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What is the relationship between child nutrition and school outcomes?

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WHAT IS THE RELATIONSHIP BETWEEN CHILD NUTRITION AND SCHOOL OUTCOMES?

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Executive summary

Introduction and background

Existing knowledge about the relationship between nutrition and educational outcomes in children and the current dietary practices of schoolchildren has led to specific questions about the impact of nutritional intake on the educational experience. The diet of children has risen to the top of the political agenda, not only for the potential health repercussions later in life, but also for its immediate effects on the physical and mental health of children and their consequent school experience and attainment.

In the UK, policies driven by both the Department for Education and Skills and the Department for Health have worked to increase healthy eating in schools. The issue has also become of popular interest due to the *Jamie's School Dinners* television programmes aired in 2005 that raised awareness about the poor nutritional content of school meals and children's preference for foods that are high in calories, fat, sugar and salt.

Arising from this ongoing academic, political and public debate about the aspects of nutrition that impact on school outcomes, the Smith Institute commissioned research to examine the current state of knowledge about the effects of children's diets on their health and education. We report the outcomes of this research in the Department for Education and Skills Research Brief Series due to its relevance to developing educational policy in this area.

Key findings

- There is a complex interrelationship between nutrition, social and economic factors and health and education. Food preferences are affected by social and family factors such as the behaviour of parents and peers, advertising and marketing and practices related to food production and consumption. And, while the constraints of low income create practical barriers to healthy eating, additional socio-environmental factors, such as culture and lack of literacy and education reinforce the effects of deprivation.

- Nutritional deficiencies prior to school entry have the potential to impact upon cognitive outcomes in school-aged and adolescent children. For instance, clinical research has found an association between early life vitamin B_{12} deficiency and reduced scores on cognitive tests in adolescence.

- Children with nutritional deficiencies are particularly susceptible to the moment-to-moment metabolic changes that impact upon cognitive ability and performance of the brain. Treatment with nutritional supplements can result in improved performance. Among the well-nourished, augmentation of nutrient intake has less of an impact on cognitive performance.

- Maintaining adequate levels of glucose throughout the day contributes to optimising cognition, suggesting that nutritional intake should be designed to

sustain an adequate level of glucose and to minimise fluctuations between meals.

- Nutrition, particularly in the short-term, is believed to impact upon individual behaviour, (e.g. concentration, activity levels). These behaviours have the potential to affect school performance and interaction with peers, and to compromise self-esteem. For example, lack of thiamin (Vitamin B) in the diet appears to have causal relationship with behavioural problems in adolescents, such as irritability, aggressive behaviour and personality changes.

- The development of food preferences in children depends on a range of biological and social factors. Therefore, interventions designed to promote healthy eating among children should address all of these factors.

- It is clear that much of the groundwork in cultivating food preferences in children occurs outside school - early in life, before the start of school, and through parenting, advertising and marketing. For example, analysis of longitudinal data found that mothers who reported that they introduced lumpy food to their children before six months were less likely to experience eating difficulties.

- The constraints of low income create practical barriers to healthy eating. However, additional socio-environmental factors, such as lack of literacy and education, and culture reinforce the effects of deprivation.

- Obesity has adverse health implications but there are also important social repercussions of obesity experienced in youth. Stigmatisation and social exclusion in the school environment accompanies overweight status and add further difficulty to an often challenging school experience.

Methodology

We conducted a review of the literature on the relationship between aspects of nutrition and physical health, mental health and behavioural or social outcomes in children. Titles were sourced through a snowballing method that began with searches of journal databases and websites, and advice from professionals working in the field of nutrition. The search produced a wealth of literature from a range of professional disciplines, including medicine, public health, sociology and psychology. An initial review of the literature informed the construction of a conceptual model outlining both the established direct and indirect effects of child nutrition on school outcomes.

We did not limit our review to those studies using experimental methods or even to large sample quantitative analyses. Rather we intended to describe and summarise the general findings of the broad range of existing studies that were of use in the development of a conceptual model for understanding the importance of nutrition for child development and for considering the policy implications of this. The review was not intended to be systematic in terms of its assessment of the precise effect size and is therefore distinct from the forthcoming systematic review conducted by the Food Standards Agency. That study will apply different selection criteria to their review of the literature, including only those reports which meet specific, scientific standards of

causal robustness of the kind required and appropriate for a meta-analysis. This reflects the different purposes of the two reviews: here we do not aim to measure specific effects, nor provide an exhaustive account of the literature published in the area, but rather to provide a conceptual review of the relevant research in child nutrition that indicates potential for impacts on school outcomes in order to offer information about how, why and when nutrition may matter and what the implications may be for policy. We leave the assessment of the robustness of the effect of nutrition upon cognitive development to others.

Findings

The importance of nutritional intake for health outcomes has been established. Deficiencies in dietary intake are precursors to disease and illness that impact upon morbidity and mortality. Additionally, the timing, frequency, content and quality of food eaten is related to developmental, cognitive and behavioural outcomes that influence quality of life. This is particularly important in childhood, not only for the potential developmental impacts, but also for other experiences, such as school life.

There is a complex interrelationship between nutrition, social and economic factors and health and education. Food and taste preferences are determined in part by biological and genetic predisposition, but social and family factors such as the behaviour of parents and peers are also strong influences. This is particularly true for young children. Dietary behaviours may also be affected by other social and cultural factors relating to food such as advertising and marketing and practices related to food production and consumption – for instance whether food is consumed while watching television. And, while the constraints of low income create practical barriers to healthy eating, additional socio-environmental factors, such as culture and lack of literacy and education reinforce the effects of deprivation. These factors influence both short- and long-term outcomes for children directly and indirectly. For instance, in the short-term poor diet may contribute to a negative experience of school. These experiences have significance as an indicator of, and probable contributor to, likely adult health outcomes, as other Centre for Research on the Wider Benefits of Learning research has shown. Although the precise timing and magnitude of these effects is not clear, acknowledgement of the associations is important for further research and policy formulation.

The research highlights the importance of the early years: not only do nutritional deficiencies prior to school entry have the potential to impact upon cognitive outcomes in school-aged and adolescent children, but much of the groundwork in cultivating food preferences in children is laid early in life – generally before the start of school.

Nutritional effects on cognition may operate in different ways and to different degrees:

- Children with nutritional deficiencies are especially vulnerable to changes in metabolism that impact upon cognitive ability and performance of the brain. Evidence has shown that treatment with nutritional supplements can improve performance. Though among well-nourished children the impact is less pronounced.

- Maintaining adequate levels of glucose throughout the day contributes to optimising cognition. These findings have implications for the appropriate timing of meals and snacks through the school day.

There are also nutritional effects which may affect not only performance but participation and engagement at school:

- Poor nutrition may also result in decreased immunity and greater susceptibility to infectious disease. This in turn has the potential to lead to increased levels of absence from school through ill health.

- Nutrition, particularly in the short-term, is believed to impact upon individual behaviour. In its more extreme form this may manifest itself through the presence of developmental disorders, including attention-deficit-hyperactivity disorder (ADHD), dyslexia, dyspraxia and autistic spectrum disorders. The relationship between diet and ADHD has gained a lot of attention in the last decade. Children diagnosed with ADHD suffer from difficulty concentrating, sitting still and being quiet and tend to have short attention spans. These behaviours have the potential to affect school performance and interaction with peers, and compromise self-esteem.

- Obesity should be prevented for its health implications but there are also important social repercussions of obesity experienced in youth. Stigmatisation and social exclusion in the school environment may accompany overweight status and add further difficultly to an often challenging school experience.

Recommendations

Given that children's diet depends not only on the availability of foods but, crucially, on their preferences and that these are largely developed early in life, any effective interventions must address the multiple determinants of children's preferences for particular foods. In particular, the role of parents is important and there may be a need to adopt a collaborative approach between schools and parents to address children's nutritional choices. There is an opportunity to capitalise on initiatives such as the extended schools policy, which have created an opportunity for schools to engage with parents and local communities, to improve diets and promote healthy eating among children.

Linking to the National Healthy Schools Standards, schools can advance children's understanding and valuation of healthy eating and provide them with examples of good diet. However, research on children's conceptualisation of food categories suggests that in developing interventions to improve diets, imposing adult notions of nutrition may not be useful. It may be more effective for curricula to be developed that incorporate children's understandings of nutrition and thus be more likely to encourage change.

It is also important to realise the influence of the media on children's eating patterns and conceptions of food. While this cannot be addressed directly by education policy, the design of educational policy interventions and curricula addressing the issue of food need to take it into account.

Institutions have already acknowledged the importance of breakfast by creating breakfast clubs in schools and developing health promotion campaigns that encourage students to eat in the morning. It may be appropriate to consider other changes, for example, to the structure of the school day, to improve the maintenance of glucose levels and promote better cognition among students.

Conclusions

The effects of the development of preferences for, and intake of, foods of poor nutritional value early in life can have long-term health implications. Ultimately, the aim must be to prevent such deficiencies from arising, but the relationships between nutrition, health, education and social and cultural factors are complex and multi-directional and we do not fully understand the nature of the interactions between these factors. Nonetheless there is evidence that appropriately designed interventions can help to address early deficiencies and engage both children and parents in healthy eating. The challenges faced in improving the nutritional intake of children in the UK call for a collaborative approach to addressing this issue. A concerted effort between schools, families, government departments and other agencies is necessary to improve children's nutritional intake inside and out of school.

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1. Introduction

Nutrition is related to five of the ten leading risks as causes of disease burden measured in DALYs (Disability Adjusted Life Years)[1] in developed countries *i.e.* blood pressure, cholesterol, overweight (obesity), low fruit and vegetable intake, and iron deficiency (WHO, 2002). The above measurements of health indicate the biological relationship between nutritional intake or diet and physical health outcomes. These risks are precursors to disease and illness that impact upon morbidity and mortality (Must, 1996; Pinhas-Hamiel *et al*., 1996). However, the timing, frequency, content and quantity of food eaten are additionally related to developmental, cognitive and behavioural outcomes that influence quality of life.

The importance of managing diet for adults is frequently addressed and has historically been the focus of public health initiatives. Recent research has highlighted the importance of addressing diet in childhood and adolescence, as the precursors to disease have been traced back to very early in life warranting public health attention (Must, 1996; van Kries *et al*., 1999; Freedman *et al*., 2001; Pinhas-Hamiel *et al*., 1996; Wanless, 2004). As such, the diet of children has risen to the top of the political agenda, not only for the impact nutritional intake has for health outcomes later in life, but also for the immediate implications for the physical health, mental health, and overall wellbeing of children.

1.1 Current debate on school dinners

In early 2005, celebrity chef Jamie Oliver appeared in a television series documenting his visits to elementary schools throughout the UK to learn about the nutritional content of school meals and to improve what children were eating for school dinners (Channel 4, 2005). Nearly half of children and young people in England and Wales use the school meals service (Crawley, 2005). The programme, *Jamie's School Dinners,* was successful in raising awareness about the poor nutritional content of school meals and also students' preferences for foods that are high in calories, fat, sugar and salt. Since the programme aired, nearly every day a new article, paper or press report emerges discussing the effects of food on aspects of the health of children in the UK (example BBC 5 April, 2005).

Through the course of the television programme, Jamie Oliver attempted to introduce healthier foods to the schools and the students. The challenges he faced in this endeavour pushed the issue of children's health and diets to the forefront of public debate and prompted a policy reaction. The search for solutions to improve the diets of young children highlighted the complex nature of the problem and the need for many-sided solutions.

The content of the children's school meals proved to be only an indication of wider issues of diet and nutritional intake for children around the country. It was not merely a question of changing the food served in school. The children resisted eating the healthier foods introduced through the programme and in many cases were supported

[1] The disability-adjusted life year is an indicator of the time lived with a disability and the time lost due to premature mortality (World Bank).

by their parents. The true challenge appeared to involve cultivating healthier dietary preferences in young children and their families.

The *Jamie's School Dinners* programme raised questions about the impact of unhealthy diets on the wellbeing of our children. The television programme focused specifically on food served in schools. Thus, questions about the relationship between foods consumed around and during time spent in school and the educational experience easily follow. This paper reviews how nutrition affects educational and school outcomes for children.

1.2 Policy context

The connection between health and learning has become an important issue internationally. During the 1990 World Conference on *Education for All: Meeting Basic Learning Needs* the focus on education shifted from an emphasis on developing infrastructure to a focus on addressing the process of learning and the needs of learners. Among other factors, health and nutrition came to the forefront. Although much of the focus has been on the needs of students in developing countries, many of the points addressed were applicable in more developed contexts. At this conference, it was substantiated that "…to learn effectively, children need good health…" (Vince-Whitman, 2001).

The nutritional status of children in the United Kingdom, and in fact in Europe, has become a major topic for debate in recent years (Lambert *et al*., 2004). In the United Kingdom, the Public Health White Paper, *Choosing Health: Making Healthy Choices Easier*, released by the Department of Health in 2004 listed several overarching priorities, many of which included a focus on improvement of health outcomes related to nutrition. In response to the increase in child and adult obesity of the past ten years, the Department of Health set out to focus on "reducing obesity and improving diet and nutrition" (Jotangia *et al*., 2005; Department of Health, 2004).

For example, in *Choosing Health*, the Department of Health specifically set out to address food promotion to children. In 2005, the Food and Drink Advertising Forum was established including members of a number of UK stakeholder agencies. If current efforts fail to shift the balance of food promotion to children toward healthier options by 2007, the government is open to introducing legislation that would limit the advertising and promotion of foods that are high in fat, salt and sugar content in both broadcast and non-broadcast media, in schools and on packaging (Department of Health, 2006).

The school setting is also set to be a central location for many of the interventions designed to address nutrition and health for children. The Department for Education and Skills and the Department of Health collaborated to develop the National Healthy Schools Standard designed to assist schools in developing and maintaining healthy learning environments as part of the government's goal to reduce health inequalities and promote social inclusion and school standards. The Health Development Agency has taken initiative to address health problems, such as obesity, through children's education institutions by employing a "whole-school" approach that encourages changes in attitudes towards, for example, the consumption of fruits and vegetables,

among students, staff, families and communities (Department of Health, and Department for Education and Skills, 2006).

The Department for Education and Skills has implemented a number of interventions starting September 2005 and for the next three years to address eating in schools. Below are some examples:

- £220 million new funding grants to schools and Local Education Authorities (LEAs) to improve school meals.
- School Meals Review Panel was established in May 2005 to advise the revision of existing minimum nutrition standards for primary and secondary schools to reduce consumption of fat, salt and sugar and increase intake of fruits and vegetables.
- Minimum nutrition standards rolled out to primary and secondary schools from September 2006.
- School Foods Trust set up to provide independent support and advice to Local Authorities and schools to improve the standard of school meals and other food provided in schools.
- Plans to enable parents to work with schools and the School Foods Trust to improve the quality of children's school meals.
- Ofsted to review a school's approach to healthy eating as part of regular school inspections.
- New guidance for schools and LEAs on drawing up catering contracts to source healthy school meals' services and healthy food in vending machines and tuck shops, or breakfast clubs.
- New qualifications to meet the skills needs of all kitchen staff, from the basics of hygiene and nutrition through to food preparation and cooking.
- New or upgraded school kitchen facilities where fresh produce can be prepared and served will be prioritised in current school rebuilding and refurbishment programmes.

(Department for Education and Skills, 2005)

Above we have only touched on some of the activities taking place around nutrition for children and focussed mostly on work being conducted through the DfES and in England; however several other projects and programmes have been conducted, planned or are underway through other government agencies (e.g. Ofsted, 2006; Valentine and Jupe, 2004). Individually and collaboratively, government institutions are developing strategies for addressing children's dietary intake within and around the school environment. Child nutrition has become a central policy issue prompting action and further research.

1.3 Research question

Given the current situation with regard to children's nutrition and the efforts of the UK Department for Health and Department for Education and Skills to improve nutrition in schools, a question arises regarding the relationship of nutrition, not only to short- and long-term health outcomes, but to the impact of those short- and long-term outcomes on the potential for attainment and experience in school. This review attempts to address the following research questions:

- How does nutrition impact upon health outcomes in children?

- How can the health outcomes that manifest as a result of nutrition impact upon school life experiences and outcomes?

We conducted a review of the literature on the relationship between aspects of nutrition and physical health, mental health and behavioural or social outcomes in children. Titles were sourced through a snowballing method that began with searches of journal databases and websites, and advice from professionals working in the field of nutrition. The search produced a wealth of literature from a range of professional disciplines, including medicine, public health, sociology and psychology. An initial review of the literature informed the construction of a conceptual model outlining both the established direct and indirect effects of child nutrition on school outcomes.

2. What is nutrition? Setting out a conceptual framework

> "Nutrition is a fundamental pillar of human life, health and development across the entire life span. From the earliest stages of foetal development, at birth, through infancy, childhood, adolescence, and into adulthood and old age, proper food and good nutrition are essential for survival, physical growth, mental development, performance and productivity, health and well-being. It is an essential foundation of human and national development." (WHO, 2000)

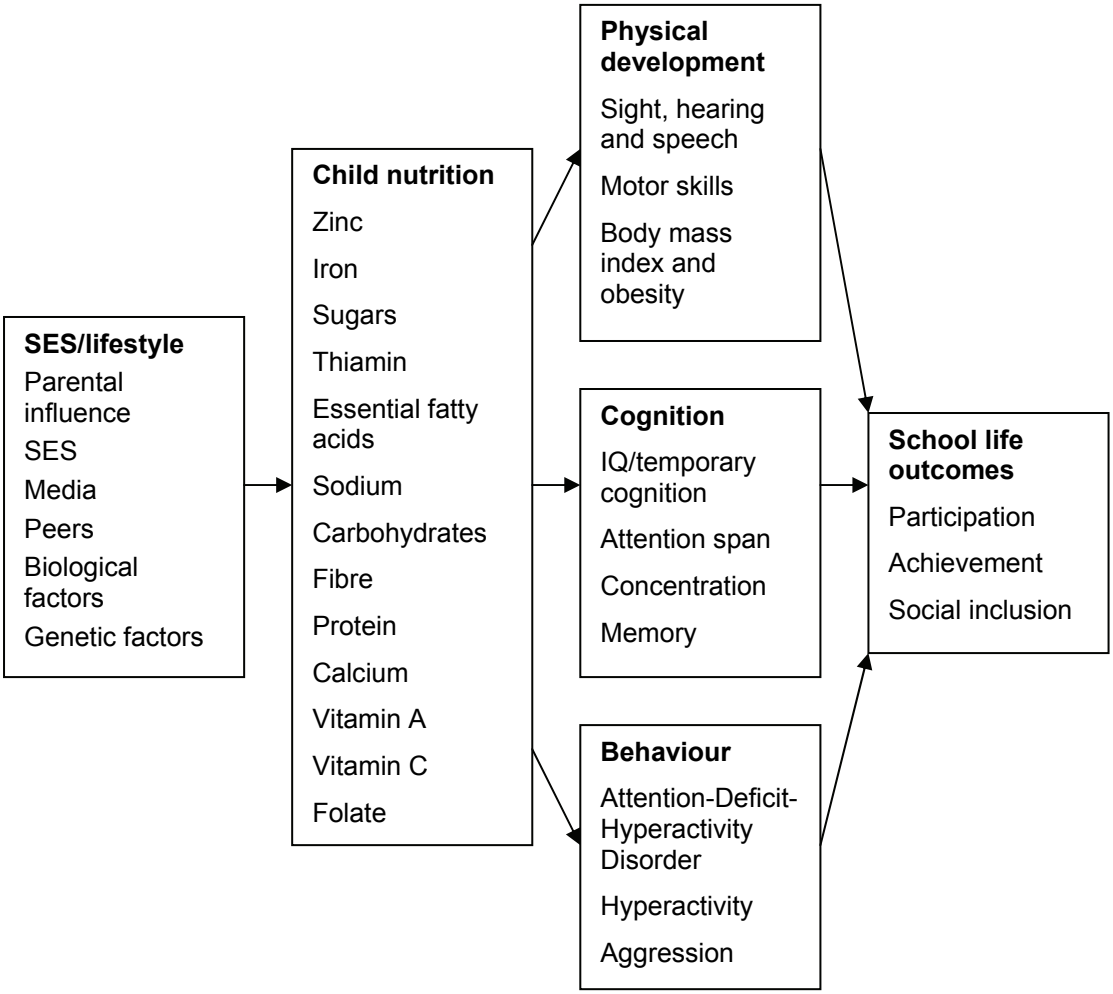
The World Health Organization views nutrition as a fundamental human right that supports and influences every stage of life, at every level of being. It is within this broad context that the relationships between health outcomes, nutrition and school life are viewed. There are several potential impacts of diet on learning. One objective of this project was to narrow and identify specific relationships for further consideration.

The search for answers to the research questions set out in section one produced a wealth of literature which addressed distinct although related issues. In addition, we found studies that considered the impact of various specific nutritional deficiencies or excesses on physical health, cognitive development and behavioural outcomes. Some research sought to locate the precursors to child nutrition, naming parental influences, socio-economic status, peers and the media and genetic and biological factors as collectively responsible for cultivating food preferences in children. These preferences ultimately determine how and what children consume; though, research on changing eating patterns demonstrates that preferences may be altered through targeted intervention. There is evidence that diet has a number of consequences for health and wellbeing.

For the purposes of this report, the outcomes that were considered were chosen for their potential impact upon school outcomes. Thus, this section of the review was limited to those implications that were most likely to impact upon participation, achievement and social inclusion. The literature discussed here focuses on the impact of nutrition on physical outcomes, such as sight, hearing and speech, body mass index and obesity and the development of adequate motor skills. In terms of cognition, research that considered the impact of nutrition on short- and long-term cognition, intelligence, attention, concentration and memory was included. The adverse behavioural consequences to nutrition include a number of disorders including attention-deficit-hyperactivity disorder (ADHD) which impairs the ability to sit still and complete tasks. Although touched upon in various sections, for example the discussion on obesity, this report will not focus on health outcomes such as cardiovascular health as it does not directly impact upon school outcomes. However, by omitting research on such outcomes, we are not underestimating their importance.

Separately and in combination, these outcomes have the potential to impact upon a student's ability to perform in school and to ostracise those who are unable to conform. It is through this view that the following review is constructed.

Figure 1: Conceptual model of the relationship between nutrition and school life outcomes



2.1 What nutrients do children need?

There are a number of nutrients that individuals, particularly the young, need to ensure proper development and health (see the Appendix). Children in the UK are falling short of meeting some of their daily nutritional requirements (Scientific Advisory Committee, 2005). The basis for the nutritional requirements for children and adolescents is debated. In fact, some researchers propose moving to measures such as the "functional effects" of food and concepts such as optimal nutrition, which take into account the prevention of particular negative health outcomes (Aggett, 2004).

Generally, it is the management and optimisation of nutrients that amounts to a healthy diet. In fact, there are no "bad" foods, only badly managed diets. For example, in an investigation of the relationship between the percentage of energy from fat and nutrient intakes in young children, researchers found that the amount of energy consumed from fat had a negative effect on the intake of other nutrients such as zinc, retinol, iron and vitamin C (Rogers *et al*., 2002).

Below is a summary of nutrients traditionally considered important in certain amounts for a healthy diet (British Nutrition Foundation, 2005).

Zinc
Zinc is found in protein-rich foods such as meat, shellfish, dairy products, bread and cereals. It is found to help with the production of new cells and enzymes. It helps process protein, fat and carbohydrates and with the healing of wounds. However, excess zinc can lead to anaemia and weakening of bones.

Iron
Iron is found in liver, meat, beans, nuts, dried fruit, whole grains (brown rice), soybean flour and dark leafy vegetables, for example spinach. Iron helps with the production of red blood cells that carry oxygen around the body.

Sugars (glucose/sucrose)
Sugars, such as sucrose, fructose, and maltose, are naturally found in fruit and milk, but are added to many other manufactured foods.

Carbohydrates
Carbohydrates are found in sugars and starch and are a major source of energy. In terms of sugars there are two types: extrinsic, not part of the cellular make-up of a food, e.g. table sugar, honey; and intrinsic, part of the cellular make up of the food, e.g. in whole fruits and vegetables. Starch can be found in items such as potatoes and bread.

Thiamin (Vitamin B1)
Thiamin is found in pork, vegetables (especially peas), milk, cheese, fresh and dried fruit, eggs, whole grain breads and some breakfast cereals. It helps to break down and release energy from the food that we eat and also helps to maintain nerves and muscle tissue.

Essential fatty acids
There are two categories of essential fatty acids: unsaturated fat found in oily fish, avocados, nuts and seeds, sunflower and vegetable oils; and saturated or trans-fat, found in meat, cheese, butter and pastry. Essential fatty acids help the body to absorb vitamins and are also a source of energy. However, too much fat, particularly saturated and trans-fat, leads to weight gain and increased cholesterol in the blood that leads to heart disease.

Sodium chloride (found in salt)
The amount of sodium needed can easily be obtained from a healthy diet. Too much can raise blood pressure, potentially leading to heart disease and stroke.

Fibre
Fibre is a type of carbohydrate found in plants and is important for digestion.

Protein
Protein is essential for growth and repair of the body. The main sources of protein include meat, fish, eggs, milk, cheese, cereals and cereal products (e.g. bread), nuts and pulses (beans and lentils).

Calcium
Calcium is mainly important for the development and maintenance of bones and teeth. The primary source in the UK is milk, cheese and other dairy products.

Vitamin A (Retinol)
Vitamin A is important for the function of the skin and mucous membranes. It is also essential for vision and the immune system. It is related to cell differentiation and thus is crucial for growth and development. Vitamin A is normally found in liver, milk, cheese and butter, and can also be found in vegetables such as carrots and leafy vegetables.

Vitamin C
Vitamin C is responsible for the formation of connective tissue found in skin, cartilage and bone and is thus part of the healing process from injury. It is also implicated in the development of blood vessels and in neurological function. It is mostly found in fruits and vegetables, but can also be sourced in milk and liver.

Folate
As with Vitamin A, Folate is important for normal cell division that preludes growth and development. It is also partly responsible for the formation of blood cells. Folates are found in liver, yeast extract, orange juice and green leafy vegetables.

Nutritional requirements vary between individuals and at different stages in the life course. For example, they vary with age, gender and state of health. Individual requirements depend not only on how much of a particular nutrient the respondent needs to successfully digest, but also on their ability to absorb and make use of each type of nutrient. Thus, a range of suggestions are published for required nutritional intake for various populations (British Nutrition Foundation, 2005).

3. Effects of nutrition

It is difficult to discuss the effects of nutrition on physical, cognitive and behavioural development separately, as nutritional outcomes typically cut across several areas of maturation. However, for the purposes of this report, discussion of the implications or effects of nutrition will be discussed individually to allow for closer analysis of the outcomes and the illumination of more precise pathways, which we hope will be useful for policy development. Sections 3.1 to 3.4 focus on the impact of nutrition on: physical development, with an emphasis on the growing epidemic of obesity; cognition; behaviour; and school life. Each section points out areas that are prominent in research and are of current policy concern, but is not exhaustive.

3.1 Nutrition and physical development

This section is the most challenging to tease away from other nutritional outcomes. Physical development is mediated by cognitive development as, generally, nutritional deficiencies first affect the brain then manifest in physical outcomes. However, there are a number of specific areas in physical development where diet is one of the main influences of outcomes.

3.1.1 Sight, hearing and speech

Throughout this report, the importance of sufficient intake of highly unsaturated fatty acids (HUFAs) is apparent. HUFAs are important for many areas of physical development, particularly cardiovascular health and immunity. However, sources of HUFAs, such as oily fish, are lacking in Western diets. Deficiencies are implicated in a number of neurodevelopmental disorders (Richardson and Puri, 2002).

Recent evidence points to a link between essential fatty acid deficiency and a range of common developmental disorders, including ADHD, dyslexia, dyspraxia and autistic spectrum. In a randomised controlled trial with 102 dyslexic 8 to 12 year olds, six months of treatment with fatty acid supplements significantly improved reading age on standardised tests of single word reading (Richardson, 2004). A further trial, testing the efficacy of HUFA supplements in improving ADHD related problems (including dyslexia) among 41 children also demonstrated considerable benefits (Richardson and Puri, 2002).

3.1.2 Motor skills

As mentioned above, dyspraxia, or developmental coordination disorder, and other overlapping neurodevelopmental disorders are associated with highly polyunsaturated fatty acid deficiency. Dyspraxia affects approximately 5 per cent of school-aged children and results in impairments of motor function, independent of general ability (Richardson, 2002). Dyslexia and dyspraxia share many common characteristics. Both manifest difficulties with spelling, handwriting and written expression. Additionally, ADHD and dyspraxia are implicated in deficits in attention and poor motor control and coordination (Richardson, 2002). Research in Durham, UK with 117 children between the ages of 5 and 12 diagnosed with dyspraxia found marked improvements

in reading, spelling, and behaviour after 3 months of dietary fatty acid supplements, but no effect on motor skills (Richardson and Montgomery, 2005).

3.1.3 Skeletal development

Bone density in youth can determine vulnerability to osteoporosis and fractures in old age. Development in adolescence is the final opportunity to improve bone density before consolidation of the skeleton. Bone density is affected by a number of factors including nutrition. Analysis of cross-sectional data of about 1200 adolescents in Northern Ireland found that high intake of fruits was significantly related to elevated bone density in 12-year old girls even when controlling for potential confounders. As women are more susceptible to osteoporosis, this finding presents a cost-effective public health opportunity for reducing vulnerability to the disease later in life. (McGartland *et al*., 2004).

3.1.4 Body mass index and obesity

Obesity is the most frequently occurring nutritional disorder among children, and is a major risk factor for cardiovascular disease in adulthood (van Kries *et al*., 1999; Freedman *et al*., 2001). Obesity occurs when energy is consumed in excess of what the body can use. To measure obesity the Body Mass Index (BMI), weight (kg) divided by height squared (m^2), is determined. In the UK, a National BMI percentile classification is used to describe childhood overweight and obesity. Using this classification, a measurement of BMI above the 85 percentile corresponds to overweight and above the 95 percentile is defined as obese (Jotangia *et al*., 2005). However, internationally acceptable measures that take into account cut-off points widely used in determining overweight and obesity in adults are being developed for children (Cole *et al*., 2005).

British children have grown in size in the past decade. In England, between 1995 and 2003, the prevalence of obesity among children aged 2 to 10 rose from 9.9 to 13.7 per cent. The proportion of children aged 2 to 10 who were classified as being overweight (including those who were obese) increased from 22.7 per cent in 1995 to 27.7 per cent in 2003 (Jotangia *et al*., 2005). This trend matches international patterns where levels of obesity are rising among children, in many cases before they reach elementary school (age 6) (Yoshinaga *et al*., 2004).

As with adults, improvements in technology that have reduced the cost and time needed to prepare meals and increased engagement with sedentary work and activities have increased calorie consumption and reduced calorie expenditure. This phenomenon is the main explanation for the rise in overweight and obesity in industrialised countries, such as the UK (Propper, 2004).

Overweight and obesity in childhood has a number of adverse short-term and long-term health implications. Contrary to common belief, many of the effects of childhood obesity are observable in youth. A review conducted by Must and Strauss (1999) listed several immediate consequences including the development of gallstones, sleep apnoea and increased intercranial pressure. They state that young obese women experience a change in hormone development that delays menarche. Additionally, 20-

30 per cent of obese children between the ages of 5 and 11 have increased blood pressure.

Central fatness is a measure of adiposity linked to the determination of cardiovascular disease. In a cross-sectional study that considered data on over 1800 British children between 1987 and 1998, researchers found a significant increase in central fatness over the time period. When compared to a measure of overall adiposity, it appears that a higher proportion of the fat increase is a result of central deposits rather than peripheral fat deposits, which has implications for health outcomes, particularly cardiovascular risk factors (McCarthy *et al*. 2005).

A rise in non-insulin-dependent diabetes amongst young people appears to be accompanying the international rise in obesity. Non-insulin-dependent diabetes has traditionally been rare among young people; however, recent measurement in Western countries indicates an increase and is causing public health concern. Obesity is implicated in the development of insulin resistance limiting the body's ability to absorb glucose (Hannon *et al*., 2005). Research in the United States found that among adolescents (n=1027) presenting at a large city hospital between 1982 and 1994 a 10-fold rise in this form of diabetes was detected, particularly among the obese (Pinhas-Hamiel *et al*., 1996). Children who develop diabetes at an early age are susceptible to further complications later in life, such as stroke, myocardial infarction, renal insufficiency and chronic renal failure. While still in their youth, children with diabetes require intervention from medical professionals to manage the disease and are also vulnerable to complications (Hannon *et al*., 2005).

Recent evidence suggests that a child's early life environment can determine their later risk for obesity (Reilly *et al*., 2005). Early reduction of overweight and obesity can improve outcomes later in life. Viner and Cole (2005) recently found that obesity limited to childhood has little impact on socio-economic, educational, social, and psychological outcomes in adult life.

In addition to the physical health implications for overweight and obesity, there are a number of important social and psychological implications discussed later in this report.

3.2 Nutrition and cognition

Diet has an impact on children's ability to think in the short- and long-term. A recent review of research on the effects of deficiencies in zinc, iodine, iron and folate on the cognitive development of school-aged children highlighted the significance of nutrition in the post-infancy period. For example, deficiencies in iron and zinc have been associated with impairment of neuropsychologic function, retardation of growth and development, reduced immunity and increased vulnerability to infectious diseases (Sandstead, 2000). Tests on animals suggest that zinc deficiency reduces the ability to concentrate and memorise. During periods of rapid growth, as in early life, zinc deficiency has additionally been associated with increased emotional responses to stress and impaired motor activity (Bryan *et al*., 2004).

Iodine helps the body to synthesise thyroid hormones. These hormones are required for brain development during foetal and early postnatal life. Deficiencies accompany low visual-motor performance, motor skills and, perceptual and neuromotor abilities and low development quotients on intelligence tests. Iodine deficiency is considered one of the major preventable causes of brain damage and mental retardation (Delange, 2000).

It appears that sufficient B vitamin intake early in life is important for the development of the central nervous system and thus later cognition. A recent review collated research on the relationship between B vitamins, particularly folate, and cognitive performance. According to the review, much of the research conducted in this area has been with adults and adolescents. Clinical research has found a connection between early life vitamin B_{12} deficiency and reduced scores on cognitive tests in adolescence. Another example, from cross-sectional research with adults, found a positive association between low folate intake or status and cognitive performance, particularly memory (Bryan *et al*., 2004).

Omega-3 Polyunsaturated Fatty Acids (PUFAs) found in fish, grain, poultry and eggs have been found to have a number of health benefits, particularly in brain functioning. Western diets are low in omega-3 PUFAs and children consuming less than adequate amounts of the nutrient may be compromising their cognitive development. Most of the research in this area has been conducted among pre-term and low-birth weight infants. In their review, Bryan and colleagues (2004) discussed studies that have found relatively poor scores on tests for visual and cognitive performance among infants related to omega-3 deficiency. The authors report that there have been few studies on the link between PUFAs and cognitive performance in children. However, there are implications for behavioural development, which are discussed later in this report (Bryan *et al*., 2004).

Protein-energy malnutrition refers to the combination of nutritional deficits and infections. Iron deficiency indicates a depletion of stores of iron in the body. Both are developmental risk factors that are prevalent among low-income children in developed countries. Such malnutrition in early life impacts upon cognitive and behavioural development. Experiments on the ability of nutrition interventions to improve the performance of stunted or malnourished children on mental and motor development tests have been successful. After allowing for socio-economic and schooling factors, young undernourished children benefited from nutritional supplements, more so than healthier children from higher socio-economic backgrounds (Pollitt and Gorman, 1994).

A theme running through the above studies is that deficiencies early in life have the potential to impact upon cognitive outcomes in school-aged and adolescent children. Therefore, appropriate early childhood diets are important, if not crucial, for later school outcomes.

The key point emerging from this research is that the cognitive ability and performance of the brain is susceptible to moment-to-moment metabolic changes and that this is more pronounced in children with low nutritional status. Further, that among the well-nourished, augmentation of nutrient intake has less of an impact on cognitive performance.

3.2.1 Glucose and the importance of breakfast

The supply of glucose to the brain impacts upon memory and mood. Benton's (2001) research suggests that when engaging in cognitively demanding tasks, such as schoolwork, repeated supplies of glucose to the brain enhances cognitive functioning and improves memory and mood. In 2004, Bellisle published a review on the effects of diet on behaviour and cognition in children. The paper drew together a wealth of research on the short- and long-term effects of nutritional composition and meal pattern on children. Research on the immediate effects of glucose on cognition demonstrated that the brain appears to be sensitive to short-term fluctuations in supply. In research on the impact of fasting on cognition, both well- and under-nourished 9 to 11 year olds (n=71) were tested for the effects on memory and attention. Pollitt and colleagues found that an overnight and morning fast among schoolchildren had deleterious effects on memory and attention (Pollitt *et al*., 1998; Pollitt and Gorman, 1994).

The notion that whether breakfast is eaten in the morning impacts upon cognitive abilities later in the day is familiar. Research on the effects of breakfast on cognition shows that, particularly for younger children, skipping breakfast can have adverse effects on both general energy-levels and cognition of school children (Bellisle, 2004). Three experiments testing the effect on memory and mood found that consuming breakfast resulted in better scores on three different types of memory tests. In 1998, Benton and Pearl reported on the results of these experiments, which were conducted with university students in Wales. In the first experiment, 33 students were randomly allocated to either fast from 7pm the previous evening or to eat normally in the evening and consume a glucose drink for breakfast before taking a series of tests for memory. The results showed that the students who fasted took longer to complete the memory tests than those who consumed the breakfast drink. During this experiment, blood glucose levels were measured for each student. Later analysis found a correlation between blood glucose levels and performance on the memory test regardless of whether breakfast was consumed, indicating that individual variation in the ability to maintain an optimal glucose level is also important for cognitive ability.

The second experiment aimed to pinpoint a causal relationship between glucose level and memory that controlled for individual ability to maintain optimal glucose levels. Here, Benton and Pearl allocated 80 undergraduate women to four groups: those who ate breakfast and consumed a glucose drink; those who ate breakfast and consumed a placebo drink; those who fasted and consumed a glucose drink; and those who fasted and consumed a placebo drink. Allocation to a breakfast eating or non-breakfast eating group was determined by the woman's normal eating pattern. After undergoing a series of tests for memory, those who did not have breakfast benefited from consuming the glucose drink. In the other group, eating breakfast improved cognitive performance whether the glucose drink was consumed or not, additional glucose provided no added benefit (Benton and Pearl, 1998).

The third of these experiments tested for the effect of breakfast on memory and intelligence. The researchers separated over 180 university students into the same groups used in experiment two before they underwent a series of memory and intelligence tests. Similar to the findings of the above experiments, having breakfast or a glucose drink in lieu of breakfast improved performance on tests for memory.

However, increased glucose levels through breakfast or consuming the drink did not appear to impact upon the performance test for intelligence. The findings suggest that breakfast affects the ability to retain new information, but is not related to intelligence (Benton and Pearl, 1998).

When summarising the effects of glucose on cognitive ability, it seems the overriding point is the value of keeping adequate levels of glucose throughout the day to optimise cognition. The implications of these findings suggest that nutritional intake should be designed to sustain an adequate level of glucose and to minimise fluctuations between meals (Bellisle, 2004).

3.3 Nutrition and behaviour

3.3.1 Attention-deficit-hyperactivity disorder (ADHD) and hyperactivity

The relationship between diet and attention-deficit-hyperactivity disorder (ADHD) has gained a lot of attention in the last decade. Children diagnosed with ADHD suffer from difficulty in concentrating, sitting still and being quiet and tend to have short attention spans. These behaviours have the potential to affect school performance and interaction with peers, and compromise self-esteem.

As part of a review on the relationship between nutrition and behavioural and cognitive outcomes, Bellisle (2004) assembled research on the link between hyperactivity and sugar intake. Observations led to the suspicion that the intake of sugar and food additives might be related to the occurrence of the disorder. But experimental research disproved any theories on this relationship. Studies dating back to the 1970s suggested that when sucrose (sugar) was removed from children's diets, their behaviour improved; however, many of these studies lacked rigour and later, more thorough experiments produced opposing results. One explanation for the observed relationship is reverse causality – that very active children need more energy and thus are likely to have high intakes of sugar (Bellisle, 2004).

In her review, Bellisle (2004) reported on the 1977 experiment by Feingold testing the hypothesis that hyperactivity resulted in children as a reaction to food additives, e.g. artificial sweeteners, artificial colours and preservatives typically prevalent in manufactured foods and drinks. He formulated a diet regimen that eliminated all additives, though results from his studies were inconclusive. Repeat experiments also failed to demonstrate a link between additives and hyperactivity.

However, research on the impact of long-chain polyunsaturated fatty acids in children with ADHD points to an inverse relationship between intake and development of the disorder (Burgess *et al*., 2000).

3.3.2 Other behaviours

Bellisle (2004) also summarised Benton's work on lack of thiamin (Vitamin B) in the diet and its causal relationship to behavioural problems in adolescents, such as irritability, aggressive behaviour and personality changes.

Research on the relationship between zinc deficiency and behavioural outcomes has typically been conducted with animals. In studies with human populations, research during stages of rapid growth, infancy and adolescence is limited. However, observational studies suggest that dietary zinc, along with other nutrients, is related to behaviour and activity level in the classroom (Golub *et al*, 1995).

From the studies reviewed for this report it appears that, although the relationship between nutrition and behavioural outcomes has historically been an important area for research, there are limitations on what is understood due to lack of research with humans, a dearth in rigorous experiments with infants and children and conflicting evidence. Nevertheless, what is known provides further support for the importance of managing diets to optimise school outcomes.

3.4 Nutrition and school life

The effects of dietary intake upon physical development, cognition and behaviour have implications for school life. The following section considers some of the direct and indirect outcomes related to nutrition.

3.4.1 Achievement

Iron deficiency in infancy can cause developmental problems in the central nervous system that later impact upon cognition. Research in the United States found that of 5398 children between the ages of 6 and 16, lower standardised math test scores were found among those with iron deficiency. Children deficient in iron were twice as likely to score below average on math tests even after allowing for potential confounders and this finding was more pronounced among girls (Halterman *et al*., 2001).

3.4.2 Social inclusion

Recent research in the US using data from the Third National Health and Nutrition Examination Survey (NHANES) (1988-1994) found an association between a history of school suspension and low serum total cholesterol[2] among 4852 non-African American children aged 6 to 16. This association remained after controlling for known confounders, such as cognitive and academic performance and nutritional status. As school suspensions are typically ordered in response to aggressive behaviours, these results support previous research with adults that demonstrated a link between low serum cholesterol and aggression (Zhang *et al*., 2005).

3.4.3 Social inclusion and obesity

The short-term consequences of obesity are more often psychosocial than physical (Must, 1996). Self-esteem and peer-acceptance are related measures of perceived and actual engagement with society and high ratings of both are assumed to be universal desires that are particularly important in youth. These measures of social inclusion are often initially tested in the school environment. Overweight and obesity are often seen

[2] The sum of all cholesterol in a person's blood.

as undesirable conditions, particularly among women. They are believed to limit peer-acceptance and damage self-esteem. Such social exclusion in the school environment can inhibit positive school life experiences (Philips and Hill, 1998).

Research in the north of England tested these presumptions among 313 nine year old pre-adolescent girls. After taking weight measurements and administering a series of tests for self-esteem and peer popularity, researchers found that obese girls had significantly lower self-esteem in the areas of physical appearance and athletic competence than their non-obese peers. Although they were not unpopular—other students considered them their friends—they were rated as unattractive by their peers and by themselves. The researcher concluded that among this age group, obesity had not had a severe impact upon social inclusion, but still influenced self-perceptions and esteem (Philips and Hill, 1998).

In another study among 188 boys and girls in an area of northern England, researchers assessed children's perception of body shape stereotypes. Students in the study were asked to evaluate drawings of a thin and obese child to determine their attitudes towards peers of different body types. Attitudes towards the obese drawings scored significantly higher ratings of fewer friends, less liked by their parents, doing less well at school, less content with their appearance, and as wanting to be thinner. When asked about their attitudes to their own appearance, children with high BMI were less happy with how they looked and expressed a desire to be thinner (Hill and Silver, 1995).

As with adults, negative attitudes and stigmatisation tends to accompany overweight and obesity. Research with a cross-section of high school students (n=786) in the US found that only 12 per cent of the students had dated someone who was overweight and that students reported being generally uncomfortable with the idea of dating someone who could be considered overweight or very overweight. The same study found that many students with high body weight were unlikely to study with, sit at lunch with, and go to a movie with an overweight or very overweight partner. The authors point out that adolescence is a time when individuals are developing their identity and overweight students may be attempting to avoid associations with others who are stigmatised and excluded (Sobal *et al*., 1995).

4. Lifestyle and barriers to healthy eating

Until now, this report has highlighted the impact of nutrition on different aspects of child development and thus school life. But what determines how we eat? This information is crucial to locating opportunities for intervention and change.

4.1 Cultivation of preferences

4.1.1 Biological and genetic factors

Early childhood appears to be important for the cultivation of preferences for a healthy diet in children. There are a number of mechanisms through which children acquire their food and taste preferences. Some of these are predetermined by biological, genetic or innate inclinations. In 2004, Benton conducted a review of how genetic predisposition, parental style and cultural differences work to define children's food preferences from a very young age. Benton highlighted genetic analyses of behaviour that suggest that genetic similarity explains about 50 per cent to 90 per cent of variation in the adiposity of members of a family. However, he carefully points out that this research merely reflects a relationship and that rather than determining particular outcomes, high heritability simply indicates limited variation in the environment. This means that although particular families may be genetically predisposed to weight gain, their lifestyle and environment will also influence actual outcomes. There remains a question, though, about whether genetic predisposition can influence the likelihood that individuals will seek out particular environments that lead to weight gain, e.g. high fat intake or aversion to physical activity.

Benton (2004) also reviewed research that genetic similarity, in the case of twins, was also related to the intake of macronutrients. In three studies, heritability accounted for the intake of macronutrients even when accounting for shared environment. Although the foods themselves differed, the pattern of macronutrient intake was similar. These studies suggest that heritability is partially responsible for choices about nutrient intake.

Benton (2004) further considered the issue of genetic predisposition through the review of research on innate taste preferences. He pointed to research conducted in the late 1970s and 1980s that found that newborns seemed to demonstrate preference for sweet and salty flavours. It is hypothesised that this reflects an evolutionary trait that encourages intake of food that is high in energy.

4.1.2 Environment and parental influence

Although there are innate taste preferences, a number of learning processes can modify these inclinations. For example, exposure to unknown foods increases the likelihood of acceptance of new tastes. There are additionally general global trends around the meaning of food that influence child (and adult) preferences and intake. Westenhoefer (2001) identified five changes in the wider societal relationship with food that influence eating. Firstly, abundance and availability of food in industrialised countries may have diminished its value in recent times. Advertising and marketing of

food has added emotion to consumption similar to that associated with other non-food products. The development of food production has increased the distance between the origins of food and the product consumed, with consequent potential changes in the way we relate to food. Previously, certain foods were only available during particular seasons and in certain regions. Development in transportation and distribution has meant that many foods are now available anywhere, all year around. Some argue that this has diminished the human relationship with food. Lastly, the social context in which food is consumed has also changed. Presently, food is more often eaten alone than in company. This has particular importance for children, as will be discussed later. Also illustrated below, parental and peer modelling and the media influence children's food acceptance (Westenhoefer, 2001).

There are additional aspects of a child's environment, experiences or influences, e.g. parenting style that may impact upon the development of taste preferences. A study using data from ALSPAC found that the age at which young children are introduced to "lumpy" foods is related to their later eating practices. For example, mothers who reported that they introduced lumpy food to their children before six months were less likely to experience eating difficulties, such as not eating enough, refusing the right foods, being choosy with food, resisting to becoming part of a routine or developing clear likes and dislikes around food. Later weaning was associated with more difficulty around eating (Northstone *et al*., 2001).

No one of these elements, predisposition or familial influences, is solely responsible for the cultivation of food preferences. Rather, it is more likely a combination of these factors that determines the foods and eating styles that children ultimately prefer. In 2003, researchers at the University College London tested this theory among 564 London parents or caregivers of 2 to 6 year old children. Analysis of survey data found associations between demographic, individual child and parental feeding characteristics and fruit and vegetable consumption. When these factors were considered independently, the children of parents with more education more often ate vegetables and the amount of fruit and vegetables eaten by parents predicted children's intake. Additionally, family feeding practices had a bearing on children's fruit and vegetable intake. For example, the children of families who held traditional family mealtimes also had higher intakes of fruit and vegetables. Age of introduction of fruits and vegetables was inversely related to fruit and vegetable intake. And children who were breastfed exclusively as infants ate fruits and vegetables more often. When considered together in multivariate statistical analysis, children's fruit intake was strongly predicted by parental consumption. Early initiation of feeding and introduction to fruit, and breastfeeding remained important. These factors accounted for 20 per cent of the variance in fruit consumption. For vegetables, parental behaviour was the most important determinant of intake. Other factors were no longer predictive in the multivariate analysis, suggesting that these mechanisms were mediated by other variables in the model. The main message rising from this research is the complexity of the factors that influence preferences and eating patterns and the overriding importance of parental role-modelling. The authors suggest impressing upon parents the importance of their fruit and vegetable intake on the intake of their children in health promotion interventions (Cooke *et al*., 2003).

From the above, it is clear that much of the groundwork in cultivating food preferences in children is laid early in life – generally before the start of school.

Therefore, specific strategies taking into account the factors underlying food preferences are essential for improving diets and eating practices among school children.

4.1.3 School dinners vs. packed lunches

Research in Australia found that contrary to common belief, food purchased in school canteens was no less healthy than food brought from home; the nutritional value of both sources of lunch meals needed improvement (Bell and Swinburn, 2004).

Closer to home, a study using data from the Avon Longitudinal Study of Parents and Children (ALSPAC) compared the nutritional content of school dinners and packed lunches of British 7 year olds. Data on ten per cent of a cohort of nearly 15,000 children were analysed. Carers reported the diet consumed by their primary school children over a course of three days. Analysis of these data found that neither school dinners nor packed lunches met the dietary guidelines recommended by the UK Food Standards Agency. Both meals exceeded recommended daily intake of fat and overall energy intake although packed lunches were higher in saturated fat and sugar. These results demonstrated overall inadequacy in both sources of midday meals, but highlighted particular deficiency in packed lunches (Rogers *et al.* 2005).

Research in a similar vein studied the health of students eating school lunches. Whincup and colleagues (2005) found that among 13 to 16 year olds in 72 secondary schools in England and Wales between 1998-2000, the average health status of those who regularly ate school dinners was no worse than those who consumed packed lunches. In fact, some of the data suggested that they were healthier.

Some research has found that although many young people aspire to a healthy diet, limitations in their environment, particularly in school, prevent them from eating well. A small focus group study of staff and seventh and eighth grade students in New England found that the quality of foods served in cafeterias were not considered healthy and were actually considered a barrier to healthy eating by both students and staff. The students stated that they would be willing to eat fruits and vegetables if they were offered in the school cafeteria in great quality and quantity. Schools aiming to meet minimum standards for nutrition do not seem to offer up tasty meals. Not only were options limited, but non-nutritious foods sold in vending machines and snack carts tempted students and staff away from healthy options. The title of the paper quoting a student, “How can we stay healthy when you’re throwing all this in front of us” illustrates the difficultly young people experience with choosing nutritious meals when the school environment is inundated with unhealthy alternatives (Bauer *et al*., 2004).

4.1.4 The impact of school interventions

Children attending school are a captive audience for health interventions on nutrition. Interventions designed to encourage children to improve their eating habits have borrowed their theoretical frameworks from child psychology. For example, employing understandings about children’s positive responses to peer modelling and rewards, researchers from the University of Wales at Bangor designed an intervention to increase fruit and vegetable consumption and tested its impact in three primary

schools in England and Wales. The "Food Dudes Programme" ran for 16 days. Children in the selected schools watched videos of heroic peer models, slightly older children, eating and enjoying fruits and vegetables while commenting positively on its taste. By the end of the intervention period, fruit and vegetable consumption increased by 15- to 27-fold among the children who at baseline had the lowest intakes (Lowe *et al.*, 2004).

To determine whether this intervention had lasting results, the Food Dudes programme was introduced to two inner-city London schools. Following the 16-day intervention, among 5 to 7 year olds there was a 9 and 6 per cent increase between fruit and vegetable consumption, respectively between baseline and follow-up 4 months later. Among the older children, 7 to 10 years, there was about a 4 per cent increase of both fruits and vegetables in consumption between the two time periods (Horne *et al*., 2004).

Many schools are testing interventions to change the eating habits of their students. Couched in the social-cognitive theory (Hogg and Vaughan, 1995), programmes have been designed to change eating behaviours through changing social-environmental factors. A project in the US called the "Cafeteria Power Plus" programme aimed to increase fruit and vegetable consumption among elementary-age children enrolled in 26 schools in Minnesota by increasing opportunities to eat healthily through providing role models and social support around eating fruits and vegetables. Half of the schools participated in the programme and the remaining 13 served as controls. At the end of the two year study period, researchers recorded significantly higher intakes of fruit among the intervention students, though the magnitude of the difference was modest. In any case, this research demonstrated the potential for targeted programmes to improve intake of fruits. Additionally, the researchers suggested that a multi-component effort, including changes in cafeteria environment, classroom curricula and parental involvement will have the greatest impact upon changing fruit and vegetable consumption in school age children (Perry *et al*., 2004).

Interventions for improving children's diet or encouraging the consumption of healthier foods need to take into account a number of issues around children's ability to determine the nutritional value of different foods. Research on the ability of children ages 11 to 16 to classify foods into different groups demonstrated that younger children were less able to categorise specific food groups than older children. The children were asked to categorise several photographs of foods into groups based on their subjective interpretations of foods that "go together". Of the traditional food groups spontaneously indicated by the children, fruits and vegetables were most frequently used. Further, children of all ages used evaluative terms to categorise food, such as healthy/unhealthy. Older children seemed more likely to incorporate traditional classifications into their understanding of food than younger children (Bullen and Benton, 2004).

In a similar study conducted by Bullen (2004) a small sample (n=32) children in Key Stage 2 were similarly asked to classify food before and after a nutrition education programme. The results demonstrated that students' conceptualisation of food remained unchanged even following a nutrition education programme employing diverse teaching methods. These young children used their own ideas about food to complete the task and this was resistant to intervention (Bullen, 2004).

Children are less likely to classify foods by their health status than by what they are familiar with. In research conducted by Turner (1997) that allowed primary school students to choose from a group of picture cards what they would eat for breakfast, lunch and dinner, children chose food that they usually ate at home or in school lunches and that they liked or was their favourite. For younger children, food eaten in the home was important for determining what they considered to be healthy. Foods that are high in fat and sugar are also often considered status foods or treats. Parents may feel compelled to buy their children such food items to allow them these "luxuries" for enjoyment and for social inclusion (Coakley, 2001).

During the *Jamie's School Dinners* programme, it became apparent that simply changing the food available to children was not enough to shift preferences for foods high in energy, salt, fat and sugar. It appears that children purchase at school what they are accustomed to eating at home. This reality adds an additional dimension to efforts to improve children's diets in highlighting the necessity for a collaborative approach between schools and families.

The campaign to cultivate healthy food preferences is struggling against biological and environmental influences that together encourage consumption in the opposite direction. Additionally, there is evidence that advertising and marketing even further complicate matters.

4.2 Advertising and marketing

The impact of the media on children's health has historically been a topic for intense discussion and debate. Over twenty years ago, policy makers in the United States were considering actions such as banning the advertisement of "heavily sugared food products" in an effort to reduce the demand for foods that compromised children's health (Comstock, 1981). More generally, research in developmental psychology suggests that advertising stimulates materialism in children and may instigate parent-child conflict and unhappiness (Buijzen and Valkenburg, 2003).

However, there is an argument in defence of the media that suggests that it is the space for suggestion left open by parents, teachers and guardians that is responsible for the influence of advertising and marketing on children's preferences. It is the responsibility of carers to instil healthy preferences in children and not the job of advertising agencies and policymakers to protect them (Comstock, 1981). Some argue that there are too few rigorous studies on the relationship between food advertising and food consumption behaviour in the UK to draw definitive conclusions about the impact of the media on children's diets (Ashton, 2004). In fact the US and the UK have some of the most lenient restrictions on children's advertising in the West (Lewis and Hill, 1998).

Currently children are bombarded by messages through the media, especially television, encouraging them to purchase and consume foods that are largely high in calories, fat, sugar and/or salt. Advertising companies use a number of aggressive marketing mechanisms that work to pervade such messages into television programming, video games, films and packaging of foods. Through the use of cartoon characters, advertising companies are now linking food with entertainment directed

towards children. These campaigns are designed to encourage children to influence their parents' shopping decisions (Linn, 2004).

In 2002, a group called "Stop Commercial Exploitation of Children Coalition" held aggressive marketing and advertising by the food industry responsible for the increase in childhood obesity, including complications such as type-2 diabetes (McLellan, 2002).

Some researchers argue that the strength of these campaigns thwarts parents' attempts to regulate the content of their children's diets and thus the health of their children. This moves the practice of marketing to children out of the familial arena and into the societal and suggests the need for a change in commercial practices as a matter of public health (Linn, 2004).

4.2.1 The role of television

Another complicated area of concern around nutrition is television viewing. Several studies have determined an association between television viewing and nutritional intake. Food is more often consumed while watching television than while taking part in other activities. Further, research suggests that in some cases healthier foods, such as vegetables, are less likely to be consumed while watching television. The findings of such research suggest that watching television is linked to obesity (Matheson *et al*., 2004).

There is evidence that television viewing reduces the consumption of fruits and vegetables among adolescents. This research found that an increase in television viewing was related to, on average, in 2.225 fewer servings of fruits and vegetables per week among a sample of 548 children (Boynton-Jarrett *et al*., 2003). The general trend suggests three explanations for this relationship. One, that time viewing television displaces time that could be used playing or engaging in physical activity that would burn calories, preventing children from becoming "couch potatoes". Another explanation is that advertising campaigns that are interspersed between children's television programmes encourage children to eat unhealthy food, generally. A third explanation combines the previous two. It suggests that advertising campaigns encourage children to eat while watching television, thus increasing caloric intake while also reducing the opportunity for physical, calorie-burning, activity (Dietz, 1990).

Research on the content of television advertising of food during 'prime time' in the United States showed that the majority of food advertised during this time was for less healthy foods and that few of these food advertisements promoted products that were high in nutritional value (Henderson and Kelly, 2005).

Content analysis of television commercials on UK television by Lewis and Hill (1998) found that food advertisements are the largest category of products advertised and are dominated by commercials for breakfast cereals and snack foods. Further, advertisers used animation, stories and humour that are all particularly appealing to children, thus achieving greater attention and increasing children's emotional response (Lewis and Hill, 1998). Other research has demonstrated the strong influence of television advertisements on children's food product choices. Research with

children aged 2 to 6 years old in the United States found that children who viewed 10 to 30 second television advertisements for specific food products were more likely to choose the advertised product over a similar local product. This was particularly the case for products that were advertised more than once. This finding was not influenced by media technology in the home.

There is evidence that parents can be taught skills to help counterbalance the influence of television advertising on their children's food choices. In research by Hindin (2004) with 35 mothers of 3 to 6 year olds taking part in the Head Start programme in New York, results of an intervention programme showed that a nutrition education curriculum designed to teach mothers how to critically assess television advertisements and understand the persuasive techniques used by the media to influence their children's requests for food was successful at increasing parents' self-confidence and the extent to which they value good nutrition.

5. The impact of socio-economic status

Laced throughout the literature on nutrition is the suggestion that deprivation and poverty mediate negative practices and outcomes. Recent research has found that, particularly among younger children, both under-nutrition and obesity associated with social deprivation is prevalent in contemporary UK societies. In Scotland, children aged 3 to 4 in the poorest families had a 30 per cent higher risk of obesity and a 50 per cent higher risk of under-nutrition when compared to children from the least economically deprived group. Among the social groups, children from the middle and low socio-economic groups, obesity was more common; and under-nutrition was most common in the most deprived groups (Armstrong *et al*., 2002).

A study in Plymouth, UK demonstrated a strong positive association between childhood obesity and socio-economic deprivation. In Plymouth, prevalence rates of obesity were measured as two and a half times that expected nationally: 5 per cent vs. 2 per cent in a cross-sectional study of over 20,000 children (Kinra *et al*., 2000).

Low income is a major barrier to healthy eating. Deprived households are more likely to have unhealthy food and insufficient amounts of food. Families with limited finances are under pressure to buy foods that are higher in energy (high in fat and sugar) and cost less per unit of energy when compared to less fattening but nutritionally much richer foods, such as fruits and vegetables (Kinra *et al*., 2000).

A qualitative research project based on interviews with Irish mothers highlighted the important relationship between diet and poverty. However, the ability to pay for particular types of food often dictates diets that are ultimately consumed. Among these mothers, despite a strong desire to feed their children healthy food and awareness of the components of a healthy diet, income limitations forced them to choose meals with lower nutritional content. Having to make such choices was very stressful for these mothers. Along with being obliged knowingly to feed their children cheaper, less nutritious food, they made personal sacrifices, such as skipping or reducing meals for themselves in order to give the most to their children (Coakley, 2001).

In the United States, advertising campaigns aimed at encouraging Americans to consume at least five servings of fruits and vegetables a day failed to reach the low socio-economic groups. An evaluation of the campaign demonstrated that although individuals from low socio-economic backgrounds recognised the campaign, fewer than 25 per cent of those surveyed understood its meaning (Weaver *et al*., 1999).

The limitations constructed by low income create practical barriers to healthy eating. However, additional socio-environmental factors, such as culture and lack of literacy and education may reinforce the effects of deprivation.

6. When is nutrition most important?

One of the many complications in addressing nutritional deficiencies and disorders is determining at what age interventions are most effective.

In a study on the impact of breast feeding upon prevalence of being overweight or obese in childhood, researchers found that in a sample of 13,000 German children born in the 1990s there was a "consistent, protective, and dose dependent" effect of breast feeding on obesity, even when controlling for a positive family history of obesity and being overweight. Based on these cross-sectional data, the risk of obesity in children at the time of school entry was lower for children who had been breastfed. For example, children who were breastfed for 3 to 5 months are a 35 per cent less likely to be obese at the time of school entry (von Kries *et al*., 1999). In a prospective cohort study conducted with nearly 20,000 children in the United States, rapid weight gain in the first four months of life was associated with an increase risk of overweight status at the age of 7. The authors stated that this association appeared to be independent of birth weight and weight attained at the age of 1 (Stettler *et al*., 2002).

It seems likely that good nutrition from infancy is important for children's development. This has implications for determining who is responsible for ensuring healthy nutrition in infants and children. Placing the onus on children themselves is problematic due to their development and lack of ability to identify healthy food before a particular age.

7. Policy implications and conclusions

As discussed at the start of this report, UK government institutions have made strides in addressing childhood nutrition in schools, families and communities. As a result of Jamie Oliver's television programme and campaign, and the findings of research on nutrition and child attainment, the UK government has instituted new policies and standards for nutrition in schools. For example, the Education and Inspections Bill, published in February 2006, will establish new nutritional standards for all food and drink served in maintained schools (Department for Education and Skills [DfES], 2005). The research collated here identifies avenues through which policy can proceed in improving the diets of UK children.

The research summarised above prompts the following policy questions:

- What is the most effective method of cultivating healthier preferences in children?
- When and under what circumstances are children most receptive to healthy nutritional suggestions?
- Who is in the best position to influence children's eating?
- How much of an impact can education and the school environment have on child nutrition and thus attainment?
- How can policy impact upon the availability of healthy options outside of controlled environments? (marketing, advertising)

Children's choice of diet depends not only on the availability of foods but on their preferences. These are developed from birth and in response to biological, familial and societal factors. Any effective interventions must therefore address the multiple determinants of children's preferences for particular foods—for example it may be necessary to adopt collaborative approaches between schools and families in efforts to improve children's diets.

A recurring theme in the literature is the importance of early nutritional intake. An overwhelming amount of the research on nutrition points to the deleterious and in some cases irreversible effects of deficiencies early in life. Evidence of the ability of nutritional and dietary supplements to reverse adverse the effects of deficiencies highlights avenues for intervention (Pollitt and Gorman, 1994). Nevertheless, later intervention runs the risk of failing to capture the majority of those in need and should probably only be employed as a back-up.

The behaviour of parents and peers strongly influence the eating patterns of children, particularly when they are young. Parental involvement is important for cultivating healthy preferences before and during the school years.

Researchers across disciplines offer suggestions for change. Based on their latest research comparing school dinners and packed lunches, Rogers *et al.* (2005) suggested that both need improvement. However as packed lunches are more frequently consumed, it maybe more important to address the nutritional content of food brought in to school from home.

The media clearly has an influence on children's eating. Advertising should take some responsibility for conveying healthy messages to children and families. Government has a responsibility to oversee the use of advertising and monitor the extent to which it benefits the public.

Another theme threading the literature is the heightened vulnerability of the undernourished and the increased potential for improvement through interventions among the worst off. The above work highlights the added benefit of breakfast and supplementary programmes to children who are undernourished.

Our understanding of the link between nutrition and behavioural outcomes such as ADHD is limited. Additional research is required in the area. Though once the connections are better understood, there is likely to be plenty of scope for addressing behavioural problems that limit the school experience for many children.

Obesity should be prevented for its health implications. Additionally, research summarised here has outlined the deleterious social implications of overweight and obesity experienced in youth. Stigmatisation and social exclusion in the school environment accompanies overweight status and add further difficulty to an often challenging school experience. Obesity should be addressed for the sake of public health, but also for the psychosocial wellbeing of children experiencing high levels of adiposity.

The findings of Bullen and Benton's (2004) research on children's conceptualisation of food categories suggests that in developing intervention to improve diets, imposing adult notions of nutrition may not be useful. They propose that a curriculum be developed that incorporates children's understandings of nutrition and thus is more likely to encourage change.

Based on research, there appears to be additional changes that can be made to the structure of the school day to promote better cognition among students. If as Benton (2001) suggests, regular supplies of glucose enhances memory and mood, could the timing of meals be adjusted to optimise cognition during the school day? Institutions have already acknowledged the importance of breakfast by creating breakfast clubs in schools and developing health promotion campaigns that encourage students to eat in the morning. Research by Benton and Pearl (1998) and Pollitt and colleagues (1994) further supports the importance of these programmes.

The promotion of healthy eating is a complex endeavour that requires multifaceted interventions. The research summarised here helps to determine the efforts that have been well placed and are likely to be successful and signposts areas for further policy development and research.

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Appendix

Table 1: Dietary reference values and derived amounts for nutrients per day, boys

DRV (Dietary Reference Value): the amount of energy and nutrients required by groups.
EAR (Estimate Average Requirement): the average amount of energy or nutrients needed by a group of people.
RNI (Reference Nutrient Intake): the quantity of nutrients needed to meet the dietary requirements of about 97 per cent of a group of people.

	DRV		4-6 yrs	7 -10 yrs	11-14 yrs	15-18 yrs
Energy	EAR	kcals	1715	1970	2220	2755
Fat	DRV: average 35% of food energy*	g	66.7	76.6	86.3	107.1
Saturated fat	DRV: average 11% of food energy*	g	21.0	24.1	27.1	33.7
Total carbohydrate	DRV: average 50% of food energy*	g	228.7	262.7	296.0	367.3
Non-milk extrinsic sugars	DRV: average 11% of food energy*	g	50.3	57.8	65.1	80.8
Fibre	Proportion of DRV for adults (18g)/CRV**	g	13.7	15.8	17.8	22.1
Protein	RNI	g	19.7	28.3	42.1	55.2
Iron	RNI	mg	6.1	8.7	11.3	11.3
Zinc	RNI	mg	6.5	7.0	9.0	9.5
Calcium	RNI	mg	450	550	1000	1000
Vitamin A	RNI	µg	500	500	600	700
Vitamin C	RNI	mg	30	30	35	40
Folate	RNI	µg	100	150	200	200
Sodium	SACN recommendation	mg	1177	1961	2353	2353

Source: Crawley H. (2005) *Nutrient-based standards for school food*, London: Caroline Walk Trust and National Heart Forum.

SACN = Scientific Advisory Committee on Nutrition
*As there is no absolute requirement for sugars or fats (except essential fatty acids), these values represent a maximum.
**The dietary reference value for non-starch polysaccharides (fibre) is 18g for adults, and children should eat proportionately less, based on lower body size. This has been calculated for these guidelines as a percentage of the energy recommendation, to give the Calculated Reference Value. The calculated NSP guideline is 8g per 1,000 kcal.

Table 2: Dietary reference values and derived amounts for nutrients per day, girls

DRV (Dietary Reference Value): the amount of energy and nutrients required by groups.
EAR (Estimate Average Requirement): the average amount of energy or nutrients needed by a group of people
RNI (Reference Nutrient Intake): the quantity of nutrients needed to meet the dietary requirements of about 97 per cent of a group of people.

	DRV		4-6 yrs	7-10 yrs	11-14 yrs	15-18 yrs
Energy	EAR	kcals	1545	1740	1845	2110
Fat	DRV: average 35% of food energy*	g	60.1	67.7	71.8	82.1
Saturated fat	DRV: average 11% of food energy*	g	18.9	21.3	22.6	25.8
Total carbohydrate	DRV: average 50% of food energy*	g	206.0	232.0	246.0	281.3
Non-milk extrinsic sugars	DRV: average 11% of food energy*	g	45.3	51.0	54.1	61.9
Fibre	Proportion of DRV for adults (18g)/CRV**	g	12.4	14.0	14.8	16.9
Protein	RNI	g	19.7	28.3	41.2	45.0
Iron	RNI	mg	6.1	8.7	14.8	14.8
Zinc	RNI	mg	6.5	7.0	9.0	7.0
Calcium	RNI	mg	450	550	800	800
Vitamin A	RNI	µg	500	500	600	600
Vitamin C	RNI	mg	30	30	35	40
Folate	RNI	µg	100	150	200	200
Sodium	SACN recommendation	mg	1177	1961	2353	2353

Source: Crawley H. (2005) *Nutrient-based standards for school food*, London: Caroline Walk Trust and National Heart Forum.

SACN = Scientific Advisory Committee on Nutrition
*As there is no absolute requirement for sugars or fats (except essential fatty acids), these values represent a maximum.
**The dietary reference value for non-starch polysaccharides (fibre) is 18g for adults, and children should eat proportionately less, based on lower body size. This has been calculated for these guidelines as a percentage of the energy recommendation, to give the Calculated Reference Value. The calculated NSP guideline is 8g per 1,000 kcal.

WIDER BENEFITS OF LEARNING RESEARCH REPORT NO.18

What is the relationship between child nutrition and school outcomes?

In recent times, the diet of children has risen to the top of the political agenda, not only for the potential health repercussions later in life, but also for its immediate effects on the physical and mental health of children and their consequent school experience and attainment.

In this report we review the literature on the relationship between aspects of nutrition and physical health, mental health, behavioural and social outcomes in children. Our research attempts to address the following questions:

- How does nutrition impact upon healthy outcomes in children?
- How can the health outcomes that manifest as a result of nutrition impact upon school life experiences and outcomes?

We find that the early development of preferences for foods of poor nutritional value can have long-term health implications. Ultimately, the aim must be to prevent nutritional deficiencies from arising but the relationships between nutrition, health, education and social and cultural factors are complex and multi-directional. There is evidence that appropriately designed interventions can help to address early deficiencies and engage both children and parents in healthy eating.

Given that the diet of children depends not only on the availability of foods but, crucially, on their preferences, any effective interventions must address the multiple determinants of children's preferences for particular foods. In particular, the role of parents is important and there may be a need to adopt a collaborative approach between schools and parents to address children's nutritional choices. There is an opportunity to capitalise on existing initiatives such as the extended schools policy, which has created the chance for schools to engage with parents and local communities, to improve diets and promote healthy eating among children. Moreover, we need to recognise that issues on the supply side and in relation to marketing and the mass media are also important, even if they are outside the immediate policy domain of the Department for Education and Skills. As is so often the case, an integrated approach from government is required on this policy issue.

The challenges faced in changing the eating habits of children in the UK call for a collaborative approach. A concerted effort between schools, families, government departments and other agencies is necessary if children's nutritional intake, both in and out of school, is to be improved.

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