A systematic review of the effect of nutrition, diet and dietary change on learning, education and performance of children of relevance to UK schools

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1.1.1 Background

The Government is committed to promoting healthier schools and lifestyles among school children, for example through improving the quality of school meals and national nutritional standards. Whilst the commitment to improve school meals was primarily made on health grounds, there was considerable interest in how good nutrition may also impact on behaviour, learning and performance among school aged children. However the evidence base to support clear associations in this area were confused and lacked cohesion. It was therefore recommended that the UK Government 'be encouraged to undertake an assessment into the links between good nutrition and educational performance'. This review was commissioned by the Food Standards Agency.

1.1.2 Aims

1. To create a systematic map of all empirical research that has been undertaken to evaluate the effect of nutrition, diet and dietary change on learning, education and performance in school aged children (4-18years) from the UK and other developed countries.

2. To perform a systematic in-depth review of the best evidence from controlled trials studies that have investigated the effects of nutrition, diet and dietary change on learning, education and performance in school aged children (4-18years) from the UK and other developed countries.

1.1.3 Methodology

A systematic review of the current evidence base was performed. This involved exploration of the health and education databases using a tailored search strategy. The citations were then uploaded into Evidence for Policy and Practice Information (EPPI) reviewer, which was used to select English language papers investigating the effect of nutrition on educational outcomes in school aged children from the developed world.

1.1.4 Key Findings

Sixty nine studies were identified for key word mapping, of these twenty nine were Randomised / Case Controlled Trials (RCT/CCT) studies that were taken forward for in-depth review. The majority (58%) of all studies originated from the USA. Of the studies selected for in-depth review, fifteen examined the effect of breakfast, of which ten identified an association between breakfast provision and some small cognitive and behavioural improvements. However, the variation in quality and research designs made it impossible to draw any firm conclusions. Six studies examined the effect of short term exposure to sugar intake in populations of predominantly primary school aged children with Attention Deficit Hyperactivity Disorder. However, collectively these studies showed that sugar intake had no clinically significant adverse effects on learning or behavioural outcomes. Five studies investigated the effect of fish oil supplementation in a population aged 5-13 years with symptoms of neuro developmental disorders, however the findings were mixed and therefore inconclusive. Of the remaining three studies one examined 'good diet' in the first year of school but lack sufficient detail and quality to inform the evidence base. The final two studies examined the effect of vitamin/mineral supplementation: one in Hispanic low income children from the USA, which showed a significant positive effect on IQ in a small sub sample, and the other in UK teenagers which found no effect. These two studies alone provided insufficient evidence to formulate any conclusion.

Only six studies originated from the UK (3 breakfast, 2 fish oil and 1 vitamin/mineral supplementation). In addition to this, several studies lacked quality in research methodology and reporting (particularly those investigating breakfast consumption). Many studies failed to account for important confounders such habitual dietary intake, physical activity levels, locality and family context, whilst two thirds of the studies were carried out in primary age children and over a half took place over a short duration (<1 month).

1.1.5 Conclusions

The findings from this review suggest there is insufficient evidence to identify any effect of nutrition, diet and dietary change on learning, education or performance of

school aged children from the developed world. Further research is required in settings of relevance to the UK and must be of high quality, representative of all populations, undertaken for longer durations and use universal standardised measures of educational attainment. However, challenges in terms of interpreting the results of such studies within the context of confounders such as family and community context, poverty, disease and the rate of individual maturation and neurodevelopment will remain.

Whilst the importance of diet in educational attainment remains under investigation, the evidence for promotion of lower fat, salt and sugar diets, high in fruits, vegetables and complex carbohydrates, as well as promotion of physical activity remains unequivocal in terms of health outcomes for all school children.

1.2 Lay Summary

1.2.1 Background

The Government is committed to promoting healthier schools and lifestyles among school children, for example through improving the quality of school meals and national nutritional standards. Whilst the commitment to improve school meals was primarily made on health grounds, there was considerable interest in how good nutrition may also impact on behaviour, learning and performance among school aged children. However the evidence base to support clear associations in this area were confused and lacked cohesion. It was therefore recommended that the UK Government 'be encouraged to undertake an assessment into the links between good nutrition and educational performance'. This review was commissioned by the Food Standards Agency.

1.2.2 Rationale and Objectives

This report was undertaken to draw together the best evidence to examine the effect of good nutrition on the behaviour, learning and performance of school-aged children, both in the UK and across the developed world. It is hoped this information will inform practitioners and policy makers.

1.2.3 Approach

The objectives were achieved through a systematic review of published research studies. This involved methodically exploring health and educational databases to identify studies that examined the effect of diet / nutrition on learning, education and performance in school aged children. The included studies were investigated to establish the distribution, number and type of studies that have been carried out across the developed world. The rigorous studies (controlled trials) were examined in greater detail to find out whether there was any evidence to show an association between diet / nutrition and education in school aged children from the developed world.

1.2.4 Key Results

Sixty nine studies were identified for this report. The majority of these studies were carried out in the USA and took place in schools and had a small number of participants (<100). Of these studies only twenty nine were controlled trials, that were taken forward for in-depth investigation:

- Fifteen studies examined the effect of breakfast.

- Six studies examined the effect of short-term sugar intake in a population of predominantly primary aged children with Attention Deficit Hyperactivity Disorder symptoms.

- Five studies examined the effect of fish oil supplementation in a population aged 5-13 years with symptoms of learning / behavioural disorders.

- Two studies examined the effect of vitamin/mineral supplementation.

- One study investigated good nutrition in the first year of school

Only six of these studies originated from the UK (3 breakfast, 2 fish oil, 1 vitamin/mineral supplementation). In addition to this, two thirds were carried out in primary age children and over a half took place over a short time period (<1 month). Most concerning however, was the lack of research quality and reporting in several studies (particularly those investigating breakfast consumption). Many of the studies

also failed to account for habitual diet, physical activity levels and family environment, which may all potentially independently have influenced the findings reported.

Due to the small numbers of studies, the great variation in study designs and the lack of quality in many of the studies it was impossible to reach any firm conclusions as to the effect of diet on learning, education and performance of school aged children from the developed world.

1.2.5 What it means and why it's important

The findings from this report suggest that currently there is not enough evidence to show that diet / nutrition effects education, learning and performance of school aged children. This report is important, as it will inform policy makers and practitioners of the need to carry out more research (particularly within the UK) before any decisions can be made with regard to the role of nutrition in education.

Whilst the association between diet and education remains under investigation, for the health of school children it remains important to maintain a diet lower in fat, salt and sugar but high in fruits, vegetables and complex carbohydrates, in addition to being physically active.

2. GLOSSARY

AA	Arachidonic Acid
ADHD	Attention Deficit Hyperactivity Disorder
CCT	Case or Cluster Control Trial
DHA	Docosahexanenoic Acid
DRV	Dietary Reference Value
EFA	Eicosapentaenoic Acid
EPPI Centre	Evidence for Policy and Practice Information Centre
GLA	Gamma-linolenic acid
HDI	High Development Index
IQ	Intelligence Quotient
RCT	Randomised Control Trial
RDA	Recommended Daily Allowance
Cross over study	Where subjects participate in all study arms, thus controlling for themselves.
Power	The ability to demonstrate an association when one exists. Power is related to sample size; the larger the sample, the grater the power and lower the risk of missing a possible association.

3. BACKGROUND

The Government and those involved in education are committed to improving learning and raising standards in schools, as well as meeting the needs of individual pupils. There is widespread belief that nutrition and diet may have a part to play in this process; however, there is a degree of uncertainty as to what interventions or supplements work. Much of the available evidence is confusing and contradictory. In essence those charged with supporting and delivering education are seeking clear guidance for both individuals and groups of children, so as to be able to identify what probably works, what might work and what probably does not work.

The Government is committed to promoting healthier schools and lifestyles among school children, for example through improving the quality of school meals and national nutritional standards [1]. The rationale for these improvements was based on evidence relating to poor nutrient and food intake among some school aged children taken from the National Diet and Nutrition Survey: young people aged 4-18 years [2] and from data collected as part of new research on school meals by Nelson et al [3]. Whilst the commitment to improve school meals was primarily made on health grounds, there was considerable interest in how good nutrition may also impact on behaviour, learning and performance among school aged children. However the evidence base to support clear associations in this area were confused and lacked cohesion, and the panel were therefore unable to make a clear evidence based statement at the time. It was therefore recommended that the UK Government 'be encouraged to undertake an assessment into the links between good nutrition and educational performance'[4]. This review was commissioned by the Food Standards Agency.

4. AIMS AND OBJECTIVES

1. To create a systematic map of all empirical research that has been undertaken to evaluate the effect of nutrition, diet and dietary change on learning, education and performance of school aged children from the developed world.

2. To perform a systematic in-depth review of the best evidence from RCT/CCT studies that have investigated the effects of nutrition, diet and dietary change on learning, education and performance of school aged children from the developed world.

5. METHODOLOGY

5.1 Search Strategy

A comprehensive search strategy was developed to explore the aims of this review (the complete list of the search terms is shown in Appendix 1). A computerised systematic literature search was then carried out on the 21st and 22nd of December 2005. As the topic area lies at the interface between health sciences, education and social sciences, the following electronic databases were explored: MEDLINE; CINAHL; Psychinfo; BEI (British Educational Index); ERIC (Education Research Information Center); Australian ERIC; Social Science Citation index (SSCI); Applied Social Sciences Index and Abstracts (ASSIA); International Bibliography of the Social Sciences; Sociological Abstracts; SPECTRE; and The British Library's electronic table of contents of current journals, and conference proceedings (ZETOC).

All databases were searched from the date of their inception and where possible, limits were applied to fit the inclusion criteria (listed below). Every citation was stored using the EPPI Centre software (EPPI-reviewer), where they were combined, de-duplicated and then screened to meet the following inclusion / exclusion criteria:
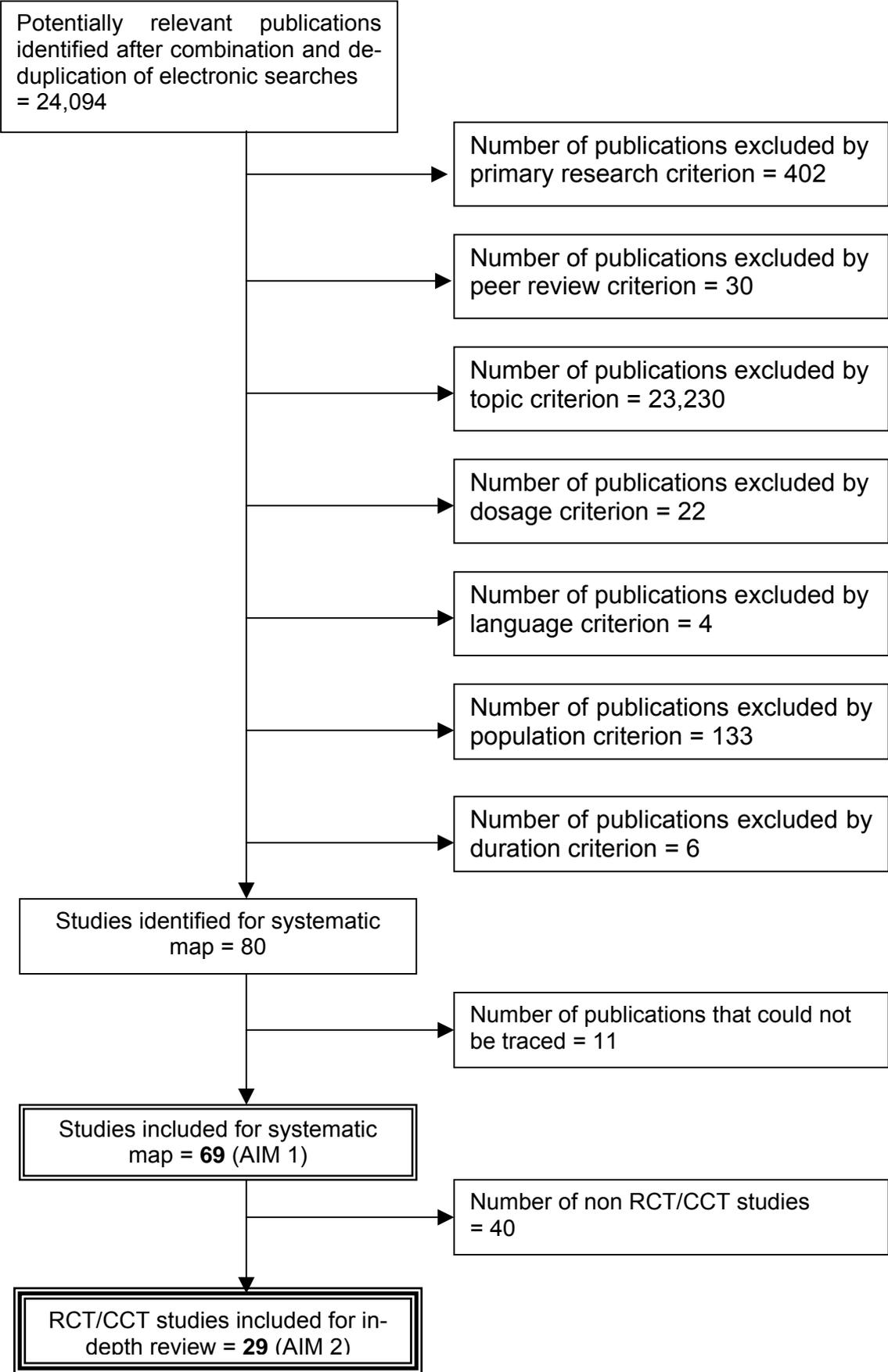
ALL INCLUDED STUDIES HAD TO BE:
1. primary studies reporting empirical research *(primary research criterion).*
2. studies that have been peer reviewed (i.e. appear in an edited journal) *(peer review criterion).*
3. studies that include an exposure/intervention focusing on nutrition, diet or dietary change AND at least one of the following outcomes – educational performance, behaviour and motivation in humans *(topic criterion).*
   Note: the effect of artificial colourings and preservatives are not discussed within this review, as this area was recently reviewed by the Food Standards Agency.
4. studies that include a nutritional and dietary exposure that can be achieved through normal dietary intake (no more than twice the daily recommended Dietary Reference Value (DRV)[5] *(dosage criterion).*
5. studies focusing on school aged children aged 4 -18 years *(age criterion).*
6. studies written in English *(language criterion).*

7. studies undertaken in developed countries (as defined by the world bank as countries of 'high human development' i.e. an HDI score of >0.800 http://web.worldbank.org) *(population criterion)*.

8. studies of a duration >5 days (except for high carbohydrate studies where any time frame >2hrs is acceptable) *(duration criterion).*

9. studies reporting exposures/interventions based in any type of setting - e.g. mainstream, special schools, pupil referral units and community centres. *(setting criterion)*

All studies fulfilling these criteria were put forward for key word mapping to achieve study aim 1. Further methodological inclusion criteria were then applied to this selection of studies, to identify those that were conducted using a Randomised, Case or Cluster Controlled Trial (RCT/CCT). These studies were then put forward for further in-depth review, to achieve study aim 2.

A summary of the methodology is shown in figure 1.

Figure 1: Methodology summary flow diagram

5.2 Systematic Key Word Mapping

All included studies underwent key word mapping (carried out by one reviewer), to produce a systematic map of empirical research. A key word mapping document was developed for this process using the EPPI reviewer software and templates (Appendix 2).

5.3 Systematic In-depth Review

Quantitative and qualitative data was extracted from each of the studies selected for in-depth review by two independent researchers, with any discrepancies resolved after consultation with the review group to maintain consistency. Data extraction took place using a specially designed data extraction tool developed using the EPPI reviewer software and templates (Appendix 3).

5.4 Quality Assurance

Quality assurance measures were operational at several levels for this review:

Level 1: To oversee the quality of the review process and final report production, an external steering group was formed with expertise within the fields of education, social sciences, nutrition, paediatric medicine and biochemistry. None of the project team or steering group members have any conflicting interests to declare.

Level 2: To ensure the efficacy of the search strategy, a list of publications deemed 'gold standards' within this area of interest were selected after consultation with the review group and Food Standards Agency [6-17]. These publications were cross-referenced against the citations captured from the combined searches to ensure all were identified.

Level 3: To assess the quality of the papers selected for in-depth review, two quality assurance protocols were utilised. The first protocol was based on the Scottish Intercollegiate Guidance Network (SIGN – www.sign.ac.uk) quality assurance assessment for the RCT. This accounted for critical quality issues such as randomisation, blinding, concealment and intention to treat analysis, upon which a numerical scoring system was applied (see section E&F of the EPPI data extraction tool – Appendix 3). The second protocol was based on the quality assurance template produced by EPPI reviewer, which weighted the evidence into low, medium and high categories (see section G of the EPPI data extraction tool – Appendix 3).

6. RESULTS AND DISCUSSION:

6.1 Systematic Key Word Mapping

A summary of the results from the systematic key word mapping exercise [18-86] is tabulated in Appendix 4 (for all non-RCT/CCT studies) and Appendix 5 (for all RCT/CCT studies). The majority of studies included in this scoping exercise involved both boys and girls, primarily in the primary (6-10 years) and secondary (11-15 years) age groups. Most of these interventions were short (<24hours) and took place within a school setting, usually with a small number of participants (n<100). Twenty nine of these studies were RCT or CCT studies, which were put forward for in-depth review (see Section 6.2), the remainder were mostly cross sectional studies with a very small number of uncontrolled cohort and case studies.

The key findings are illustrated in Figures 2 and 3. The distribution of studies across the developed world is shown in Figure 2 and clearly illustrates the abundance of studies originating from the USA (40 out of 69 included studies). The UK sits in second place with a total of 8 studies, whilst the remaining countries gave rise to just 1 or 2 studies meeting the inclusion criteria for this scoping exercise. The data presented in Figure 3 demonstrates the dramatic rise in the number of studies carried out over the past four decades. The most commonly examined exposures were breakfast (n=24) and nutrient supplementation / testing of blood indices (n=13), many of which were carried out during the last two decades. This figure also illustrates the very recent surge in studies examining the effect of fish oils on the educational performance of the child/youth population.

Figure 2: The geographical distribution of studies included for key word mapping.
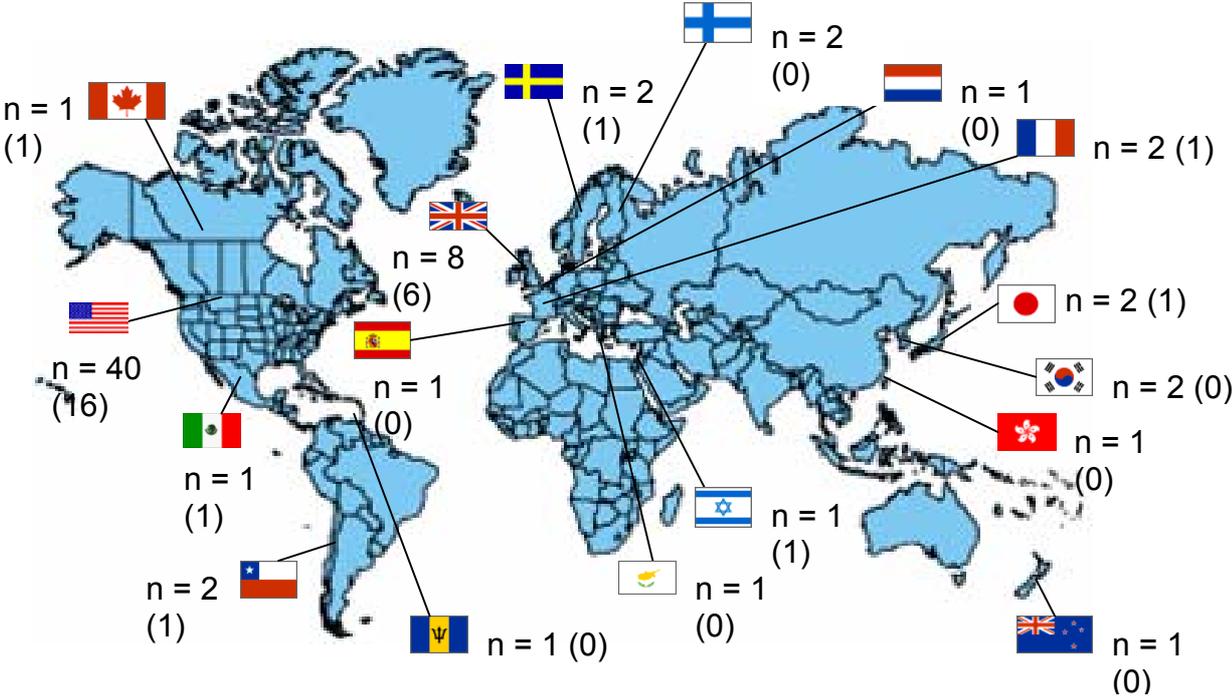
Key:

Barbados		Canada		Chile	
Cyprus		Finland		France	
Hong Kong		Israel		Japan	
Korea (south)		Mexico		Netherlands	
New Zealand		Spain		Sweden	
UK		USA			

Note: figures in brackets represent RCT/CCT studies selected for in-depth review.

Figure 3: A graphical representation of the number of studies and exposures examined over the past four decades.
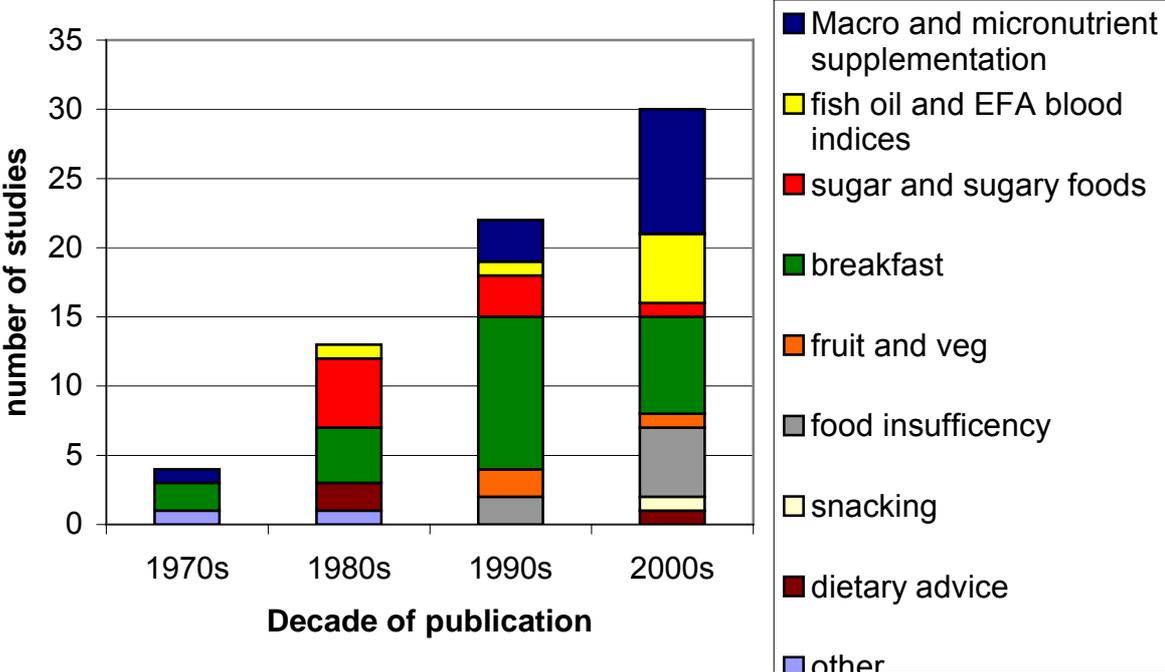
* and blood indices

6.2 Systematic In-depth Review

6.2.1 General Overview

The twenty nine studies [58-86] that met the inclusion criteria for data extraction and in-depth review are tabulated in Appendix 5. A breakdown of the exposures examined are illustrated in Figure 4 and discussed in the following sub-sections.

Figure 4: A breakdown of the exposures examined for in-depth review.

6.2.2 Breakfast

By far the largest number of included publications (n=15: 8 USA, 3 UK, 1 France, 1 Chile, 1 Israel, 1 Sweden) examined the effec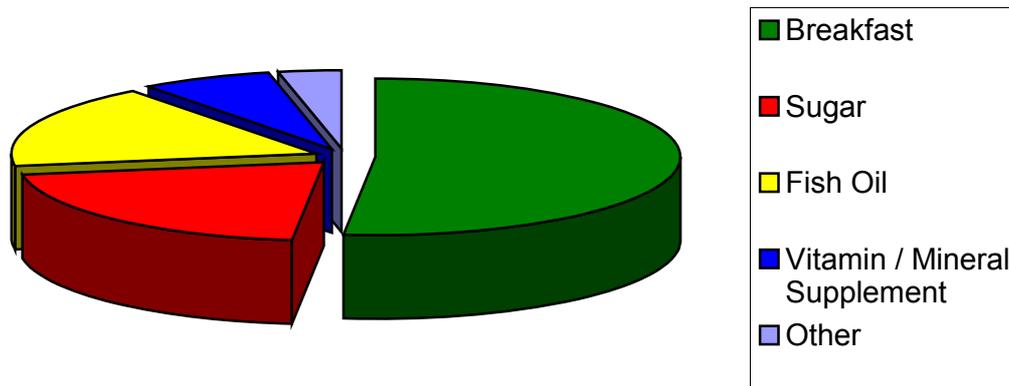t of breakfast [58-72]. Eleven of these studies focused on children within the 4-12 year age bracket, whilst the remaining four [53,64,65,70] included a teenage population. Generally the size of the study populations were small (predominantly <100 participants) and of short duration (<1 week, these studies were included due to the high carbohydrate content of the breakfast intervention). All studies examined predominantly healthy, mixed gender populations from mainstream education. Most participants (where recorded) were white Caucasian, with the exception of those participating in studies [58, 59 & 63] who were predominantly black, mixed race and hispanic, respectively. Ten studies reported socio-economic status (using a variety of scales and indicators), of these, half recruited children from low income families [58,59,63,66,71] and half recruited children from middle to high income families [60,61,62,64,72].

The type of breakfast interventions investigated fell into five categories: 1) the impact of the provision of breakfast clubs [58,63,69,71]; 2) breakfast consumption vs fasting [60,61,62,66,70,72]; 3) low vs high protein breakfast consumption [59]; 4) low vs high calorie breakfast consumption [64,68]; 5) habitual breakfast consumption vs a standardised breakfast consumption [65,67]. Of the studies investigating breakfast clubs, three identified a small but positive impact of breakfast club participation on a selection of educational outcomes, whilst the remaining study found no effect. Four of the six studies investigating breakfast consumption vs fasting identified some

improvements in problem solving [61,62]; attention and epidsodic memory after cereal consumption [70] and complex visual display [72] after consuming breakfast, although the remaining two studies were unable to identify any significant differences. The study investigating the protein content of breakfast was unable to demonstrate any significant differences between consumption of high or low protein breakfasts. When calorie content was examined, one study demonstrated a disadvantage of a low calorie breakfast in terms of mood, physical endurance and creative thinking however the other study found no significant differences between the two breakfast conditions. When habitual breakfast conditions were compared against a standardised breakfast provision, both studies demonstrated some improvements to cognitive function after consumption of the standard breakfast. However, although the study by Michaud [65] demonstrated an increase in memory scale results after consumption of the standard breakfast, this was accompanied by a negative reduction in concentration.

The diverse range of different breakfast interventions and research designs makes it very difficult to draw together the findings presented. The majority of studies (10 out of 15) however, were able to demonstrate that the provision of breakfast may have some small benefit to a limited selection of short term behavioural and cognitive functions. However, this very generalisable overview must be considered within the context of the numerous shortcomings of many of these studies: 1) only three studies [65,66,72] considered the impact of habitual diet, which particularly given the very short duration of many of these studies may have had a substantial confounding effect; 2) in general many of the studies failed to adjust or even acknowledge many of the confounders listed, which like habitual diet, may impact significantly upon the findings presented; 3) there are a huge number of behavioural and cognitive indices that are important in measuring educational attainment, however most studies selected a limited range of subjective and objective methodologies, many lacking appropriate validation, with very little consistency in methodology between studies; 4) as mentioned previously, many of the studies were of short duration, making it extremely difficult to control for different rates of emotional and neurological maturation, as well as being unable to quantify sustainability and longer term benefits.   Given these shortcomings, it was unsurprising that many of the studies

gained very low quality assurance scores with eight achieving a SIGN grading of under 10 and an EPPI weighting of low.

6.2.3 Sugars

Six of the included studies [73-78] (5 from the USA, 1 from Canada) investigated the effect of sugar intake on learning and behavourial outcomes in school aged children. All studies were carried out between 1985 and 1994, and examined a population of pre-teens (3-12years) with the exception of the Saravis study [76] that included teenagers. Every study examined the effect of sucrose against aspartame or aspartame and saccharin in an RCT cross over design. The period of exposure to the sugar or sweetener substitutes was short in most cases (1-2days) with the exception of the Wolraich and Rosen studies [78 & 75] which examined each exposure over 1 week.

Only one study [76] examined the effects of sugar in an entirely healthy population of children. The remaining studies were investigated in a population of chidren with symptoms of Attention Deficit Hyperactivity Disorder (ADHD), either on their own (two studies) or alongside control healthy children (three studies). The two small studies (population n=16 in each) carried out in an all male ADHD population, found no significant difference between the sugar and aspartame exposure on any of the objective or subjective outcomes measured. Of the remaining studies, two [75 &76] identified small statisticially (but often not clinically) signficiant adverse effects on behavourial outcomes in the sucrose group, whilst another [77] could only identify a disadvantage in the ADHD subgroup. The only long term diet that combined the sugar/sweeteners into habitual diet rather than a drink was unable to identify any difference between the sucrose and sweetener in primary aged children. This was, incidentally, the only study also to examine any blood biochemistry. However, a small but significant improvement was seen in a small number of the subjective behaviour scores for the infants, although this finding was inconsistent with a significant decrease in the score for one of the objective performance measures in the same group.

Whilst all but one study [77] gained reasonable quality assurance scores (for both EPPI and SIGN), only two studies calculated power. As with the breakfast studies very little attention was paid to important confounders, particularly physical activity and habitual diet, both of which could significantly impact upon the metabolic responses to sugar consumption. Given the small number of studies included and diversity of the populations examined, it becomes difficult to derive any conclusive outcome from these studies. However the data presented does suggest that short term exposure to sucrose has no dramatic detrimental effects on educational and behavioural outcomes in school aged children, when compared to common artificial sweeteners.

6.2.4 Fish Oil Supplementation

A total of five included studies [79-83] examined the effect of fish oil supplementation on learning and behavioural outcomes. All studies were carried out during the last five years and used a placebo controlled RCT design in a population aged between 5-13 years, with symptoms of neurodevelopmental disorders (dyspraxia and ADHD). The study population sizes were small, ranging from 40-117 particpants, all of which included both boys and girls although boys predominated in most cases, most probably due to the prevalence of male ADHD diagnoses. Studies were carried out for periods between two and four months and took place in the USA (two studies), UK (two studies) and Japan (one study). Both USA and UK studies used fish oil capsules, whilst the Japanese study incoporated the test oil into pre-prepared food and drink. The fatty acid composition selected for each study differed, with four out of the five studies using a mixture rich in Docosahexanenoic acid (DHA), whilst the most recent Richardson study [83] used a composition rich in eicosapentaenoic acid (EPA), which also contained Gamma-linolenic acid (GLA).

Whilst all studies gained medium to high quality ratings the outcome assessment measures and results varied considerably. Only two of the studies [79 & 81] measured blood biochemistry alongside objective testing and subjective parental and teacher observations. However, despite concurrent increases in blood concentrations of long chain n-3 fatty acids in the treatment groups, Voigt [79] found no significant differences in the behavioural and educational outcomes between the treatment and

control groups. Stevens [81] detected a small improvement in just 2 out of 16 subjective parental and teacher observations after secondary intention to treat analysis, although blood fatty acid concentrations were shown to correlate significantly with further parent and teacher rated behaviours. Of the remaining three studies, Richardson [80] showed a small statistically significant improvement in 3 out of 14 subjective parental behaviour scores in the fish oil group. Hirayama [82] found no significant difference between treatment and placebo groups, apart from a small significant improvement in continuous performance and visual short term memory in the control group only. The most recent Richardson study [83] was the only study to report consistent and highly significant improvements in both objective and subjective behavourial and educational outcomes assessed in the EPA rich treatment group.

Despite the recent surge of research interest in the effect of fish oil supplementation on educational and behavioural outcomes in school children there remain too many inconsistencies between studies to reliably inform any conclusion. There also remain several areas of concern in the studies published to date, including: 1) all studies have been carried out in children with varying degrees of neurodevelopmental disorders, which may raise questions over the applicability of this data to mainstream children without any developmental complications; 2) there is lack of biochemical data, whilst the extraction of blood samples from child populations raises many ethical implications, further metabolic and neurophysiological analyses are required in order to place these findings into any mechanistic context; 3) the dosage used in these studies are both inconsistent and unlikely to be achieved through dietary means in the UK; 4) whilst the fish oils consumed in the aforementioned studies appeared to be well tolerated, there is currently no national UK DRV or RDA and it is essential that optimal dose, duration and fatty acid compositions be established.

6.2.5 Vitamin/Mineral Supplementation

Two relatively recent studies [84,85] examined the effect of low dose multi-vitamin and mineral supplementation on measures of IQ, assessed by the established WISC-R test. Both studies took place over several months, were well conducted and gained high quality assurance assessments. The larger and more recent of the two studies [85] utilised an RCT design in a USA population comprised of predominantly

Hispanic working class preteens (6-12years). The authors reported a moderate, but statistically significant average increase in the non verbal IQ of children from the active supplement group. However, further matched pairing analyses indicated this may have been accounted for by a substanital net IQ increase from just a small sub sample of these children. Analysis of blood biochemistry and / or habitiual diet would have assisted the interpretation of these findings. The second smaller, slightly older, case control study [84], carried out in a British population of teenagers (13-14years) reported no significant effect of supplementation on verbal and non-verbal IQ, although this study may have been under powered. Interestingly however, blood biochemistry of the participants demonstrated a significant association between plasma ascorbic acid and non verbal IQ of boys and whole blood glutathine peroxidase activty and non verbal and verbal IQ of both sexes. This highlights the importance of examining baseline nutritional status before the functional significance of vitamin and mineral supplementation can be determined.

Although well conducted, these two studies alone provide insufficient evidence as to the effects of low dose vitamin and mineral supplementation on the IQ score of school children from the developed world. As both of these studies indicate that particular subgroups of children may be more 'at risk', it is imperative that future studies determine baseline and habitual nutritional status. As there may also be potential gender and age differences, it remains important to assess mixed gender populations powered to represent different age groups.

6.2.6 Other

One study [86], examined the effect of a supplemented diet of 'good food' vs no supplementation in a very small group of deprived Mexican school children during their first year of elementary school. Whilst significant improvements were observed in the examination results and behaviour of those children who had received the supplemented diet, this study lacked detail, quality and rigour, making it difficult to draw any reliable conclusions.

6.3 Comparison of UK and non-UK data

Only six RCT/CCT studies were included from the UK (3 breakfast studies [60,70,71], 2 fish oil studies [80,83] and 1 multi-vitamin study [85]), all of which were carried out during this decade, with the exception of [60] which was published in 1982. As there was not a sufficient number of studies from the UK, the search strategy was expanded to include other countries categoried as 'highly developed' according to the World Bank criterion. It is however, important to acknowledge the potential dietary, economic, social, educational and cultural differences that may exist between countries. Indeed, the differences in markers of educational attainment varied between countries making it difficult to draw parallels across the datasets. This review highlighted the requirement for further high quality, longer term research examining the effect of diet on the educational attainment of UK school children.

6.4 Quality Assurance Issues

In general the quality scores for the studies investigating sugar, fish oils and multi-vitamin and mineral supplementation were higher than those investigating breakfast. It is however important to recognise the difficulties of delivering a complex intervention such as breakfast within the rigorous framework of an RCT. There were however, several quality assurance issues arising generally across the studies included for this review:

1. *Confounders:*

Whilst nearly all studies took account of age and gender, ten studies accounted for body weight, six recorded ethnicity and seven adjusted for disease status (although the majority of these studies were in children with ADHD like behaviours). Only five studies considered habitual nutritional status and socio-economic status (four of these also accounted for parental education) whilst just two studies considered family status. As discussed previously, habitual dietary intake may have a significant confounding effect, particularly in the studies of short duration, where the body is mechanistically adapted to override any short-term stresses. Although logistically difficult to measure in some circumstances, family status may also impact upon measures of educational attainment, through a complex interplay of socio-cultural modifying effects. Whilst not within the scope of this review, family status may also be linked to other early life confounders

such as low birth weight, weaning, breastfeeding, nutrition *in utero* and incidence of illness, which have also been shown to be implicated in later educational attainment [2,87].

Only one study accounted for smoking status, whilst no studies reported alcohol intake, illegal drug misuse or physical activity levels. Whilst it is unlikely in very young children that smoking, alcohol and drug misuse are prevalent, it would be prudent to control for these measures, particularly in older children, given the potential influence on educational and behavioural measures [2]. Physical activity levels have also been shown to positively impact upon cognitive performance in school-aged children [88,89,90] and must consequently be considered an important confounder in all age groups. Similarly no studies adjusted for locality and context, although it is accepted that this confounder is highly complex and may be very difficult to control for particularly within 'free living' situations. However, if studies are carried out under tightly controlled conditions such as a research laboratory, it raises question over the potential impact of stresses that may be encountered within this artificial environment and the applicability of the findings to 'real life' situations.

2. Maturation and development:

Although the majority of studies focused on the preteen population, only two studies [64,66] formally assessed pubertal development. The mean age at entry to puberty in UK females is 11.2 years [91] with the current definitions of normality for entry into puberty being aged 8 years or more in females and 9 years or more in males. Therefore a significant number studies would have included pre-pubertal and pubertal children. It is now acknowledged that brain and cognitive development progresses through puberty [92] and studies assessing cognitive function should if possible, control for this confounder (particularly in short term studies).

3. Measurement of educational outcomes:

There was little consistency in methodological assessments of educational attainment (including behaviour). The included papers gave rise to a vast array of different objective and subjective measures of behavioural and educational

outcomes, often lacking in appropriate validation. This variety of assessment tools may have at least in part, been accountable to international differences, however it may also reflect the vast range of indices that make up an educational achievement i.e. the complex interaction of mood, motivation, knowledge, application and capability to name but a few.

4*. Power, concealment, compliance, randomisation and blinding:*
Statistical power was calculated in just five of the twenty nine included studies. In addition to this the degree to which concealment and compliance was reported varied dramatically, which made interpretation and comparisons between studies difficult.

6.5 Future Research

The current evidence base examining the effect of diet and dietary change on educational attainment (including behaviour) remains weak and inconclusive, it is therefore imperative that future research is undertaken. More research is required within the UK to investigate the effects of supplementation (e.g. vitamin and fish oils), specific nutrients (e.g. sugar) and complex meals (e.g. consumption and nutritional composition of breakfasts and school meals). However, the limitation of existing studies should inform future research, in order to improve the quality and depth of evidence:

1. Additional longer term/duration studies are required to assess long term impact, sustainability and overcome the possibility of short-term mechanistic adaptations and differences in the rate of pubertal maturation and neurological development.
2. More studies are required within older (teenage) young people.
3. Biochemical monitoring is important not only to establish base-line levels of nutrients under investigation, but also to assess compliance and support the understanding of mechanisms. However, withdrawal of blood samples from children requires careful ethical consideration and other alternatives such as finger pick blood, hair and salvia analyses should be considered where possible.

4. Studies should be statistically powered and provide clear details regarding randomisation, blinding, concealment and compliance, where an RCT structure can be easily applied (e.g. for supplementation studies). In free living situations (e.g. breakfast), that may not easily fit into the rigid confines of the RCT, extremely well designed cohort studies should be considered as a possible alternative.

5. Studies should measure and adjust for all potential counfounders, where feasibly possible.

6. Authors should acknowlege any limitations of their research and use this to place their findings into context.

7. There should be a broad range of investigations that include children in care, with special needs and from different ethnic minority and socio-economic groups, in order to address populations that may have different needs to the 'mainstream'.

8. Authors should base research on existing mechanistic evidence and where possible use this to place their findings into context.

9. Universal standard measures of educational attainment should be implemented to assist comparisons between studies and allow for appropriate meta analyses.

6.6 Summary and Conclusion

The effect of nutrition, diet and dietary change on learning, education and performance is clearly an important question with significant policy implications. However, the current evidence base remains limited and inconclusive. Many studies included within this review lacked quality in research methodology and reporting (particularly those investigating breakfast consumption) and failed to account for potentially important confounders, such as habitual dietary intake, physical activity levels, locality and family context. Two thirds of the included studies were carried out in primary aged children and over a half took place over a short duration (<1 month). There was insufficient quantity and consistency to draw any firm conclusions from the studies examining sugar intake, fish oil or vitamin / mineral supplementation. Whilst the majority of included studies examined breakfast interventions, the quality of much

of this research remains questionable, which in conjunction with the diversity of interventions and inconsistency in research design and methodology, made it impossible to reach any definitive conclusions.

The current evidence base would greatly benefit from further research, particularly based in the UK. However it is essential that future studies reach a high quality standard, are representative of all populations (including minority groups), are undertaken for longer duration and use universal standardised measures of educational attainment. Although the importance of this area warrants further research, this will continue to present many challenges given that the effects of nutrition on educational attainment are intrinsically interwoven with multifaceted confounders such as family and community context, poverty, disease and individual rates of maturation and neurodevelopment. Whilst the importance of diet in educational attainment remains under investigation, the evidence for promotion of physical activity and a diet low in fat, salt and sugar but high in fruits, vegetables and complex carbohydrates, remains unequivocal in terms of health outcomes for all school children.

KEY FINDINGS:

➢ The majority of studies originate from the USA (*Section 6.1*).

➢ 15 studies examined the effect of breakfast, 10 identified an association between breakfast provision and some small cognitive and behavioural improvements, however the questionable quality and inconsistency in research design made an inconclusive picture *(section 6.2.2)*.

➢ 6 studies examined the effect of short term exposure to sugar intake in populations of predominantly primary school aged children with Attention Deficit Hyperactivity Disorder. However, collectively these studies showed that sugar intake had no clinically significant adverse effects on learning or behavioural outcomes. *(section 6.2.3)*.

➢ 5 studies examined the effect of fish oil supplementation in a population aged 5-13 years with symptoms of neurodevelopmental disorders, however the findings were mixed and therefore inconclusive *(section 6.2.4)*.

➢ 2 studies examined the effect of vitamin/mineral supplementation: 1 in Hispanic low income children from the USA, which showed a significant positive effect on IQ in a small subsample and the other in UK teenagers which found no effect. These two studies alone provided insufficient evidence to formulate any conclusion *(section 6.2.5)*.

➢ Only 6 studies originated from the UK (3 breakfast, 2 fish oil and 1 vitamin/mineral supplementation) *(section 6.3)*.

➢ Several studies lacked quality in research methodology and reporting (particularly those investigating breakfast consumption) *(section 6.4)*.

➢ Many studies failed to account for important confounders such habitual dietary intake, physical activity levels, locality and family context *(section 6.4)*.

➢ Two thirds of the studies were carried out in primary age children and over a half took place over a short duration (<1 month) *(section 6.6)*.

➢ Further research is required in settings of relevance to the UK and must be of high quality, representative of all populations, undertaken for longer duration and use universal standardised measures of educational attainment *(section 6.5)*.

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9. APPENDICES:

Appendix 1: Search Terms Explored

Exposures/Interventions
Nutri$ or Malnutrition$ or Diet$ or Food$ or Meal$ or Breakfast$ or Lunch$ or Dinner$ or Tuck or Menu$ or Snack$ or Drink$ or Beverage$ or Juice$ or Confectionary or Sweet$ or Energy or Fat$ or Carbohydrate$ or Protein$ or Fibre$ or NSP$ or Starch$ or Cereal$ or Wholegrain$ or whole grain$ or Refined or Dair$ or Milk$ or Meat$ or Poultry or Fish or Seafood or Shellfish or Egg$ or Sugar$ or Glucose or Sucrose or Fructose or Fatty acid$ or Fish oil$ or Plant oil$ or Omega 3 or Veg$ or Fruit$ or Pulses or Legumes or Soy$ bean$ or Nut$ or Seed$ or Glycem$ or Glycaem$ or Vitamin$ or Niacin or Nicotinic acid or Carotene or Folic acid or Folate or Riboflavin or Thiamine or Retinal or Ascorbic acid or Biotin or Mineral$ or Calcium or Phosph$ or Iron$ or Zinc or Copper or Selenium or Potassium or Manganesse or Molybdenum or Magnesium or Fluoride or Chromium or Sodium or Chloride or Iodine or Pantothenic acid or Supplement$ or Fortif$ or Fast$

AND

Outcome
school performance or educational performance or academic performance or learning performance or test result$ or test score$ or exam result$ or exam score$ or examination result$ or examination score$ or attainment result$ or attainment score$ or high attainment$ or low attainment$ or higher attainment$ or lower attainment$ or school$ attainment$ or pupil$ attainment$ or child$ attainment$ or student$ attainment$ or school$ achievement$ or student$ achievement$ or pupil$ achievement$ or school$ result$ or gcse result$ or gcse score$ or alevel result$ or alevel score$ or higher skills or lower skills or student$ assessment$ or pupil$ assessment$ or child$ assessment$ or formative assessment$ or summative assessment$ or academic achievement$ or academic success$ or academic failure$ or academic underachievement$ or pupil$ underachievement$ or student$ underachievement$ or child$ underachievement$ or cognitive abilit$ or cognitive development$ or cognitive process$ or cognitive function$ or cognition or learning development$ or learning achievement$ or learning improvement$ or learning success$ or learning failure$ or learning problem$ or learning readiness or learning motivation or learner$ motivation or student$ motivation or pupil$ motivation or mental performance$ or memory process$ or long term memory or short term memory or problem solving or reasoning or thinking skill$ or improved standards or lower standards or improved knowledge or increased knowledge or lower knowledge or increased IQ or lower IQ or improved IQ or increased intelligence or lower intelligence or improved intelligence or verbal intelligence or non-verbal intelligence or student$ aptitude$ or pupil$ aptitude$ or child$ literacy or pupil$ literacy or student$ literacy or child$ literacy level$ or pupil$ literacy level$ or student$ literacy level$ or child$ numeracy or pupil$ numeracy or student$ numeracy or child$ numeracy level$ or pupil$ numeracy level$ or student$ numeracy level$ or student reading skill$ or pupil$ reading skill$ or child$ reading skill$ or student$ reading abilit$ or student reading level$ or pupil$ reading level$ or child$ reading level$ or student$ reading level$ or student$ writing skill$ or pupil$ writing abilit$ or child$ writing abilit$ or student$ writing level$ or pupil$ writing level$ or child$ writing level$ or pupil$ behaviour$ or student$ behaviour$ or child$ behaviour$ or pupil behavior$

or student$ behavior$ or child$ behavior$ or improved attention span$ or decreased attention span$ or lower attention span$ or higher attention span$ or lower attention or higher attention or improved attention or increased attention or pupil$ behaviour$ or student$ behaviour$ or child$ behaviour$ or child$ behaviour$ or pupil$ behavior$ or student$ behavior$ or child$ behavior$ or behavioural development$ or behavioral development$ or classroom behavior$ or classroom behaviour$ or school$ exclusion$ or pupil$ exclusion$ or student$ exclusion$ or child$ exclusion$ or temporary exclusion or permanent exclusion or child$ suspension$ or student$ suspension$ or pupil$ suspension or child$ truan$ or pupil$ truan$ or student$ truan$ or school$ expulsion$ or pupil$ expulsion$ or student$ expulsion$ or child$ expulsion$ or educational participation or pupil$ participation or student$ participation or educational engagement or pupil$ engagement or student$ engagement or student$ concentration or pupil$ concentration or student$ motivation or pupil$ motivation or student$ emotional behaviour$ or pupil$ emotional behaviour or student$ emotional behavior$ or pupil$ emotional behavior$ or pupil$ attention or student$ attention or school disrupti$ or pupil$ disrupti$ or student$ disrupti$ or child$ hyperactiv$ or pupil$ hyperactiv$ or student$ hyperactive$ or school attendance or pupil$ attendance or student$ attendance or unauthorised abscence$ or authorised abscence$ or child$ absence$ or pupil$ absence$ or student$ absence$ or pupil$ self-efficacy or student$ self-efficacy or child$ self-efficacy or pupil$ self-esteem or student$ self-esteem or child$ self-esteem or pupil$ self-worth or student$ self-worth or child$ self-worth or pupil$ aggression or student aggression or child$ aggression or classroom aggression or verbal aggression or aggressive behav$ or student$ well being or pupil$ well-being or child$ well-being or student$ aspiration$ or pupil$ aspiration$ or child$ aspiration$

AND

Populations
Child$ or adolescen$ or infan$ or teen$ or young people or young person$ or young adults or youth$ or youngster$ or schoolchild$ or schoolpupil$ or school pupil$ or boy$ or girl$ or student$ or class$ or male$ or female$ or school child$ or learners or educational establishment or pupil referral unit or school exclusion unit$ or pupil exclusion unit$ or special education school$ or secondary school$ or primary school$ or infant school$ or high school$ or elementary school$ or kindergarten or college$

Appendix 2: EPPI Key Word Mapping Tool
Teesside - Review specific keyword guidelines

Section A: Review specific keywords

A.1 Programme name (if applicable)
A.1.1 Please specify

A.2 Exposure
A.2.1 Supplement

A.2.2 Thiamin

A.2.3 Riboflavin

A.2.4 Niacin

A.2.5 Vitamin B6

A.2.6 Vitamin B12

A.2.7 Folate

A.2.8 Vitamin C

A.2.9 Vitamin A

A.2.10 Vitamin D

A.2.11 Calcium

A.2.12 Phosphorus

A.2.13 Magnesium

A.2.14 Sodium

A.2.15 Potassium

A.2.16 Chloride

A.2.17 Iron

A.2.18 Zinc

A.2.19 Copper

A.2.20 Selenium

A.2.21 Iodine

A.2.22 Fruit and vegetables

A.2.23 Milk

A.2.24 Breakfast

A.2.25 After school club

A.2.26 Carbohydrate

A.2.27 Dietary advice

A.2.28 Fish oil

A.2.29 Cooking skills

A.2.30 Other
Please specify

A.3 Measurement
Please specify
A.3.1 Blood indices

A.3.2 Interview

A.3.3 Practical test

A.3.4 Self-report

A.3.5 Psychological test

A.3.6 Curriculum based examination/test

A.3.7 School records

A.3.8 Teacher's observations

A.3.9 Parent's observations

A.3.10 Researcher observations

A.3.11 Medical records/clinical reports

A.3.12 Focus groups

A.3.13 Other

A.3.14 Meal frequency

A.3.15 Snacking frequency

A.4 Outcome
A.4.1 Blood indices

A.4.2 School performance/achievement

A.4.3 Behaviour/well-being

A.4.4 IQ/knowledge/problem solving

A.4.5 Literacy/numeracy

A.4.6 Attendance/truancy

A.4.7 Other

A.5 Duration
A.5.1 Carbohydrate >2hrs <24hrs

A.5.2 Carbohydrate >24hrs <1 week

A.5.3 Carbohydrate >1 week <1 month

A.5.4 Carbohydrate >1 month <3 months

A.5.5 Carbohydrate >3 months <6 months

A.5.6 Carbohydrate >6 months <1 year

A.5.7 Non carbohydrate >5 days <1 week

A.5.8 Non carbohydrate >1 week <1 month

A.5.9 Non carbohydrate >1 month <3 months

A.5.10 Non carbohydrate >3 months <6 months

A.5.11 Non carbohydrate >6 months <1 year

A.5.12 Non carbohydrate >1 year

A.5.13 Not applicable - Cross sectional study

A.6 Study size
A.6.1 0-100

A.6.2 101-1000

A.6.3 1001-10000

A.6.4 >10000

A.7 Setting
A.7.1 State school (inc before and after school clubs)

A.7.2 Independent school (inc before and after school clubs)

A.7.3 Community

A.7.4 Pupil referral unit/correctional institution/young offenders

A.7.5 Special needs school

A.7.6 Clinician referral

A.7.7 Workplace

A.7.8 Home

A.7.9 Research Centre/laboratory

A.7.10 Other
Please specify

A.8 Intervention implementer
A.8.1 Parents or parental support group

A.8.2 The individual school

A.8.3 The education authority

A.8.4 The health authority

A.8.5 University researchers/research group

A.8.6 Charitable organisation

A.8.7 Other
Please specify

A.8.8 Not applicable - No intervention

A.9 Age group
A.9.1 Infants 4-5yrs

A.9.2 Primary 6-10yrs

A.9.3 Secondary 11-15yrs

A.9.4 Young adults 16-18yrs

A.10 Sex of population
A.10.1 Male

A.10.2 Female

A.10.3 Mixed

A.10.4 Not reported

A.11 Study type
A.11.1 Cross Sectional

A.11.2 RCT

A.11.3 Non-Randomised Control Trial/Quasi-experimental

A.11.4 Uncontrolled trial

A.11.5 Case Control Study

A.11.6 Cohort

A.11.7 Time Series

A.11.8 Case series

A.11.9 Case Only

A.11.10 Other
Please specify

A.12 Geography
A.12.1 Argentina

A.12.2 Australia

A.12.3 Austria

A.12.4 Bahrain

A.12.5 Barbados

A.12.6 Belgium

A.12.7 Bulgaria

A.12.8 Canada

A.12.9 Chile

A.12.10 Costa Rica

A.12.11 Croatia

A.12.12 Cyprus

A.12.13 Czech Republic

A.12.14 Denmark

A.12.15 Estonia

A.12.16 Finland

A.12.17 France

A.12.18 Germany

A.12.19 Greece

A.12.20 Greenland

A.12.21 Guam

A.12.22 Hong Kong

A.12.23 Hungary

A.12.24 Iceland

A.12.25 Ireland

A.12.26 Israel

A.12.27 Italy

A.12.28 Japan

A.12.29 Kuwait

A.12.30 Lithuania

A.12.31 Luxembourg

A.12.32 Mexico

A.12.33 Netherlands

A.12.34 New Zealand

A.12.35 Norway

A.12.36 Poland

A.12.37 Portugal

A.12.38 Qatar

A.12.39 Singapore

A.12.40 Slovakia

A.12.41 Slovenia

A.12.42 South Korea

A.12.43 Spain

A.12.44 Sweden

A.12.45 Switzerland

A.12.46 United Arab Emirates

A.12.47 United Kingdom

A.12.48 Uruguay

A.12.49 United States

A.13 Decade of publication
A.13.1 1960s

A.13.2 1970s

A.13.3 1980s

A.13.4 1990s

A.13.5 2000s

A.14 Conflicting interest declared
A.14.1 Yes

A.14.2 No

A.15 Funding
A.15.1 Commercial

A.15.2 Government/Research Council

A.15.3 Other
Please specify

A.15.4 Not declared

A.16 Have all keywords been applied
A.16.1 Yes

A.16.2 No

A.16.3 If not, why?

Appendix 3: EPPI Data Extraction Tool
Teesside - Review specific data extraction guidelines

Section A: Administrative details

A.1 Name of the reviewer
A.1.1 Details

A.2 Date of data extraction
A.2.1 Details

A.3 Unique Identifier
A.3.1 Details

A.4 Authors
A.4.1 Details

A.5 Title
A.5.1 Details

A.6 Year of Publication
A.6.1 Details

A.7 Does this study have a formal programme name?
Note this has already been asked in keyword Q1
A.7.1 Yes
Please give details

A.7.2 No

A.8 Where in the developed world did the study take place?
A.8.1 Details

A.8.2 Unclear
Information not provided

A.9 What are the study aims?
A.9.1 Details
Please provide as much information as available

Section B: Study population details

B.1 Age
Please select the appropriate age bracket (note this has already been asked in keyword Q8). Use further details to expand upon this.
B.1.1 Further details
Please provide mean, SD/SE, range and any other age related data if available.

B.1.2 Infants (4-5yrs)

B.1.3 Primary (6-10yrs)

B.1.4 Secondary (11-15yrs)

B.1.5 Young adults (16-18yrs)

B.1.6 Unclear

B.2 Gender
Please provide further information where available eg n, %
B.2.1 Female only

B.2.2 Male only

B.2.3 Mixed

B.2.4 Unclear

B.3 Was ethnicity recorded?
B.3.1 No

B.3.2 Yes
If yes - please give further details such as which ethnic groups were studied and what proportion of the study population they represented.

B.3.3 Unclear

B.4 Was socio-economic status recorded?
B.4.1 Yes
Please give details of what was recorded and how.

B.4.2 No

B.4.3 Unclear

B.5 Were children with special educational needs/disability/disease recorded?
B.5.1 Yes
If yes please give details of numbers and name/nature of disability/disease if available

B.5.2 No

B.5.3 Unclear

B.6 Was there any other useful information provided about the study population?
B.6.1 Yes
If yes, please provide as much information as possible

B.6.2 No

Section C: Study design and methodology

C.1 What trial design was used?
C.1.1 RCT

C.1.2 CCT

C.2 How many arms were studied?
C.2.1 Details
Please provide exact information about the number of arms studied and what treatment was allocated to each arm.

C.3 How many participants were recruited at baseline?
Please select an appropriate bracket (this information was provided for keyword Q6), then go on to give precise details where available.
C.3.1 0-100

C.3.2 101-1,000

C.3.3 1,001-10,000

C.3.4 >10,000

C.3.5 Details
Please provide the exact number of participants recruited and how many were allocated to each arm at the beginning of the study.

C.4 Was a formal power calculation used?
C.4.1 Yes

C.4.2 No

C.4.3 Unclear

C.5 How many participants dropped out?
C.5.1 Details
Please provide details of how many participants dropped out, from which study arm and what reasons were given if any.

C.6 Was intention to treat analysis used?
C.6.1 Yes

C.6.2 No

C.6.3 Unclear

C.7 Did the participants recruited to each arm differ in any way other than the treatment received?
C.7.1 Yes
Please provide as many details as possible to describe how the groups differed

C.7.2 No

C.7.3 Unclear

C.8 Did the authors report how the subjects were recruited?
C.8.1 Yes
Please provide details to describe the method of recruitment eg letters of invitation, telephone contact, face to face contact etc

C.8.2 No

C.8.3 Unclear

C.9 Was informed consent gained?
C.9.1 Yes
If yes please state who gave consent and if consent was written or oral

C.9.2 No

C.9.3 Unclear

C.10 Was subject allocation randomised?
C.10.1 Yes
Please give details of methodology uses (eg, random numbers table, telephone/computer randomisation, sealed opaque envelopes, etc)

C.10.2 No

C.10.3 Unclear

C.11 Who was blinded?
C.11.1 Researchers

C.11.2 Participants

C.11.3 Analysts

C.11.4 Intervention co-ordinators

C.11.5 Others
Please give details

C.11.6 No blinding occurred

C.11.7 Unclear

C.12 How long was the intervention period?
C.12.1 Details
Please provide as many details as possible

C.13 Where was the study set?
Note the information for this question was provided in keyword Q7
C.13.1 State school (inc before and after school clubs)

C.13.2 Independent school (inc before and after school clubs)

C.13.3 Community

C.13.4 Pupil referral unit/correctional institution/young offenders

C.13.5 Special needs school

C.13.6 Clinician referral

C.13.7 Workplace

C.13.8 Home

C.13.9 Other
Please specify

C.13.10 Unclear

C.14 Who provided or implemented the intervention?
Note the information for this question was provided in keyword Q8
C.14.1 Parents or parental support group

C.14.2 The individual school

C.14.3 The education authority

C.14.4 The health authority

C.14.5 University researchers

C.14.6 Charitable organisation

C.14.7 Other
Please specify

C.14.8 Unclear

C.15 What exposures were examined?
*Note the information for this question was provided in keyword Q2. Please use this
section to expand on each category giving as much information as available. Please
include exact doses, composition of supplement, meals, quantity provided etc*
C.15.1 Supplement (not fish oil)
please give further details (eg vitamin/mineral type)

C.15.2 Thiamin

C.15.3 Riboflavin

C.15.4 Niacin

C.15.5 Vitamin B6

C.15.6 Vitamin B12

C.15.7 Folate

C.15.8 Vitamin C

C.15.9 Vitamin A

C.15.10 Vitamin D

C.15.11 Calcium

C.15.12 Phosphorus

C.15.13 Magnesium

C.15.14 Sodium

C.15.15 Potassium

C.15.16 Chloride

C.15.17 Iron

C.15.18 Zinc

C.15.19 Copper

C.15.20 Selenium

C.15.21 Iodine

C.15.22 Fruit and vegetables
Please give more further details (eg which fruit/vegetables were used)

C.15.23 Milk
Please give further details eg skimmed/semi-skimmed

C.15.24 Breakfast
Please give further details

C.15.25 After school club
Please give further details

C.15.26 Carbohydrate
Please give further details

C.15.27 Dietary advice
Please provide further details

C.15.28 Fish oils
please give further details

C.15.29 Cooking skills
Please provide further details

C.15.30 Other
Please provide as many details as possible

C.16 What measurement tools were used?
Note the answer to this question was provided in keyword Q3. Please use this section to expand upon each category, providing as many details as possible eg the name of any particular blood tests or examination.
C.16.1 Blood indices
Please provide further details

C.16.2 Interview
Please provide further details

C.16.3 Practical test
Please provide further details

C.16.4 Self-report
Please provide further details

C.16.5 Psychological test
Please provide further details

C.16.6 Curriculum based examination/test
Please provide further details

C.16.7 School records
Please provide further details

C.16.8 Teacher's observations
Please provide further details

C.16.9 Parent's observations
Please provide further details

C.16.10 Medical records/clinical reports
Please provide further details

C.16.11 Focus groups
Please provide further details

C.16.12 Other
Please provide further details

C.16.13 Unclear

C.17 What comparisons are made in the study?
Are comparisons made between treatments or between treatment and placebo / no treatment?
C.17.1 Details

C.18 How long are subjects followed -up in the study?
Length of time participants are followed from beginning of participation in the study. Note specified end points used to decide end of follow-up. Note if follow-up period is shorter than originally planned.
C.18.1 Details

C.19 What confounders are adjusted for?
C.19.1 Socio Economic Status

C.19.2 Nutritional Status

C.19.3 Physical Activity

C.19.4 Alcohol use

C.19.5 Smoking

C.19.6 Illegal drug use

C.19.7 Ethnicity

C.19.8 Disease status (particularly in special schools)

C.19.9 Parental Education

C.19.10 Body weight status

C.19.11 Family status

C.19.12 Age

C.19.13 Gender

C.19.14 Locality/context

C.19.15 Other
Please specify

C.20 What methodology was used to analyse the data?
C.20.1 Details

C.21 Did the authors give any rationale to their chosen analytical tool?
C.21.1 Yes

C.21.2 No

C.21.3 Unclear

C.22 Do the authors describe any ways they addressed the reliability or their data collection tools/methods?
C.22.1 Details

Section D: Study results and conclusions

D.1 What outcomes were measured?
Note the answer to this question is provided in keyword Q4. Please use this section to report the findings under each category. Please include means, ranges, absolute and relative risks, sd, se, CI, P values etc. IT IS IMPORTANT TO PROVIDE ALL RELEVANT RESULTS - IF DATASETS ARE TOO LARGE PLEASE REFER TO PAGE AND TABLE NUMBER IN ORIGINAL PAPER.
D.1.1 Blood indices
Please provide results

D.1.2 School performance/achievement
Please provide results

D.1.3 Behaviour/well-being
Please provide results

D.1.4 IQ/knowledge/problem solving
Please provide results

D.1.5 Literacy/numeracy
Please provide results

D.1.6 Attendance/truancy
Please provide results

D.1.7 Other
Please provide results

D.1.8 Unclear

D.2 Do the authors discuss the reliability of their data?
D.2.1 Yes
Please give details

D.2.2 No

D.2.3 Unclear

D.3 Are there any obvious shortcoming in the reporting of the data?
D.3.1 Yes
Please describe

D.3.2 No

D.3.3 Unclear

D.4 Do the authors report on all variables described in their aims?
D.4.1 Yes

D.4.2 No
Please detail variables not reported

D.4.3 Unclear

D.5 What do the authors conclude about the findings of the study?
Please provide as much information as possible. If several conclusions are drawn please bullet point each conclusion concisely in the details box.
D.5.1 Details

D.5.2 Unclear

D.6 Do you agree with the authors conclusions?
D.6.1 Yes

D.6.2 No
Please discuss

Section E: QA - section 1 Internal validity
This RCT methodology checklist is based on the SIGN 50 guidance. Please see the accompanying guideline developers handbook for further information. Scoring allocation is shown in brackets.
E.1 The study addresses an appropriate and clearly focused question
E.1.1 well covered (3)

E.1.2 adequately addressed (2)

E.1.3 poorly addressed (1)

E.1.4 not addressed (0)

E.1.5 not reported (0)

E.1.6 not applicable (0)

E.2 The assignment of subjects to treatment groups is randomised
E.1.1 well covered (3)

E.1.2 adequately addressed (2)

E.1.3 poorly addressed (1)

E.1.4 not addressed (0)

E.1.5 not reported (0)

E.1.6 not applicable (0)

E.3 An adequate concealment method is used
E.1.1 well covered (3)

E.1.2 adequately addressed (2)

E.1.3 poorly addressed (1)

E.1.4 not addressed (0)

E.1.5 not reported (0)

E.1.6 not applicable (0)

E.4 Subjects and investigators are kept 'blind' about treatment allocation
E.1.1 well covered (3)

E.1.2 adequately addressed (2)

E.1.3 poorly addressed (1)

E.1.4 not addressed (0)

E.1.5 not reported (0)

E.1.6 not applicable (0)

E.5 The treatment and control groups are similar at the start of the trial
E.1.1 well covered (3)

E.1.2 adequately addressed (2)

E.1.3 poorly addressed (1)

E.1.4 not addressed (0)

E.1.5 not reported (0)

E.1.6 not applicable (0)

E.6 The only difference between groups is the treatment under investigation
E.1.1 well covered (3)

E.1.2 adequately addressed (2)

E.1.3 poorly addressed (1)

E.1.4 not addressed (0)

E.1.5 not reported (0)

E.1.6 not applicable (0)

E.7 All relevant outcomes are measured in a standard, valid and reliable way
E.1.1 well covered (3)

E.1.2 adequately addressed (2)

E.1.3 poorly addressed (1)

E.1.4 not addressed (0)

E.1.5 not reported (0)

E.1.6 not applicable (0)

E.8 All the subjects are analysed in the groups to which they were randomly allocated (often referred to as intention to treat analysis)
E.1.1 well covered (3)

E.1.2 adequately addressed (2)

E.1.3 poorly addressed (1)

E.1.4 not addressed (0)

E.1.5 not reported (0)

E.1.6 not applicable (0)

E.9 What percentage of the individuals or clusters recruited into each treatment arm of the study dropped out before the study was completed
E.9.1 Details

E.10 Where the study is carried out at more than one site, results are comparable for all sites
E.1.1 well covered (3)

E.1.2 adequately addressed (2)

E.1.3 poorly addressed (1)

E.1.4 not addressed (0)

E.1.5 not reported (0)

E.1.6 not applicable (0)

Section F: QA - section 2 Overall assessment of the study
This RCT methodology checklist is based on the SIGN 50 guidance. Please see the accompanying guideline developers handbook for further information.
F.1 How well was the study done to minimise bias?
F.1.1 ++

F.1.2 +

F.1.3 -

F.2 If coded as + or - what is the likely direction in which bias might affect the study results?
F.2.1 Details

F.3 Taking into account clinical considerations, your evaluation of the methodology

used, and the statistical power of the study, are you certain that the overall effect is due to the study intervention?
F.3.1 Details

F.4 Are the results of the study directly applicable to the subject group targeted by this guideline?
F.4.1 Details

F.5 How was the study funded?
This information is provided in keyword Q14.
F.5.1 Commercial

F.5.2 Government/Research Council

F.5.3 Other
Please specify

F.5.4 Not declared

F.6 Does this study help to answer your key systematic review question?
F.6.1 Yes

F.6.2 No

F.6.3 Unclear

Section G: EPPI specific evidence weighting

G.1 Weight of evidence A: Taking account of all quality assessment issues, can the study findings be trusted in answering the study question(s)?
In some studies it is difficult to distinguish between the findings of the study and the conclusions. In those cases, please code the trustworthiness of this combined results/conclusion.
G.1.1 High trustworthiness (please specify)

G.1.2 Medium trustworthiness (please specify)

G.1.3 Low trustworthiness (please specify)

G.2 Weight of evidence B: Appropriateness of research design and analysis for addressing the question, or sub-questions, of this specific systematic review.
Please specify basis for this judgement
G.2.1 High

G.2.2 Medium

G.2.3 Low

G.3 Weight of evidence C: Relevance of particular focus of the study (including conceptual focus, context, sample and measures) for addressing the question or sub-questions of this specific systematic review.
Please specify basis for this judgement.
G.3.1 High

G.3.2 Medium

G.3.3 Low

G.4 Weight of evidence D: Taking into account quality of execution (Question G1), appropriateness of design and relevance of focus, what is the overall weight of evidence this study provides to answer the question of this specific systematic review?
Please specify basis for this judgement.
G.4.1 High

G.4.2 Medium

G.4.3 Low

Section H: Effect

H.1 What overall effect of the study?
H.1.1 positive effect on education/performance

H.1.2 negative effect on education/performance

H.1.3 no effect on education/performance

Appendix 4: Systematic Mapping: Summary of Key Findings

Author, year, country	Study type	Study size range	Age Range & (Gender: ♀/♂/NR)	Duration	Setting	Exposure	Outcome Measure	Funding
Breakfast								
Bro et al. 1994 [18]	Non-Randomised Control Trial/Quasi-experimental	0-100	Secondary 11-15yrs Young adults 16-18yrs (♂)	Carbohydrate >2hrs <24hrs	Vocational School	Breakfast	Behaviour/well-being Attendance/truancy	Not declared
On et al. 1994[19]	Cross Sectional	0-100	Secondary 11-15yrs (♀)	Not applicable	State school	Breakfast	School performance/achievement	Not declared
Bro, 1996 [20]	Uncontrolled trial	0-100	Secondary 11-15yrs Young adults 16-18yrs (♀&♂)	Carbohydrate >2hrs <24hrs	Vocational School	Breakfast	Behaviour/well-being	Not declared

Author, year, country	Study type	Study size range	Age Range & (Gender: ♀/♂/NR)	Duration	Setting	Exposure	Outcome Measure	Funding
Murphy et al. 1998[21]	Cross Sectional Uncontrolled trial	101-1000	Primary 6-10yrs Secondary 11-15yrs (♀&♂)	Carbohydrate >3 months <6 months	State school	Breakfast	School performance/achievement Behaviour/well-being Literacy/numeracy Attendance/truancy	Kellogg Corporation Mid Atlantic Milk Marketing Association
Worobey & Worobey, 1999[22]	Non-Randomised Control Trial/Quasi-experimental *Study 2* Uncontrolled trial *Study 1*	0-100	Infants 4-5yrs (NR)	Carbohydrate >2hrs <24hrs	State school	Breakfast	IQ/knowledge/problem solving	Nutrition Education and Training Program, New Jersey Department of Education
Simpson, 2001[23]	Uncontrolled trial		Primary 6-10yrs (♀&♂)	Carbohydrate >6 months <1 year	State school Special needs school	Breakfast	Attendance/truancy	Not declared

Author, year, country	Study type	Study size range	Age Range & (Gender: ♀/♂/NR)	Duration	Setting	Exposure	Outcome Measure	Funding
Kleinman et al. 2002[24]	Cross Sectional Uncontrolled trial	0-100	Primary 6-10yrs Secondary 11-15yrs (♀&♂)	Carbohydrate >6 months <1 year	State school	Breakfast	School performance/achievement Attendance/truancy	Project Bread/The Walk for Hunger
Lopez-Sobaler et al. 2003 [25]	Cross Sectional	101-1000	Primary 6-10yrs Secondary 11-15yrs (♀&♂)	Not applicable	State school	Breakfast	IQ/knowledge/problem solving	Not declared
Chen et al. 2005 [26]	Cross Sectional Cross sectional data from a longitudinal study	1001-10000	Secondary 11-15yrs (♀&♂)	Not applicable	State school Community	Breakfast Snacking	Behaviour/well-being	Ministry of Health, Labour and Welfare, the Toyama Medical Associaion Japan Heart Foundation.

Author, year, country	Study type	Study size range	Age Range & (Gender: ♀/♂/NR)	Duration	Setting	Exposure	Outcome Measure	Funding
Sugar (sucrose) and sugary foods								
Prinz & Riddle. 1986 [27]	Cross Sectional	0-100	Infants 4-5yrs (♂)	Not applicable	In a controlled setting but not specified	Carbohydrate: Sucrose	Behaviour/well-being Attention	Not declared
Wolraich et al. 1986[28]	Cross Sectional	0-100	Primary 6-10yrs Secondary 11-15yrs (♂)	Not applicable	Research Centre/laboratory	Sugar Protein Fat	Behaviour/well-being	Sugar Associates, Inc General Research Center Program, Division of Research Resources, National Institutes of Health
Koivusilta et al. 2003[29]	Cohort	>10000	Secondary 11-15yrs Young adults 16-18yrs (♀&♂)	Non carbohydrate >1 year	Community	Milk (& milk fat) Snack foods Sweets & pastries	School performance/achievement	Academy of Finland and the Ministry of Social Affairs and Health

Author, year, country	Study type	Study size range	Age Range & (Gender: ♀/♂/NR)	Duration	Setting	Exposure	Outcome Measure	Funding
Fish oil and EFA blood indices								
Mitchell et al. 1983[30]	Cross Sectional	0-100	Primary 6-10yrs Secondary 11-15yrs (♀&♂)	Not applicable	State school Special needs school	EFA serum levels	Behaviour/well-being	Not declared
Stevens et al. 1996 [31]	Cross Sectional	0-100	Primary 6-10yrs Secondary 11-15yrs (♂)	Not applicable	State school Research Centre/laboratory	EFA plasma levels	Behaviour/well-being	Crossroads grant from the state of Indiana

Author, year, country	Study type	Study size range	Age Range & (Gender: ♀/♂/NR)	Duration	Setting	Exposure	Outcome Measure	Funding
Macro and Micro nutrient supplementation and blood indices								
Krischer, 1978[32]	Cross Sectional	0-100	(N/R)	Not applicable	Other Not stated	Zinc Copper	Learning disability	Not declared
Middleman et al. 1996[33]	Case Only	0-100	Secondary 11-15yrs (♂)	Not applicable	Research Centre/laboratory	Vitamin B12 Folate Iron	School performance/achievement Behaviour/well-being	Maternal and Child Health Bureau
Andreou et al. 1997[34]	Cross Sectional	101-1000	Secondary 11-15yrs (♀&♂)	Not applicable	State school	Nutrient intake	School performance/achievement Behaviour/well-being Self-esteem	Not declared

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Author, year, country	Study type	Study size range	Age Range & (Gender: ♀/♂/NR)	Duration	Setting	Exposure	Outcome Measure	Funding
Louwman et al. 2000[35]	Cross Sectional (Cobalamin status exposure) Cohort Retrospective (Microbiotic vs omnivorous diet exposure)	101-1000	Primary 6-10yrs Secondary 11-15yrs (♀&♂)	Non carbohydrate >1 year (Microbiotic vs omnivorous diet exposure) Not applicable (Cobalamin status exposure)	Research Centre/laboratory	Cobalamin status Microbiotic vs omnivorous diet since birth	IQ/knowledge/problem solving	Dutch Prevention Fund
Halterman et al. 2001 [36]	Cross Sectional	1001-10000	Secondary 11-15yrs Young adults 16-18yrs (♀&♂)	Not applicable	Community	Iron	IQ/knowledge/problem solving	National Research Service Award Institutional Training grant
Kim et al. 2003 [37]	Cross Sectional	1001-10000	Primary 6-10yrs Secondary 11-15yrs Young adults 16-18yrs (♀&♂)	Not applicable	State school	Nutrient intake Regular meals	School performance/achievement	Government/Research Council Supported, in part, by grant from Ministry of Education

Author, year, country	Study type	Study size range	Age Range & (Gender: ♀/♂/NR)	Duration	Setting	Exposure	Outcome Measure	Funding
Ivanovic et al. 2004 [38]	Cross Sectional	1001-10000	Infants 4-5yrs Primary 6-10yrs Secondary 11-15yrs Young adults 16-18yrs (♀&♂)	Not applicable	State school Independent school	Nutrient intake	School performance/achievement	National Fund for Scientific and Technologic Department Research and Development Department, University of Chile
Konofal et al. 2004[39]	Cross Sectional Controlled group comparison study	0-100	Infants 4-5yrs Primary 6-10yrs Secondary 11-15yrs (♀&♂)	Not applicable	University Hospital	Iron	Behaviour/well-being IQ/knowledge/problem solving	Not declared
Kim 005 [40]	Cross Sectional	101-1000	Primary 6-10yrs Secondary 11-15yrs (♀&♂)	Not applicable	State school	Nutrient intake	School performance/achievement	Not declared

Author, year, country	Study type	Study size range	Age Range & (Gender: ♀/♂/NR)	Duration	Setting	Exposure	Outcome Measure	Funding
Mansson et al. 2005 [41]	Cross Sectional Uncontrolled trial	101-1000	Young adults 16-18yrs (♀&♂)	Non carbohydrate >1 month <3 months	State school	Iron	Behaviour/well-being IQ/knowledge/problem solving, mental concentration	Not declared
Zhang et al. 2005a [42]	Cross Sectional	1001-10000	Primary 6-10yrs Secondary 11-15yrs (♀&♂)	Not applicable - Cross sectional study	Community	Nutrient intake	Behaviour/well-being IQ/knowledge/problem solving	Not declared

Author, year, country	Study type	Study size range	Age Range & (Gender: ♀/♂/NR)	Duration	Setting	Exposure	Outcome Measure	Funding
Fruit and vegetables								
Neumark-Sztainer et al. 1996[43]	Cross Sectional	>10000	Secondary 11-15yrs Young adults 16-18yrs (♀&♂)	Not applicable	State school	Fruit and vegetables	School performance/achievement	Not declared
Story et al. 1998[44]	Cross Sectional	>10000	Secondary 11-15yrs Young adults 16-18yrs (♀&♂)	Not applicable	Community	Fruit and vegetables	School performance/achievement	Maternal and Child Health Bereau, Health Resources and Services Administration
Roos et al. 2001[45]	Cross Sectional	>10000	Secondary 11-15yrs Young adults 16-18yrs (♀&♂)	Not applicable	State school	Fruit and vegetables	School performance/achievement	Academy of Finland

Author, year, country	Study type	Study size range	Age Range & (Gender: ♀/♂/NR)	Duration	Setting	Exposure	Outcome Measure	Funding
Food insufficiency								
Murphy et al. 1998[46]	Cross Sectional	101-1000	Primary 6-10yrs Secondary 11-15yrs (♀&♂)	Not applicable	State school Community	Food insufficiency	Behaviour/well-being Attendance/truancy	Kellogg Corporation Mid Atlantic Milk Marketing Association
Kleinman et al. 1998[47]	Cross Sectional	101-1000	Primary 6-10yrs Secondary 11-15yrs (♀&♂)	Not applicable	Community	Food insufficiency	Behaviour/well-being Psychosocial dysfunction	Kellogg Corporation National and local funders (not stated)
Alaimo et al. 2001 [48]	Cross Sectional	1001-10000	Primary 6-10yrs Secondary 11-15yrs Young adults 16-18yrs (♀&♂)	Not applicable	Mobile examination centre	Food insufficiency	Behaviour/well-being IQ/knowledge/problem solving Attendance/truancy	NIH Training Grant

Author, year, country	Study type	Study size range	Age Range & (Gender: ♀/♂/NR)	Duration	Setting	Exposure	Outcome Measure	Funding
Weinreb et al. 2002[49]	Cross Sectional	101-1000	Primary 6-10yrs Secondary 11-15yrs Young adults 16-18yrs (♀&♂)	Not applicable	Community	Food insufficiency	Behaviour/well-being Literacy/numeracy	Economic Research Service of the US Department of Agriculture, National Institute of Mental Health, and the Maternal and Child Health Bureau
Dunifon et al. 2003 [50]	Uncontrolled trial	1001-10000	Primary 6-10yrs Secondary 11-15yrs (♀&♂)	Not applicable	State school Community	Participation in School Lunch Program Food insecurity	School performance/achievement Behaviour/well-being	USDA Small Grants program

Author, year, country	Study type	Study size range	Age Range & (Gender: ♀/♂/NR)	Duration	Setting	Exposure	Outcome Measure	Funding
Slack & Yoo. 2005[51]	Cross Sectional	1001-10000	Infants 4-5yrs Primary 6-10yrs Secondary 11-15yrs (♀&♂)	Not applicable	Community	Food insufficiency	Behaviour/well-being	John D. and Catherine T MacArthur Foundation Joyce Foundation Woods Fund of Chicago National Institute of Child Health and Human Development, Administration for Children and Families.
Zhang et al. 2005b[52]	Cross Sectional	1001-10000	Primary 6-10yrs Secondary 11-15yrs (♀&♂)	Not applicable - Cross sectional study	Community	Serum cholesterol Food sufficiency	Behaviour/well-being	Not declared

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Author, year, country	Study type	Study size range	Age Range & (Gender: ♀/♂/NR)	Duration	Setting	Exposure	Outcome Measure	Funding
Snacking and meal frequency								
Eisenberg et al. 2004 [53]	Cross Sectional	1001-10000	Secondary 11-15yrs Young adults 16-18yrs (♀&♂)	Not applicable	State school	Frequency of family meals	School performance/achievement Behaviour/well-being	Department of Health and Human Services, US Public Health Service
Dietary Advice								
Gietzen & Vermeersch, 1980 [54]	Cross Sectional Cross sectional data from a case-cohort study	101-1000	Primary 6-10yrs (♀&♂)	Not applicable	State school	Dietary advice Lunch	School performance/achievement Attendance/truancy	Not declared
Galler & Ramsey, 19__	Uncontrolled trial	101-1000	Primary 6-10yrs Secondary 11-15yrs (♀&♂)	Non carbohydrate >1 year	State school, community, other	Dietary advice	Behaviour / well-being	Ford foundation and Thrasher Research Fund

Author, year, country	Study type	Study size range	Age Range & (Gender: ♀/♂/NR)	Duration	Setting	Exposure	Outcome Measure	Funding
Sacher et al, 2005 [56]	Uncontrolled trial	0-100	Primary 6-10yrs Secondary 11-15yrs (♀&♂)	Non carbohydrate >3months < 6months	Sports centre	Dietary advice	Behaviour / wellbeing	Sainsburys supermarket

Other

Bird et al. 1977 [57]	Case Only	0-100	Primary 6-10yrs (♂)	Non carbohydrate >1 week <1 month	Research Centre/laboratory	Gluten containing food	Behaviour/well-being	Maternal and Child Health Service, Department of Health, Education and Welfare

KEY:

Country Flag Codes

Barbados	Canada	Chile	Cyprus	Finland
Hong Kong	Israel	Japan	France	Sweden
Korea (south)	Mexico	Netherlands	New Zealand	Spain
UK	USA			

Gender

♀ Female   ♂ Male   NR Not Reported

Appendix 5: Systematic In-depth Data Extraction: Summary of Key Findings

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance		Funding
								SIGN	EPPI	
Breakfast										
Lieberman et al. 1976 [58]	CCT Case Control Study 617 (11.8%)	3rd-6th grade predominant black low income (♀&♂)	8months 2 state elementary schools (S&U)	Free state breakfast vs no free state breakfast	School attendance and performance records, five psychological tests to assess concentration, memory, abstract thoughts and work in class, measurement of body growth.	There were no significant differences between the control and intervention schools for any of the outcomes measured.	K,H, E,D, LL,B, J,A, G, L	11/24	med	Not declared

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance SIGN	Quality Assurance EPPI	Funding
Morrell et al. 1977 [59]	RCT 52	Kindergarten – 6th grade Mixed race qualified to receive free breakfasts (♀&♂)	20days state school (U)	Standard state breakfast (cereal or bread and 1/2pt milk providing an average of 11g protein and high sugar content) vs a high protein low carbohydrate (average 24g protein)	Task perseverance test, observed on task behaviour, digit span forward and backward, termination responses, teacher rating scale adapted from the adaptation behaviour scale, attendance at breakfast club and school, blue gunkies attitude survey.	There was no significant difference between the two breakfasts over 20 days of consumption on any of the outcomes measured.	E,A, G	9/24	low	Not declared
Dickie & Be 1982[60]	RCT 53 *Study 2* only	Average age 16.2y Privileged background *(NR)*	3 days collection of baseline data followed by 3 days of intervention Four independent boarding schools	Breakfast consumed (>2.1MJ) vs no breakfast in children who normally habitually consume breakfast	Memory was assessed using the MAST4&6, a sentence verification task analysed reading rate and a simple addition test assessed numeracy.	The authors found no consistent significant relationship between the outcome measures and the omission of breakfast.	-	7/27	low	Kellogg Company

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance SIGN	Quality Assurance EPPI	Funding

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	SIGN	EPPI	Funding
Pollitt et al. 1981 [61] & Pollitt et al. 1982-83 [62] (which reported findings from both [61&62])	RCT RCT Cross over Study 2 only (study 1 see [60]) 32 [61] 39 [62]	9-11y middle class well nourished children (♀&♂)	1 morning for breakfast and 1 morning for fasting Research Centre (U)	Breakfast (535kcal in [61] & 448kcal in [62]) vs no breakfast (dinner and overnight fasting – standardised and supervised) breakfast served at 8.00 and testing took place between 8.30-12.00.	Blood glucose, beta hydroxybutyrate and free fatty acids [61], blood glucose & insulin [62], Matching familiar figure MFF test and hagen central incidental test, Peabody picture vocabulary test [61], slossom intelligence scale [62]. Short term memory test [62].	Skipping breakfast was found to have adverse effects on the children's late morning problem-solving performance. Glucose and insulin levels were significantly different in the two groups and correlated negatively with MFF score in the fasted group. Children were divided equally, for the analysis, into those of high and low IQ. When hard and easy MFF tasks were combined, the difference between breakfast and fasting conditions was large and significant (p<0.01). The effects were greater in the high IQ group.	A,G, IQ	16/27	Med-low	Ford Foundation

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance SIGN	Quality Assurance EPPI	Funding
Meyers et al. 1989 [63]	CCT Case Control Study 1023	3rd-6th grade mixed ethnicity predominant Hispanic from low income families (♀&♂)	3months	Participation and non participation of state breakfast program.	Comprehensive test of basic skills CTBS (battery of standardized achievement tests which are administered annually to all grades), attendance and tardiness from school records.	Increases in scores from 1986-1987 were significantly greater for the breakfast participants than non-participants in CTBS battery total scale score (p<0.01) and language sub score (p<0.05). Participation contributed negatively to 1987 rates of absenteeism (P=0.05) and tardiness (P=0.0001).	K,E,I,A,G	8/27	low	William T Grant Foundation Helmut Wolfgang Schumann Foundation

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance		Funding
								SIGN	EPPI	
Cromer et al. 1990 [64]	RCT 34	Mean age 14.2sd0.4 Healthy, post or mid pubertal Middleclass predominant white (♀&♂)	4hours Research Centre (U)	High 424kcal calorie breakfast (doughnut, orange juice and chocolate milk) vs low 12kcal breakfast (sugar free and gelatine drink)	Blood glucose and beta hydroxybutyrate continuous performance test, matching familiar figure, rey auditory verbal test, stat trait anxiety scale.	There were no significant differences between either breakfast and the outcomes of the tests assessing short term auditory memory, vigilance, impulsivity and mood. Neither serum glucose or beta hydroxybutyrate levels correlated significantly with any of these behavioural outcomes.	K,A, B,G, & IQ & pube-rty	15/24	Med-low	NIH Grant

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance SIGN	Quality Assurance EPPI	Funding

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	SIGN	EPPI	Funding
Michaud et al. 1991 [65]	RCT Cluster random-ised Cross over 319 (30% for blood glucose)	13-20y (♀&♂)	14 days (d0 on breakfast d14 the other breakfast) breakfast was consumed at home and testing carried out at 11.30. 11 state schools (S)	Habitual breakfast vs a higher energy breakfast provided by the school	Food diary and interview to evaluate habitual and test diet consumption. Blood glucose, Herbert self reported mood, memory and concentration,	Higher energy breakfasts increased short term memory scale test results. p<0.01 but reduced concentration test scores p<0.05. There was no significant effect on blood glucose or mood. The difference in energy consumed between both diets had no significant effect on any of the parameters investigated.	B,A, G,H	12/27	Med-low	Dietetique et Sante S.A. Sopad-Nestle.

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance SIGN	Quality Assurance EPPI	Funding
Lopez et al. 1993 [66]	RCT 279	8-10y children from low income families (♀&♂)	1 morning – breakfast provided and testing takes place 1 hour after for 2 hours 12 state schools (U)	Breakfast (394kcal from 2 cakes and a 200ml flavoured milk) vs no breakfast in children classified as nutritionally normal, stunted and wasted.	Tests designed for study included cognition test, memory test (modification of WISC digits subtest), Domino test (based on Anstey's domino test) and Attention test and plasma glucose.	There was no consistent association between study condition and performance of any of the tests examined in any of the three nutritional group.	A, G, K,H, D,B, J & IQ and Puberty	8/27	low	Nestle Nutrition Universidad de Chile Ministerio de Educacion, Chile

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance SIGN	Quality Assurance EPPI	Funding
Vaisman et al. 1996 [67]	RCT 569 (24.4%)	11-13y (♀&♂)	2 weeks 5 elementary schools	Habitual Israeli breakfast or not breakfast (1/3 of pupils) at home vs daily consumption of 200ml milk & 30g sugared cornflakes eaten at school (2/3 pupils).	Rey Auditory-Verbal learning test was used to assess cognitive functions. Memory for narrative prose was tested by two alternative forms of logical memory subtest of the revised Wechsler memory scale and visual memory was tested by 2 versions of Benton visual retention test.	After 15days, children who ate breakfast at school scored significant higher on most of the test modules than did children who ate breakfast at home or ate no breakfast at all (p<0.05).	G	7/27	low	Not declared

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance		Funding
								SIGN	EPPI	
Wyon et al. 1997 [68]	RCT 195 (15.4%)	10y (♀&♂)	4days carried out in an ABAB or AABA pattern of breakfast consumption 5 schools (although breakfasts consumed at home) (U)	High calorie breakfast A (rolls, light margarine, cheese, ham, milk, cornflakes, apple and orange juice) vs low calorie breakfast B (rolls, light margarine, jam and diet orange cordial)	Voluntary physical endurance (3 out of 5 schools), short food questionnaire, subjective visual analogue mood scale, addition test, multiplication test, grammatical reasoning test (Baddeley), Wallach, number checking test and Wallach & Hogan creativity test.	The low calorie breakfast was found to have a significant and negative effect on a test of creative thinking (p<0.0257) and initial voluntary physical endurance (P<0.01). Children were more hunger on the low calorie breakfast (P<0.001) and boys were more alert (P<0.05). Multiplication and grammatical reasoning were not effected by energy intake. Reduced energy intake caused more children to report feeling bad (P<0.0001).	A,G	9/27	low	Kellogg Co. UK

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance		Funding
								SIGN	EPPI	
Wahlstrom & Begalle, 1999[69]	CCT Case Control Study ~2901	Elementary/ school age (♀&♂)	3years 6 state schools (E)	Universal Breakfast Program vs no Universal Breakfast Program	Student interview (sub sample only),standardized achievement tests, school records of attendance, discipline & attendance. Interviews with teachers, number of visits to the health office and interviews with a sub sample of parents.	Very selective reporting showed that the breakfast clubs gave rise to better concentration, increased alertness and energy and a decrease in stomach aches and headaches. Discipline problem decrease and benefits in social behaviour, attendance and a general increase in maths and reading scores were also reported for the breakfast group.	-	5/27	low	Not declared

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance		Funding
								SIGN	EPPI	
Wesnes et al. 2003 [70]	RCT Cross over 29	9-16y (♀&♂)	5 days – day1 to eliminate training effect – day 2-4 test breakfast with testing occurring for 3 hours after breakfast on each day Research Centre (private cognitive drug research unit)	Four breakfasts conditions: 1-shreddies 45g plus 125ml semi skimmed milk, 2-cheerios 30g plus 125ml of semi skimmed milk, 3-orange flavoured drink 330ml providing same carbohydrate as shreddies and 4-no breakfast	Attention, working memory and episodic secondary memory assessed using research centres test.16 additional bipolar ratings of mood and alertness were also tested	Results showed that power of attention and epidsodic memory showed significant main effect of treatment (p<0.0025 and <0.041 respectively). Satiety ratings were also significantly better after consumption of the 2 cereals (p<0.0001). Significant treatment effects were also seen with the mood factors alertness and contentment (p<0.0001) after cereal consumption.	-	9/24	low	Cereal Partners, UK

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Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance		Funding
								SIGN	EPPI	
Shemilt et al. 2004 [71]	RCT Cluster 8209* (32.7%)	Mean ages 10.13y sd3.93 control 9.59y sd2.96 intervention Predominantly white, with 69% control and 64 intervention entitled to free school meals (♀&♂)	3months (followed observationally for a further 9 months) 40 – 21 primary and 8 secondary state schools (U, E, H)	Breakfast club vs no breakfast club	Reitan Trail making test to measure concentration, self report life, health and school questionnaire. Goodman strengths and difficulties questionnaire. Family questionnaire.	Intention to treat analysis showed improved concentration amongst the intervention group at 3 months (95% CI0.81-1.00)	K,A, G	11/27	med	UK Department of Health NHS Executive

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance		Funding
								SIGN	EPPI	
Mahoney et al. 2005 [72]	RCT Cross over Study 1 30 Study 2 30	Study 1: 9-11y study 2: 6-8y All healthy children with no learning difficulties from middle class families (♀&♂)	1 day a week for 4weeks (breakfast provided at 08.00 & testing occurred between 09.30 & 10.30) Private catholic elementary school (U & Quaker oats))	Breakfast: No breakfast vs cup of breakfast cereal with half a cup of fat free milk vs 1 packet of flavoured instant oatmeal breakfast cooked and served with half a cup of fat free milk	Self assessment of mood energy level & hunger level. Cognitive tests: spatial memory test, short term memory test visual perception test visual attention test auditory attention test and verbal memory test.	Study 1 showed that breakfast intake significantly enhanced cognitive performance (p,0.05), particularly on tasks requiring processing of a complex visual display. The results showed that boys ad girls had enhanced spatial memory and girls showed improved short term memory after consuming oatmeal (p<0.05). Results from study 2 also showed effects of breakfast type with younger children showing better spatial memory and better auditory attention and girls exhibiting better short term memory after consuming oatmeal (p<0.05).	H,B,A,G	18/24	med	Not declared

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance		Funding
								SIGN	EPPI	

Sugar

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	SIGN	EPPI	Funding
Wolraich et al. 1985 [73]	RCT Cross over 16 in study 1 & 2	7-12y IQ>85 and hyperactive (♂)	3 days (1 baseline then 2 days with random assignment of sucrose then aspartame drink) outcomes tested 2.5h after drink. Research centre (U)	Drink containing either 1.75g/kg sucrose or equal sweetness aspartame study 1 drink consumed after lunch study 2 drink consumed after overnight fast	Continuous performance test, Stephens nonsense word spelling task, matching familiar figures test, draw a line fast and slow, wrist and ankle actometers, examiners & playroom observations	There were no significant differences in the childrens behaviour between the sucrose or aspartame drinks when consumed either after lunch or an overnight fast	A, G, IQ	17/24	Med	Sugar Associates Inc. General Clinical Research Centres Program

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	SIGN	EPPI	Funding
Milich & Pelham, 1986 [74]	RCT Cross over 16	6-9y all diagnosed with ADHD (♂)	4 days (2 x 2 days with random assignment of sucrose then aspartame) outcomes tested 3.5h after drink. Summer treatment program (U)	Breakfast drink containing either 1.75g/kg sucrose or equal sweetness aspartame	Grade appropriate 2min timed maths and 10min timed reading tasks, observations of recreational play, IOWA conners index rating.	There were no significant differences in the behavioural outcomes between the aspartame and sucrose breakfast drinks.	A, G, D	20/24	Med-high	University of Kentucky Summer Faculty Research Fellowship

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance SIGN	Quality Assurance EPPI	Funding

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	SIGN	EPPI	Funding
Rosen et al. 1988 [75]	RCT Cross over 30 infants (33%) 15 primary	Infants (E: black) mean age 5y4m 7 with hyperactivity Primary (E: white) Mean age 7y2m 1 with hyperactivity (♀&♂)	15weeks (5 school days for each intervention: high sugar, low sugar and aspartame randomly selected) testing occurred 30min after the meal on 2/5 days Independent Church Schools (U)	Drink containing either 50g sucrose, 6.25g sucrose or 122mg aspartame served with standard breakfast.	Paired associate learning task, matching task, product measure test, teachers Conners scale rating, observed behaviours	A few small statistically (but not clinically) significant differences were observed for high sugar drink compared to the low sugar drink only and these were: an increase (p<0.05) in errors for the paired associate task for girls only and an increase (p<0.05) in the conners global teachers scale rating for both boys and girls.	K, B, A, G	20/27	Med	Not declared

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance		Funding
								SIGN	EPPI	
Sa... al... [76]	RCT Cross over 20*	9-19y Healthy children (♀&♂)	2 days (1 day for each drink – sucrose and aspartame randomly selected) testing occurred 2h after the drink. Hospital research lab (U)	Drink containing either 1.75g/kg sucrose or 9.7mg/kg aspartame served for breakfast after an overnight fast.	Actometers, Petrides conditional associative learning task, Canadian test for basic skills and arithmetic calculation subtest, mood scales and behavioural observations.	The only significant treatment effect was a reduction in the frequency of minor (P<0.01) and gross (P<0.05) motor behaviours after the consumption of sucrose that after aspartame.	B, G, A	19/24	Med-high	International Life Sciences Institute-Nutrition Foundation
Wender & Solanto, 1991[77]	RCT cross over 17 with ADHD 9 healthy	5-7y ADHD and age, IQ and sex matched healthy children (♀&♂)	3 days (1 day for each treatment: sucrose, aspartame and saccharin) testing occurred 4 hours after drink	Test drink containing either 35g sucrose, 1.75mg saccharin or 175mg aspartame served as part of toast and butter breakfast (matched to equal same total kcal) consumed after an overnight fast.	Playroom behavioural observations and a continuous performance task	There were no significant effects of sugar or either sweetener on aggressive behaviour. However, inattention, as measured by the continuous performance task, increased significantly (statistical not clinical significance) P=0.037 after sucrose consumption in the ADHD group only.	K,A, G,IQ	13/24	Med	The Sugar Association

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance SIGN	Quality Assurance EPPI	Funding

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	SIGN	EPPI	Funding
Wolraich et al. 1994 [78]	RCT Cross over 58* (17.2%) total include :25 infants 23 primary	Infants: 3-5y All healthy Primary: 6-10y 5 with ADHD all sensitive to sugar (as reported by parents) (♀&♂)	9 weeks (3 weeks per test diet: high sucrose, high aspartame or high saccharin in random order). Testing took place every week for the trial duration apart from the blood analyses which were carried out after a fasting sucrose (1.75g/kg) tolerance test carried out on the 3rd, 6th and 9th week (U)	3 test diets consumed for 3weeks: 1 high sucrose diet, 1 low sucrose high aspartame diet and 1 low sucrose high saccharin diet.	Blood phenylalanine and glucose, subjective mood assessments, parental diagnostic interview schedule for children, the Wechsler Intelligence scale for children or preschool and primary scale. The wide range achievement test (primary age only), paired associate learning, wisconsin card sorting test, continuous performance test, grooved pegboard test, static steadiness test, timed reading and maths test, motor activity test and structured behavioural observations, Teacher assessed ADHD behaviours, Parental diet diaries.	Although phenylalanine was within in the normal range for all 3 diets it was significantly higher in the aspartame diet. (p<0.05).There were no consistent significant differences between any of the behavioural and cognitive outcomes measures in either group of older or younger children. Although for the infants only - parents rating on the cognition subscale for the paediatric behaviour scale were significantly better during the sucrose diet than the sweetener diets (P<0.008) although pegboard performance was significantly slower during the sucrose diet.	L,A	22/24	Med-high	National Institute of Child Health and Human Development, the Clinical Research Centers Branch Nutrition Foundation -Internation al Life Sciences Institute. Food industry supplied the test foods.

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Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance SIGN	Quality Assurance EPPI	Funding

Fish Oil

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	SIGN	EPPI	Funding
Voigt et al. 2001[79]	RCT Placebo control 63* (14.3%)	6-12y All ADHD treated with stimulant medication (♀&♂)	4months Home (U)	Fish oil 345mg/d DHA no information on contents of placebo	Plasma phospholipids, Test of Variable of Attention and childrens color trail test to assess ADHD symptoms in addition to 2 parental tests: Achenbach's child behaviour checklist and the Conners CPRS.	Plasma phospholipid DHA content increased by 2.5 fold in the treatment group (P<0.001) however this did not significantly correlate to any changes in assessed behaviour. There were no significant differences in the objective or subjective ADHD measures between the treatment and control group by the end of the study.	E,D,A,G	17/24	Med	Martek Biosciences Corporation

US Department of Agriculture |
| Richardson et al. 2002 [80] | RCT Placebo control 41 (22%) | 8-12y All white Caucasian Healthy with reading age <2SD below norm (♀&♂) | 12weeks Special needs school for children with literacy problems (U) | Fish oil EPA 186mg/d, DHA 480mg/d, gamma-linolenic acid 96mg/d, vitamin E 60IU, cis-linoleic acid 864mg/d, AA 42mg/d and thyme oil 8mg/d. Placebo: olive oil | Conners CPRS-L – behaviour assessment (parental assessment only) | There were significant reductions in 3 out of 14 CPRS-L scales – these were psychosomatic, conners ADHD index and DSM inattention (P = 0.05, 0.03, 0.05 respectively) | E, D, A, G | 17/24 | med | Dyslexia Research Trust |

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Conf oun ders	Quality Assurance SIGN	Quality Assurance EPPI	Funding
Stevens et al. 2003 [81]	RCT PL Control 50 (34%)	6-13y (♀&♂)	4months Home /Community (U)	Fish oil: 480mg/d DHA, 80mg EPA/d, 40mg/d AA, 96mg/d gamma linolenic acid and 24mg/d vitamin E Placebo: olive oil	Plasma EFA and red blood cell (RBC) membrane analysis. Conners continuous performance test & Woodcock-Johnson psycho-educational battery, teacher and parental conners abbrev symptom questionnaire and disruptive behaviour disorder rating. Parental thirst assessment in addition to parental 3 day food diary	Fish oil supplementation led to a large increase in EPA, DHA and alpha tocopherol in the plasma phospholipids & red blood cells. The only significant difference observed between the fish oil and placebo group was seen after intention to treat analysis which showed 2 out of the 16 outcome measures to be significantly improved in the treatment group: these were parent rated conduct problems (p=0.05) & attention teacher rated symptoms (P=0.03).Treatment also showed an improvement in oppositional deficient behaviour from clinical to a non clinical range compared to placebo (p=0.02) & also significant correlations were observed in the magnitude of change between increasing RBC EPA / DHA content & parent & teacher observed behaviours (P <0.05).	D, B, A, G, & medi catio n	17/27	Med	Commercial Scotia Pharmaceu ticals National Institute of Mental Health National Fisheries Institute

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance		Funding
								SIGN	EPPI	
Hirayama et al. 2004 [82]	RCT PL control 40*	6-12y (♀&♂) Japanese With ADHD symptoms	2 months Summer camp (U)	DHA rich fish oil Average intake 3600mg DHA/week 700mg EPA/week in bread and milk. Placebo: olive oil	ADHD DSM-IV parent & teacher assess 2xaggreesion questions Frostig visual perception test Miller short term memory test Beery visual motor integration test Corkum & siegel continuous performance test Impatience test	No significant difference between changes in test scores between active and control groups. Visual short term memory and continuous performance significantly improved over time in the control group only (p=0.02 and 0.001).	D,A, G	17/24	Med	Japan Fisheries Association Foundation for Total Health Promotion
Richardson & Montgomery. 2005 [83]	RCT PL control 117* (6.0%)	5-12y all met criteria for dyspraxia (♀&♂)	3months (+ 3months 1 way cross over/ follow up) 12 State schools (U)	EFA rich fish oil 80% fish oil and 20% evening primrose oil. Daily dose: 558mg of EPA and 174mg of DHA and 9.6mg of vitamin E. Placebo: olive oil	Henderson etal movement assessment, Wechsler Objective Reading Dimensions, Conners CTRS-L – ADHD assessment	No significant differences observed between arms for motor skills, Significant improvements in reading and spelling (P= 0.04 and <0.01) for the fish oil arm. Plus CTRS-L global scale improvements (P<0.05) and subscale improvements (P<0.05) expect for perfectionism and social problems in fish oil group.	A, D	16/27	Med - high	Dyslexia Research Trust Durham Local Education Authority

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance SIGN	Quality Assurance EPPI	Funding
Vitamin and Mineral Supplementation										
🇬🇧										
Southon et al. 1994 [84]	CCT Case control trial PL control 51 (16)	13-14 y (♀&♂)	16 weeks 2 state schools (U)	Low dose multi vitamin & mineral supplement (50% UK RDA) Placebo: mannito-based	IQ measured by the UK WISC-R test to measure verbal and non verbal IQ & Blood biochemistry	Supplementation had no significant effect on IQ score. Independent of supplementation, significant associations were found between plasma ascorbic acid and initial non verbal IQ in boys (p<0.001) and whole blood glutathione peroxidase activity and non verbal and verbal IQ in boys & girls (p<0.05).	H, N, B, A, G & IQ	18/27	Med	Ministry of Agriculture, Fisheries and Food Department of Education and Science. Vitamin Forum
🇺🇸										
Schoenthaler et al. 2000[85]	RCT PL control 468* (11.5%)	6-12y (♀&♂) working class mainly Hispanic	3months 2 State schools (U)	Low dose multi vitamin and mineral supplement vs no supplement (50-67% USA RDA) Placebo (contents unknown)	Non verbal IQ measured using WISC-R test	Intervention group had a modest significant 2.27point increase in non-verbal IQ (P=0.038) after adjustments. Matched pairing showed this could have been accountable to a net 16 point higher net gain in IQ of a sub sample of 24 supplemented children.	E,A, G& language & tester ID	19/27	High	G.B. Data (no fiscal interest in the supplements used in the study)

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	Quality Assurance SIGN	EPPI	Funding
Other										

Author, year	Study Type & n (%DO)	Population Age, sex & details	Duration Setting & (implementer)	Exposure	Measurement tool	Results	Confounders	SIGN	EPPI	Funding
Chavez & Martinez, 1981 [86]	Case Control Study 34	Deprived rural Mexican children on exact age or gender provided	From birth until the end of the first year of elementary school State school (U)	Food supplementation (supplemented from birth vs not supplemented from birth)	School and national exam results / IQ / teacher observed behaviour / reading and writing	P<0.01 improvement in school and national exams for supplemented group & improved observed behaviour – more active and alter in supplemented group	NR	5/24	Low	Not declared

KEY:

Country Flag Codes

 Barbados   Canada   Chile   Cyprus   Finland

 Hong Kong   Israel   Japan   France   Sweden

 Korea (south)   Mexico   Netherlands   New Zealand   Spain

 UK   USA

Study Design and N

PL: Placebo, n*: power calculation used; (%DO): percentage drop out.

Population Age, Sex and Details

SEX: ♀ Female   ♂ Male   NR Not Reported

Y: years

Setting and Implementer

Implementers: P: parental group; S: school; E: education authority; H: health authority; U: university researchers; NR: Not Reported

Confounders

A: Age; B: Body Weight Status; C: Physical Activity Levels; D: Disease Status; E: Ethnicity; F: Illegal Drug Misuse; G: Gender; H: Habitutal Nutritional Status; I: Alcohol; J: Family Status; K: Socio-Economics; L: Parental Education; M: Locality/context; N: Smoking; NR: Not Reported

Quality Assurance:

SIGN guidance was scored according to quality assessments made. EPPI assessment weighted the evidence as high, med (medium) or low quality.