] The length of the intervention was

limited by the funding and it has been suggested that the mean follow-up period was too short to detect any real effect. A total of 6042 pupils from 26 schools (19 primary and 7 secondary) were involved. At the three month follow up there was evidence of an improvement in cognitive function in the intervention group compared with the control group. At one year, fewer pupils in the intervention group reported having skipped classes within the last month and fewer also reported having skipped one or more days of school within the last month. The observational analysis at one year showed a higher proportion of primary school attendees reported eating fruit for breakfast compared with the control group. However, a higher proportion in the intervention group also had borderline or abnormal conduct or higher pro-social scores. An economic evaluation of the same study suggested that there were key economic differences between clubs based in primary schools and those based in secondary schools in both funding levels and cost structures.[93] Funding levels were not a significant determinant of the observed outcomes in either phase of education.

A study published in 2005, using data collected in 2003 from three Sheffield secondary schools (of which one was a girl's private school and was not required to meet the nutritional standards), showed evidence that food provision in only one of the schools met the Government guidelines. [74] Socio-economic deprivation was associated with worse food provision and children from deprived areas were more likely to choose foods of limited nutritional value than children from less deprived areas. Overall, there was evidence that intakes of total fat, saturated fatty acids, and monounsaturated fatty acids were greater in boys than in girls, whereas intake of folate was significantly greater in girls compared with boys. At all three schools, the school meal did not provide sufficient energy specified by the standards for the majority of children. Few children met the micronutrient intake targets. No child in the study met the recommendations for iron or folate, and calcium levels were also low. The optimum meal (not taken by any participants) also fell short of the recommended nutrient values. The conclusion was that the statutory nutritional standards alone, without a pricing policy to encourage healthier food choice or in the absence of restrictions in food choice towards less healthy foods are unlikely to be sufficient to effect the dietary changes necessary to ensure improvement in nutrient intakes in English schoolchildren.

Similar findings came from a study in which the meals of 64 children were analysed. The year 5 children attended a school either in Hull (n=32) or the East Riding of Yorkshire (n=32). Schools were matched on eligibility for FSMs and KS2 results. In April 2004 Hull City Council introduced free healthy school meals for all primary and special school pupils, and the aim of the study was to determine whether the free school meals served in one school conformed to the Caroline Walker Trust (CWT) nutritional guidelines. The data were collected in May and June 2005 (i.e. one year after the introduction of FSMs). Both schools exceeded the CWT recommendations for total fat, sugar, and sodium, with Hull children consuming less of all three nutrients than East Riding children. Hull children also consumed less energy, iron, zinc, folate, and magnesium than the East Riding group. It was evident that children were eating the food that they liked and were leaving the rest. If all the meal had been eaten, energy and fibre levels would have improved to provide more than the recommended minimum amounts specified in the CWT guidelines. Carbohydrate intakes would also have improved, but not sufficiently to meet the guidelines in the Hull school. Fat, sugar, and salt were all above the recommended guidelines. Levels of iron, zinc, and magnesium in the complete meal provided less than the recommended amounts, but folate and vitamin C would have been adequate. At both schools, children's intake did not meet guidelines for 11 of the 17 nutrients assessed, and although Hull's school meals aimed to provide children with adequate nutritional intakes, these findings provide evidence that children are served and consume inadequate levels of many nutrients.

The contribution of school meals to overall food consumption and nutrient intakes of young people in England was assessed at two time points.[73] Secondary analysis of data from 1,456 pupils aged 4-18 years involved in the National Diet and Nutrition Survey of Young People (1997) showed that pupils' school meal choices compared unfavourably with the Balance of Good Health, and food choices in school were less healthy than choices made outside school.

School meals failed to compensate for the shortfalls in daily intakes of non-starch polysaccharides (NSP) and zinc in primary school pupils, and in calcium, iron, zinc, vitamin A, and NSP in secondary school pupils. Pupils in both phases of education had excess levels of saturated fatty acids, NMES, and sodium. Two additional surveys were conducted and used for comparison. In 2005 a survey of school meals was carried out in a representative sample of 79 secondary schools with the choices of 5,695 pupils being reported. A similar survey of 7,058 primary was conducted in 2005. Comparisons between the 1997 survey and findings from the later two surveys showed that primary pupils at the earlier time point reported lower consumption of vegetables and salads, chips and potatoes cooked with fat, as well as pasta and other cereals. The reported consumption of soft drinks, milk, milk products, butter, margarine, sugar, preserves, and confectionary was higher than that observed directly. Secondary school pupils reported lower consumptions of higher-fat main dishes, chips and other potatoes cooked with fat, pasta, and other cereals than was directly observed in 2004 and reported higher consumptions of vegetables and salads, sugar, preserves and confectionary, and savoury snacks than was directly observed. School meals typically failed to meet the CWT guidelines, and were more likely to meet these when choice was restricted. It was concluded that school meals need substantial improvements to meet these guidelines and that the introduction of the school-based guidelines for school meals in England did not improve the food choices in school meals. A limitation of the study is that the 1997 findings are based on reported intake, whereas the later two surveys are direct observations.

Using data from the ALSPAC cohort the food and nutrient intakes of 621 seven year olds eating either school dinners (n=211) or packed lunches (n=410) were compared. Their diet was assessed using 3-day unweighed dietary records completed by the carer in advance of a routine clinic appointment (held regularly to collect detailed information from a sub-sample of the main cohort). Portion sizes of school dinners were obtained from catering services. The composition of both types of school meals compared unfavourably with dietary guidelines. Intakes of energy, NSP, calcium, iron, folate, retinol equivalents, zinc, copper, magnesium, iodine, and riboflavin were too low, and intakes of total and saturated fat were too high. School dinners were associated with higher intakes of protein, starch, NSP, and most vitamins and minerals, and with lower intakes of sugar (14.2% and 20.9% of energy in school dinners and packed lunches respectively) and saturated fat (12.0 and 16.2%). Only about half of the recommended amount of fruit and vegetables were eaten by children irrespective of type of lunch. Type of meal was also associated with nutrient intake across the whole day, with those eating packed lunches having lower daily intakes of potassium and zinc, and higher daily intakes of sugar and fat. Differences in nutrient intake were independent of maternal education. In general, the food and nutrient content of both school dinners and packed lunches needs to be improved. Recent moves to improve the nutritional content of school dinners will need to be accompanied by education about what constitutes a healthy packed lunch.

An intervention study using four Dundee primary schools paired for similarity of size, and social background and randomly assigned to either the treatment group or control group, assessed the impact of a school-based nutrition education programme on dietary intake and cognitive and attitudinal variable relating to fruit and vegetables.[103] The intervention programme had four key elements: food provision within the school; communications; learning materials; and peer/ community support. Beliefs, attitudes, and knowledge related to fruit and vegetables were measured using specifically developed age appropriate assessments. Food and nutrient intakes were assessed at base-line and follow-up on school days only using 3-day diet diaries. Although the intake of fruit was higher in the intervention school at baseline, the increase of fruit intake in these schools was significantly greater than that in the control schools. No other changes in food or nutrient intake were seen. Increases in scores for variables relating to knowledge about fruit and vegetables were also greater in the intervention group compared with the control group, although there was no difference in changes in preferences for fruit and vegetables. Although it was concluded that a whole school approach to increasing intakes of fruit and vegetables has a modest effect on fruit intake, these changes were only assessed at the end of the intervention period. The long-term benefit is unknown.

The use of an intervention based on peer modelling and rewards to increase fruit and vegetable consumption was evaluated in three primary schools.[104] The schools were in Bangor, N Wales (105 pupils aged 4-11), Harwell, Oxfordshire (134 pupils aged 4-11) and Salford, Manchester (163 pupils aged 5-11). Eligibility for FSMs was 10%, 6%, and 31% respectively compared with the national average of 17%. Over 16 days children watched six video adventures featuring heroic peers (The Food Dudes) who enjoy eating fruit and vegetables. The children received small customised Food Dude items such as stickers, pens, rulers etc as rewards for eating the foods themselves. In addition a series of letters addressed from the Food Dudes to the children were read out in class by the teacher. Fruit and vegetable consumption was significantly higher at lunchtime and break-time (measured using a five-point observation scale) during the intervention period than at baseline. Consumption outside school, measured by parental recall was significantly higher during the intervention on weekdays, but not at weekends. Following the intervention, children's liking for fruit and vegetables also increased showing the effectiveness of a peer modelling and rewards-based intervention in increasing the short-term intake and expressed liking for fruit and vegetables. No longer-term follow-up has been reported.

The programme was also evaluated in two inner London schools, both with high levels of free school meal eligibility and matched, as far as possible, in terms of size, location, level of social deprivation (as assessed by the proportion of children entitled to free school meals) and proportion of children from ethnic minorities.[105] Pupils in both schools were given fruit and vegetables but in one (the experimental school), this was supplemented by the Food Dudes programme. The intervention was effective in bringing about substantial increases in children's consumption of fruit and vegetables, and this was at least partly sustained at a four month follow-up, with almost double the amount of fruit being consumed by the intervention group compared with baseline amounts. Increases in vegetable consumption at four months were also significantly above baseline levels. The increases were significant for both 5-7 and 7-11 year olds, and increases were greatest in those with lowest consumption at baseline.

The Food Dudes intervention has subsequently been evaluated in Ireland where school meals are not provided and children take food to school in lunchboxes. [218] Two schools were randomly assigned to a control or experimental condition. During the 16-day intervention in the experimental school, children watched video adventures featuring the heroic Food Dudes, and received small rewards for eating fruit and vegetables provided. In both schools, parental provision and children's consumption of fruit and vegetables in the lunchboxes were assessed at baseline and 12-month follow-up. Fruit and vegetables were provided in both schools over an 8-day baseline phase and the 16-day intervention, and children's consumption was measured. Relative to baseline measures, children's consumption of school provided fruit and vegetable significantly increased in the experimental school during the intervention period. Consumption declined in the control school. After 12 months, parents in the experimental school provided significantly more fruit, vegetables and juice relative to baseline, and significantly more was consumed by children relative to baseline amounts and to the control school. The decline in consumption of the school-provided foods in the control school is consistent previous findings from the Food Dude programme and indicates that simply providing additional fruit and vegetables to children does not necessarily result in the food being eaten. If anything such provision leads to a decline in consumption following what may be an initial novelty effect.

The National School Fruit Scheme (NSFS) was piloted from Autumn 2000 to September 2002 and subsequently rolled out nationally. The scheme aimed to provide one free piece of fruit each school day to children aged 4-6 years. The time frame of this programme gave the opportunity for comparisons to be made a) between infant school pupils attending schools in the NSFS pilot scheme or early phase of the main scheme and pupils attending schools not yet in the scheme and b) between junior school pupils who had participated in the pilot scheme as infants and those who had not.[106] Eight schools in three areas of low-to-middle income on the

outskirts of London in SE England that had been in the pilot scheme or early main phase were selected. The three study areas were matched with three adjacent areas that had not been in the pilot scheme or main scheme from which nine schools were selected. There was strong evidence that the fruit intake of infants in the scheme was higher than that of pupils not in the scheme (median intake of fruit 117 g/d compared with 67 g/d). This difference did not persist at age 7-8 years (median intake 83 g/d in those who had participated in the scheme compared with 86 g/d in those who had not participated). For increased fruit consumption to have lasting effects, additional interventions will be needed.

The same scheme was evaluated in a non-randomised controlled trial of 3,703 children aged 4-6 years.[107] Schools involved in the pilot scheme of the School Fruit and Vegetable Scheme (SFVS also known as NSFS) were excluded and due to the advanced stage of the national scheme the number of regions suitable for the control group was limited. The study was powered (95%) to detect a difference of 0.5 portions of fruit or vegetables between the two groups. The CADET tool was used to estimate dietary intake (including portions of fruit and vegetables), energy, and nutrients. Using multilevel modelling with five levels and adjusting for potentially confounding variables, showed strong evidence that the SFVS was associated with an increase in fruit intake of 0.4 (95% confidence interval 0.2 to 0.5) portions per day and 0.6 (0.4 to 0.9) portions per day in reception and year one pupils respectively at three months. This fell to 0.2 (0.1 to 0.4) and 0.3 (0.1 to 0.6) portions per day at seven months. In year two pupils the increase in the intervention group was 0.5 (0.2 to 0.7) portions per day at three months which fell to baseline levels at seven months when these children progressed to KS2 and were no longer eligible for the scheme. No differences in vegetable intake were detected at seven months and the SFVS was not associated with any changes in levels of energy, fat, or salt. There was evidence of small changes in carotene and vitamin C intake, with carotene levels decreasing in the intervention group at 3 months in all three pupil years, but increasing at 7 months in YR and Y1 pupils. This increase was not seen in Y2 pupils who were no longer eligible for the scheme. The scheme was associated with an increase in vitamin C levels at both time points in the lowest two year groups, but was associated with a decrease in level at both time points in Y2. Although no formal long-term follow up was conducted, the trend towards baseline values when pupils were no longer eligible for the scheme, the robust analysis in this study gives further support for Wells and Nelson's findings that the benefits of the scheme are unlikely to persist beyond the period of the intervention.

Using qualitative methodology, the views of pupils and parents were sought in response to the introduction of an after-school 'Food Club' designed to promote food preparation skills and healthier food choices among 12-13 year olds in low-income areas in NE England.[52] Ten secondary schools serving less advantaged areas of Tyne and Wear were recruited into five matched pairs. One of each pair was randomly allocated a Food Club with the other serving as a control group for dietary analysis. The food club ran for two terms (September 1999 to April 2000) and was led by a specialist food technology teacher. The qualitative element of the investigation used group discussions and individual interviews with a sample of the participating pupils and their parents. A common reason for initially attending the clubs was that it would be an opportunity to try food and make dishes, although 'just something to do after school' was almost as common. The provision of all ingredients and containers removed a potential barrier to attendance although some felt guilty about having free food. The type of food cooked attracted some criticism, particularly from boys who would have preferred burgers to vegetarian burgers and would have liked to have cooked more cakes. Most pupils enjoyed the practical emphasis of food preparation and were aware of the healthy eating message underpinning the clubs. However, some messages were poorly understood despite the leader presenting the importance of a balanced diet rather than a binary model of good, healthy food versus bad, unhealthy food. Pupils generally expressed pride in taking food home, and positive reactions at home reinforced their sense of achievement. Family members would normally try the food, and pupils were keen to receive feedback. Negative reactions at home tended to lead to some ambivalence about taking food home. Over half the pupils interviewed reported making at least one dish at home, with some listing several. Despite this, pupils tended to

make only limited changes to their diets and family food consumption was unlikely to be influenced even though parents were generally in favour of their child's participation. However, under half of the parents interviewed mentioned food as one of the reasons, with giving the child something to do being a more popular reason. Overall the findings indicate that an after school 'Food Club' is an appropriate method for the development of food preparation skills in this age group. The findings also raise questions about the opportunities for children to practice food preparation skills at home, as well as the extent to which children might influence food choices in families.

The influence of the secondary school environment as a context for understanding young teenagers' eating habits and food practices was explored using semi-structured interviews with 36 teenagers aged 13 and 14 years living in disadvantaged circumstances in Scotland.[86] Each school (number not given) had its own micro-culture and this impacted on the food experiences of the teenagers. They all said that they were constrained in what they ate, where they ate, and when they ate because of decisions made at the school level or above. The restrictions of not being able to eat with friends from other year groups and not always being able to access the type of preferred food were in some cases, unacceptable, resulting in pupils leaving the school premises to buy food elsewhere. For the third of the sample who reported taking up their entitlement to a free school lunch leaving school was rarely a feasible option. The decision about which food to purchase was often dependent on the length of the queue at each counter, which in reality meant a lack of real choice. Those who left the school premises also chose outlets with the shortest queuing time which were invariably fast food outlets or a high street bakery chain. For some, the non-curriculum times of the school day were very important and food and eating were rarely given priority over other activities. Food was purchased and eaten as quickly as possible. There was support for the notion that close friends rather than peers exerted more influence on health-relevant behaviours. Eating with a crowd caused anxiety for some, particularly girls, although they remained keen to fit in with the group. However, some young people made an effort to assert their individuality by not fitting in with groups eating habits. These participants used feelings of unease about the thought of eating 'greasy' of 'fattening' foods to justify to their friends their choice of sandwiches or fruit rather than the more popular chips and burgers. The main finding was that the dislike of queuing, their ability to budget for food at school, and the desire to maximise time spent with friends all influence food choice at lunch-time.

In an attempt to improve school-based eating in secondary schools, the Peterborough Schools Nutrition Project used multiple interventions aimed at increasing the consumption of healthier foods.[87] School Food Groups were set up in two Peterborough secondary schools with the specific targets of increasing the school meal take up and increasing the availability of certain foods provided by the school caterers. One school in the same area acted as a control. These targets were set to address intakes of sugar, fat, and fibre, with these being particularly implicated in the aetiology of dental caries, obesity, CHD, stroke, and some cancers. The intervention was based on a whole school approach involving pupils, teachers, catering staff, and health professionals. The only food availability target to be met in both intervention schools was that to increase the availability of high-fibre bread. The availability of food items at the control school remained stable. The proportion of pupils consuming fruit and vegetables or salad was very low in all schools at baseline. The dietary consumption target for vegetables or salad was met in one school by the final monitoring period, and that for high-fibre bread was close to being met. Other improvements, such as increased consumption of fruit and non-fried potatoes were not sustained in the long term. Overall, the implementation of School Food Groups and target setting was not associated with changes in school-based eating. Although some positive changes were made at an early stage these were not sustained, indicating the difficulties associated with achieving sustained dietary changes in secondary school pupils.

The lack of an association between consumption of confectionary purchased from vending machines and 'poor' dietary practice or 'undesirable' lifestyle habits was shown in a study of 504 secondary school pupils.[108] The participants were from three small (n=650) secondary

schools in Wiltshire, Liverpool, and Cheshire each of which had vending machines installed. The machines included a variety of items including crisps, confectionary, biscuits and fruit. Participants completed a lifestyle questionnaire (LSQ) which was developed to determine the patterns of consumption of confectionary from the vending machines and other sources and to investigate their association with a range of dietary and lifestyle habits in British schoolchildren. On the journey to school fizzy drinks were the most frequently consumed snack, followed by chocolate bars or chocolate sweets. The most popular purchasing outlet was the local shop. No difference in the frequency of snack consumption on the way to school was seen between breakfast and non-breakfast eaters. After arrival at school the local shop remained the most popular choice for the purchase of snacks. Fizzy drinks and fruit were the most frequently consumed snacks and again there was no difference in the frequency of snack consumption between breakfast and non-breakfast eaters. Crisps were the most popular break-time snack, with the school canteen being the most likely source. Vending machines inside school were the most popular choice for purchasing snacks at lunchtime. Fizzy drinks were the most frequently consumed snack during both lunchtime and afternoon break with breakfast eaters consuming significantly more than non-breakfast eaters. Boys ate more sweets than girls, with girls tending towards greater amounts of fruit than boys. The local shop was the most popular choice for purchasing snacks after school and fizzy drinks remained the most popular snack on the way home and during the evening although chocolate bars, chocolate sweets, and fruit were also popular. The source of evening snacks was most likely to be the participant's own home. Confectionary consumption from all sources, but not from vending machines, was higher in those who were physically active on the way to school, but was also higher in those who spent more time watching television or playing computer games. The results from the study do not suggest a direct link between increased consumption of confectionary from vending machines and poor dietary quality (measured by alcohol and fruit and vegetable intake) or a reduction in physical activity.

An interview study of 181 school children (87 boys and 94 girls) aged 14-15 from 10 secondary schools in SE England investigated the relationship between food choice and perceived healthiness. Children were presented with 19 photographs of foods and dishes that would typically be offered in the school cafeteria. Most photographs were of only one item and included foods such as crisps and a can of drink that would be classified as snacks, and those, such as chicken fricassee and apple crumble that would be part of a conventional meal. Children were unaware of the purpose of the study. They were first asked to select the dishes they would choose if they were offered that range of foods (the 'preferred' meal), and were asked to explain why they had chosen this meal. They were then asked to rate the 19 food items or dishes on a nine-point scale marking the point that reflected the likelihood of choosing the item. The meal selection and rating tasks were then repeated, with children being asked to select the meal they thought would be most healthy (the 'healthy' meal) and to explain the reasons for their choice. They were asked to rate each of the 19 items according to how healthy they thought each to be. The items most likely to be chosen for the 'healthy' meal were fresh fruit, salad, mixed vegetables, milk or water. Although there were significant differences between males and females in 'the choice of 'preferred' meals, this difference was not seen in the choice of 'healthy' meals, suggesting that knowledge of healthy eating is similar in both sexes. The energy content of the 'preferred' meals was significantly higher than that of 'healthy' meals. The number of items chosen for the 'healthy' meal was also lower than the number selected for the 'preferred' meal, suggesting that children are equating 'healthy' with low calorie. The 'preferred' meal contained greater amounts of several nutrients than the 'healthy' choice, due mostly to the higher energy content. The most common reasons for the choice of the 'preferred' meal were concerned with liking it or it being a favourite food. Liking the taste or flavour, or the having a nice appearance were also mentioned frequently. 'Being good for you' or 'healthy' were also reasons, as were aspects concerned with 'convenience' or the ability to 'take it outside'. Boys were more likely than girls to choose a dish based on how filling it was. Reasons for selecting the 'healthy' meals were less well explained, with only a few children recognising the nutritional value of the meal as a whole. Many children saw the healthiness of a meal as being attributable to individual items, such as the presence of fruit or vegetables. Milk

or dairy products were often seen as healthy, and the absences of fat, and less commonly sugar, were also given as reasons. In general the 'preferred' meals were generally less healthy than the 'healthy' meals. There was an inverse relationship between the foods likely to be chosen and those perceived to be healthy.

A series of three papers[80 81 82] reported findings from a study in which the use of smart card technology was used to track the eating behaviours of nearly 1000 children in a school cafeteria. The study was based in an English Independent Boys' School where the catering was provided by Scolarest. A 4-weekly cycle of menus was operated, and each day over 900 diners passed through the cafeteria. The smart card provided a full electronic audit of all the individual transactions and the dataset was interfaced to an electronic version of the McCance and Widdowson composition of foods dataset. The data was expanded to include a full nutrient analysis of all the foods chosen. A database was constructed encompassing 30 pupils (aged 8-11), 78 days, and eight nutrients (energy, fat, protein, fibre, sugar, iron, vitamin C, and vitamin A). Data were available for 1909 meals. The CWT guidelines were used to provide figures for the recommended nutrient content. The nutrient analysis indicted that the cohort was choosing meals containing higher than the recommended maximum amounts for sugar and lower then the recommended minimum amounts of fibre, iron, and vitamin A. Protein and vitamin C contents of meals were well above the minimum requirements. Over the 1909 meals, nutrient requirements were met 41% of the time.

The technology was also used to continuously monitor the choice of beverages and desserts made by pupils. Analysis of data from all pupils (aged 7-16) collected over 89 days between November 2002 and December 2003 showed that 'buns' were the most popular choice of dessert, followed by cookies. Yogurt, fresh fruit, and ice-cream were relatively unpopular. Despite coming from an affluent, well-educated demographic group, the choice of desserts and beverages mirrored those of children in general with buns and cookies being over ten times more popular than yogurt and fresh fruit. Sugary soft drinks were over 20 times more popular than fresh fruit drinks and mild combined. It was also estimated that over any given 20 school days (one month) a reduction of 200 g fat and over 800 g added sugar could be achieved by pupils making healthier drink and dessert choices at lunch time. If, as anticipated, the pattern of food choice is generalised beyond the school environment, these nutritional trends are likely to have important implications.

Conclusions

- The introduction of breakfast clubs has mixed results, although the evidence is based on two relatively small studies.
- School meals are unlikely to meet CWT guidelines.
- The introduction of after school cooking clubs is thought to be an appropriate method for the development of food preparation skills and promotion of the health education message to teenagers.
- Interventions aimed at increasing fruit and vegetables in schools have had very limited long-term success.
- There appear to be a number of barriers to increasing the take up of school meals or improving the diet of secondary school pupils. The issues are complex and often inter-related. They may also be somewhat school specific, which may have implications for the development of any generalised approach.
- The availability of a vending machine in schools (prior to the introduction of the Healthy Vending guide[219]) is not associated with increased confectionary consumption. The local shop is the most likely source of unhealthy (and possibly healthy) snacks.
- Knowledge of the concept of healthy eating in teenagers does not necessarily translate to food choice. The concept of healthy eating may be confused with a low calorie diet.
- Smart card technology can be used effectively to monitor meal provision and nutrient intake. The study in which this was demonstrated showed similar patterns in unhealthy

food choice among pupils from an affluent, well-educated demographic group to those seen in other, more socially-varied, populations.

Health Outcomes

1. All cause mortality (1 study)

The one study contributing to this outcome investigated the effects of food supplementation on children's bone growth and later adult mortality. This non-randomised controlled trial was carried out in eight of the 16 centres participating in the Carnegie Survey of Diet and Health which was conducted in pre-war Britain (1937 – 39).[136] Food supplements were given to 545 children aged 2-14 for 12 months either at school or as a food parcel sent to the family home, and 494 children acted as controls. The children came from 465 families. The supplementation varied between study centres, but all included milk. Other food items given in at least one centre included soup, Vitamin A (as Halibut oil capsules and, or cod liver oil, or cod liver oil and malt), oranges, marmite, cheese, bemax, eggs, and blackcurrant puree. The children's height, leg length and trunk length were measured over a 12 month follow-up. All-cause mortality over 60 years follow-up to 1998 was also recorded.

There were considerable differences between the two groups of children with those in the intervention group coming from larger families with diets poorer in vitamins A, B, and C and whose head of household was from a lower socioeconomic group than children in the control group. Data collected at the time of the study were retrieved and re-analysed in 1998 using robust modern statistical methods. After adjusting for imbalances between the two groups, an additional 3.9 mm increase in height was seen in the intervention group compared with the control group. A significant increase in leg length but not in trunk length was seen in a fully adjusted model. Although both the age-adjusted and fully adjusted hazard ratios for all cause mortality were higher in the supplemented group compared with the control group, neither of these reached statistical significance.

Conclusion

Evidence from this single study shows little evidence of any effect of food supplementation on all-cause mortality. However, the difference in diet and social environment in the 1930s compared with today limits the external validity of the findings.

2. Asthma/lung function and fruit consumption (2 studies)

Two studies, both cross sectional surveys, contributed to this outcome. Cook *et al.*'s school-based survey of 2,475 8-11 year old children from 10 towns in England and Wales found, in a model adjusted for factors including socio-demographic variables, body size, and cotinine levels, a statistically significant dose-response trend between forced expiratory volume in one second (FEV_1) and the frequency of fresh fruit consumption. The improvement was from1.770 litres in the group who ate an average of up to half a portion of fresh fruit every day, to 1.845 litres in the group who ate 4.5 to 5 or more portions of fresh fruit daily. Okoko *et al*.'s population based study of 2,640 5-10 year old Greenwich children was designed to examine the association between the consumption of apples and other fruits during the previous 12 months. They adjusted for an extensive range of potential confounding factors including mould in living areas and mould in the kitchen using a propensity score. Results from the adjusted model showed a significant inverse trend for intake of apple juice made from concentrates and current wheeze (p trend = 0.003) and ever wheeze (p trend = 0.055), but not for ever asthma (p trend = 0.40). There was no evidence of an association between either apple intake or other types of apple juice and any of the three outcomes. Bananas but not other fruit were negatively

associated with ever wheeze and current wheeze, (with a weak relationship with ever asthma) but no dose-response relationship was shown.

Cooke *et al*. concluded that fresh fruit consumption appears to have a beneficial effect on lung function in children but is not associated with wheezing except for a higher prevalence of wheeze among those who never ate fresh fruit compared with those who did eat fresh fruit. The study did not evaluate the impact of individual fruits. Okoko *et al.* focused primarily on apples and found no relationship between apple intake and asthma. They did, however, find weak evidence that a higher consumption compared with a lower intake of apple juice from concentrate, and intake of bananas is associated with a lower prevalence of current wheeze.

Conclusion

The intake by children of at least 4.5 portions of fresh fruit each day is associated with improved lung function. Drinking apple juice made from concentrates or eating bananas may have a protective effect against wheeze.

3. Bone density (4 papers)

Three of the four papers contributing to this outcome use data from the Northern Ireland Young Hearts Project. This cross-sectional observational study used a random sample of 591 boys and 744 girls aged 12 or 15 years from 36 post primary schools in N Ireland and controlled for potentially confounding variables. The intake of carbonated soft drinks, non-cola intake, and diet drinks were all significantly negatively associated with heel bone mineral density (BMD), measured by dual energy X-ray absorptiometry (DXA), in girls.[60] In boys, liquid milk consumption was positively associated with both forearm and heel BMD. In girls, liquid milk consumption was positively associated with heel BMD but not with forearm BMD.

Data from the same project showed that 12 year old girls (n=378) reported eating significantly more fruit per day than 12 year old boys (n=324), whereas 12 year old boys reported eating significantly more calcium and vegetables than 12 year old girls. The older (15 year old) boys (n=274) reported eating significantly more vegetables and calcium per day than 15 year old girls (n=369). 12 year old girls with high fruit intake had statistically significantly higher heel BMD than those with moderate fruit intakes (β 0.037), a stronger association than that seen in the unadjusted model. In this age-group, those girls with high fruit intake had a significantly higher heel BMD than those with moderate fruit intake.

A follow-up study of 238 males and 205 females from The Northern Ireland Young Hearts Project assessed at 15 years and re-tested at between 20 and 25 years of age used adjusted linear regression models to examine the relationship between physical characteristics of subjects assessed as adolescents and BMD (lumbar spine and femoral neck) measured at young adulthood.[178] Variables included pubertal status at age 15, age, height, weight, physical activity, smoking, and mean intakes of energy, calcium, protein, vitamin D, phosphorous, total fat, and alcohol. In both sexes the only factor consistently positively associated with BMD at both measurement sites was body weight at adolescence and young adulthood. In males, physical activity measured at young adulthood was associated with BMD at both sites, with calcium: protein ratio measured at the same age was negatively associated with lumbar BMD and adult calcium: phosphorous ratio was positively associated with lumbar BMD. For females, vitamin D measured in young adulthood was positively associated with femoral neck BMD.

Dietary acid-base balance and the intake of bone related nutrients was investigated in 111 boys recruited from two sixth form colleges, a comprehensive school, and two independent schools and 101 girls aged 16-18 years recruited from two sixth form colleges into the Cambridge Bone Studies.[62] Using data collected via a 7 day food diary that was coded using in-house program and analysed using in-house programs based on McCance and Widdowson edition 5 showed that average calcium and phosphorous intakes for boys and girls were above

the UK RNI although 3% of both groups had calcium levels below the LRNI. The main source of calcium was milk and milk products with 20-22% of calcium coming from fortified cereal. 3% of boys and 5% of girls had a calcium: phosphorous ratio of greater than one. In general the main sources of calcium also provided phosphorous. Meat and meat dishes also contributed 19% of phosphorous in boys and 13% in girls. Potatoes and beverages were also found to be a source. Potassium and magnesium levels in boys were close to the UK RNI but below the RNI in girls. Potatoes contributed 25% of total potassium and 11-12% of magnesium. The intake of sodium from foods was higher considerably than the RNI, particularly in boys. In general calcium intake was positively correlated with all other nutrients except vitamins C and K. Despite the group being elite in terms of socio-economic status, their intake of leafy green vegetables was very low. Low intakes of vitamin K were associated with low intakes of potassium, magnesium and vitamin C, and at least 20% of vitamin K intake came from fats in cakes and biscuits, and particularly in the boys' diets, potato products such as chips and crisps. Although the recommendation is to reduce such food items, the evidence from this study suggests that such action could result in reduced vitamin K levels. This could be particularly true in children of lower socio-economic groups who are known to have a lower intake of green vegetables. The overall conclusion was that the effects of calcium and other nutrients on bone cannot be considered in isolation from the other components of diet.

Conclusion

Evidence from the four reports suggests that there is a relationship between some aspects of diet and BMD, which might be particularly important for females in later life. The nutritional analysis indicates that even in an elite group, the intake of some nutrients in adolescents does not meet UK recommended levels, and that vitamin K levels in this age-group may be compromised if recommendations for a healthier diet are followed.

4. Cancer (3 papers)

The three papers contributing to this outcome all use data from the Boyd Orr cohort which is defined as the participants who participated in the multi-centres Carnegie Survey of Diet and Health, conducted in pre-war Britain (1937 – 39) and who have subsequently been traced using the NHS central register.

The relationship between fruit, vegetables and antioxidants in childhood and risk of adult cancer was examined in 3,878 traced subjects with full data on diet and social variables.[133] Fruit intake ranged from a mean of 0.6 g in the lowest quartile of the distribution to 88.4 g in the upper quartile. There was evidence of a dose-response association between increased intake of fruit and reduced risk of incident cancer (fully adjusted model; OR for the highest quartile of fruit intake using lowest quartile as the base-line: 0.62; 95% CI 0.43 to 0.90, p trend = 0.02). The association was weaker for cancer mortality and weaker still for all-cause mortality. There was no clear pattern of any association between vegetable consumption, vitamins C, E, carotene or retinol intake and cancer incidence, cancer mortality, or all-cause mortality.

Associations between childhood energy intake and cancer mortality were examined in the same data (n=3834).[134] On 30 June 1996, 203 cancer deaths had been recorded in survey members aged 16 years and under at the time of the survey. Of these 100 were women and a total of 105 were deaths from cancers not related to smoking. A model adjusted for energy, age, household expenditure, social class, number of children, time since survey, and Townsend score of district of the last known address, showed a positive association between childhood energy intake and cancer mortality. The effect was stronger in cancers not related to smoking, with a relative hazard of 1.20 (1.07 to 1.34) for every MJ (239 kcal) increase in adult equivalent daily intake. The effects were similar in males and females. Further analysis, for both sexes combined, showed a linear trend between energy intake and mortality from cancers not related to smoking, with a hazard ratio of 2.54 (1.07 to 6.03) in the upper quintile compared with the lowest quintile of energy intake.

A similar analysis examined the association between childhood BMI and later cancer risk in 2347 participants.[135] A composite outcome was derived from the presence of a cancer code anywhere on the death certificate, or the first cancer that was registered. Analysis was based on cancer registrations up to December 2001 and deaths to January 2003. There was a 9% (95% CI -3 to 22%) increase in risk of adult cancer per standard deviation (SD) increase of childhood BMI. This increased to a 30% (10 to 54%) increase in the risk of smoking related cancers per SD increase in childhood BMI. There was no evidence of an association between BMI and cancers not related to smoking.

Conclusion

The evidence from analyses of this longitudinal study shows evidence of a relationship between (i) lower fruit intake in childhood and increased risk of incident cancer in adulthood, (ii) higher energy intakes in childhood and cancer mortality in adulthood, and (iii) higher childhood BMI and subsequent increased cancer risk. However, the diet and social environment in the 1930s is somewhat different from that experienced by today's school population which limits the external validity of the findings.

5. CHD/ CVD/ Blood pressure (3 studies)

The relationship between diet and coronary heart disease (CHD) was examined in 4,028 traced participants of the Boyd Orr cohort who were resident in Britain on 1 January 1948. Deaths were recorded to 31 July 2000.[137] Higher childhood intake of vegetables was associated with lower risk of stroke, with a significant trend (p=0.01 in a fully adjusted model) across quartiles of vegetable intake. Risk of stroke significantly increased with increased childhood intake of fish (p for trend 0.01 in a fully adjusted model). The rate ratio for coronary heart disease mortality was lower with a higher intake of fat, with a significant trend (p=0.07 in a fully adjusted model) from the lowest quartile to the highest quartile of fat intake. A similar pattern was seen for all-cause mortality and saturated fat. A possible explanation for the protective associations of childhood saturated fat intake and childhood total fat intake with all-cause mortality and coronary mortality may result from confounding as higher levels of fat and saturated fat intake were associated with higher social class.

Evidence of an association between childhood and adulthood vitamin E intake and hypertension (defined as systolic blood pressure ≥140 mmHg and diastolic blood pressure ≥90 mmHg) comes from the 1946 British Birth Cohort.[138] 2,980 survey members provided information on diet, health, and socio-demographic information at two time points: aged 4 years in 1950, and at 43 years in 1989. There was strong evidence of an increased risk of hypertension (1.78; 95% CI 1.03 to 3.08) and high waist circumference (1.58; 95% CI 1.02 to 2.43) at aged 43 in those who had low levels of vitamin E at both time points, compared with those who had high vitamin E intake at both time points. A single low intake of vitamin E was not associated with an increase risk of either outcome.

A more recent longitudinal cohort study examined the relationship between the development of biological risk factors (serum lipids, body fatness, blood pressure, and cardio-respiratory fitness) for CHD and lifestyle parameters during adolescence.[139] A representative sample of 251 boys and 258 girls aged 12 years from 16 schools in Northern Ireland was examined in 1989/90. Participants were re-examined in 1992/93 at the age of 15 years. Complete data sets were available for 229 boys and 230 girls. There were some differences between sexes in the relationship between the development of biological risk factors and lifestyle parameters. Some unexpected results were found, although the novel analytic approach limits the comparability of findings with those from previous studies. The authors concluded that education and intervention at this age to certain factors including aspects of diet appear to be justified as part of a preventative strategy for CHD.

Conclusion

Data from a relatively early cohort study showed a protective effect of vegetable intake against stroke. The unexpected inverse association between intake of saturated fat and mortality was explained in terms of potential confounding. Evidence from a different cohort study but one conducted at a similar time showed a beneficial effect of vitamin E for both the risk of hypertension and for high waist circumference. The most recent study contributing to this set of outcomes gives some unexpected results, but provides some limited evidence that education and intervention during early adolescence on certain aspects of diet may be justified as part of a preventative strategy for CHD.

6. Dental (9 studies; 4 further articles providing comments)

In the 2004 Nutrition Society Medal Lecture, Moynihan outlined the inter-relationship between diet and oral health,[160] focusing particularly on the role of both fluoride and sugar. She suggested that the increasing consumption of bottled water in preference to fluoridated tap water could lead to a marked reduction in caries protection. She also reviewed evidence indicating how sugars have been shown to be the main aetiological factors for dental caries, and how also the change in sources of sugars have changed over the past 30 years with the contribution from soft drinks more than doubling since 1980. The general message was that teeth are necessary for the maintenance of good health, with an inter-dependence between teeth and diet. A good diet is essential in the development and maintenance of healthy teeth, but healthy teeth are also important in facilitating the consumption of a varied and healthy diet throughout life.

Despite the evidence suggesting that sugar has been shown to be the main aetiological factors for dental caries, the association between diet and dental health is more complex than might perhaps be thought. Brian Mouatt (the former UK Chief Dental Officer) has commented that any causality between food habits and dental caries is difficult to establish due the many factors affecting the cariogenicity of each food.[166] In the same article, he has suggested that rather than compile a list of foods with high sugar content that should be avoided, the advice should focus on the frequency of ingestion and recommending that the frequency of snacking should be limited to two or three times daily. He also suggests that the prevalence of dental caries is more strongly associated with the frequency of exposure to sweet food and drink rather than the amount of sugar ingested and cites evidence that suggests that modifying diet at a young age has considerably less benefit to dental health than the early use of fluoride toothpaste.[166]

There are some mixed messages surrounding the suitability of dried fruit. This food is recommended by the Trust as one alternative to sweets and biscuits, although the guidance acknowledges that schools may choose to serve dried fruit only as part of a meal. In contrast the advice on the prevention of childhood tooth decay from The British Dental Health Foundation includes:

"If you want to give your child a snack, try to stick to cheese, vegetables and fruit, but not dried fruit." [168]

A search on Medline and Embase using 'dried fruit' as a free text word failed to locate any publications focusing on the association between dental health and dried fruit.

Despite Mouatt's comments about the difficulties in establishing a causal relationship between diet and oral health, a number of studies have investigated possible relationships between aspects of dietary intake and dental erosion or dental caries. As well as providing evidence on any possible relationships, several of these studies also offer evidence about the nutritional profiles of particular age groups.

The rate and frequency of consumption of drinks, foods and fruits was collected using a self-complete questionnaire, supplemented by a structured interview, from a cluster random sample of 418 (209 males and 209 females) 14 year old school children from 12 Birmingham schools. The level of tooth wear (prevalence of dental erosion) was recorded using a modification of the (TWI) index of Smith and Knight (1984) and was categorised as: low erosion (score of 0 or 1); moderate erosion (at least one score of 2); severe erosion (at least one score of 3 and, or 4). The most common drinks reported by this group were orange squash, cola, and other carbonated drinks drunk by 81%, 80% and 76% respectively at some time in the week. However, half had a low consumption with 1-7 intakes per week while 13% had a high consumption of cola (>22 intakes per week), and 10% had an equally high intake of other carbonated drinks. Of other acidic dietary components, apples were the most commonly eaten fruit, and more than two-thirds reported regularly eating oranges, bananas and grapes. A tenth of the group had more than 8 intakes of fruit per week with 2% reporting eating fruit more than 22 times per week. This contrasts with 14% of children who never ate fruit. A small number (2%) had a very high intake of other acidic foodstuffs such as tomato ketchup etc. In general girls had a greater intake of fruits. There was a strong relationship between dental erosion and the frequency of consumption of cola drinks, other carbonated drinks, apple juice, sports drinks, and beer. Milk and tea also had some correlation but this may have reflected a high overall fluid consumption. In addition, the range and amount of fruit intake was correlated with erosion as was tomato ketchup and yoghurt.

Data from the same study provided evidence that 10% of children were vegetarian. There was no evidence of an association between the prevalence or severity of erosion with type of diet.[169]

A cross-sectional study of 165 3-11 year old children with severe tooth decay attending Glasgow Dental Hospital for tooth extraction under general anaesthetic investigated the relationship between diet and BMI in children.[167] Diet data was recorded using a structured food frequency questionnaire (FFQ), completed by parents, for selected foods high in fibre or sugar and used to derive a score based on the amount of, and frequency with which, fibre and sugar were eaten. Oral health was measured using case notes to give the number of decayed, missing, or filled teeth (DMFT).The 1991 Scottish Health Board Carstairs score provided a measure of social deprivation. Regression analysis showed evidence of an association between the Carstairs index and DMFT. There was no evidence of an association between the sugar score and DMFT, nor between Carstairs and sugar consumption. This study has some weaknesses including using a simple method of collecting food information which only gave a crude estimate of food eaten. Parents are reliable reporters of what is eaten at home but not at school and this is likely to be compounded by a bias where the amount of sugar is under-reported (due to an unwillingness to admit to the amount of sugar eaten). The whole picture surrounding the association between social deprivation and DMFT or caries is complex. Social deprivation is a high risk factor for the development of caries in children. Although the amount spent on sweets by the lowest 10% of socio-economic groups spend less on sweets than other groups, they tend to buy foods richer in energy and higher in fat and sugar. This group is also less likely to attend for early restorative and preventative dental treatment.

A prospective cohort study, using a random sample of 1,753 children, investigated whether factors measured at 12 years of age were associated with dental erosion at 14 years.[161] Information on oral health behaviour, dietary habits, and a history of gastric reflux and asthma was collected at 12 years using a questionnaire. A shorter questionnaire concentrating on drinks consumption was used at the 14 year examination when children were also given a dental examination using a Doray 4000 dental light. The results, based on 1,149 usable replies, showed that fruit other than apples or citrus fruit reduced the odds of erosion by 52% (OR 0.48; 95% CI 0.36 to 0.66) at 12 years. Drinking pop increased erosion (any: OR 1.59; 1.18 to 2.13; 4+ per day 2.52; 1.69 to 3.75). Diet at age 12 could predict future erosion at age 14 with fizzy pop being the strongest predictor. Drinking pop at 14 was also strongest risk factor for erosion

at 14 (OR for drinking pop was 2.21, 95% CI: 1.47 to 3.31; 3+ intakes per day per day OR 2.82, 1.87 to 4.24; 4+ per day OR 5.13, 2.74 to 9.62).

The strengths of this study included the use of a single examiner who was trained and calibrated in the recording of all survey data. A reproducibility exercise conducted prior to main study showed good intra-examiner agreement: Kappa of 0.80 and 0.67 for erosion depth and erosion are respectively for the 12 year olds, and 0.84 and 0.71 respectively for 14 year olds. The level of pop consumption increased between 12 years and 14 years which may have led to the overall findings that the association between pop consumption and tooth erosion was strongest in 14 year olds. Eating fruit other than apples and citrus fruit (most likely to be bananas) had a negative association with tooth erosion.

A small observational study of 60 children (34 girls and 26 boys) aged 5-16 years and from the Chelsea area of London provided evidence of an association between both socio-economic status and access to vending machines, and sugar intake, food choices and oral health.[112] Diet data was collected using a three day diet diary, and analysed using Microdiet. A questionnaire was used to obtain information on demographic and socio-economic status of the family, feeding history, dietary habits, food preferences, and dental and oral hygiene practices. The questionnaire was also used to check for under-reporting of food intake in the food diaries. Just over one quarter (26%) of boys and 32 % of girls were classified as overweight and 11% of boys and 5% of girls were obese. There was a clear trend of increasing daily sugar consumption from social group 1 (58.3 g/day) to group V (231.1 g/day), with a slight decrease to 205 g/day in group VI. Intake of confectionary items per day increased from 0.23 items per day in group 1 to 3.6 items per day in group VI. Intake of crisps increased from 0.35 packs per day to 2.3 packs per day across the six groups, while the number of portions of fruit and vegetables decreased from 4.0 per day in group 1 to 0.49 per day in group V. Group VI showed a slight increase at 0.72 portions per day, although the variance in this group was high. Vending machine use was highest at 2.6 uses per day in social group IV, ranging from 0 uses in group 1 to 2.3 uses in group VI. None of these behaviours was related to weight.

The presence of DMFT was also strongly related to social class, with children in group 1 having an average of 0.5 DMFT, rising to 4.6 in group IV. This dropped slightly to 4.3 and 4.1 in groups V and VI respectively. However, the age of the children in each group is not clear, and it might be expected that age is related to DMFT. Sugar and confectionary consumption were highly correlated with DMFT, as were crisp consumption and vending machine use. However, no mention was made of any possible confounding by social class. There was strong evidence of a difference between DMFT scores for children who attended a school with a vending machine and those who attended schools without such a machine.

More robust evidence of the association between diet and dental erosion was provided by a large cross-sectional study of a random sample of 2,385 children aged 14 years and residing in NW England.[163] There was evidence of an association between an increased intake of fizzy drinks, sports drinks, and herbal or lemon tea with tooth wear. Other foods associated with tooth wear were brown and, or other sauces, vinegar, salt and vinegar crisps, and curry or spicy food. However, none of the increased risks were as high as some previous studies had suggested, and it was suggested that examination at 14 years might not be ideal as the foods implicated in tooth wear might not have had sufficient time to act.

A four-year follow up study of 315 Leeds primary-school children aged 7-11 years with complete dietary and dental data at the two time points showed no significant relationship between sugar-sweetened foods or drinks at age 7-11 and caries in the first permanent molar teeth at age 11-15 years.[165] There was, however, evidence of a positive association between current sugar-sweetened drinks consumption and caries, and of a negative relationship between reported moderate consumption of dairy products at age 11-15. The bedtime consumption of NMES drinks at bedtime at age 7-11 and also at age 11-15 was also associated with an increase in caries. Although the reported consumption of sugar sweetened

drinks was strongly related to caries, it should be noted that in general the sample had a lower DMFT index of molar teeth than that expected from larger surveys, which may indicate a biased drop-out at follow-up.

Results from a study of children from two areas with contrasting socio-demographic profiles in Yorkshire (Leeds and Halifax) showed strong evidence of a relationship between the consumption of either food or drink containing NMES in the hour before bed with both DMFT and caries (primary and permanent teeth).[164] Gender, ethnicity, and socio-economic status were not related to caries experience. The strongest relationship was between caries and the consumption of both NMES food and drink during the hour prior to bedtime; these children had four times the mean DMFT score (1.24) of those who consumed neither (0.31).

Another study of 163 5 year old children from low-income or unemployed families in North and West Belfast showed that 68% had experience of dental caries.[162] Dental decay was unrelated to employment status although diet was related to both parental employment status and parental attitude. In addition, diet was related to dental caries, particularly the consumption of carbonated drinks and sugar containing bedtime drinks. Some bias might have been introduced through self-selection: the original sample of 240 5 year old children was randomly selected from 2,666 children resident and attending school in North and West Belfast. Of these, 163 (68%) were examined.

Conclusion

The availability of fresh tap water may be more beneficial for the prevention of dental caries than bottled water. This would be also a cheaper alternative for schools. In general there is strong evidence that the consumption of carbonated sugar-sweetened drinks is associated with increased caries experience. The consumption of foods and drinks containing NMES, particularly prior to bed-time, is also associated with caries. However, many of the studies have been conducted in areas with high rates of social deprivation, with no adjustment for socio-economic status. Since it is likely that diet is strongly socially patterned, the results may be moderated with more robust analysis. In addition, the studies may suffer from a biased drop-out rate.

The apparent association between access to a school vending machine and tooth decay offers support for the shift to healthier vending. The findings of positive associations between sugar and caries, and negative associations between dairy produce and caries in the same study could be explained by the replacement of sugar by diary products, rather than a real protective effect of dairy produce. It should be noted that a weakness of follow-up studies is the attrition rate with the possibility that drop-outs are not representative of the initial cohort which can result in bias. In dental studies, it may be that there is a high drop-out rate among those with more severe dental decay or with a higher intake of sugar, which could bias the results towards the null. Evidence in support of this comes from Levine *et al*.'s study in which the mean DMFT index for molar teeth in their follow-up sample was lower than that found in a more general survey.

7. Food hypersensitivity and food allergy (five included papers; four studies)

Three of the five included papers (four studies) examining this outcome were primarily concerned with the prevalence of sensitisation of food allergens, reported adverse reaction to foods, food avoidance, food hypersensitivity among teenagers, and severe food-allergic reactions in children and the management of resulting symptoms, rather than identifying any causal relationship between diet and development of hypersensitivity. There was also some useful information about which allergens are important.

Roberts *et al*.[170] Venter *et al*.[171] and Pereira *et al*.[172] commented on the lack of information of food hypersensitivity (FHS) among young children and teenagers. The cohort studies

conducted by Venter *et al*. and Pereira *et al*. reported sensitisation rates to key allergens and self-reported or parent-reported rates of FHS, and also used objectively assessed FHS using food challenge methods to identify the prevalence of FHS in the respective age-groups. Among all consenting six-year olds living on the Isle of Wight, the prevalence of reported adverse reactions to one or more food items was 11.8% (95% confidence interval (CI) 9.6 to 14.2) with no evidence of any difference between males and females. Two-thirds of the 94 children who reported a current problem were avoiding one or more foods, although not necessarily the one to which an adverse reaction was reported. Milk and dairy products were most frequently reported as causing a problem (40% of those reporting a problem; 31% reported milk as being the problem), followed by peanuts and eggs (both 16%), additives and colourings (14%), tree nuts (12%), wheat (11%), strawberry (6%), sesame (5%), and fish (2%). Among the 700 six year olds who consented to skin prick tests (SPT), the rate of sensitisation to any of the predefined panel of food allergens (milk, egg, wheat, cod fish, peanut, and sesame) and aeroallergens (house dust mite, cat, and grass pollen) or to any other allergen reported to be a problem, was 17.8% (95% CI 15.9 to 20.1) with the majority sensitised to one or more aeroallergens. The rate of sensitisation to any of the predefined food allergen panel was 7.7%, with large numbers being asymptomatically sensitised between both grass and wheat. This dropped to 3.6% (95% CI 2.3 to 5.2) when children with a history of grass pollen allergy who were sensitised to both grass and wheat were removed. Only three children were sensitised to wheat alone. An additional four children were sensitised to other foods (one to banana, one to green pea and green bean, one to almond, and one to hazelnut). Of the 94 children reporting any problem, 83 underwent SPT of whom 13 were sensitised to the pre-defined food allergen panel. Only 12 of the 94 (13%) had a positive SPT to the food reported as a problem. In addition, 12 of the 617 1.9% consenting children not reporting a problem had a positive SPT to the pre-defined food allergen panel. Nineteen of the 94 children underwent food challenges of whom ten had a positive reaction (milk, 4; peanut, 6; wheat, 3; egg, 2; fish, 1; chocolate, 1; sesame, 1; almond, 1; banana, 1). Overall, based on open food challenges and /or a suggestive history or SPT, the prevalence of FHS was 2.5% (95% CI 1.5 to 3.8). This fell to 1.6% (95% CI 0.9 to 2.7) using stricter criteria of a double-blind challenge, a clinical diagnosis or suggestive history and positive SPT. The rates of perception of FSH are higher than the rates based on objective tests. Milk, peanuts, and wheat were the key food allergens in those with positive challenges.

A very similar study was conducted among 11 and 15 year olds on the Isle of Wight. Again the reported prevalence of FHS was much higher than that assessed by objective methods. Prevalence rates in both 11 and 15 year olds using open food challenges and positive SPT together with a history of adverse reactions were 2.3%. The most common foods implicated in FHS in the 11 year age group were peanuts, tree-nuts, egg, milk, shellfish, gluten, green beans, cheese, kiwi, tomato and additives. In the older group, the foods implicated were peanuts, tree-nuts, gluten, wheat, shellfish, egg, milk, and additives. This is consistent with previous evidence suggesting that peanut, tree nut and shellfish allergy are often reported in older children and young adults. The prevalence of peanut allergy at 1% and 0.8% in the 11 and 15 year-old groups respectively was similar to that in a group of 3 to 4 year olds in the same geographic region.[173]

The prevalence of sensitisation to aeroallergens and food allergens was estimated in the Avon Longitudinal Study of Parents and Children (ALSPAC) using skin tests. Of the 7633 subjects remaining in the cohort at 7 years of age, 6450 had a valid SPT to a defined allergen panel. Of the foods tested, the most common sensitisation was to peanut (1.4%) and mixed tree nuts (1.0%). Although the size of the cohort in this study allows prevalence rates to specific allergens to be identified, the numbers of positive reactions to many allergens is still very low.

The fourth study[172 175] was concerned with the management of clinical allergy. Using a prospective survey of children's hospital admissions for food-allergic reactions, the incidence of severe food-allergic reaction was estimated to be low. The main allergens in the reported admission rate for food-allergic reaction of 0.89 hospital admissions per 100 000 children were

peanut (21%), tree nuts (16%), cow's milk (10%), and egg (7%). This was a similar pattern to the prevalence of FSH described in the previous studies. Two-thirds of the admissions were male. Of 229 reported admissions over two years, three were fatal, with a further six classified as near fatal. All nine (except one who was too young to have been diagnosed) had a strong history of asthma. The study concluded that the deaths and near deaths were more likely to be a consequence of the control and management of asthma than of the food allergy itself.

Conclusion

Overall, the perceived sensitivity to foods is higher than that estimated by objective methods, and the rate of severe reaction is very low. The implication for school meals is that although the risk is minimal, it is a real risk, although it is expected that any pupil with a true allergy will have made themselves known to the school staff who will be aware of any action that should be taken in the event of a medical emergency.

8. Growth (1 study)

The ability of a meat-free diet to support the normal growth of children was assessed in a longitudinal study of 50 'free living' children aged 7 -11 years from schools in Merseyside following meat-free diets, matched for age, sex, and ethnic group with 50 omnivores.[176] The matched controls were friends selected by the meat-free participants. A 'vegetarian' diet was defined as one which included dairy produce, eggs, and occasionally fish but which excluded meat and meat products. The vegetarians had followed the diet for at least 3 months. Both groups of children were 'healthy', defined as having no history of illness considered likely to affect growth or diet. There was no evidence of any difference between the groups for any of the anthropomorphic measures taken at either baseline of at one year follow-up. The vegetarian children grew slightly more than the omnivorous children and the predicted mean height increment (i.e. what the means of the data would have been if the two groups had been exactly matched with respect to all the explanatory variables) of the vegetarian group was significantly larger than that predicted for omnivores (difference in mean height increment = 0.47 cm). Although the sample was skewed to high socio-economic groups, this study provides some evidence that vegetarian diets consumed by children in this group were adequate to sustain growth to at least the same degree as that of omnivores.

Conclusion

Children eating a meat-free diet have at least as satisfactory growth rate as those eating an omnivorous diet.

9. Obesity prevalence, relationship with dietary patterns, and prevention (3 reviews; 2 primary studies, one with a 3 year follow-up)

A review published in 2005 compared recent estimates of the prevalence of overweight and obesity in school-aged (10-16 years) populations from 34 countries.[114] Evidence of associations between overweight and selected dietary patterns was also presented. The results are based on data from 137, 593 participants in 34 countries (primarily European, but also including Canada and USA). Prevalence of overweight (pre-obese and obese) and obese were highest in Malta (25.4% and 7.9%) and USA (25.1% and 6.8%) and lowest in Lithuania (5.1% and 0.4% and Latvia (5.9% and 0.5%). Prevalence of both was particularly high in countries located in North America, Great Britain, and south-western Europe. When both categories were included, Wales was 3rd in rank, England was 7th, Scotland was 11th, and Ireland was 14th. Wales (at 21.5%) was one of only four countries to have a combined prevalence of over 20%. Looking at the prevalence of obesity only England, at 5.1%, was ranked 3rd behind Malta and USA. In most countries, physical activity levels were lower and television viewing times were higher in the overweight group compared with those of normal

weight. The review presented a large amount of data on possible predictors for overweight, and in most countries, physical activity levels were lower and television viewing times were higher in the overweight group compared with those of normal weight. Logistic regression, adjusted for age, gender, whether presently trying to lose weight, and each of the other dietary or physical activity variables, showed no evidence of overweight with the intakes of fruit, vegetables, soft drinks or computer use. In the majority of countries, however, there was strong evidence of an association between both physical activity level and TV viewing time with overweight status, with increased activity being associated with a reduced likelihood of being overweight up to 20% (Austria, OR 0.80; 95% CI 0.76 to 0.85). Austria also had the greatest likelihood of being overweight with increased TV viewing time (OR 1.24; 95% CI 1.16 to 1.33). For England, the OR for physical activity was 0.91 (0.86 to 0.96) and for TV viewing time was 1.11 (1.05 to 1.16). The recommendation was that strategies aimed at reducing overweight and obesity should concentrate on increasing physical activity levels and decreasing TV viewing time.

A review looking at population-based interventions for preventing childhood obesity carried out in school settings and published between 1999 and 2004 included 11 such interventions from the USA and the UK.[115] Most of these were targeted at both physical activity and nutrition behaviours although some focused on only one aspect of behaviour such as the reduction of carbonated drinks. Most measured short-term changes, with somewhat more success in changing attitudes and knowledge than in changing physical attributes such as BMI, body fat, or waist circumference.

A similar review, by the same author and using the same basic inclusion criteria (with the time period lengthened to include papers published in 2005) looked at international (excluding the USA) school-based interventions.[117] Of a total of 21 such interventions, nine targeted nutrition behaviours only, with seven targeting both physical activity and nutrition behaviours. Although the review stated that 16 of the 21 studies had at least a one-year follow-up, no details of length of follow-up for individual studies were given. It is therefore difficult to assess the long-term benefit of any included intervention. Of the nine included UK studies, several had multiple outcomes. Five did not measure obesity or adiposity, one showed no change in overweight or obesity, one showed a 0.2% decrease in overweight and obese children in the intervention group, and 4 showed an increase in fruit and/or vegetable intake.

Using a cluster randomised controlled trial, the effect of reducing the consumption of carbonated drinks on childhood obesity was investigated using a school based education programme implemented over one year.[119] Six primary schools (644 children aged 7-11 years) were randomised to either an intervention or control group. The main objective in the intervention group was to discourage the consumption of both sweetened and unsweetened fizzy drinks with a positive affirmation of a balanced healthy diet. A simple message including the benefits to general well-being and dental health was used in conjunction with a variety of activities including a music competition. All children completed 3-day (two weekdays and one weekend day) diet diaries at baseline and at the end of the intervention period. The trial was said to be blinded to schools or classes (although this is more likely to refer to allocation concealment, given the type of intervention). Some details of the power calculation were given, including an allowance for clustering. Consumption of carbonated drinks over three days decreased by 0.6 (from 1.9 to 1.3) glasses in the intervention group but increased by 0.2 (from 1.6 to 1.8) glasses in the control group. At 12 months the percentage of overweight and obese children increased by 7.5% in the control group compared with a decrease of 0.2% in the intervention group. This suggests that the modest reduction in carbonated drinks was associated with at least a short-term reduction in the number of overweight and obese children.

A three-year follow-up of 434 of the original 644 children showed that one-year benefit of the intervention was not sustained in the longer term.[119] After three years, the prevalence of overweight increased in both the intervention and control groups with no evidence of the difference seen at 12 months. BMI increased in both groups as did waist circumference.

The effect of using a school based intervention to reduce risk factors for obesity was investigated in a cluster randomised controlled trial of 10 Leeds primary schools involving 634 children aged 7-11 years.[121] The trial was adequately powered after allowing for clustering. The intervention comprised the Active Programme Promoting Lifestyle in Schools (APPLES), a programme including teacher training, modification of school meals, and the development of a school action plan targeting the curriculum, physical education, tuck shops, and playground activities. The overall findings indicated that although the programme was successful in producing changes at the school level, it had little effect on children's behaviour other than a modest increase of 0.3 portions per day in the consumption of vegetables.

Conclusion

Prevalence of childhood overweight and obesity is high in the UK, but the very limited evidence suggests that school-based interventions aimed at reducing levels have little long-term effect.

10. Visual acuity (1 study)

A retrospective cohort study using convenience sampling examined the visual acuity (VA) screening results of all primary 1, 4, and 7 children in eight Glasgow primary schools.[184] The 1,384 included children were also asked about their diet and use of display screen equipment (DSE) over the previous 24 hours using a self-complete questionnaire for the older two years. It was found that 21% of the sample had a diet lacking in meat, fruit, vegetables, and milk. The main items in this fifth of the group largely comprised chips, fizzy drinks and sweets. The risk of VA screening failure in this group was increased by 59% (RR 1.59; 95% CI 1.21 to 2.09). The authors suggested that vitamins A and B might be lacking in such a diet, resulting in a VA deficit. However, it was unclear why drinking milk, the main source of retinol in children, was not associated with an increased risk of VA screening failure. This could be due to measurement error, as the question asked was concerned with 'milk drunk' which may not have included milk used on breakfast cereals etc. The authors caution about stating a causal connection between poor diet and VA screening failure from this single study based in a relatively small geographical area.

Conclusion

There is a suggestion that a diet lacking in vitamins A and B may result in VA screening failure, although further work in a wider social population and geographical area is required.

Summary (overall conclusions for the published literature review):

There is evidence that an improved diet in childhood can improve both short and long-term health outcomes and wellbeing. However, the extent to which results from longitudinal studies are relevant to the current population may be somewhat limited. The diet of children and young people often falls below recommended guidelines and some groups may be at particular risk. Food preferences as well as intake appear to be at least partly socially patterned and dietary improvements need to be at least at a family level. A number of barriers to improving young people's diet have been identified and these need to be addressed through improved health education. School-based interventions can have some success in improving diet, although any benefit may not persist over time without continued intervention. Before 2005, school meal provision and consumption were likely to fall well below the nutritional guidelines introduced in 2007, and the nutritional intake of children having packed lunches is likely to be as poor as those having school lunches. In general, the food and nutrient content of both school dinners and packed lunches needs to be improved for any log term benefit.

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