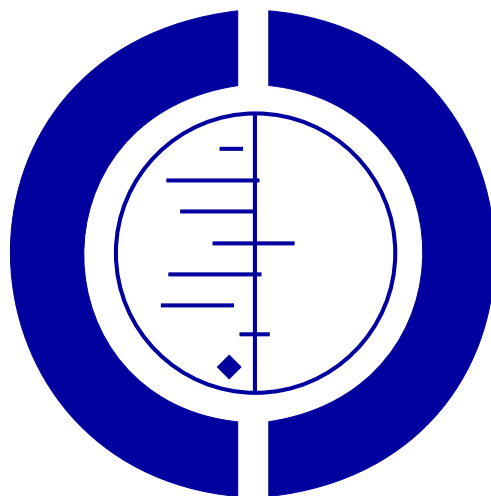


School feeding for improving the physical and psychosocial health of disadvantaged elementary school children (Review)

Kristjansson EA, Robinson V, Petticrew M, MacDonald B, Krasevec J, Janzen L, Greenhalgh T, Wells G, MacGowan J, Farmer A, Shea BJ, Mayhew A, Tugwell P



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ABSTRACT

Background

Early malnutrition and/or micronutrient deficiencies can adversely affect physical, mental, and social aspects of child health. School feeding programs are designed to improve attendance, achievement, growth, and other health outcomes.

Objectives

The main objective was to determine the effectiveness of school feeding programs in improving physical and psychosocial health for disadvantaged school children.

Search strategy

We searched a number of databases including CENTRAL (2006 Issue 2), MEDLINE (1966 to May 2006), EMBASE (1980 to May 2006), PsycINFO (1980 to May 2006) and CINAHL (1982 to May 2006). Grey literature sources were also searched. Reference lists of included studies and key journals were handsearched and we also contacted selected experts in the field.

Selection criteria

Data from randomized controlled trials (RCTs), non-randomised controlled clinical trials (CCTs), controlled before and after studies (CBAs), and interrupted time series studies (ITSs) were included. Feeding had to be done in school; the majority of participants had to be socio-economically disadvantaged.

Data collection and analysis

Two reviewers assessed all searches and retrieved studies. Data extraction was done by one of four reviewers and reviewed by a second. Two reviewers independently rated quality. If sufficient data were available, they were synthesized using random effects meta-analysis, adjusting for clustering if needed. Analyses were performed separately for RCTs and CBAs and for higher and lower income countries.

Main results

We included 18 studies. For weight, in the RCTs and CBAs from Lower Income Countries, experimental group children gained an average of 0.39 kg (95% C.I.: 0.11 to 0.67) over an average of 19 months and 0.71 kg (95% C.I.: 0.48 to 0.95) over 11.3 months respectively. Results for weight were mixed in higher income countries. For height, results were mixed; height gain was greater for younger children. Attendance in lower income countries was higher in experimental groups than in controls; our results show an average increase of 4 to 6 days a year. Math gains were consistently higher for experimental groups in lower income countries; in CBAs, the Standardized Mean Difference was 0.66 (95% C.I. = 0.13 to 1.18). In short-term studies, small improvements in some cognitive tasks were found.

Authors' conclusions

School meals may have some small benefits for disadvantaged children. We recommend further well-designed studies on the effectiveness of school meals be undertaken, that results should be reported according to socio-economic status, and that researchers gather robust data on both processes and carefully chosen outcomes.

PLAIN LANGUAGE SUMMARY

Early malnutrition and/or micronutrient deficiencies can negatively affect many aspects of child health and development. School feeding programs are designed to provide food to hungry children and to improve their physical, mental and psychosocial health. This is the first systematic review on the topic of school feeding. Eighteen studies were included in this review; nine had been done in higher income countries and nine in lower income countries. In the highest quality studies (randomized controlled trials [RCTs] from low income countries, children who were fed at school gained an average of 0.39 kg more than controls over 19 months; in lower quality studies (controlled before and after trials (CBAs)), the difference in gain was 0.71 kg over 11.3 months.

Results from higher income countries were mixed, but generally positive. For height, results from lower income countries were mixed; in RCTs, differences in gains were important only for younger children, but results from the CBAs were large and significant overall. Results for height from High Income countries were mixed, but generally positive. In low income countries, children who were fed at school attended school more frequently than those in control groups; this finding translated to an average increase of 4 to 6 days a year per child. For educational and cognitive outcomes, children who were fed at school gained more than controls on math achievement, and on some short-term cognitive tasks. School meals may have small physical and psychosocial benefits for disadvantaged children.

We recommend that further well-designed studies on the effectiveness of school meals be undertaken, that results should be reported according to the socio-economic status of the children who take part in them, and that researchers gather robust data on outcomes that directly reflect effects on physical, social, and psychological health.

BACKGROUND

The world has entered the new millennium inheriting an impressive legacy in health from the 20th century. Life expectancy in most countries has reached a new high and infant mortality a new low (PHAC 1999). However, these averages obscure the fact that health is unevenly and unfairly distributed according to socio-economic position; health and longevity are highest for the richest, and decrease steadily with decreasing income (PHAC 1999; Wilkins 1983; Wilkinson 1996). These social gradients in health, or socio-economic inequalities in health, are pervasive in all countries of the world (Diderichsen 2001) and are evident in most diseases, injuries, and health behaviours (Marchand 1998). Health inequalities have been defined as “the virtually universal phenomenon of variation in health indicators ... associated with socio-economic status” (Last 1995); inequalities may also be seen between different sexes or geographic groups. Health inequalities require three components for calculation: a valid measure of health status, a measure of social position or status, and a statistical method for summarizing the magnitude of the health differences between people in different social positions. Health inequities ‘are unfair and remediable inequalities’ (Tan-Torres 2001; Peter 2001). Thus, health inequalities are measurable, while health inequities require a value judgment.

The rationale for school feeding programs

According to Wynn (Wynn 1987) socio-economic differences in nutrition may be one of the most important factors causing socio-economic differences in health and mortality. Global estimates suggest that, in the period 2000-2002, over 852 million people across the world were undernourished (FAO 2004). Many of these were children. Most of these were in developing countries, but even

in the United States, more than 3 million children experienced ‘food insecurity with hunger’ in the period between 1998 and 2000 (Sullivan 2002).

Early malnutrition and/or micronutrient deficiencies can adversely affect physical, mental, and social aspects of child health. Effects on physical health may include underweight, stunted growth, lowered immunity, and mortality. Early malnutrition and/or micronutrient deficiencies have been linked to poorer cognitive functioning (Scrimshaw 1998; Worobey 1999; Leslie 1990). Short-term hunger can adversely affect attention and interest (Wilson 1983, cited in Levinger 1996; Read 1973). Overnight and morning fasting (e.g. skipping breakfast) has been shown to adversely affect performance on cognitive tasks, particularly for children who are nutritionally at risk (Pollitt 1995).

School feeding programs may help to ameliorate some of these problems. The goals of school feeding programs differ, but often include relieving short-term hunger (Allen 2001), improving micronutrient status (Allen 2001), growth (Allen 2001; Levinger 1986), cognition (Levinger 1986) and academic performance (Allen 2001; Levinger 1986) in both higher and lower-income countries. Worldwide, 115 million primary school aged children were ‘out of school’ in 2001/2002; most were from developing countries (UNESCO 2005) Therefore, in developing countries, school feeding also aims to increase school attendance and enrolment (Allen 2001, Levinger 1986) and to encourage students to stay in school longer. Agricultural and community development may be secondary outcomes in developing countries if locally grown food is used (Sanchez 2005).

However, there is some controversy over the effectiveness of school feeding programs. According to the World Food Program “Research and experience show that when food is provided at school,

hunger is immediately alleviated, and school attendance often doubles within one year” (WFB 2005a). However, experts at a School Feeding/Food for Education Stakeholders meeting in 2000 concluded that there is little evidence for nutritional benefits of school feeding and that school feeding only enhances learning when other improvements in school quality are made (World Bank n.d.). MacIntyre argued that school feeding programs address a symptom, rather than the root causes of hunger and that they may be stigmatizing (McIntyre 1992).

One important concern in school feeding studies is that, in poor families, the home diet may be reduced for children who are receiving food at school: this is termed ‘substitution’. For example, a survey on school feeding in Malawi showed that 77% of children reported that they get less food at home when they receive school meals. This is substantiated by caregivers; 82% of caregivers reported that substitution was occurring. When there is extra food, it is used to benefit other household members, particularly children (Galloway 2006).

Rationale for this review

Many countries have school feeding programs. For example, in 2004 the World Food Program alone had school feeding programs in 72 countries, covering 16.6 million school children (WFP 2005b). A great deal of money is invested in these programs. Yet, to date there has been no formal systematic review of the effectiveness of school feeding programs across the world. It is therefore important to learn whether or not this is an effective and cost-effective intervention for improving the health, nutritional status, school enrolment and school performance of disadvantaged children.

The purpose of this review is to assess the effectiveness of school meal programs for improving the health of socio-economically disadvantaged children. Another purpose is to study their effectiveness in terms of equity: are they benefiting those children who are more disadvantaged children at least as much as those who are more advantaged?

Previous non-systematic reviews

We have thus far been unable to identify an existing systematic review on the effectiveness of school feeding programs. However, we have identified some non-systematic reviews of school feeding programs (Grantham-McGregor 05; Levinger 1986; Pollitt 1978; Pollitt 1995; Walker 1986; Papamandjaris 2000), and reviews of supplementary feeding programs for children (Beaton 1982; Beaton 1993; Dickie 1982).

Some conclusions from these reviews are that: 1) the largest effects of feeding in early childhood on growth are likely to be found between the ages of 6 and 24 or 36 months, 2) growth may not be as important as other outcomes such as improved physical and psychological health (Beaton 1993), 3) the brain is sensitive to short-term lack of nutrients and that this may be particularly problematic for children who are undernourished (Pollitt 1995), 4) morn-

ing feeding might produce emotional benefits, enhance ability to work (Pollitt 1978), lead to ‘transient’ improvements in cognition (Grantham-McGregor 05) and improve classroom behaviour (Papamandjaris 2000) if classrooms are well set up (Grantham-McGregor 05), 5) school-feeding programs may increase attendance (Pollitt 1995), particularly in rural low income schools in developing countries (Levinger 1986), 6) many studies covered in the early reviews were poorly done (Pollitt 1978, Levinger 1986), 7) outside factors such as home environment seemed to have at least as much effect as school feeding; greater improvement might be achieved if both diet and the environments in which children lived and learned were improved, (Levinger 1986) and, 8) evidence is mixed (Pollitt 1995).

Although the above reviews provided valuable information, they fail to give us a comprehensive picture of the effectiveness of school feeding across the globe. All were limited in their scope: some to just a few countries, most to either developing or industrialized countries, others to one feeding time (e.g. morning), and others to just a few outcomes. Furthermore, none were systematic reviews. Thus, standard methods were not used; details on search strategies, inclusion and exclusion criteria, number of studies found and considered, and quality of studies was not formally assessed. Importantly, little formal synthesis has been done.

OBJECTIVES

1. To determine the effectiveness of school feeding programs in improving physical and psychosocial health outcomes for low income school children.
2. To compare the effectiveness of school feeding programmes for socio-economically disadvantaged children and advantaged children.
3. To understand the process by which school feeding programs achieve (or fail to achieve) an impact on growth, cognitive development, and school performance.

CRITERIA FOR CONSIDERING STUDIES FOR THIS REVIEW

Types of studies

Randomized controlled trials (RCTs), non-randomized controlled clinical trials (CCTs), interrupted time series (ITS), and controlled before and after studies (CBAs) were included. Control groups could be either “no-treatment” controls (lunch or breakfast at home or no feeding/fortification) or placebo controls (e.g. low energy glucose syrup at school). Other study designs were excluded.

Types of participants

Children and adolescents, in any country, aged 5 to 19, who attended primary or high school. Note that this age range represents

a change from the published protocol, which was focused solely on elementary school children. In the review, elementary and high school children were both included due to the dearth of studies on high school students.

Based on the 2004 World Bank List of Economies (World Bank 2005), countries were classified into two groups: 1) Lower income countries (Low and Lower Middle Income Countries) and 2) Higher income countries (Upper-Middle and Higher-income countries). Inclusion and exclusion criteria were somewhat different for these two groups. These criteria represent a modification of the published protocol; this was necessary in order to be more precise.

1. Lower Income countries

1.1 Included: Those studies in which children were classified as 'predominantly disadvantaged' by one or more of the following criteria: 1) Living in a rural area or village; 2) Living in an urban area and described as socio-economically disadvantaged (e.g. poor or low-income) or from poor areas (e.g. slums); 3) if statistics were presented showing that 30% or more of the children in the sample were underweight, or stunted (nutritionist judgement) or that the average weight, height, and Body Mass Index (BMI) were low (nutritionist judgement) and 4) studies were implicitly or explicitly aimed at disadvantaged children, and indicators of disadvantage were provided in the paper.

1.2 Excluded: Studies were excluded if: 1) children were from urban areas only with a large proportion of high socio-economic status (SES) children and results could not be broken out by SES or other proxy variables; or 2) where information was insufficient to allow us to judge the extent of disadvantage.

2. Higher-income countries

2.1 Included: Those in which children were classified as disadvantaged by the following criteria: 1) they were from areas described as economically marginalized or disadvantaged (e.g. Low income area, ghetto, social housing projects, from mining communities); 2) they were described as low SES (e.g. working class) 3) more than half were from lower SES groups (including unemployed parents); 4) they were described as marginalized or "at-risk" due to social circumstances.

We also included studies in which some children were advantaged but results could be broken down by SES or baseline nutritional status.

2.2 Excluded: 1) Students were described as being from middle or high SES backgrounds only, 2) students were from mixed high and low SES and results were not broken down by SES or 3) if information was insufficient to allow us to judge disadvantage.

Types of intervention

Included: Meals (breakfast or lunch) or snacks (including milk) administered in a school setting. If a study included two or more experimental groups given different types of meals, we chose the

meals with the highest energy and/or protein content for data extraction and analysis.

Excluded interventions: micronutrient supplementation or fortification of existing meals, stand-alone nutrition education in schools or at home, obesity prevention programs, breastfeeding programs, food stamps, modifications to school meals to change nutrient content, community kitchens, food banks, and feeding centres.

Because of the increasing emphasis on reducing obesity in higher-income countries, programs built around school meals in these countries increasingly aim to enhance the nutritional content of children's diets by increasing availability and access to low-fat choices, fruits, and vegetables (Coleman 2005; Luepker 1996). However, the focus of this review is not on changing content of school meals, but rather on studying the effect of provision of food to children. Thus, these types of interventions are not part of this review.

Types of outcome measures

We extracted data on changes in the intervention group relative to the control/comparison group.

Physical health outcomes included nutritional status (anthropometry, bone mineral density, bone mineral content, micronutrient status, and haemoglobin, and hematocrit). Both hemoglobin and hematocrit are indices of anaemia, a condition in which the blood cannot carry enough oxygen, and most often due to iron deficiency.

Psychological health outcomes included educational outcomes (e.g., school achievement in math, reading, or spelling, school enrolment, school attendance) and other tests of cognition such as intelligence test scores, psychomotor and mental development, attention, memory, reasoning, verbal fluency, vocabulary, on-task behaviour.

Behavioural outcomes included on-task behaviour, attention problems, and behaviour problems.

Adverse outcomes included stigmatisation, dependency, disruptive behaviour at school, and obesity or excessive weight loss.

Excluded outcomes: Reduction of dental caries, increased nutritional knowledge, and intermediate physical health outcomes such as reduction of hunger and nutrient intake.

SEARCH METHODS FOR IDENTIFICATION OF STUDIES

See: Cochrane Developmental, Psychosocial and Learning Problems Group methods used in reviews.

Electronic searches. The search was performed by JM on the following electronic databases:

Cochrane CENTRAL Register of Controlled Trials (2006 ISSUE 2) via the OVID interface
 MEDLINE (1966 to May 2006) via the OVID interface
 EMBASE (1980 to May 2006) via the OVID interface
 ADOLEC - Literature on adolescent health (To May 2006) - via Virtual Health Library interface
 AMED (Allied and complementary medicine) (1985-May 2006) via the OVID interface
 CAB Health (1973-May 2006) via the Silver Platter interface
 CINAHL (1982 to May 2006) via the OVID interface
 Current Contents (to May 2006) via the OVID interface
 Dissertation Abstracts (1981 to May 2006) via the OVID interface
 EBM Review (searched in May 2006) via the OVID interface
 ERIC (1966 to May 2006) via the OVID interface
 PsycINFO (1980 to May 2006) via the OVID interface
 Food and Agriculture Organization Corporate Document Repository (<http://www.apps.fao.org>)
 Food Poverty Projects database (http://www.sustainweb.org/povdb_index.asp) (to May 2006)
 Graylit Network (<http://graylit.osti.gov/>) (to May 2006)
 Grey Literature New York Academy of Medicine (<http://www.nyam.org/library/grey.shtml>) (to May 2006)
 HMIS (Health Management Information Consortium),
 Healthstar (1985 to May 2006) via the OVID interface
 Healthpromis (<http://healthpromis.hda-online.org.uk/>) (to May 2006)
 LILACS database - Latin American and Caribbean Health Sciences Literature (to May 2006) - via Virtual Health Library interface
 MEDCARIB - Caribbean Health Sciences Literature (to May 2006) - via Virtual Health Library interface
 PAHO - PAHO HQ Library Catalog (To May 2006) - via Virtual Health Library interface
 Premedline (2002 to May 2006), EBM Reviews (to May 2006) via the OVID interface
 SIGLE - System for Grey literature in Europe (1980 -May 2006) via the Silverplatter interface
 Sociofile (1980 to May 2006) via the OVID interface
 C2-SPECTR (Social, Psychological, Educational and Criminological Trials Register - <http://128.91.199.101/>) (to May 2006)

Search Strategy in MEDLINE:

1. Milk.sh,tw.
2. (feeding or school-feeding or meal\$ or snack\$.tw.
3. (breakfast or break fast or lunch or mid-day or mid day or dinner or supper).tw.
4. Or/1-35. Exp Schools/
6. (school\$ or school-based or kindergarten or preschool or pre-school or daycare or day care).tw.
7. 5 or 6
8. 4 and 7
9. Breastfeeding/ or (breastfeed\$ or breast feed\$.tw.

10. 8 not 9
11. Exp Child Nutrition/
12. Bone density/ or bone densit\$.tw.
13. Exp growth/
14. Body mass index/
15. Nutritional status/ or nutrition\$.tw.
16. (growth or bone mass or weight or height).tw.
17. Dietary services/ or diet/
18. Food services/
19. Hunger.sh,tw.
20. Food, Fortified/ or (fortification or fortified).tw.
21. (iron or iodine).tw,sh.
22. Dietary Supplements/ or (Dietary Supplement\$ or nutritional Supplement\$ or food Supplement\$.tw.
23. Exp Vitamin A/
24. Or/11-23
25. 10 and 24

The strategy was amended where necessary to search the other databases listed. An RCT filter was not used as we were also looking for CBA and ITS. No language restrictions were applied.

Handsearching

We handsearched the electronic versions of the American Journal of Clinical Nutrition, Journal of Nutrition, European Journal of Clinical Nutrition, Nutrition Reviews, and Social Sciences and Medicine from the beginning of 1998 through to May 2006; Public Health Nutrition was handsearched from the beginning of 1999 to 2006. References of included articles and relevant reviews (Levinger 1986; Pollitt 1978; Pollitt 1995) were scanned for eligible studies. The annotated Bibliography "School Feeding Works" (WFB 2005a) was also scanned for relevant studies.

Personal contacts

People and or organizations focusing on nutrition, hunger, and international development were contacted by email to identify relevant studies on school feeding programs that we may have missed; these include Arlene Mitchell and Francisco Espejo of the WFP 2005b Food Program School Feeding Team, UNICEF, Ms. Catherine Bertini of the United Nations System Standing Committee on Nutrition (SCN), Dr. Ernesto Pollitt, and Dr. Susan Walker.

METHODS OF THE REVIEW

1. Data Abstraction

The abstracts and titles of articles retrieved by the electronic and hand searches were independently assessed for eligibility by two reviewers (EK and VR) and/or one reviewer (EK) and one research assistant (CB), according to the inclusion criteria above.

Full copies of all those deemed potentially eligible by one of the reviewers were retrieved for closer examination. Two reviewers (EK and VR) determined whether or not they met eligibility criteria.

We sought the advice of BM, JK and TG when we needed input on whether or not the children were disadvantaged. We sought the input of MP in cases where CBAs had inappropriate controls.

We developed our data abstraction forms a priori based on the data collection forms from the Effective Practice and Organization of Care (EPOC) review group (EPOC 2002). They were modified to capture specific items of data needed for this review. These forms were pilot-tested with four included studies to ensure clarity, completeness and ease of use. Data were extracted by one of four reviewers and checked by another reviewer who had not done the original extraction. We extracted data on study design, description of the intervention (including process), details on participants (including age, sex, number in each group), length of intervention, definition of poor/low income, other socio-demographic variables, including place of residence, race/ethnicity, age, and nutritional status, critical appraisal (see below), physical, cognitive, and behavioural outcomes. We had planned to extract data on cost-effectiveness, but found none. Where possible, we recorded effects by socio-economic position. JK or BM reviewed the included studies, summarizing data on nutritional content, percent of the Recommended Dietary Allowance (RDA) for energy the meal provided.

2. Process evaluation

In order to identify possible confounders, data on a number of process elements were extracted. Our list was chosen to represent factor that could impact on effectiveness. It included:

1. Intensity of approach (percentage of RDA for energy and whether low or high)
2. Type of feeding and time of day food given
3. Settings (e.g. Where is food given- type of school, given in classroom, lunchroom)
4. Provider delivering intervention (was it peer supervised, teacher supervised, supervised by lunchroom staff, volunteers?)
5. Monitoring intake
6. Compliance
7. Quality/acceptability of food given
8. Duration of intervention
9. Substitution

A 2.3. Detail on the Process evaluation

Contemporary research practice recommends process evaluation alongside empirical trials of complex interventions so as to identify how the intervention was implemented in practice, the mechanism by which it achieved its impact, and any local contextual issues that may have influenced outcome (Campbell 2000; Calnan 2003). Process evaluation can also be undertaken as part of a systematic review, by extracting, analysing and synthesising any data from the included studies that may help explain mechanism(s) of action and/or heterogeneity of outcomes. Thus, when a complex social intervention appears to have had a significant effect in one trial but no effect (or a negative effect) in another, an analysis of the link between the context (as described in the paper),

intervention and outcome aims to generate further hypotheses about the circumstances in which this intervention might be more or less successful. To this end, TG reviewed all papers included in the final review in order to identify information on process elements that may have helped to explain the process by which each intervention achieved (or failed to achieve) an impact in each primary study. Descriptive data were extracted from the papers on historical context, local political and economic climate, funding source, extent of involvement and partnership with local researchers, sampling (e.g. how 'disadvantage' was defined and measured), methodological detail of the implementation (e.g. level of supervision during the supplemented meal), context in which growth measurements and psychometric testing were undertaken, and so on. These data were tabulated in an Excel spreadsheet and used alongside the quantitative findings to help generate the various process hypotheses that are included in the methods, results, and discussion. The process evaluation was particularly helpful in the current review as we lacked sufficient data for meta-regression.

2.1. Energy content

One important process element was energy content, which was assessed by the nutritionists (BM and JK). Only energy was considered as many studies only provided the average kilocalorie content of the meal/snack, but did not provide sufficient detail regarding the food to estimate other nutrients.

2.1.1 Rules used in calculating energy content:

1. When the total kilocalories or % Recommended Daily Allowance (RDA) of energy were provided in the text of the study, this figure was used. When the amount of kilocalories were not provided but the descriptions of food were sufficient (quantity and type of food), the kilocalorie content of the meal/snack was estimated using the United States Department of Agriculture (USDA) nutrient data file.
2. When meals/snacks with different kilocalorie contents were provided on different days (Powell 1983), a weighted average was taken (e.g. if a meal with 400 kcals was provided 3 days a week and a meal with 600 kcals was provided 2 days a week, then the weighted average of 480 kilocalories was used.
3. When the number of days on which different meals/snacks were given on was not specified (Agarwal 1989) or when the energy content was different in year 1 than year 2 of the study (Neumann 2003), a straight average was used for the energy content.

2.2.2. Calculating % RDA for energy

The % RDA for energy was calculated by dividing the given or estimated average kilocalorie content of the meal/snack by the RDA for the age/sex specific target group in each study (SCN 1989). When the intervention group of a study was comprised of various age and sex groups, and outcomes were given for the entire group only, a weighted average for the RDA was used to calculate the % RDA. In addition, as a check, the % RDA was calculated for each age and sex group for which there was a corresponding RDA by dividing the total kilocalories provided by the meal/snack by

the age and sex specific RDA. Energy intensity was considered as a continuous variable. However, for purposes of helping to interpret the data, interventions will also be characterized as having two levels of energy content: low (interventions providing <15% of the RDA for energy) and higher (interventions providing 15% or more of the RDA for energy).

Due to lack of information, we were unable to calculate energy content for three studies (Bro 1994, Bro 1996, Shemilt 2004). After data abstraction was completed, tables of included and excluded studies were developed.

3. Data extraction and analysis

Results were analysed separately for lower and higher-income countries because the settings and populations are so different it would be misleading to combine them.

3.1 Continuous data. RCTs, CCTs, and CBAs

To perform meta-analyses of continuous data, we input data on means, standard deviations, and the number of participants for each outcome in the two groups. It is important to note that, in all cases, these means and standard deviations were unadjusted for confounders; however, they were adjusted for clustering when needed. We used mean and standard deviation for change in the meta-analyses in all but one case (Agarwal 1989). In this case, we used end-of-study results for intelligence because we could not find an appropriate Rho (correlations between beginning and end-of-study in the control group).

In cases where standard deviations and/or standard deviations for change were not published, and the study was published < 30 years ago (after 1976), we wrote to the authors requesting this information. Susan Walker provided us with means and standard deviations for change, and with before and after correlations in the control group for the Powell 1998 study; data from the Powell 1983 study was unavailable. For Du 2004, Zhang Qian provided change data for weight and height, corrected for clustering (Zhang 2006). We received no reply from Agarwal and Paige concerning their respective studies (Agarwal 1989, Paige 1976).

Change data

Data on change was either taken directly or calculated from other information presented in the papers for the following studies: Bailey (Bailey 1962), Baker (Baker 1980 (boys)), Corry-Mann (Corry-Mann 1926), and Devadas (Devadas1979: 5-6). Susan Walker provided data on change and on correlations between the beginning and end-of study for the Powell 1998 study (Walker 2004). These correlations were used in calculating standard deviations for change for the Agarwal (Agarwal 1989) and Powell 1983 studies.

In cases where data were not meta-analyzed, regression analyses, multilevel analyses, or Analyses of Variance were selected as providing the better estimate of effect, because: a) multilevel analyses accounted for clustering or because b) other ANOVAs and regressions provided results for change.

3.2. Interrupted time series

We used the average of before and after session presented in the two ITS studies (Bro 1994, Bro 1996).

We did not have any discrete outcomes in our meta-analyses.

3.4 Skewness

Except for Shemilt 2004's trail-making test (Shemilt 2004), skewness was not indicated in any of the studies included in this review. For all papers except Corry-Mann 1926, summary statistics were provided rather than the original raw data and we were thus unable to check the raw data for skewness. Furthermore, because change scores were used in most analyses, we were unable to do the rough check described in Section 8.5.2.11 of the Cochrane Handbook (Higgins 2005).

3.5 Data synthesis

We conducted meta-analysis using a random effects model. Weighted mean differences were calculated unless otherwise stated. We conducted separate analyses for each outcome across: 1) Lower income countries vs. Higher-income country, and 2) Different study designs (i.e. ITS, RCT and CBA). A clinical psychologist (LJ) commented on the clinical relevance of the psychological outcomes.

3.6 Methods of analysis for studies with potential unit of analysis errors

Studies which allocated by school or class could have unit of analysis errors if they did not adjust for between-cluster correlation. Therefore, we reviewed each primary study to determine whether or not clustering was part of the study design. If it was, we then determined whether or not the analyses adjusted for clustering. If analyses were adjusted in the primary study, we used them.

3.6.1. Methods used to correct for design effect in clustered trials or CBAs that were not adjusted for clustering:

1. When the pooled estimate used was an SMD (because of varying metrics), the method outlined in section 8.11.2.4 of the Cochrane Handbook (Higgins 2005) was used exactly as described to inflate the standard error. First, we calculated the unadjusted SMD and 95% confidence interval. The unadjusted SMD was entered as the effect estimate in the generic inverse variance method, then we inflated the standard error of the effect estimate by multiplying by the square root of the variance inflation factor, calculated as: $(1 + (m-1) \text{ multiplied by } (ICC))$, where m is the average cluster size. The standard error was calculated at the confidence interval divided by 3.92.

2. When the pooled estimate was the WMD approach, we used the Variance Inflation Factor (VIF) to adjust the standard deviations in the treatment and control groups separately. These standard deviations were then used in the meta-analysis, and so are incorporated in the standard error of the mean difference and the weighting procedures. The result of this is equivalent to the method outlined in the Cochrane Handbook (following the SMD approach) when the variance inflation factors are the same in the treatment and control groups.

This approach was used because there is a real possibility that the cluster sizes differ between the treatment and control groups and therefore the VIF, which depends on cluster size, would be different. Therefore, the adjustment for variance inflation would differ between the treatment and control groups. As far as we know, the Cochrane Handbook does not provide for this eventuality. However it is necessary to take account of this difference in VIFs (see, for example, Agarwal in our review (Agarwal 1989)).

3.6.2 Calculating the Variance Inflation factor

a. First we calculated cluster size. When numbers of participants in each analysis were provided, these numbers were divided by the number of clusters to calculate cluster size. Otherwise, we used the number of participants provided in the methods sections of the primary studies and divided that by the number of clusters.

b. Then, we found appropriate Intra-Cluster Correlations (ICCs). For weight and height for Agarwal 1989, Bailey 1962, Du 2004, and Powell 1983, we used the ICCs published in Du's 2005 letter to the editor; (Du 2005). Thus we used ICCs of 0.025 and 0.016 for weight and height respectively. Sensitivity analyses were conducted with ICCs of .01, .05, and .10 for both weight and height. We conducted further sensitivity analyses for each outcome to assess how large the ICC needed to be to change the results. Varying the ICC to these extreme values did not change the statistical significance of any of the pooled results.

For math, reading, spelling, attendance and intelligence outcomes in Agarwal (Agarwal 1989 - boys) and/or the Powell (Powell 1983) studies, we used ICCs of 0.15, with sensitivity analyses at 0.10 and 0.20. This was based on recommendations from the Schochet report (Schochet 2005) for math and reading.

c. Then, for experimental and control groups separately, we calculated the VIF as follows:

$(1 + (m-1) \text{ multiplied by } (ICC))$, where m is the average cluster size (Ukoumunne 1999). We then multiplied the original standard deviation by the square root of the VIF for experimental and control groups separately. These adjusted standard deviations were then entered into the RevMan data tables.

3.7 Subgroup analyses

3.7.1 Equity question. We had planned to perform subgroup analyses by socio-economic status as well as baseline nutritional status. However, none of the included studies presented tables stratified by SES (although two did briefly describe results by SES). Two studies presented results stratified by baseline nutritional status (Powell 1998 (A), Agarwal 1989), this was used in a subgroup analysis as a proxy for SES. Meta-regression was used to test for an interaction between baseline nutritional status and height and weight.

3.7.2 Age

Because growth rates may vary by age, we conducted a subgroup analysis across age groups for weight and height. We also planned to do subgroup analyses by age for cognition, as it is possible that the effectiveness of school meals in changing cognitive outcomes may vary according to age. However, our data were not sufficient

to do this.

3.7.3 Sex

We also conducted subgroup analyses by sex, and reviewed each study to determine whether or not they reported interactions between sex and outcomes.

3.8. Potential effect modifiers

We carefully examined several of the process elements listed above: high/low energy, compliance, substitution, and duration of the intervention. Study quality may also impact on findings; studies of lower quality often show higher effect sizes than those of higher quality. For example, biased outcome assessment is possible in situations where those who assess the outcome variables are not blinded to study group (i.e., intervention or control).

To better understand the influence of potential effect modifiers, we tabulated effects for each study sorting them by type of study, blinding versus unclear blinding, date of study, and high versus low energy (Table 06, Table 07).

3.9 Presentation of raw and absolute differences

Since absolute and relative differences convey different information, and both are needed to make an informed decision (Hembroff 2004) we calculated both absolute and relative differences between intervention and control conditions. The absolute difference in change from baseline was calculated by the Review Manager analysis as the difference in change from baseline between the school meal and control groups. We calculated the relative % change as the difference in change divided by the baseline of the control group of the most representative study. Because height and weight both increase over time, we also calculated the % change relative to the rate of change as the difference in change scores (over the study periods) divided by the control group rate of change over the same time period (using a weighted average of the rate of change in all studies, using the same weights as the Review Manager analysis).

3.10 Heterogeneity

Where meta-analysis was conducted, we assessed heterogeneity using the steps below.

1) Common sense (e.g. Are the interventions, participants or outcomes so different that they cannot be combined?)

2) I^2 measure for heterogeneity (Higgins 2003)

3) The Chi-Square test for heterogeneity.

3.11. Assessment of publication bias

There were too few studies in meta-analyses to evaluate the risk of publication bias by means of funnel plots (Egger 1997). As the best protection from publication bias is a robust search strategy, we made strenuous efforts to locate unpublished and grey literature.

DESCRIPTION OF STUDIES

After initial screening of titles and abstracts, we retrieved 400 potentially useful articles. Reviewers agreed that 30 studies were potentially relevant and of the appropriate design. Each was read in

full. Of these, 18 studies met inclusion criteria; 12 were excluded. The 18 papers included 45 separate comparison groups (see Table of Characteristics of Included Studies).

1. Excluded studies

Twelve studies that met study design criteria (e.g. RCT, CCT, CBA and ITS), but that did not meet other criteria are presented in the Table of Excluded Studies. Among the 12 excluded studies, six were excluded because the interventions and/or outcomes were not relevant for our study, three were excluded because they were not in a school setting, 2 were excluded because the description of SES was not complete enough for us to make a judgement on SES and one was excluded because some control areas were replaced between baseline assessment and follow-up.

2. Description of included studies

2.1 Study design

The 18 included studies comprised seven randomized controlled trials (RCTs), nine controlled before and after studies (CBAs), and two interrupted time series (ITS). Details of included studies are contained in the Characteristics of Included studies).

2.1.1. Allocation/clustering

Clustering was an issue in nine studies; these were all allocated by school or class. Of these nine, three (Jacoby 1996; Neumann 2003; Shemilt 2004) adjusted for clustering in their analyses. We adjusted for clustering in five (Agarwal 1989 - boys; Bailey 1962; Du 2004; Orr 1928 - 13 yrs; Powell 1983). We were unable to adjust for clustering in one study (Chandler 1995) and therefore reported unadjusted Analysis of Variance results. Clustering was not an issue in the other nine studies (Baker 1980 (boys), Bro 1994; Bro 1996; Corry-Mann 1926; Devadas 1979: 5-6; Lieberman 1976; Paige 1976; Powell 1998 (A); Tisdall 1951). In five of the studies, students were allocated by individual and in four one experimental and one control school were allocated or we chose one experimental group to compare to another.

2.1.2. Inclusion in meta-analyses

Eight studies were not included in any of the meta-analyses. In five of these (Bro (Bro 1994; Bro 1996)); Lieberman (Lieberman 1976); Paige (Paige 1976), and Tisdall (Tisdall 1951)), standard deviations were unavailable. We report Analysis of Variance results from Jacoby (Jacoby 1996) and regression analyses from Shemilt (Shemilt 2004) as these analyses corrected for clustering. The Powell 1998 study (Powell 1998 (A)) and the Kenya study (Neumann 2003) were both included in meta-analyses for weight and height, but for psychosocial outcomes, we used results of multilevel regression. Similarly, the Orr study (Orr 1928 - 13 yrs) was included in meta-analyses for height, but lacked appropriate data for weight.

2.2 Location

Nine studies were from Lower Income Countries; five of the seven RCTs and four of the eight CBAs. Of the nine studies performed in higher-income countries; two of these were RCTs, six were CBAs, and two were Interrupted Time Series (see also Characteristics of Included Studies).

2.3 Participants

Children participating in studies included within this review ranged in age from 5 to 19 years; most studies included primary school children. Details on age, sex, and socio-economic characteristics of children in each study can be found in the 'Characteristics of Included Studies' table.

2.4 Description of the interventions

2.4.1 Lower income countries

Five programs provided meals: four provided breakfast and one provided lunch. The remaining four programs provided snacks/milk. Energy provided ranged from 195 to 730 kcal and protein provided ranged from 10-27 grams per day. Three studies (Bailey 1962; Du 2004; Neumann 2003) provided less than <15% of RDA for energy, at 8-10% of the RDA for energy, 10% of the RDA for energy and 13% of the RDA for energy, respectively.

Five studies in lower-income countries provided no intervention to children in control groups; these children may have had meals at home, or had no meals. In four studies, children in the control group were given a very low energy snack (e.g. quarter of an orange), drink (e.g. syrup) or iron pill; the three Jamaican studies (Chandler 1995; Powell 1983; Powell 1998 (A)), did this to control for the effects of benevolent attention. In one study (Bailey 1962) boys in the control group were given iron tablets.

2.4.2 Higher-Income Countries

Five of the feeding programs involved meals: four breakfasts and one lunch, and four involved snacks/milk. Energy content of seven studies ranged from 126 to 705 kcal and the amount of protein provided ranged from 3 to 26 grams.

2.5. Outcomes

2.5.1 Physical outcomes included: weight gain in kg and height gain in cm (11 studies), change in weight and height-for-age z-score or percent height and weight-for-age (three studies), change in mid-upper arm muscle area (one study), change in mid upper arm fat area (one study), change in Bone Mineral Density, Bone Area and Bone Content (one study), and change in haemoglobin (two studies), hematocrit (one study), and in other biochemical indices (two studies).

2.5.2. Psychosocial outcomes included educational and cognitive test outcomes

Educational outcomes comprised: change in school attendance (five studies), change in achievement in arithmetic (four studies), reading (two studies), spelling (two studies). Change in cognitive test outcomes included: end-of-study general intelligence (one study), change in Raven's Progressive Matrices score (one study), change in performance on Trail Making Test (Part A) (one study), sparse reports on 'mental tests' or achievement (three studies), and short-term change in cognitive tasks (two studies). Although we had planned to include school enrolment, we could not find any studies on enrolment that met our criteria.

2.5.3. Behavioural outcomes

Change in playground activity was considered in one study, change in hyperactivity (one study), behavioural conduct (two studies),

and in on-task behaviour (two studies). Adverse outcomes were not reported by any studies in this review.

METHODOLOGICAL QUALITY

Our quality criteria were modified from the EPOC checklist (EPOC 2002). The purpose of quality ratings was not to give an overall score, but rather to provide a descriptive overview of the methodological robustness of the included studies. Details are below and in Table 05.

1. Criteria used

1.1. Criteria for RCTs

We considered allocation concealment, comparability of groups on physical and/or psychological measures at baseline, reliable primary outcome measures, protection against contamination, blinded assessment of primary outcomes, co-intervention, and loss to follow-up. For each of these criteria, a rating of adequate (criteria met), unclear, or inadequate (criteria not met) was given. We also used the Jadad Scale (Jadad 1996). For the purposes of this review, we report on individual elements of the Jadad scale rather than on an overall score. For each of the Jadad criteria, a score of 1 (for met) or 0 (for not met) was given. One of the elements in the Jadad scale is double blinding, but it is important to note that double blinding is not always possible in a school meals situation.

1.2. Criteria for CBAs

In assessing methodological quality of the CBAs, we considered equivalence of baseline measurement of physical/psychological outcomes across groups, reliable primary outcome measures, protection against contamination, blinded assessment of primary outcomes, co-intervention, and loss to follow-up. For each of these criteria, a rating of adequate (criteria met), unclear, or inadequate (criteria not met) was given.

1.3 Criteria for ITS

In assessing methodological quality of the ITS designs, we considered protection against secular changes (including intervention independent of other changes, appropriate data analysis, and reason for number of pre and post points given), protection against detection bias (including intervention unlikely to affect data collection and blinded assessment), reliability of the outcome measures, and completeness of the data set. Each aspect of these criteria is described in more detail in Figure One. For each of these criteria, a rating of adequate (criteria 'met'), 'unclear', or 'inadequate' (criteria not met) was given.

Detailed methods for rating

Two reviewers (EK and BS) independently rated each aspect of study quality (EK and VR rated Shemilt). Disagreements were resolved at a consensus meeting. A nutritionist (JK) and a registered dietician (AF) assessed the reliability of anthropometric measurements and equivalence of baseline anthropometric mea-

asures across experimental and control groups. A registered clinical psychologist (LJ) assessed the reliability of psychological measures and the equivalence of baseline psychological measures across groups. An internal medicine specialist (PT) assessed the quality of haemoglobin, hematocrit, and bone mineral density measurements. Table 03 and Table 04 provide details on baseline equivalence of physical and psychological outcomes.

2. Results of Quality Rating

The results of the quality assessment of the included studies are listed in the Table of Included Studies and a complete summary can be seen in Table 05. Results from the Jadad Criteria and the EPOC criteria are presented separately below.

2.1. Jadad criteria

2.1.1. *DESCRIBED AS RANDOMIZED*. All seven RCTs were described as randomized.

2.1.2. *DOUBLE BLINDING*. Double-blinding was not done in any of the studies.

2.1.3. *DESCRIPTION OF WITHDRAWALS AND DROPOUTS*. Five RCTs provided descriptions of withdrawals and dropouts, two did not provide this description.

2.1.4. *DESCRIPTION OF METHOD OF RANDOMIZATION*. None of the studies described their method of randomization.

2.1.5. *DESCRIPTION OF METHOD OF DOUBLE-BLINDING*. This was not given for any of the studies.

2.2. EPOC criteria

2.2.1. *RELIABLE OUTCOME MEASUREMENTS*. Five studies were rated as adequate for all, seven studies were rated as unclear for all, five studies were rated as mixed adequate and unclear, and one study was rated as inadequate.

2.2.2. *EQUIVALENCE OF BASELINE MEASURES*. Seven studies were rated as adequate for all, five were rated as unclear for all, two studies were rated as mixed adequate and unclear, one was rated mixed inadequate and adequate, and three were not applicable.

2.2.3. *PROTECTION AGAINST CONTAMINATION*. Nine ratings of adequate were given, five were unclear, two were inadequate, and two were not applicable.

2.2.4. *BLINDING OF OUTCOME ASSESSMENT*. Blinding of outcome assessment was generally poor; six were rated adequate, nine were unclear, two were inadequate, and one was mixed inadequate and unclear.

2.2.5. *CO-INTERVENTION*. Co-intervention was almost always unclear; we gave fifteen ratings of unclear, one of adequate, and two were rated not applicable.

2.2.6. *LOSS TO FOLLOW-UP*. Loss to follow-up was rated adequate for seven of the studies, unclear for seven, inadequate for two, and not applicable for two.

2.2.7. *ALLOCATION CONCEALMENT* (RCTs only). Allocation concealment was rated as unclear for all 7 of the RCTs.

RESULTS

A. Physical Outcomes

A1. Weight gain

A1.1 Lower income countries: RCTs. Three RCTs (Du 2004; Neumann 2003; Powell 1998 (A)) were included in a meta-analysis for weight. There was some heterogeneity (Chi-square = 3.49, $df = 2$, $p = 0.18$, I-squared = 41.1%). Children who were fed at school gained an average of 0.39 kg more than those who were not supplemented (95% confidence interval 0.11 to 0.67); this is significant. Sensitivity analyses with ICCs at 0.01, 0.05, and 0.10 made little difference. This absolute difference of 0.39 kg represented a 1.2% difference relative to baseline and 12% relative to the control rate of weight gain. Study duration ranged from 7 to 24 months. Taking 19 months as the average study duration, this works out to a gain of 0.25 kg a year.

A1.2. Lower Income Countries: CBAs. Three CBAs in lower income countries (Agarwal 1989 - boys, Bailey 1962; Devadas 1979: 5-6) were included in meta-analyses for weight. These CBAs were heterogeneous (Chi-square = 15.8, $df = 5$, $p = 0.007$, I-squared = 68.3%). A statistically significant difference was found between supplemented and non-supplemented groups; on average, intervention groups gained 0.71 kg more than the control groups (95% confidence interval 0.47 to 0.95). Sensitivity analyses with ICCs of 0.01, 0.05, and 0.10 made little difference. This absolute difference in weight of 0.71 kg represented a 3.9% difference relative to baseline weight and a 44% difference relative to the control rate of weight gain. Study durations ranged from 10 to 12 months, for an average of 11.3 months. This works out to an average gain of 0.75 kilograms a year.

A1.3. Higher Income Countries: RCTs. Only one RCT in higher income countries assessed weight gain (Baker 1980 (boys)). Our analyses in REVMAN show no statistically significant differences in weight gain between children who received school milk and those who did not (WMD (kg) = 0.13 (95% confidence interval, -0.23 to 0.49)).

A1.4. Higher Income Countries: CBAs. Four CBAs in higher-income countries assessed changes in weight. In the year long Corry-Mann study (Corry-Mann 1926), boys who received milk gained an average of 1.42 kg more than controls (95% C.I. = 1.19, 1.65) over 12 months. In the 7 month long Orr (Orr 1928) study, compared to controls, 5-year-old, 8 year olds, and 13 year olds who received milk gained from 0.18 to 0.44 more, eight-year-old children gained from 0.01 kg to 0.54 kg and 13-year-old children gained from 0.28 kg to 0.38 kg more. In Paige 1976, the average weight increment for children who received the fortified drink was 0.5 kg greater than that of the controls (P value < 0.001); according to the graphs, the gain was much greater in younger children (below 7 and 7 to 8 years) than in the older children (8 and 9 year old) age groups (significance not given). In the Tisdall study, children in the school lunch group gained an average of 0.32 kg more than

the controls (n.s.) over the 27 month period of the study (Tisdall 1951).

A2 Height gain in cm

A2.1. Lower Income Countries: RCTs. Three RCTs (Du 2004; Neumann 2003; Powell 1998 (A)) were included in a meta-analysis; these studies were heterogeneous (Chi-square = 7.9, $df = 2$, p value = 0.02; I-squared = 74.8%). Overall, there was a small, non-statistically difference in change in height between experimental and control groups (WMD = 0.38, 95% confidence interval -0.32 to 1.08). The height gain of 0.38 represented a 0.2% difference relative to baseline height (134.5 cm) and a 5% difference relative to the control group (Additional Table 01). The duration of these studies ranged from 7 months (Powell 1998) to 24 months (Du 2004).

A2.2. Lower Income Countries: CBAs. Three CBAs with six independent samples (Agarwal 1989 - boys; Bailey 1962; Devadas 1979: 5-6) were included in the meta-analysis. There was severe heterogeneity (Chi-square = 81.8, $df = 5$, $P < .0001$, I-squared = 96%). Significant gains in height were seen; children in the intervention groups gained an average of 1.45 cm more than children in the control groups (95% confidence interval 0.52 to 2.38). Sensitivity analyses made little difference. This height difference represented a difference of 1.2% relative to the baseline height (of 116.6 cm), and a 33% difference relative to control group rate of height gain.

A2.3 Higher-Income Countries: RCTs. Only one RCT (Baker 1980 (boys)) studied height. Our analyses in RevMan indicate that children who were given school milk gained a small amount more than controls over two years (WMD = 0.28, 95% confidence interval: -0.01 to 0.56).

A2.4 Higher-Income Countries: CBAs. Height gain was studied in four CBAs. In a meta-analysis of the Corry-Mann (Corry-Mann 1926) and 1928 Orr (Orr 1928 - 13 yrs) studies, high heterogeneity was observed (Chi-Square = 29.66, $df = 3$, $P < 0.0001$, I-squared = 89.9%). Children who received milk gained an average of 0.92 cm in height more than children in the control group (95% C.I.: 0.16 to 1.6). In the 7-month long Paige study, the average height gain in the experimental group was greater than that of controls by 0.5 cm in the 6 year old group (n.s.), 1.0 cm in the 7 year old group, ($p < 0.01$), 0.6 cm in the 8 year olds ($p < 0.01$) and 0.2 cm in the 9 year olds (n.s.) (Paige 1976). In the Tisdall study, the intervention group grew 0.25 cm more than the controls over two years; this was non-significant (Tisdall 1951).

A3. Change in Weight-for-age z-scores

A3.1 Lower Income Countries: RCTs. Powell 1998 (A) assessed change in weight-for-age z-scores in Jamaica using the U.S. National Center for Health Statistics references. Analyses showed a statistically significant effect of treatment on weight-for-age; the change in z-score was 0.07 higher in the experimental group than in the control group (95% confidence interval 0.04 to 0.10).

A3.2. Lower-Income Countries: CBAs. In the 1983 Powell study (Powell 1983) there was no difference in final percentage of expected weight-for-age between children who were given breakfast and children in two control groups; one given a low energy syrup and a no treatment control group (WMD = 0.75, 95% C.I. = -0.61, 2.40). Sensitivity analyses did not change the outcome.

A4. Change in Weight-for-height z-scores

A4.1 Lower-Income Countries: RCTs. Grillenberger reported that in the Kenya study the decline in z-score was 0.20 less for the children who received meat as a snack than for the control group; this difference was not statistically significant (95% confidence interval, -0.24 to 0.64) (Grillenberger 2003; Neumann 2003).

A5. Change in Height-for-age z-scores

A5.1 Lower-Income Countries: RCTs. In a meta-analysis of two RCTs (Neumann 2003; Powell 1998 (A)) there was no heterogeneity (Chi-square = 0.49, df = 1, p = 0.49; I-square = 0%). A small, significant effect of school feeding on height-for-age (z-score diff = 0.04, 95 % confidence interval 0.02 to 0.06) was seen.

A6. Percentage of Height-for-age

A6.1. Lower-Income Countries: CBAs. Our analyses for Powell's study (Powell 1983) show a small, significant difference in percentage height that favors control children (WMD = -.75, 95% C.I. = -0.75, 95% C.I. = -1.19, -0.32).

A7. Change in mid-arm muscle area, mid-arm fat area, and mid-upper arm circumference

A7.1 Lower-Income Countries: RCT. Authors of the Kenya study presented data on change in mid-arm muscle area, mid-arm fat area, and MUAC (Neumann 2003). They reported that children who were given meat gained significantly more mid-upper arm muscle area than controls (WMD = 68.22 mm-squared (95% confidence interval 39.57 to 96.87)). No differences were found for change in mid-upper arm fat area between the experimental children who were given meat and the controls (WMD = -0.31 mm-squared; 95% confidence interval = -26.12 to 25.50). There was a significant increase in MUAC in the meat group compared to controls (WMD = 0.31 cm (95% confidence interval 0.14 to 0.48)).

A8. Change in bone mass and body composition

A8.1 Lower-Income Countries: RCT. Du and his colleagues (Du 2004) studied the effects of milk fortified with calcium. These results were initially not adjusted for clustering, but in a later letter to the editor reporting on an updated analysis controlling for clustering, results showed no significant differences in percentage change in Bone Mineral Content (Exp - Control = 1.7, P = 0.12) and bone area (Exp - control = -1.2, P = 0.22). However, for Bone Mineral Density, the group who received milk with calcium experienced a 3.1% greater gain than the control group (P = 0.03).

A9. Biochemical outcomes

A9.1. Lower-income countries: RCT. In the Kenya study (Neumann 2003), a number of micronutrient status indicators includ-

ing hemoglobin, plasma ferritin, serum iron, serum zinc, serum copper, plasma vitamin B-12, folate and retinol, and erythrocyte riboflavin were assessed. After a year of intervention, the only significant difference was in plasma vitamin B-12. While plasma Vitamin B-12 concentration increased by 47 pmol/L (s.d. = 66) in children who received a meat supplement, it decreased by 13 (s.d. = 65) in the control group (p < 0.0001).

A9.2. Higher income countries. Tisdall (Tisdall 1951) compared 'good attenders', 'poor attenders' and controls on serum ascorbic acid, serum carotene, and serum Vitamin A. Statistically significant differences were found favouring the school lunch children.

A10. Hemoglobin and hematocrit

A10.1 Lower-Income countries. RCT. One paper produced from the Kenya study (an RCT in a lower-income country) found no differences in hemoglobin increase between the experimental (meat) and the control group; the mean increase in g/L was 7.5 (s.d. = 15.1) in the experimental group and 11.5 (s.d. = 19.8) in the control group (Siekmann 2003; Neumann 2003).

A10.2. Lower-Income Countries: CBAs. Devadas (Devadas1979: 5-6) reported a greater increase in haemoglobin in the experimental groups of 0.38 g/dl. Significance was not reported. Bailey (Bailey 1962) reported a decrease of 0.83 percent in the experimental group and no change in the iron-supplemented control group. However, iron supplementation is not an appropriate control group for this outcome.

A10.3 Higher income countries: CBAs. Tisdall (Tisdall 1951) reported no significant difference in increase in hemoglobin between 'good attenders', 'poor attenders', and controls (statistics not given). Paige (Paige 1976) reported a larger increase in % hematocrit in the supplemented group (35.9% to 39.4%) than in the control group (increase from 35.8% to 38.2%; p < 0.001). Paige reported that the end-of-study difference in percent of children with levels below 33.9% was significant (p value < 0.01).

B. Psychosocial Outcomes (Educational outcomes, short and long-term cognition)

B1. School Attendance

B1.1 Lower-Income Countries: RCTs. Jacoby and colleagues (Jacoby 1996) and Powell and colleagues (Powell 1998 (A)) assessed school attendance. In the Powell study, multilevel analysis (school, class and pupil as fixed parameters) and with initial score, sex, grade, and nutrition group as covariates revealed a significant effect of breakfast on attendance (b (unstandardized regression coefficient) = 2.32, s.e. = 0.78, p < .05). This means that children in the experimental group attended school 2.3% more days in the study period than children in the control group. Jacoby and his colleagues (Jacoby 1996) performed descriptive analyses on attendance, and reported significant effects of school feeding on attendance (note that they were unable to provide us with standard deviations). In the experimental group, attendance increased by 0.58% while it decreased by 2.92% in the control group. In the

first month of the intervention, the attendance of the experimental group was 5.1% higher than that of the control group. The difference in change between the experimental and control groups is 3.4 %.

B1.2 Lower-Income Countries: CBAs. Our meta-analyses adjusting for clustering in the control groups showed that change in attendance was not significantly different between the breakfast group and the pooled control groups (WMD = 4.95, 95% C.I. = -3.95, 13.46). Sensitivity analyses at 0.10 and 0.20 did not change the outcome.

Agarwal (Agarwal 1989) provided a very sparse report on attendance; in his discussion, he noted that there was 'significant improvement in attendance' (p.172). It is unclear whether this was based on statistical analyses or was merely impressionistic.

B2.1.3 Higher-Income Countries: CBAs. Three authors (Paige 1976; Tisdall 1951; Lieberman 1976) all reported that children who received school meals attended school more days per year than children in control groups. Paige found that children who received school meals attended, on average, 2.5 more days per year than children in the control group (significance not reported). Lieberman reported that in the group of children who received school breakfast, attendance increased from 158 to 161 days per year while in the control group, attendance decreased from 158 to 156 days (non-significant). Tisdall found that students who received school lunch attended 1.4 days more than controls (non-significant); it is not clear whether this was over the two-year period of the study, or per year. Tisdall also reported that the rate of absence for medical causes per 1000 pupil days was 36.0 for school lunch children and 39.8 for control children; the rate was only 31.8 per 1000 pupil days among the group of children who regularly attended the school lunch program.

B2. Math performance

B2.1. Lower-Income Countries: RCTs Two RCTs (Powell 1998 (A)); and the Kenya study (Whaley 2003; Neumann 2003)) reported data measuring change in math performance. Powell (Powell 1998 (A)) used the Wide Range Achievement Test (WRAT), and Whaley used an adapted arithmetic test from the Wechsler Intelligence Scale for Children (WISC). In the 1998 Powell study, multilevel analyses were performed; predictors included initial score, sex, grade, nutrition group, treatment group, school, class, pupil, and a treatment by grade interaction (Powell 1998 (A)). Powell reported a significant effect of breakfast on arithmetic achievement over the seven month period of the study; children in the experimental group gained significantly more than those in the control group; (b = 0.71, s.e. = .031, P value < 0.05). Multi-level regression analyses in the Kenya study performed by some of the authors of the Kenyan study showed that children who were given meat gained 0.17 points per year, (s.e = 0.10, P value < 0.05) in math knowledge than children in the control group (Whaley 2003; Neumann 2003).

B2.2. Lower income Countries: CBAs. Two CBAs (Powell 1983; Agarwal 1989) assessed math achievement. Results of our adjusted meta-analysis (with ICC = .15) show no heterogeneity (Chi-Square = 1.47, df = 4, P = 0.86, I-squared = 0). Change in math achievement was significantly greater for children who had received school meals than those who did not (SMD = 0.66, 95% C.I. = 0.13 to 1.18). We also performed an analysis in which Agarwal was broken down into four nutritional subgroups; results were very similar (SMD = 0.72, 95% C.I. = 0.34 to 1.09) (Agarwal 1989). Sensitivity analyses for ICCs of 0.10 and 0.20 made little difference.

B3. Spelling achievement

B3.1 Lower Income Countries: RCTs. Multilevel regression analyses performed by Powell (Powell 1998) showed no difference in change in spelling achievement as measured by an adapted version of the WRAT for the experimental group than for the controls (b = -0.5, s.e. = 0.27, ns.).

B3.2 Lower Income Countries: CBAs. In one CBA (Powell 1983), our adjusted meta-analysis (ICC = 0.15) shows a small, significant difference between children in the experimental and two control groups combined (SMD = 0.24, 95% C.I. = 0.01, 0.47). Sensitivity analysis with an ICC of 0.10 showed much the same results, however, the sensitivity analysis with an ICC of 0.20 was non-significant.

B4. Reading achievement

B4.1 Lower-Income countries: RCTs. Powell and colleagues (Powell 1998 (A)) assessed change in reading performance on an adapted version of the WRAT. A multi-level regression analysis demonstrated that there was no difference in reading performance between experimental and control groups after adjusting for baseline performance, age, and sex (b = 0.12, s.e. = .29, n.s.).

B4.2 Powell and colleagues (Powell 1983) assessed the effect of school breakfast on reading performance using the adapted version of the WRAT. Our adjusted meta-analyses demonstrated no difference between children in the experimental groups and those in the control groups combined (SMD = 0.09, 95% C.I. = -0.11, 0.29). Sensitivity analyses made little difference.

B5. Intelligence-type test scores

B5.1 Lower Income Countries: RCTs. Some trialists (Whaley 2003) involved with the Kenya study (Neumann 2003) studied effects of a school snack on fluid intelligence using Raven's Progressive Matrices. They found a significant effect of treatment: children in the group who received meat gained an average of 0.34 points per year more than the control group who were not fed (P value < 0.05).

B5.2. Lower Income Countries: CBAs. In the Agarwal study (Agarwal 1989 - boys), our adjusted analyses (ICC = 0.15) show moderate positive, but non-significant effects of school feeding on Full Scale, Performance, and Verbal IQ. Children who were given school lunches had an end-of-study Full-Scale IQ that was 3.9

points higher than those who were not given school lunch (WMD = 3.9, 95% C.I. = -11.33, 19.13). The end-of study Performance IQ was 5 points higher for those children who were given lunch than for the controls (WMD = 5.0, 95% confidence interval -11.97 to 21.97). Differences in Verbal IQ were smaller (WMD = 3.10, -10.5 to 16.7). Sensitivity analyses made very little difference to either the point estimate or the significance.

In another analysis, we used subgroups from Agarwal (Agarwal 1989). Here, our adjusted analyses (ICC = 0.15) show significant effects of school feeding on Full Scale and performance IQ. Children who were given school lunches had an end-of-study Full-Scale IQ that was 3.8 points higher than those who were not given school lunch (WMD = 3.80, 95% C.I. = 0.51, 7.10). Sensitivity analyses with ICCs at 0.10 and 0.20 were still significant. Larger differences were seen in performance IQ; the end-of study Performance IQ was nearly 6 points higher for those children who were given lunch than for the controls (WMD = 5.78, 95% confidence interval 2.12, 9.45). Sensitivity analyses with ICCs at 0.10 and 0.20 were both significant. Differences in Verbal IQ were smaller and non-significant (WMD = 3.32, 95% C.I. = -0.21, 6.92). Sensitivity analyses made very little difference to either the point estimates or the significance.

Another CBA (Devadas 1979: 5-6) provided very sparse reports on mental ability; she found no differences between experimental and control groups in end-of-study mental ability.

B5.3. Higher Income Countries: CBAs. One CBA in a higher income country (Lieberman 1976) reported no difference in magnitude of improvement on Raven's Progressive Matrices and other psychological tests (figure copying, making x's, listening attention, and memory for numbers). Another CBA (Tisdall 1951) reported no significant differences in change in intelligence test scores, school marks, and reading and math tests.

B6. Short-term effects on cognition

B6.1 Lower-income countries. RCTs. Chandler and her colleagues (Chandler 1995) performed a randomized cross-over study of the short-term effects of providing breakfast on four cognitive tasks. They report significant treatment effects for verbal fluency (P value < 0.02) and a significant treatment by nutritional status interaction (P value < 0.05). Those children who were undernourished (defined as 1 or more than 1 standard deviation below National Centre for Health Statistics references) had scores (unadjusted for clustering) that were 1.5 points higher after receiving breakfast than when they received the placebo (P value < 0.01). However, breakfast made no difference to the children who were classified as adequately nourished (above - 1 s.d. for weight- for-age). No significant effects of school feeding were found on information processing, visual search or digit span for either well-nourished or undernourished children.

Jacoby and his colleagues (Jacoby 1996) studied the short-term effects on performance in a battery of psycho educational tests: 1) the coding subtest from the Weschler Intelligence Scale for Chil-

dren, 2) a test of reading comprehension from the Inter-American Series, 3) a test of vocabulary from the Inter-American Series, and 4) a test of functions and abilities related to the math curriculum. An Analysis of Covariance controlling for sex, height-for-age z-score, weight - residual (weight regressed on age and height), SES, home language, repetition of any grade, and age on entry to school; current enrolment in grade, school nested in treatment group, and interactions between height-for-age and treatment and weight-for-age and height was used. Significant effects were seen for vocabulary only; the main effect of breakfast overall was not significant, but there was a significant interaction between baseline weight-for-age and height and treatment (parameter estimate = 0.37, F = 4.97, P value < 0.05). This interaction meant that the heavier children benefited most from school breakfast. The authors noted that the combination of smaller than average stature and normal weight for height are common among poor Peruvians, and that 'this phenomenon reflects a protracted deficit of critical nutrients due to poor diet and infection' (p. 62) (Jacoby 1996). Thus he hypothesized that those who were heavier than normal were likely to be of poorer health and less well nourished than the other children.

B6.2. Higher Income Countries: RCTs. One cluster RCT in a high income country (Shemilt 2004) assessed concentration with the Trail Making Test three months after breakfast clubs were initiated in a number of schools where each school decided on meal content. For children in school years 2-11, the time taken to complete the Trail Making Test was significantly shorter in the intervention group at 3 months; the time taken by the intervention group was 3.70 seconds logged and the time taken by the control group was 3.71 seconds. The ratio of adjusted geometric means was 0.90, 95% confidence interval 0.81 -1.00). It is important to note that contamination had occurred; by the time of first follow-up, 2 schools randomized to the control group were running breakfast clubs. Furthermore, not all of the 17 schools randomized to the experimental conditions ran breakfast clubs.

C. Behavioural Outcomes

C1 Lower Income Countries: RCTs. In the Kenyan RCT, eight aspects of playground activity were considered; high activity, low activity, positive emotion, leadership, initiates, ongoing behaviour, aggression, and solitary play. The children who were given meat outperformed those who were given no snack in comparisons; high activity, low activity, leadership, and initiating social interactions (p < .001 for all) (Neumann 2003).

In a sub-study of the larger Chandler study (Chandler 1995), Chang and colleagues reported that the behaviour of a sub-sample of children was observed during structured teaching and during work on an assigned task (Chang 1996). Behaviour only improved with school breakfast in one school, deteriorated in two schools, and was not affected in the other. The authors noted that the school in which behaviour improved was the only school that had

separate classrooms for each class and where each child had his or her own desk.

C.2. Higher-Income Countries: RCTs. One cluster RCT of breakfast clubs in the UK (Shemilt 2004) examined differences in abnormal or borderline conduct and hyperactivity after three months (first follow-up). Although the percentage of students with borderline/abnormal conduct, hyperactivity, and total difficulties was lower in the intervention group, these differences were not significant in multilevel regression analyses.

C.3. Higher Income Countries: ITS. Two small interrupted time series studies (Bro 1994; Bro 1996) found improvements in the percentage of time students were engaged in on task behaviour when they were given breakfast. In the first study (Bro 1994), the percentage of time that students were on task rose from an average of 41% during the second baseline to an average of 93% in the second phase when they were given breakfast (significance not reported). Results of the second study (Bro 1996) were similar. In the first class, mean percentage of on task behaviour rose from an average of 49% to an average of 90%, while in the second class, mean percentage of time spent in on task behaviour rose from an average of 62% to an average of 70% (significance not reported). These are small studies, and there are some issues around whether the intervention is confounded by other interventions so we place less importance on them.

D. Subgroup analyses

D1. Effects by socio-economic status

D1.1. Lower-Income countries: RCT. None of the included studies displayed data on outcome by SES. However, Grillenberger and her colleagues (part of Neumann 2003) reported that the effect of school meals on weight was greater for children of lower SES (Grillenberger 2003).

D2. Effects by baseline nutritional status

D2.1. Lower-Income Countries

D.2.1.1. Weight. A subgroup analysis for change in weight from the Powell study (Powell 1998 (A)) showed no interaction between treatment and baseline nutritional status (fixed and mixed effects: $Q/Z = 0.01$, P -value = 0.97).

D.2.1.2. Height. Subgroup analysis of the Powell RCT (Powell 1998 (A)) in RevMan demonstrate a significant gain of 0.30 cm in the undernourished group and a non-significant gain of 0.17 in the well-nourished group. However, formal analyses showed a non-significant interaction between baseline nutritional status and height gain (fixed and mixed effects $Q/Z = 69.7$, $P = 0.404$). Grillenberger (Grillenberger 2003, Neumann 2003) presented a graph showing results by baseline height-for-age z-score. They reported that height gain was not significantly different between the meat and control group for either the low HAZ (< -1.4 standard deviations below the mean) or the high HAZ (> -1.4) groups.

D2.1.3. As previously described, Jacoby (Jacoby 1996) reported an interaction between weight-residual (based on regressing weight-

on-height and age) and treatment; those children in the experimental group with higher initial weights showed significantly improved vocabulary scores. Chandler (Chandler 1995) found that breakfast significantly improved verbal fluency only for children who were underweight (≤ -1 s.d. below reference values in weight-for-age).

Another way of looking at effectiveness by need is to compare lower-income countries and higher income countries. The assumption here is that if school meals are more effective for those in greatest need, they should show larger effects in lower-income countries where the need is presumably greatest. As Table 06 and Table 07 show, effect sizes for weight and height are generally higher in lower-income countries when comparing studies in lower-income countries to studies in higher income countries from the latter half of this century (Paige is the exception to this (Paige 1976)). However, if one examines studies done in the 1920s in higher income countries, effect sizes for weight and height are very similar (or higher) than those for later studies in lower-income countries. The study by Paige also resulted in significant effects on weight and height (Paige 1976).

D3. Age

D.3.1. Lower Income countries: weight. In a meta-regression of the three RCTs (Du 2004; Neumann 2003; Powell 1998 (A)) with a total N of 1462, no significant treatment by age interaction for weight was found (Z (Q) Fixed and mixed effects = -4.58, $P = 0.67$).

In a meta-regression of the 3 CBAs (Agarwal 1989; Bailey 1962; Devadas 1979: 5-6) with a total N of 1022, there was a significant age-by-treatment interaction. The greatest benefit of school meals was shown for 5-6 year olds and 9 to 10 year olds (.95 and .89 kg respectively). The effect for 6 to 8 year old children was also large at .67 kg, but there was no effect in the Bailey study which included children up to age 13 in the analyses.

D.3.2. Higher Income Countries: weight. As previously shown, in the Paige study (Paige 1976), weight gain was highest in the youngest children and lower and non-significant for older children.

D.3.3. Lower Income Countries: height. Meta-regression analysis for height in three RCTS (Du 2004; Neumann 2003; Powell 1998 (A)) with an overall N of 1462 showed a significant interaction between age and treatment (Z (Q) Fixed and Mixed (moment) = -2.284, $P = 0.022$). An examination of the subgroup data shows that children who were 9 to 10 years old grew more relative to controls (0.40 cm., 95% CI = 0.03, 0.77) than did children in a group aged 6 to 16 (-0.37 cm, 95% C.I.= -1.30, 0.56) Meta-regression of the CBAs also showed a significant interaction with age (Z (Q) Fixed = -9.608, $p = .000$; Mixed = -2.137, $P = 0.033$). In the three CBAs (Agarwal 1989; Bailey 1962; Devadas 1980) with an overall N of 1022, significant effects of feeding were seen only for the youngest children (aged 5-6 and 6 to 8 years). These children gained 2.26 cm and 1.25 cm, respectively, more than children in the control groups. In the 9-10 and 6 -13 year old

groups children who were fed did not gain significantly more in height than children in the control groups.

The relative differences in weight and height also show a gradient in benefit across age, with a relative benefit of 98%, 41%, 45%, 0.9% for the ages 5-6, 6-8, 9-10 and mixed ages respectively.

D.3.4. Higher income countries: height. As mentioned previously, the average height gain was larger in the middle two age groups (7 and 8 year olds) in the Paige study (Paige 1976).

For cognition, Powell (Powell 1998 (A)) reported a significant grade by treatment interaction for math ($b = -0.85$, $s.e. = 0.44$, $p = 0.05$) indicating that the effect of school breakfast mainly occurred for younger children.

D4. Sex

D4.1. Lower Income countries: RCTs. Powell (Powell 1998) found no significant sex by treatment interaction for height and weight. However, Grillenberger (Neumann 2003) reported that school feeding (meat versus control) had a greater effect on weight and MUAC for boys than for girls. Furthermore, while feeding with meat had a significant positive effect on WHZ for boys, there was no significant effect for girls (for boys, WHZ declined less in the experimental group than in the control group).

D4.2 Lower Income: CBAs In the Agarwal study (Agarwal 1989), effects of feeding on weight and height were very similar for boys and girls. For girls, weight gain of the experimental group relative to the control group was 0.70 (significant) while for boys, the weight gain relative to controls was 0.80. There was no significant relationship between feeding and height for either boys or girls.

D4.3. Higher Income countries: RCTs. In the Baker study, no differences were evident between boys and girls in weight gain of the experimental group relative to the controls (Baker total 1980). For height, girls in the experimental group grew 0.45 of a cm more than controls (n.s.); results boys in the experimental group grew only 0.11 of a cm (n.s.).

None of the studies tested a treatment by sex interaction for cognition.

E. Potential Confounders

E1. Study quality

E1.1. Comparison of RCTs and CBAs. Our meta-analyses of height and weight gain described above show there was a large difference between RCTs and CBAs in height gain (0.35 cm (n.s) in RCTs and 1.45 cm (sig) in the CBAs). For weight, differences between RCTs and CBAs in meta-analyses were smaller (0.39 kg in RCTS and 0.71 kg in CBAs); both showed significant overall effects. For most of the cognitive functions, comparisons of effect sizes are difficult, as every study used different scales and different methods of reporting. For arithmetic, two RCTs and two combined CBAs showed significant effects.

In higher income countries, both weight and height gains were non-significant and very small in one RCT, but higher in the CBAs. However, it must be noted that the % RDA for energy provided

in that RCT was very low. No comparison of cognitive functions is possible, as this RCT did not assess cognitive function.

E1.2. Comparison of blinding to unclear blinding

Findings for this comparison were very similar to findings from comparisons of study types. However, for attendance, one of two RCTs in lower-income countries that assessed attendance had unclear blinding. This study had a very slightly larger effect size than the one that did blind outcome assessment.

E2. Substitution

Only three included studies (Agarwal 1989; Jacoby 1996; Murphy 2003 in Neumann 2003) assessed this issue, and all report evidence of substitution. They all found that the net increase in energy intake was far lower than the amount of energy provided by the meal. For example, Agarwal reported that the mid-day meal program provided 450-500 kcal and 25% of the RDA for energy, but that the average daily increase in the supplemented group was only 200 kcal while in the Peruvian breakfast study (Jacoby 1996), the meal contained an average of 600 kcal but the net increase in intake was 288 kcal. In the Kenyan study, the net increase in the meat group was only 140 calories when 239 were given; the milk and energy groups actually showed decreases in net intake, and the control group showed an increase of 196 calories a day.

E3. Compliance

Compliance was very poor in some studies from higher income countries. For example, in the Lieberman study, only 10% of children attended breakfast 90% of the time, and less than half attended 55% or more of the time (Lieberman 1976). In this study, non-significant results were found on cognitive tests. The Tisdall study (Tisdall 1951) sheds important light on the issue as they compared 'good attenders' to 'poor attenders' (nearly 2/3 of the school lunch groups) in many analyses. In these analyses, the 'good attenders' did better than the 'poor attenders'.

DISCUSSION

In performing this review, we found that many of the articles on school feeding did not use rigorous outcome assessment. Many articles simply provide descriptions of the nutritional quality of school meals and /or the dietary intake of participants, others describe program operation, management, or cost, others simply survey participants, parents, or providers. Another group of studies comprise cross-sectional comparisons of participants and non-participants; still others are longitudinal studies with no control. The 18 included and 12 excluded studies included in this review are the only studies we found which assessed effectiveness with a reasonable degree of rigour. Despite the practical difficulties involved in undertaking research on school meals, it is clear that more high quality research on school feeding programs needs to be undertaken in both higher and lower income countries.

We included a wide range of studies in this review; they were conducted over eight decades and in many different countries.

Their heterogeneity in terms of setting, historical/policy context, sample, inclusion criteria, interventions, and outcomes is striking. Sorting the studies into historical order gives a feel for the way the focus of the research has moved from en masse feeding of the disadvantaged and measuring growth plus 'general condition' of the children to a much tighter focus on selected samples of the socially excluded and measuring cognitive and educational performance as well as growth.

The quality of included studies improved over time. Some of the earlier studies (which go back to the 1920s) were probably excellent according to standards of their time, but were not described in enough detail to allow them to meet current quality criteria. Reports from studies in the 1960s and 1970s also lacked sufficient detail. Methodological quality was highest in the more recent studies from lower-income countries. Our process evaluation showed a great deal of variability in study implementation and in attention to important confounders. This is discussed more fully under potential confounders.

A. Effects of school feeding on growth

In this review, we found positive, significant effects of school feeding on weight in lower-income countries and mixed, but generally positive effects in higher income countries. Extrapolating from the average yearly gain seen in RCTS in our review, if meals were given throughout six years of primary school as suggested by Powell 1998 (A), total gains could be 1.3 kg. Extrapolating from the CBA results suggests gains of 4.5 kg over the six year period of primary school. The gain of 0.35 kg over 19 months in low income countries (0.22 kg per year) is similar to the gains of 0.38 kg reported in a systematic review of anthelmintic treatments (Dickson 2000).

In terms of height, results from lower income countries were mixed, but in higher income countries, results were moderate and positive. Interestingly, evidence from our subgroup analyses in lower income countries shows that height gain was significantly greater for younger children than for mixed age groups. However, it is difficult to determine whether this trend is due to age, or to the fact that the studies that did not separate participants out age provided low energy content.

It is difficult to determine clinical significance for growth, particularly in this review. There are a number of reasons for this: 1) lack of standards for weight and height gain in school age children, 2) few studies presented data on baseline nutritional status and the importance of change depends on this, and 3) growth velocity will differ among different ages of school age children, and in most studies, results were not presented by age group. It is important to note, however, that effects on weight were small.

As noted in the introduction, growth may not be the most important outcome of school feeding. Other outcomes may have an important impact on education and on later functioning. These outcomes include: decreased morbidity, increased muscle mass,

improved attention and behaviour, improved academic achievement and improved cognitive functioning. Although these benefits are sometimes seen at the same time as improved growth, it is essential to study them separately rather than infer them from increased growth.

B. Other physical outcomes

Results from one study suggested that school feeding with meat led to an increase in muscle mass. Grillenberger et al, when considering the Kenya study, hypothesized that the higher quality protein and more available micronutrients in the meat supplement may have been responsible for these differences. If this finding on increased muscle mass was replicated, it could be important, as increased muscle mass has important practical implications, including the potential for increased work and play capacity. However, it is important to note that, as this outcome was only assessed in one study, results can only be taken as preliminary (Grillenberger 2003, Neumann 2003).

One study (Du 2004) reported increased bone mineral content and bone mineral density in pre-adolescent Chinese girls who had been given milk fortified with calcium at school. The percentage change from baseline (3.1%) is comparable to a 2% change reported in a systematic review of the effectiveness of calcium in post-menopausal women and of 1.8% found in a systematic review of the effectiveness of exercise in post-menopausal women. Higher BMD means stronger bones through life, and lower possibility of fracture. Further study in this area is clearly warranted.

Effects on Biochemical outcomes

It is difficult to draw any firm conclusions about the effects of school feeding on biochemical outcomes, as only a few studies reported on them. In those that did, results for haemoglobin and hematocrit were mixed, and except for Vitamin B12 and Vitamin A, other biochemical outcomes were unaffected by feeding. In the case of Vitamin A, Tisdall noted that differences were not clinically meaningful (Tisdall 1951). However, Seikmann (Neumann 2003) noted that the high prevalence of disease and infections among the children in their study could have accounted for their null biochemical findings. Furthermore, studies in this review focused on feeding rather than micronutrient supplementation.

C. Psychological outcomes/ clinical relevance

In general, there are two ways through which school feeding may impact on cognitive function; 1) long-term contributions of feeding to overall health and brain function and 2) short-term metabolic changes due to immediate energy supply (Pollitt 1995).

Thus far in school feeding studies, only a few researchers have paid attention to the selection of appropriate cognitive outcome measures (Hughes 2003). None of the studies administered a comprehensive battery of neuropsychological tests, which would include intelligence, attention, processing speed, executive functioning, learning and memory, visual skills, motor and sensory performance, and academic achievement. With the exception of a few

studies, test selection largely appeared arbitrary. The finding of affected cognitive functions is partially dependent on tests given. Most of the tasks administered in the reviewed studies emphasize processing speed, attention, working memory, semantic retrieval, and academic achievement. Very few studies focused on long-term memory retention, sensory or motor abilities.

In the majority of the studies included in this review, it is difficult to determine the clinical significance of the findings. Many of the reports fail to include the range, mean and standard deviation of the specific cognitive measures, fail to adequately describe the cognitive measures used or how conventional measures were adapted or modified, and how the reported scores were derived. Furthermore, there is no universally agreed-upon definition of clinical significance in this field. However, we were able to draw some inferences about clinical relevance.

Significant improvements in math performance were consistently found in studies from low income countries. Thus, we conclude that school feeding can result in improvements in math performance. The arithmetic measures used in these 4 studies vary and it is difficult to determine the clinical relevance of these statistically significant findings without further information about the psychometric properties of the tests. However, it seems as if the small effect found in the Kenya study (Whaley 2003; Neumann 2003) is probably not clinically significant. In contrast, authors of the Powell RCT (Powell 1998 (A)) noted that although the improvement in arithmetic as a result of breakfast was small, the increase represents about 30% of the average yearly progress. Furthermore, the difference found in the two CBAs represent a gain in the experimental group that is 2/3 of a standard deviation greater than the gain in controls (SMD = 0.66, 95% confidence interval = 0.13 to 1.18).

Results from two studies suggest that school feeding may impact on intelligence type tests, but these results are far from conclusive. Results from the Agarwal study (a small CBA) are difficult to interpret because we had to use ICCs from achievement tests and significance differed according to whether subgroups or totals were used (this was due to differences in cluster size). If replicated, these results would be important. For example, the Performance IQ increase of 5 points represents a third of a standard deviation. The observed FSIQ increase of 4 points (one-fourth of a standard deviation) is comparable to that seen between breast-fed and formula fed infants, which is considered to be clinically significant and is used extensively to promote breast-feeding (Anderson 1999). For the Kenya study (Neumann 2003) on Raven's progressive Matrices, as the authors report that the range of scores on this test is 0-30, a 0.34-point per year advantage seems rather modest.

In the Chandler study those who received breakfast generated 1.5 more words on average on the semantic verbal fluency task than controls. Assuming that scores across two categories were summed, the undernourished children in the treatment group generated less than 1 additional word per category relative to controls. A review

of norms for 1 minute semantic verbal fluency tasks (similar to those used by Chandler et al) for 8 and 9 year olds reveal standard deviations in the range of 2.7 to 3.9 words per category (Halperin 1989). Thus, a relative increase of less than one word per category is probably not clinically significant.

Although there are discrepancies, most of the psychosocial outcomes in this review that improved as a result with school feeding are related. These include: fluid intelligence, processing speed, and arithmetic. These functions require more concentration and attention; and application of skills and/or rules to novel situations. In contrast, outcomes such as spelling achievement are done by rote. It has been hypothesized that these cognitive functions are highly dependent on the functional integrity of the central nervous system (CNS) and may fluctuate from moment to moment due to physical or emotional factors (Belsky 1990).

Effects on School Attendance

One of the most commonly cited benefits of school feeding is in improved attendance. The mechanisms for enhancing attendance may include not only the attraction of a free meal, but also possible effects on immune function that reduce illness and the effect on concentration that may make school more enjoyable.

The results of this review are consistent with other findings showing that school meals can improve school attendance in lower income countries. However, effects were small. Taking estimates from the two RCTs together, in a school year of 172 days a year (i.e. Peru), this would mean an increase of 4 to 6 days per year. The improvement in attendance noted in three CBAs in the United States was lower (and non-significant). This difference may be due to the fact that children in higher-income countries had more regular attendance at baseline than those from lower-income countries. It may also be due to the fact that families in lower-income countries were more motivated by the prospects of receiving food. This fits well with the high non-compliance rate we observed in many of the North American studies. These studies suggest that the impact of free school meals on school attendance may be greatest in areas of greatest poverty.

Improved attendance could mean greater opportunities for learning and mental stimulation and consequently, improved academic performance, more opportunities for social interaction with adults and peers, and possibly, a better attitude towards school. However, it is difficult to say whether the projected 4 to 6 days of increased attendance per year in lower and lower-middle income countries is sufficient to result in such changes.

Behaviour

Playground activity. Results from one study in our review indicate that playground activity levels, particularly pro-social activity, are higher for those who received school meals; although absolute differences are small, relative differences are large.

Evidence from three of our included studies shows that school feeding may have positive effects on classroom behaviour in both high and low income countries. However, as discussed below, effects may depend on the quality of the educational environment.

D. Possible Confounders

There are a number of factors that could have impacted on effectiveness; here we provide details on a few of them. It is important to note that although potential confounders are looked at individually, the reality is much more complex and confounders are likely highly intertwined.

D1. Substitution

As mentioned in the introduction, one important concern in school feeding studies is substitution. In poor families, to spread limited resources, the home diet may be reduced for children who are receiving food at school. In two studies that assessed substitution (Agarwal 1989; Jacoby 1996), the net increase in energy realized by the children was less than half of that provided by school feeding (breakfast and lunch). In the Kenyan study, the net increase was 140 out of 239 calories for the meat group (our experimental group). Children who were given the 'milk' and 'energy' supplements actually showed net decreases of more than 100 calories. This may reduce the effectiveness of school feeding programs on children's growth and cognitive performance. Therefore, experts recommend that the amount and composition of food should be sufficient to overcome this problem. It may be that a mid-morning meal could help prevent substitution since it would be seen as a snack, not a meal (personal communication, Galloway 2006). Our data do not allow us to explore this hypothesis since none of these three studies with data on substitution used mid-morning snacks.

Interestingly, the results from the Kenyan Study (Murphy 2003; Neumann 2003) suggest that parents of control children may compensate for the fact that their children don't get fed at school. Over the 24 month period of the study, energy increase for the children in the control group increased by nearly 200 calories. This finding may be peculiar to this particular study, but it is quite interesting.

D2. Energy intensity of meal/snack

It seems logical that the energy intensity provided by school meals would impact on outcome. Our review provides some support for this hypothesis. Three (Bailey 1962; Baker 1980; Neumann 2003) that provided low energy levels (9, 5, and 13 percent, respectively) showed either small or null effects on weight and height, while two (Du 2003; Paige 1976) showed effectiveness for both, and another one (Lieberman 1976) did not report changes in weight relative to controls. However, in the two low energy studies that showed effectiveness (Du 2003; Paige 1976) fortified milk or drink was provided; this may have produced positive results in the absence of high energy. Furthermore, students in the Du study that did not drink the milk on > 4 days were excluded from the analyses, indicating a high compliance rate for this study (Du 2004). Therefore, although the energy content was higher in some studies, children

may have been ingesting more calories and other nutrients due to higher compliance.

D3. Pupil / student compliance

Another factor that is almost certain to impact on effectiveness is compliance. While compliance rates were very high in the Kenya study (Neumann 2003), two studies from higher income countries (Lieberman 1976; Tisdall 1951) reported very low compliance rates. It is therefore, not surprising that these studies showed little effect. Results from Tisdall (Tisdall 1951) substantiate the idea that children who attend regularly are more likely to benefit. In analyses comparing 'good attenders' to 'poor attenders' and controls, the 'good attenders' did better than the poor attenders. In addition, Du 2004 eliminated non-compliant children (those not taking the milk supplement on >4 days for any reason) from analyses and had large effects for both weight and height gain. Thus, it seems as if compliance can indeed affect outcomes of school feeding. Most studies in the review did not report on compliance. We suggest that in the future, compliance be carefully monitored and reported.

The lack of compliance shown in several studies in high income countries suggests that school feeding programs in higher income countries should take measures to increase compliance. Timing of the meal may be important in high income countries; it seems logical that students would be less likely to attend school breakfast (which means leaving home early) than they would be to attend lunch or a snack session.

The degree to which those who implement the intervention comply with the protocol (e.g. continuous provision of food, complying with group assignment) is very likely to impact on results. For example, in the Shemilt study, some experimental schools implemented breakfast clubs before baseline measurements could be taken; others (4 out of 17) did not have breakfast clubs at the time of first follow-up (Shemilt 2004). Also, two of the control groups provided breakfast at the time of the first follow-up. This type of contamination could have influenced results, although the extent of this influence is not clear.

D4. Short-term reduction in hunger

Evidence from this and other reviews (Pollitt 1995) shows that short-term relief of hunger through breakfast can improve performance on cognitive tasks carried out on the same morning. Thus, in long-term studies, it is quite important to control for this by giving a meal to all children on the day of testing. In that way, researchers can determine whether results are due to the long-term effects of providing food rather than simply to immediate improvements as a result of morning feeding. However, only one of the longer-term studies in this review (Powell 1983) did this. We would suggest that in the future, all studies assessing the impact of feeding on outcomes such as intelligence, neuropsychological functioning, and academic achievement should consider controlling for the effects of hunger by feeding children in both the intervention and control groups.

D5. Study duration

For growth, one would expect to see effects on weight with shorter study durations, and effects on height only with longer durations. In this review, studies that assessed growth were generally of long duration; the shortest was seven months. In reviewing the results, it is difficult to discern any clear pattern by duration of the study. The Du study (Du 2004) was the longest at 24 months and showed large changes in height, but others with similar durations of 23 months (e.g. Grillenberger (Neumann 2003) had smaller effects. It is possible that the very large changes shown in the Du study were due to factors other than study duration (e.g. compliance and addition of calcium).

For cognition, the importance of study length depends on the outcome measure. It is reasonable to expect to see improved attention and concentration following short-term interventions, while increased performance in other cognitive domains may be demonstrated only following longer feeding intervals. Two studies in this review have suggested that when performance is evaluated using a mechanical, stimulus-response format (for example, "put a ring round all the letter As on this page"), short-term feeding has little impact on performance, whereas if the test involves a greater degree of creativity and motivation and the expenditure of cognitive effort (for example, "name as many animals as you can in time limit Y"), feeding has a significant effect. For example, the Chandler study (Chandler 1995) showed a small impact on verbal fluency for children who were at least one standard deviation below normal weight-for-age. However, this improvement was not seen in other tasks that are more rote such as digit span or information processing.

Within the longer-term interventions, it is difficult to discern whether or not a pattern exists according to length of the study. This is largely due to the fact that outcomes were so different, and few could be combined. For math, effects were strongest for the Agarwal study (Agarwal 1989), which lasted longest 24 months. The Kenya study (Neumann 2003) lasted 23 months, however, and effects were quite small.

The interval between feeding and cognitive testing may also prove to be an important variable. It is expected that feeding would have immediate, but short-lived effects on cognitive processes such as processing speed and attention. Measurement of these functions should occur within minutes or hours of the feeding in order to quantify these changes. In contrast, feeding programs of a longer duration, such as months to years would be required to effect improvements on language, learning or academic tests and the interval between feeding and testing is less important when measuring these functions.

D6. Benevolent attention

A mechanism of action, implicit in some later studies, is that provision of school breakfast makes children feel valued and increases the general attention given to them. According to Powell (Powell 1983), benevolent attention may be possible confounding factor

in school feeding studies. Thus it is important to ensure that children in the control group receive the same amount of attention as those in the experimental group. However, in the Powell 1983 study, benevolent attention didn't seem to make a difference. Despite this, we conclude that control groups in school-based feeding studies should receive benevolent attention in order to control for this potential confounder.

D7. Quality of the educational environment

The quality of the educational environment plays an important role in learning. For example, Levinger (Levinger 1996) noted that quality of instruction, teacher quality, and quality of the learning materials can play an important role in improving children's capacity to learn. There is some evidence for this in a sub-study of the larger Chandler study. Here, improvements in behaviour were only seen in one school that was 'adequately equipped and organized'. Chang speculated that when classroom conditions were conducive to learning, the extra energy provided by breakfast could result in improved behaviour. However, when the atmosphere for learning was poor, this extra energy could not be channelled appropriately.

E Effect modifiers

E1 Age

Evidence from this review shows that younger children realize greater height benefits than older children. However, it is important to note that few studies on growth involved older children and that some of our studies did not separate out age groups. Few studies in our review assessed the interaction between age and treatment effectiveness on cognition, although one study did show that younger children benefited more from feeding.

E4. Sex

We found that there was generally little evidence for difference in effectiveness by sex.

In terms of cognition, developmental studies have shown that sex differences in cognition in children are evident as early as the age of five. For example, girls are more proficient than boys in verbal memory, (Maccoby 1974; Kramer 1997) verbal fluency and spelling (Gaddes 1975; Barr 2003) and one study suggested that in adolescence, females surpass males in information processing speed and working memory (Barr 2003). Thus, we might expect to find sex differences in cognitive responsiveness to school feeding. However, none of the studies presented data on this topic. We also found no discussion of potential cultural and social differences (e.g. in food intake at home) according to sex.

Considering that the World Food Program strategic plan includes reduction of sex disparities as a goal of school-feeding, the relationship between sex and the effectiveness of school meals clearly warrants further investigation.

F. Equity question: Effectiveness by level of disadvantage

Results from this review provide some preliminary evidence that school meals may be more effective for those who are more in

need. Furthermore, relative to controls, undernourished children showed greater gains in short-term cognitive performance than did well nourished children. The findings on short-term cognition support Pollitt's (Pollitt 1995) conclusions that children who are undernourished seem to be more responsive cognitively to short-term increases in energy.

A further bit of evidence for greater effectiveness in poorer children is suggested by our findings that: 1) effects on attendance and cognition were greater in low income countries, 2) within more recent studies, effects on weight were higher in lower income countries, and 3) effects from very old studies in higher income countries were highest. The latter finding can be explained by that fact that children in the Corry-Mann study were from a home for destitute, or orphaned boys in 1920s England, and that the Orr study was performed in a mining village in 1920s Scotland in a time of recession and, unemployment. Thus these children were very disadvantaged.

However, it is very important to note that data on effectiveness by level of disadvantage was very limited.

AUTHORS' CONCLUSIONS

Implications for practice

School meals may have a number of small benefits for children. In the studies reviewed, school meals resulted in small improvements in weight, height in younger children, attendance, math performance, and behaviour. Evidence suggests a possible impact on intelligence tests, but replication is needed. Evidence from single studies shows that school meals may also increase bone mineral density, arm muscle, and Vitamin B concentrations. The magnitude of benefits realized are probably dependent on the design of the program, amount of energy and other nutrients provided by the meal/snack, baseline nutritional status, conditions for learning in the classroom, timing of meal/snack, substitution and social environment at home, age of the child, and not surprisingly, on compliance. However, it is unrealistic to expect that school meals or any other single intervention can be a panacea for all of the deprivation of children living in poverty.

In considering the worth of school meals, it is also important to consider intangibles such as the worth and pleasure derived from having a full stomach and eating a good meal. This is something qualitative that it is difficult to measure adequately, but the relief of hunger alone is important.

School meal programs should be well-designed, and provide sufficient energy, protein, fat and micronutrient content for children's age and baseline nutritional status. Special attention should be paid to ensure that micronutrients important for growth, physical health, and cognition such as iodine, iron, zinc, Vitamin B-12,

and calcium are provided. The amount and type of fat and cholesterol should also be taken into account given their role in structure and function of parts of the brain which continue to develop into adolescence and influence cognitive outcome. Since 1969, the pattern of nutritional status in high-income countries has shifted from under-nutrition to increasing obesity (Dubois 2006). Thus, in higher income countries, it is important to provide well-balanced meals that are not overly energy or fat laden.

Palatability and special needs of the target population are also extremely important. Food should be appealing, acceptable, and locally available. Most of the researchers in included studies went to a great deal of trouble to ensure that foods were culturally acceptable and tempting to the palate. In terms of digestibility, Paige hypothesized that the African-American children in the population studied had a high prevalence of lactose deficiency (that is, they were intolerant of milk), as evidenced by the fact that in a pilot study, 25% of them had rejected a cow's milk supplement even when chocolate flavoured. The definitive intervention comprised a specially formulated low-lactose milk supplement tailored to the particular physiological make-up of the population and refined in response to the children's feedback on its palatability; a significant impact on growth was demonstrated. This study prompts the additional conclusion that piloting a school nutrition intervention is not just about confirming palatability, but about identifying specific nutritional issues / needs in the program's target population. Follow-up results from one study in the developing world reported that most effects of feeding with milk disappeared three years after feeding stopped; this would suggest that school feeding should be continued throughout school years (Du 2004).

Implications for research

Considering the dearth of high quality evidence on school meals, as well as the complexity of our findings, we conclude that further well-designed research is needed in both lower and higher income countries. RCTs are needed in order to ensure that causality can be attributed. We suggest randomisation by school, and appropriate statistical methods to account for cluster randomization. In order to more clearly answer the question about effects by level of disadvantage, we would like to see all primary researchers provide breakdowns of effects by socio-economic status of parents as well as by sex and baseline nutritional status. Double blinding should also be considered in terms of providing, meals/snacks with similar appearance but high and negligible content of energy and other nutrients (e.g. high and low calorie milk shakes).

In conducting studies, attention needs to be paid to ensuring that the intervention is delivered as intended. Process evaluation is crucial. As shown in this review, it is very important to encourage full participation, and to measure participation, and consumption carefully. We might tentatively conclude for future trials that measuring non-consumption of food is best done for each individual child. Substitution should also be monitored. We also conclude that studies on long-term effects of school feeding should

feed children in both groups on the day of testing to control for the relief of short-term hunger. Other factors such as benevolent attention and quality of educational environment should also be considered.

We suggest that in terms of physical health, important outcomes are: changes in weight and height, muscle mass, body fat percentage, micronutrient status, physical activity, and bone mineral density. Weight is an important outcome, both in lower income countries where programs seek to increase growth of under-nourished children, and in high income countries where school feeding programs increasingly aim to reduce childhood obesity rather than increase growth.

For psychosocial outcomes, attendance, enrolment, and retention in school are all highly important for lower-income countries. This is particularly true for girls. As education of the populace is key to a country's improved development, school feeding should be combined with other interventions that aim to improve country educational attainment. It is essential to measure educational achievement and cognitive outcomes in all countries. We suggest that in the next generation of studies of school feeding on cognitive performance, the choice of tests should be explicitly hypothesis-driven so as to discriminate between different cognitive and motivational effects. It is important to measure a full range of brain function with neuropsychological testing: we suggest a comprehensive assessment of intelligence, processing speed, attention, executive functions, memory, language, visual-abilities and motor and sensory function. In order to disentangle the effects of short-term hunger relief from long-term physiological changes, we suggest that all children be fed before psychological testing.

School meal programs take place in a context which may significantly impact on their effectiveness. As noted by Levinger (Levinger 1986), greater improvements can be expected if the environment in which children live and learn is also improved. Thus, in addition to school meals, schools should have the basic amenities necessary to good education: adequate materials, good teaching, and an emphasis on development of the whole child. Others such as Glew have emphasized the importance of improvements in water supply, health, and health education (Glew 1980) while Del Rosso (Del Rosso 1999) emphasized micronutrient fortification or supplementation and health and nutrition education. As others have suggested (Levinger 1986; Del Rosso 1999) we conclude that school meals should be one of multiple interventions designed to improve the health and development of poor and marginalized children.

NOTES

This review is co-registered within the Campbell Collaboration.

POTENTIAL CONFLICT OF INTEREST

None known.

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* Indicates the major publication for the study

T A B L E S**Characteristics of included studies**

Study	Agarwal 1989
Methods	LLMIC: India Study Design: CBA Unit of allocation: schools Duration: 2 years. Feeding for 175 days in first year, 181 days in second year Total N in all groups: 450 at end (146 in exp, 304 control) Subgroup analysis: weight and height by age group, cognitive tests by grade of nutrition. Withdrawals: Not described. Fewer in cognitive analyses than in weight analyses.
Participants	SES: All rural Age: 6-10 yrs Gender: Experimental: 103 boys, 40 girls. Control: 228 boys, 75 girls Nutritional status: 80% malnourished at baseline. Exp: 29 normal, 56 Grade I malnutrition, 48 Grade II malnutrition, 6 Grade 3 malnutrition. Control: 15 normal, 47 Grade 1, 28 Grade II, 2 Grade III Height, weight: Not mentioned (NM)
Interventions	Feeding: mid-day meal Protein: 10-12 g Calories: 450- 500 calories Intensity: % RDA for energy: 25 Sufficient % DRI for protein: 58 Control: no food Provider: Field workers Supervised: Seems like Y Compliance: 72% in supplementation group attended first year and 77% attended second year. Dietary survey of subsample found increase of only 200 calories a day in supplemented children. Substitution was occurring.
Outcomes	Gain in height,weight, change in Grade of Malnutrition Full, Performance, and Verbal IQ Arithmetic achievement Piagetian tasks
Notes	Baseline measurement:A for all: Weight, height, intelligence, math Reliable Outcome: U for all Protection against contamination: A Blinded assessment: U Co-intervention: U Loss to follow-up: U

Characteristics of included studies (Continued)

Allocation concealment D – Not used

Study **Agarwal 1989 (girls)**

Methods Same methods as Agarwal 1989

Participants Data for girls only, n=75

Interventions

Outcomes

Notes

Allocation concealment D – Not used

Study **Agarwal 1989 - boys**

Methods Same methods as Agarwal 1989

Participants Data for boys only, n=228

Interventions

Outcomes

Notes

Allocation concealment D – Not used

Study **Agarwal 1989 boy 10y**

Methods Same methods as Agarwal 1989

Participants Data for boys, aged 10 years old only, n= 21

Interventions

Outcomes

Notes

Allocation concealment D – Not used

Study **Agarwal 1989 boys 7y**

Methods Same methods as Agarwal 1989

Participants Data for boys aged 7 years old, n= 84

Interventions

Outcomes

Notes

Allocation concealment D – Not used

Study **Agarwal 1989 boys 8y**

Methods Same methods as Agarwal 1989

Participants Data for boys aged 8 years old only, n=126

Interventions

Outcomes

Notes

Allocation concealment D – Not used

Study **Agarwal 1989 boys 9y**

Methods Same methods as Agarwal 1989

Characteristics of included studies (Continued)

Participants Data for boys aged 9 years old, n=105

Interventions

Outcomes

Notes

Allocation concealment D – Not used

Study Agarwal 1989 girl 10

Methods Same methods as Agarwal 1989

Participants Data for girls aged 10 years old, n=9

Interventions

Outcomes

Notes

Allocation concealment D – Not used

Study Agarwal 1989 girl 7y

Methods Same methods as Agarwal 1989

Participants Data for girls aged 7 years old, n=22

Interventions

Outcomes

Notes

Allocation concealment D – Not used

Study Agarwal 1989 girl 8y

Methods Same methods as Agarwal 1989

Participants Data for girls aged 8 years old, n=42

Interventions

Outcomes

Notes

Allocation concealment D – Not used

Study Agarwal 1989 girl 9y

Methods Same methods as Agarwal 1989

Participants Data for girls aged 9 years old, n =77

Interventions

Outcomes

Notes

Allocation concealment D – Not used

Study Agarwal 1989 grade I

Methods Same methods as Agarwal 1989

Participants Data for children with grade I nutritional status (n=103), defined using Gomez's cut off points and the 50th percentile of National Centre for Health Statistics (1977) as a reference point

Interventions

Outcomes

Notes

Characteristics of included studies (Continued)

Allocation concealment D – Not used

Study **Agarwal 1989 grade2**

Methods Same methods as Agarwal 1989

Participants Data for children with grade II nutritional status (n=76), defined using Gomez's cut off points and the 50th percentile of National Centre for Health Statistics (1977) as a reference point

Interventions

Outcomes

Notes

Allocation concealment D – Not used

Study **Agarwal 1989 grade3**

Methods Same methods as Agarwal 1989

Participants Data for children with grade I nutritional status (n=8), defined using Gomez's cut off points and the 50th percentile of National Centre for Health Statistics (1977) as a reference point

Interventions

Outcomes

Notes

Allocation concealment D – Not used

Study **Agarwal 1989 normal**

Methods Same methods as Agarwal 1989

Participants Data for children with normal nutritional status (n=44), defined using Gomez's cut off points and the 50th percentile of National Centre for Health Statistics (1977) as a reference point

Interventions

Outcomes

Notes

Allocation concealment D – Not used

Study **Agarwal total**

Methods Agarwal total

Participants Same methods as Agarwal 1989

Interventions Data for all children, boys and girls

Outcomes

Notes

Allocation concealment D – Not used

Study **Bailey 1961**

Methods As below

Participants As below

Interventions As below

Outcomes As below

Notes As below

Allocation concealment D – Not used

Characteristics of included studies (Continued)

Study	Bailey 1962
Methods	LLMIC: India Study Design: CBA Unit of allocation: schools Duration: 12 months Total N in all groups: Originally sounds like 100 in each group ages 7 to 15. Analyses restricted to boys age 13 and below; about 80 in each group. Results given for 140 in selected groups Subgroup analysis: None Withdrawals: Not clear
Participants	SES: All Indian schoolboys in government schools. From ordinary village homes. Age: 7-13 Gender: all male Nutritional status: Height: Initial heights ranged from 112 cm for 7 year olds to 133 cm for 13 year olds. Weight: Initial weights ranged from 18 kg for 7 year olds to 31 kg for 13 year olds.
Interventions	Feeding: Green gram and palm sugar given mid-morning. Protein: 12 g Calories: 195 Intensity: % RDA for energy: 8-10%. Insufficient % DRI for protein: 35-63% Control: 100 mg iron Provider: NC Supervised: NC Free: NC Compliance: NC
Outcomes	Change in Height Weight Haemoglobin over 12 months.
Notes	Baseline measurement: U Reliable Outcome: U for height/weight. A for hemoglobin Protection against contamination: U Blinded assessment: U Co-intervention: U Loss to follow-up: U
Allocation concealment	D – Not used

Study	Baker 1980 (boys)
Methods	Upper Income country: Wales Study Design: RCT Unit of allocation: Individual Duration: 6 school terms (21 and a half months) Total N in all groups: 581 Subgroup analysis: describes results by SES. Withdrawals: 8%
Participants	SES: Mid Glamorgan, South Wales, from families with 4 or more children. 1.5% in Class II, 41% in class III, 19% in Class IV and 6% in Class V. 23% had unemployed fathers; 9% fathers 'other employment' Age: 7-8 yrs, Gender: Exp group=51.2 male %, Control= 51.5% male Nutritional status: children in both groups 2-3 cm shorter and 1.5 kg lighter than other children in the country. Height: ranged from 120.6 to 130.2 cm

Characteristics of included studies (Continued)

	Weight: ranged from 23 kg to 28.7 kg
Interventions	Feeding: Milk supplement- 1/3 pint (190 ml) daily. Protein: 6.5 g Calories: 126 Intensity: % RDA for energy: 6.3, or insufficient % DRI for protein: 19-34% Control: no milk Provider: NC Supervised: Y Compliance: 13 in milk group disliked milk
Outcomes	Growth difference for weight and height.
Notes	Jadad R: 1 Jadad B: 0 Jadad W: 1 Baseline measure: A height, U weight. Reliable outcome: U Protection against contamination: I Blinded assessment: A Co-intervention: U Loss to follow-up: A
Allocation concealment	B – Unclear

Study Baker girls 1980

Methods	Same methods as Baker 1980 boys
Participants	Data for girls only
Interventions	
Outcomes	
Notes	
Allocation concealment	B – Unclear

Study Baker total 1980

Methods	Baker total 1980
Participants	
Interventions	Data for overall results from Baker 1980, combined data for boys and girls
Outcomes	
Notes	
Allocation concealment	D – Not used

Study Bro 1994

Methods	Upper Income country: USA Study Design: ITS. ABAB design. 10 observations at baseline 1, 10 during breakfast program, 10 at baseline 2, and 10 during breakfast program Unit of allocation: student Duration: 10 days baseline, 10 days intervention, 10 days 2nd baseline, 10 days 2nd intervention. Total N:10 Subgroup analysis:
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Characteristics of included studies (Continued)

	Withdrawals: None
Participants	SES: residence: urban. Male vocational high school students. 6 of 10 'at risk' (living alone, living with one parent, living with other than natural parents, and/or single teen parent). Age: 14-18 yrs Gender: 100% male Nutritional status: NM
Interventions	Feeding: nutritious, well-balanced breakfast Protein: not mentioned (NM) Calories: NM Intensity: %RDA for Energy: % DRI for Protein: Unclear, but large meals provided. Control: subjects were their own controls Provider: U.S. Government through School Breakfast Supervised : Y Compliance: NM
Outcomes	Cognition: On-task behaviour (defined as percentage of time that students were engaging in clearly defined tasks in the class) Behavioural: school attendance.
Notes	Baseline measurement: NA Reliable outcome: A Protection against contamination: NA Blinded assessment: I Co-intervention: NA Loss to followup: NA Intervention ind of other changes; U Data analyzed appropriately: I Reason for number of pre and post intervention points given: U Shape of intervention: I Intervention affect data collection: A Completeness: A
Allocation concealment	D – Not used

Study	Bro 1996
Methods	Upper Income country: USA Study design: ITS Unit of allocation: student. Two classes used. Duration: Baseline: 5 days and 10 days, 21- 30 school days Total N in all groups: 18 Subgroup analysis: No Withdrawals: not mentioned
Participants	SES: all Caucasian, 9 out of 12 in Class One "at risk" (living alone, living with single parent, alone, teenage parent, living with other than natural parent). Some special needs. All 6 students in second class at risk for dropping out. Age: 15-19 yrs in class 1, 16-18 yrs in class 2 Gender: 11 boys, 1 girl in class 1; 6 boys in class 2 Nutritional status: NC
Interventions	Feeding: Nutritious breakfast in school. Protein: NM Calories: NM Intensity: unclear, but large meals provided. %RDA for Energy: NM % DRI for Protein: NM

Characteristics of included studies (Continued)

	Control: subjects were their own controls Provider: teacher Supervised : Y Compliance: NM
Outcomes	Cognition: On-task behaviour Class 1, welding: setting up, welding, and putting away Class 2: retrieving study materials, reading, answering questions, written tests.
Notes	Baseline measurement: NA Reliable outcome: I Protection against contamination: NA Blinded assessment: I Co-intervention: NA Loss to followup: NA Intervention ind of changes :U Data analyzed appropriately: I Reason for number of pre and post intervention points given: U Shape of intervention: A Intervention affect data collection: A Completeness: A Intervention affect data collection: U Completeness: A
Allocation concealment	D – Not used

Study	Chandler 1995
Methods	LLMIC: Jamaica Study Design: Crossover RCT Unit of allocation: class, stratified by school Duration: feeding 1 week before testing, and during testing. Total N in all groups: 200 Subgroup analysis: undernourished vs adequately nourished Withdrawals: 3/100 (3%) in undernourished. None in adequately nourished.
Participants	SES: all rural in mountainous area. School served children of subsistence farmers. Age: 9.3 yrs Gender: 99 male, 98 female Nutritional Status: 97 undernourished. (weight for age <= 1 s.d. below NHS references. 100 adequately nourished. Height, weight not given.
Interventions	Feeding: Breakfast in school, 225 mL chocolate milk+ cheese sandwich. Protein: 21.3 g Calories: 2174 kJ Intensity: % of RDA for energy: 26 %, sufficient % of DRI for protein: 63% Control: 1/4 orange Provider: teacher Supervised : Y Compliance: NM
Outcomes	Verbal fluency, digit span visual search, speed of

Characteristics of included studies (Continued)

	information processing Classroom attention and behaviour (on a subset).
Notes	Jadad R: 1 Jadad B: 0 Jadad W: 1 Baseline measurement: NA Reliable outcome: A Protection against contamination: A Blinded assessment: A Co-interventions: U Loss to follow-up: A
Allocation concealment	B – Unclear
Study	Chandler Under
Methods	Same study as Chandler
Participants	Data for under-nourished children from Chandler study
Interventions	
Outcomes	
Notes	
Allocation concealment	D – Not used
Study	Corry-Mann 1926
Methods	Upper Income country: England Study Design: CBA Unit of allocation: Individual Duration: 1 year, 2 years and 3 years all year round Total N in all groups: 102 with complete data for a year Subgroup analysis: None Withdrawals: Says that boys were replaced as they moved out of houses. But analysis seems to include only boys with data for full year.
Participants	SES: All in foundling home, many came there destitute and in poor condition. Lived in 'colony' 11 miles outsider of London Age: 6 to 11 years. Gender: All male Nutritional status: Control baseline weight: 53.54, Exp: baseline weight: 55.18, Control: baseline height: 48.5, Exp: baseline height: 48.76
Interventions	Feeding: Milk supplement in addition to basic diet: 1 pint daily; 1/2 pint given in morning and 1/2 half pint given in afternoon. Protein: 18 g Calories: 388 cal. Intensity: % RDA for energy: % DRI for protein: 19-34% Control: no milk Provider: NM Supervised: seems like Y Compliance: NM
Outcomes	Change in height, weight

Characteristics of included studies (Continued)

Notes	Baseline measurement: A Reliable outcome: U Protection against contamination: U Blinded assessment: U Co-intervention: U Loss to followup: U
Allocation concealment	D – Not used

Study	Devadas1979: 5-6
Methods	LLMIC: India Study design: CBA Unit of Allocation: individual Duration: 10 months Total N in all groups: 400 Subgroup analysis: reported by age group. Withdrawals: Not clear
Participants	SES: Six villages. Children consumed fewer calories and micronutrients than recommended. Age: 3 groups: 5-6, 6-7, and 7-8 Gender: 107 boys and 93 girls in exp. Similar in control. Nutritional status: Height: 104.5 cm for 5-6 year olds to 116.6 cm for 7-8 year olds Weight: 14.9 kg for 5-6 year olds to 18.2 Kg for 7-8 year olds.
Interventions	Feeding: Vegetable protein mixture Protein: 14g. Calories: 345-395 cal per day Intensity: % RDA for energy: 17-19%; sufficient % DRI for protein: 50% Control: No food Provider: NM Supervised : Y, at least for selected school children. Compliance: No plate waste. Children "relished the mixture."
Outcomes	Mean initial and final heights and weights, change: mean + s.e. Mean initial and final haemoglobin.
Notes	Baseline measurement: A Reliable outcome: U for height/weight: A for hemoglobin Protection against contamination: U Blinded assessment: U Co-intervention: U Loss to follow-up: U
Allocation concealment	D – Not used

Study	Devadas1979: 6-7
Methods	Same study as Devadas 1979 5-6
Participants	Data for age group 6-7 years old, n= 136
Interventions	
Outcomes	
Notes	
Allocation concealment	D – Not used

Characteristics of included studies (Continued)

Study	Devadas1979:7-8
Methods	Same study as Devadas 1979 5-6
Participants	Data for age group 7-8 years old, n=158
Interventions	
Outcomes	
Notes	
Allocation concealment	D – Not used
Study	Du 2004
Methods	LLMIC: China Study design: RCT Unit of allocation: school Duration: 24 months on school days. Total N in all groups: 757 Subgroup analysis: no Withdrawals: 7.8%, many of these excluded bc of non-compliance, others moved, were concerned about venepuncture,
Participants	SES: School girls from Beijing. Low calcium intake (43% of normal), Vitamin D intake only 9% that of recommended value. Age: average 10.1, 10.1, and 10.0 in 3 groups. Gender: female Nutritional status: Height: 140.4 to 140.7 cm Weight: 33.4 5 to 33.9 Kg. BMI: 16.8 to 17.1.
Interventions	Feeding: Milk with Calcium added. Protein: Calories: % RDA for energy: 10%. Insufficient % DRI for protein: Control: no milk Provider: Health worker distributed to one student in charge in each class. Supervised: Y, by teachers. Students kept records of compliance. Compliance: Not fully given, but mentions that 33 from both groups were excluded due to failure to drink milk on 4 days or more
Outcomes	Pre-test and end of study weight, height, BMI, BMC, BMD, Bone Area, Plasma Vitamin D, Serum PTH, Plasma Calcium, and Urine Calcium. Also report percentage change from baseline in all variables.
Notes	Jadad R: 1 Jadad B: 0 Jadad W: 0 Baseline measurement: A Reliable outcome: U for height/weight. A for BMD Protection against contamination: U Blinded assessment: A Co-intervention: U Loss to follow-up: A
Allocation concealment	B – Unclear

Characteristics of included studies (Continued)

Study	Jacoby 1996
Methods	LLMIC: Peru Study Design: RCT Unit of allocation: School Duration: Program 5 weeks. Data collection started after 2 weeks. Total N in all groups: 352 Subgroup analysis: Tested interaction between baseline nutritional status and treatment Withdrawals: NM
Participants	SES: all schools were located in rural periphery (1hr) of city, mostly agricultural communities. Houses adobe, typically no more than 3 rooms. Avg. maternal education: 2.3 treatment and 2.7 control. Age: Exp: 136.2 months. Control: 138.9 months Gender: experimental group: 90% male control group: 80% male Nutritional status: Weight for height z-score: exp: 0.51 (0.7), Control: 0.43 Height for age z-score: exp: -2.21 Control: -2.20
Interventions	Feeding: Breakfast of 4 cookies and an instant drink, sometimes a cake and drinks of different flavours. Protein: 19.5 g Calories: 600 kcal Intensity: % RDA for energy: 23-33%: sufficient % DRI for protein: High: 57-103% Control: no feeding. All received food in another phase. Provider: Institute de Investigacion Nutritional (IIN), a local private NGO Supervised (Y/N): not given Compliance:
Outcomes	Energy intake Protein intake Iron intake Attendance Coding Test Math Test Reading Test Vocabulary Test Pre/post breakfast.
Notes	Jadad R: 1 Jadad B: 0 Jadad W: 0 Baseline measurement: A Reliable outcome: A Protection against contamination: A Blinded assessment: Attendance: I psychoed; U Co-intervention: U Loss to follow-up: U
Allocation concealment	B – Unclear

Study	Lieberman 1976
Methods	Upper income country: USA Study Design: CBA Unit of allocation: school Duration: 8 months between 1970-1971 (school year) Total N in all groups: 539 Funding: in part by a grant from the Department of Health, Education, and Welfare

Characteristics of included studies (Continued)

	<p>Subgroup analysis: Withdrawals: Experimental- 14.6%, Ctrl- 9.3%</p>
Participants	<p>SES: Predominately black, low-income area of L.A. County, CA. Highest grade parent attended- experimental: 10.2, control: 10.6, Percentage of children living in families receiving NO welfare- exp: 37, Control: 33 Age: Grade 3: Exp- 8.7, Control- 8.9 Grade 4: Exp-9.8, Control- 9.7 Grade 5: Exp- 10.7, Control- 10.9 Grade 6: Exp- 11.6, Control- 11.8 Gender (%male): Grade 3- Exp: 52, Ctrl: 51; Grade 4- Exp: 44, Ctrl: 49; Grade 5- Exp: 49, Ctrl: 59; Grade 6- Exp: 46, Ctrl: 49 Nutritional status: no unequivocal signs of malnutrition noted. Study groups slightly taller and heavier than reference groups. Height: 130.3 cm to 149.6 cm Weight: 27.5 to 43 kg.</p>
Interventions	<p>Feeding: Breakfast described as traditional and hot, designed to provide $\sim 1/4$ of the RDA for 9 and 10 yr olds. Protein: 3-5 g per breakfast Calories: NM Intensity: sufficient % RDA for energy: NM % DRI for protein: NM Control: no breakfast Provider: NM Supervised: NM Compliance: Poor. Only 30% of children attended 75% or more of breakfasts.</p>
Outcomes	<p>Assessed anthropometry, but not before and after. Looked at change in cognition: five psychological tests assessing ability to concentrate, remembrance, thinking abstractly, and working in a classroom. Change in reading and math performance Change in school attendance Report very few numbers, except for change in attendance.</p>
Notes	<p>Baseline measurement: U Reliable outcome: U for growth and for psychological measurements. Protection against contamination: A Blinded assessment: U Co-Intervention: U Loss to follow up: A</p>
Allocation concealment	D – Not used

Study	Neumann 2003
Methods	<p>LLMIC: Kenya Study design: RCT. Unit of allocation: school Duration: 23 months Total N in our selected groups: 236 Subgroup analysis: mention effects by SES Withdrawals: Exp. 3 left school, 11 excluded. Control: 2 left school, 10 excluded.</p>
Participants	<p>SES: rural Kenya. Maternal schooling: 6 years. Fathers schooling: 7 years Age: 6-14 years. Median age 7.4 years. Exp: mean age: 93.6 months. Control: mean age: 88 months. Gender: Exp: 50% male. Control: 53% male</p>

Characteristics of included studies (Continued)

	Nutritional Status: Height:, Weight: 19.4% of sample stunted. 30% underweight (< 2 WAZ). Mild underweight in 42.1% of of boys and 31.1% of girls.
Interventions	Feeding: Githeri + meat: Protein: 19.2 g 1st year, 21.7 second. Calories: 239 kcal first year, 313 second. Intensity: % RDA for energy: 15-20% sufficient. % DRI for protein: Control: nothing Provider: Supervised: Y Compliance:
Outcomes	Average increase in height, weight, weight for age, triceps skinfold, mid-upper arm muscle and fat area. Yearly increase in Raven's progressive matrices, Verbal meaning, arithmetic performance. Regression used; mean growth and s.e. calculated.
Notes	Jadad R: 1 Jadad B: 0 Jadad W: 1 Baseline measurement: A for all Reliable outcome: A for growth, A for psychological measurement, U for hemoglobin, hemotocrit. Protection against contamination: A Blinded assessment: A Co-intervention: A Loss to follow-up: A
Allocation concealment	B – Unclear

Study	Orr 1928 - 13 yrs
Methods	Upper income country: Scotland Study design:CBA Unit of allocation: individual Duration: 7 months in 1927 and another 7 months study in 1928 Total N in all groups: unclear. First study: took 40 to 50 in each of 4 exp. groups from each of 7 centers; thus 1120 to 1400 altogether. But one center started late, and one center not given whole milk. Also, those who missed feeds or were ill, were not included in analysis. Second study: Same children, but in all centers. Total of 1425. 268 excluded from analysis. Subgroup analysis: NM Withdrawals: Not clear. Original study: Dropped those who missed more than 25% of school days, had severe illnesses, or who had problematic weights and heights from analysis. Also, whole milk was not given continuously in Glasgow so these children weren't in analysis. Second study: CBA done on same children in same centers the next school year. N = 1425 to start. Dropped 268 from analysis due to poor school attendance. In second study, did some cross-over with children of certain ages from a few centers.
Participants	SES: urban, from working class families. Ages: 5-6, 8-9, and 13-14 in first, and same children 6, 9 13 in second Gender: NM Nutritional status: Height: weight: NM
Interventions	Feeding: Whole milk; 3/4 pint to 1/1/4 pint depending on aget. Second study: same, except said 1 pint for oldest group Orr study: Protein: 13.8 to 23.6 g Calories: 213 to 355 kcal Intensity: % RDA for energy: 14-17%. Sufficient

Characteristics of included studies (Continued)

% DRI for protein: 44-72%
 Control: nothing
 Provider: NM
 Supervised : Yes, at least in 1928
 Compliance: NM

Outcomes	Mean increase in height, weight.
Notes	Baseline measurement: U Reliable outcome: U Protection against contamination: A Blinded assessment: U Co-Intervention: U Loss to follow-up: U
Allocation concealment	D – Not used

Study Orr 1928 - 6 yrs

Methods	Same study as Orr 1928
Participants	Data for children aged 6 years old only (n=251)
Interventions	
Outcomes	
Notes	
Allocation concealment	D – Not used

Study Orr 1928 - 9 yrs

Methods	Same study as Orr 1928
Participants	Data for children aged 9 years old only (n=216)
Interventions	
Outcomes	
Notes	
Allocation concealment	D – Not used

Study Paige 1976

Methods	Upper income country: USA Study design: CBA. Unit of allocation: school Duration: 9 months. Total N in all groups: 344 Subgroup analysis: results reported by age group Withdrawals: 20% of exp, 22% of control
Participants	SES: urban poor black children from lower socio-economic decile tracts. 60 and 64% of families on public assistance Age: Exp: 5 years 1 month to 9 years 1 month Control: 5 years 1 month to 9 years 5 month Gender: Nutritional Status: Height:, Weight:
Interventions	Feeding: High protein drink supplement providing iron, calcium, protein. vitamin D. Snack given mid-morning. All children got school lunch, and some got school breakfast too. Protein: 14.5 g Calories: 240 Intensity: % RDA for energy: 12-13%. Insufficient.

Characteristics of included studies (Continued)

% RDI for protein: 46-73%. Control: no supplementation

Provider: In classroom

Supervised : Y

Compliance: Consumption of supplement was about 88% overall.

Outcomes	Mean increase in height, weight, hemoglobin. Change in proportion considered anemic.
Notes	Baseline measurement: A for weight, U for height Reliable Outcome: A for height weight. and for hemotocrit. Protection against Contamination: A Blinded assessment: U Co-intervention: U Loss to follow-up: I
Allocation concealment	D – Not used

Study Paige 7 year olds

Methods	Same study as Paige 1976
Participants	Data for children aged 7 years old only
Interventions	
Outcomes	
Notes	
Allocation concealment	D – Not used

Study Paige 8 year olds

Methods	Same study as Paige 1976
Participants	Data for children aged 8 years old only
Interventions	
Outcomes	
Notes	
Allocation concealment	D – Not used

Study Powell 1983

Methods	LLMIC: Jamaica Study Design: CBA Unit of allocation: Class Duration: 3 months (January to March 1977) Total N in all groups: 44 in exp group, 38 in no placebo control; 33 in syrup control. Subgroup analysis: Withdrawals: 4 from experimental group and 3 from 2 control groups
Participants	SES: Rural, mountainous area, most from "poor" farming families Age: Breakfast- 12.6, Control- 12.5, Syrup- 12.6 Gender: Breakfast- 36 boys, 8 girls; Control- 13 boys, 25 girls; Syrup- 27 boys, 6 girls Nutritional status: Height: Breakfast- 94.29% of std; Control- 95.28% of std; Syrup- 93.5% of std Weight: Breakfast- 82.68% of std wt for age; Control- 87.58% of std wt for age; Syrup- 82.25% of std wt for age.
Interventions	Feeding: Exp: Breakfast- patty with meat, vegetables, milk or banana cake Calories: 380-730 kcal (depending on whether children took cake or patty) Protein: average 17g Intensity: % RDA for energy: 17-20% for males 23% for females; sufficient.

Characteristics of included studies (Continued)

	<p>% DRI for protein: 33-50% for males; 37-50% for females; Control group 1: syrup drink: 33 kcal Control group two: nothing. Provider: Researcher Supervised: Y (teacher) Compliance: NM</p>
Outcomes	<p>Nutritional status: percent of standard weight for age and height for age School performance: WRAT- reading, spelling, arithmetic Behavioural: School attendance</p>
Notes	<p>Baseline measurement: I for reading, spelling, unclear for math. A for weight for age, height for age Reliable Outcome: U for weight, height. U for psychological tests. Protection against contamination: A Blinded assessment: A Co-intervention: U Loss to follow-up: A</p>
Allocation concealment	D – Not used

Study Powell 1998 (A)

Methods	<p>LLMIC: Jamaica Study design: RCT Unit of allocation: Children stratified by class and nutritional group. Duration: 8 months. Total N in all groups: 813 Subgroup analysis: tested interaction between nutritional status and treatment. Withdrawals: 3 in undernourished placebo; 7 in undernourished breakfast; 7 adequate nourished placebo; 6 adequate nourished breakfast</p>
Participants	<p>SES: all rural (mountainous), children mostly from poor families. Age: across both - 107.6 ± 14.7 months Gender: DK Nutritional status: Height for age: Exp: =1.44 and .43. Control: -1.26 and .33. Weight for age: exp: -1.65 s.d for undernourished and .12 for adequately nourished. Control: -1.49 s.d. for undernourished and .13 s.d. for adequately nourished</p>
Interventions	<p>Feeding: breakfast in school - cheese sandwich or spiced bun and cheese + flavoured milk Protein: 27.1 g Calories: 576-703 kcal Intensity: % RDA for energy: 32%, sufficient % DRI for protein: 80% Control: 1/4 orange (18 Kcal) Provider: teacher Supervised: Y Compliance:</p>
Outcomes	<p>Arithmetic Reading, Spelling from Wide Range Achievement Test, Attendance, Height, Weight, Weight for age, Height for age, Body mass index</p>
Notes	<p>Jadad R: 1 Jadad B: 0 Jadad W: 1 Baseline measurement: A for all Reliable Outcome: A for all Protection against contamination: A Blinded assessment: A Co-interventions: U Loss to follow-up: A</p>
Allocation concealment	B – Unclear

Study Powell 1998 Total

Methods	<p>LLMIC: Jamaica Study design: RCT Unit of allocation: Children stratified by class and nutritional group. Duration: 8 months. Total N in all groups: 813 Subgroup analysis: tested interaction between nutritional status and treatment. Withdrawals: 3 in undernourished placebo; 7 in undernourished breakfast; 7 adequate nourished placebo; 6 adequate nourished breakfast</p>
Participants	<p>SES: all rural (mountainous), children mostly from poor families. Age: across both - 107.6 ± 14.7 months Gender: DK Nutritional status: Height for age: Exp: =1.44 and .43. Control: -1.26 and .33. Weight for age: exp: -1.65 s.d for undernourished and .12 for adequately nourished. Control: -1.49 s.d. for undernourished and .13 s.d. for adequately nourished</p>
Interventions	<p>Feeding: breakfast in school - cheese sandwich or spiced bun and cheese + flavoured milk Protein: 27.1 g Calories: 576-703 kcal Intensity: % RDA for energy: 32%, sufficient % DRI for protein: 80% Control: 1/4 orange (18 Kcal) Provider: teacher Supervised: Y Compliance:</p>

Characteristics of included studies (Continued)

Outcomes	Arithmetic Reading, Spelling from Wide Range Achievement Test, Attendance, Height, Weight, Weight for age, Height for age, Body mass index
Notes	Jadad R: 1 Jadad B: 0 Jadad W: 1 Baseline measurement: A for all Reliable Outcome: A for all Protection against contamination: A Blinded assessment: A Co-interventions: U Loss to follow-up: A
Allocation concealment	D – Not used

Study Powell 1998(u)

Methods	
Participants	Data for under-nourished children only (n=396)
Interventions	
Outcomes	
Notes	
Allocation concealment	D – Not used

Study Shemilt 2004

Methods	High income country: UK Study design: cluster RCT for first 3 months, observational for second followup at 1 year Unit allocation: school Duration: Sept 1999 to Sept 2000: 12 months Total n in all groups: 29 schools, 5837 children Funding: National Department of Health Withdrawals: 10 schools declined to provide data after randomization. Designed as pragmatic cluster RCT while program was being rolled out on a national level, by the end of 3 months, 4 out of 17 schools in the intervention group did not have breakfast clubs, and 2 of the schools in the control group had breakfast clubs. At the 1 year, 72% of intervention and 76% of control schools had a breakfast club operating in the schools, Contamination occurred; at first follow-up, Designed as a pragmatic cluster trial
Participants	SES: deprived areas in England Age: control: 10.13 yrs, intervention: 9.59 yrs Gender: 52% male, 49% female Nutritional status: not assessed Height: n/a Weight: n/a
Interventions	Feeding: Breakfast club before school, each school planned own breakfast club. Caloric content below is from case studies of 5 schools (Norwich 2001) Protein: 8.9-13.7 g Calories: 334-695 kcal % RDA for energy: %DRI for protein: Provider: Children could choose from available foods Supervised: minimal Compliance: Feeding: 13 out of 17 schools had breakfast club (BC) at first follow-up; control: 2 out of 10 schools had BC at first follow-up Attendance records: median 34%, range 8-72% of children reported ever attending breakfast clubs
Outcomes	Primary outcome: behaviour difficulties with Strengths and Difficulties Questionnaire (Goodman 1997) Nutritional status: not measured General health: Life, health and school questionnaire Parent family assessment: Family Questionnaire on employment, access to child care. We report on the first follow-up only.

Characteristics of included studies (Continued)

Notes
 Jadad R:1
 Jadad B: 0
 Jadad W: 1
 Baseline Measurement:: U for Total Difficulties (10% difference), days of school skipped, and number of days on which classes skipped. A for Rutter's score.
 Reliable Outcome: A for trail-making, strengths and difficulties, Rutter's. U for health, lifestyle questions.
 Protection against contamination: I, Blinded assessment of primary outcomes: U, Co-Intervention: U, Loss to Follow-up: U

Allocation concealment B – Unclear

Study Tisdall 1951

Methods
 Upper income country: Canada
 Study Design: CBA
 Unit of allocation: Student
 Duration: January 1947- April 1949. 25 months (excluding summers).
 Total N in all groups: Estimated that they needed 600 at beginning. Had 416 at end of study
 Funding: The Canadian Red Cross Society
 Subgroup analysis:
 Withdrawals: Seems like 33% exp, 26% control.

Participants
 SES: Moss Park area of Toronto, urban, schools in low income area
 Age: 5.5 to 10.5 yrs for both. control and experimental groups
 Gender: DK
 Nutritional status: Height: 49.6 inches exp, 49.3 controls. Weight: 97.5 on McLoy weight index at start of study. McLoy is actual weight divided by 'ideal weight'

Interventions
 Feeding: Lunch at school
 Protein: 26 g
 Calories: 705 cal
 Intensity:
 % RDA for energy: 28-39%. Sufficient.
 % DRI for protein: 77-131%
 Control: Went home for lunch as usual
 Provider:
 Supervised: Y
 Compliance: Very poor. Most of exp group attended lunch less than 90% of time.

Outcomes
 Nutrient and micro-nutrient intake: home dietary surveys for one week were done on 1/4 families.
 Nutrition and micronutrient status: Weight (McLoy Weight indices), change in weight, height, change in height, change in forearm and calf circumference. Serum ascorbic acid, serum carotene, and Vitamin A.
 Cognition: Intelligence tests.
 School performance: marks, achievement tests (different tests administered before and after)
 Behavioural: Attendance, change in attendance

Notes
 Baseline measurement: U probably I
 Reliable outcome: Height and weight, intelligence and achievement: U
 Biochemical: U for hemoglobin Girth U
 Protection against Contamination: U
 Blinded assessment : U
 Co-intervention: U
 Loss to follow up: I

Allocation concealment D – Not used

Characteristics of excluded studies

Study	Reason for exclusion
Ahmed 2004	Mixed cross-sectional survey and retrospective CBA. For CBA, 2 control upsalsas were excluded due to contamination, and 3 new control schools selected.
Arvedson 1969	CBA - type of breakfast not school feeding
Cadogan 1997	RCT - not in school, mixed SES
Cook 1996	CBA - changes made in cost of the program, not implementation of the program
Cromer 1990	RCT - in lab setting - predominantly white, middle class
Fellers 1967	CBA - High school was for all students in town. Not enough information on SES.
Guthrie 1977	RCT - Inappropriate intervention. Compares chocolate milk with white milk.
Lopez 1993	RCT -omission of breakfast - also self-selected experimental in some
Morrell 2002	CBA -school meal modification (high protein, low carbohydrate)
Simeon 1989	Cross-over - not feeding. Omission of breakfast.
Tuttle 1954	ITS -not in school setting; lab study
Vaisman 1996	RCT -mixed SES. Author is unable to provide SES breakdowns.

ADDITIONAL TABLES

Table 01. Absolute and relative differences for randomized controlled trials

A	B	C	D	E	F	G
Outcome	# children, # studies	Baseline (control group)	Absolute change from baseline	Weighted absolute difference in change	% change relative to baseline	% change relative to rate of change
Weight (kg)	1462 children, 3 studies	29.4 kg	2.88 kg	0.39 kg	1.3%	13.5%
Height (cm)	1462 children, 3 studies	134.5 cm	6.34 cm	0.38 cm	0.3%	6%

Table 01. Absolute and relative differences for randomized controlled trials (Continued)

A	B	C	D	E	F	G
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Table 02. Absolute and relative differences for controlled before after studies

A	B	C	D	E	F	G
Outcome	# children, # studies	Baseline (control group)	Change from baseline (control group)	Absolute difference in change	Relative % change	% change relative to rate of change
Weight (kg)	991 children, 3 studies	18.22 kg	1.62 kg	0.71 kg	3.9%	44%
Height (cm)	988 children, 3 studies	116.6 cm	4.33 cm	1.45 cm	1.2%	33%

Table 03. Absolute and relative differences for subgroup analysis by age: RCTs

A	B	C	D	E	F	G	H
Age group	Outcome	# children, # studies	Control baseline	Control change from baseline	Absolute difference in change	% change relative to baseline	% change relative to rate of change
9-10 years	Weight (kg)	1226, 2 studies	21.8 kg	1.62 kg	0.42 kg	1.9	26%
Mixed age, 6-16 years	Weight (kg)	236 children, 1 study	20.4 kg	3.47 kg	0.28 kg	1.4%	8.1%
9-10 years	Height (cm)	1226 children, 2 studies	123.6 cm	4.29 cm	0.40 cm	0.33%	9.3%
Mixed 6-16 years	Height (cm)	236 children, 1 study	115.5 cm	10.04 cm	-0.37 cm	-0.32%	-3.7%

Table 04. Absolute and relative differences for age subgroups: CBAs

A	B	C	D	E	F	G	H
Age group	Outcome	# children, # studies	Control baseline	Control change from baseline	Absolute difference in change	% change relative to control baseline	% change relative to rate of change
5-6 years	Weight (kg)	106 children, 1 study	15.11 kg	0.97 kg	0.95 kg	6.4%	98%
6-8 years	Weight (kg)	564 children, 2 studies	18.22 kg	1.64 kg	0.67 kg	3.7%	40.8%
9-10 years	Weight (kg)	212 children, 1 study	22.72 kg	2.0 kg	0.89 kg	3.9%	44.5%
Mixed ages, 7-13 years	Weight (kg)	140 children, 1 study	22.9 kg	2.28 kg	0.21 kg	0.9%	0.9%

Table 04. Absolute and relative differences for age subgroups: CBAs (Continued)

A	B	C	D	E	F	G	H
5-6 years	Height (cm)	106 children, 1 study	104.69 cm	4.06 cm	2.62 cm	3.9%	65%
6-8 years	Height (cm)	564 children, 2 studies	116.6 cm	3.8 cm	1.25 cm	1.1%	33%
9-10 years	Height (cm)	212 children, 1 study	124.1 cm	5.3 cm	-0.21 cm	-0.2%	-4.0%
Mixed ages, 7- 13 years	Height (cm)	140 children, 1 study	123.6 cm	5.24 cm	0.2 cm	0.2%	3.8%

Table 05. Quality of included studies

Study	Shape intervention	Baseline measure	Reliable outcome	Contamination?	Blinded assessment
Agarwal		A for all	U for 4	A	U
Bailey		U	U A for hemoglobin	U	U
Baker		A height U weight	U	I	A
Bro 1994	I	n.a.	A	n.a.	I
Bro 1996	A	n.a.	I	n.a.	I
Chandler, 1995		n.a.	A	A	A
Corry-Mann		A	U	U	U
Devadas, 1979		A	U for weight, height, A for hemoglobin	U	U
Du 2004		A	U for weight, height, A for BMD	U	A
Jacoby 1996		A	A	A	I for attendance U for psychological
Lieberman, 1976		U	U for all	A	U
Neumann 2003		A	A for weight, height, A for psychological tests, U for hematocrit, hemoglobin	A	A
Orr 1928		U	U	A	U
Paige 1976		A weight, U height	A	A	U
Powell 1983		I for spelling, reading, U for math, A for height for age, weight for age	U	A	A
Powell 1998		A for all 6	A	A	A

Table 05. Quality of included studies (Continued)

Study	Shape intervention	Baseline measure	Reliable outcome	Contamination?	Blinded assessment
Shemilt 2006		U for 3, A for one	A for 3, U for 1	I	U
Tisdall, 1953		U	U	U	U
Totals		7 A for all, 5 U for all, 2 mixed A and U, 1 mixed A and I	5 A for all, 7 u for all, 5 mixed, 1 I	9A 5 U, 2I, 2na	6A, 9U, 2 I, 1mixed

Table 06. Table 6: LLMIC: Effect size and significance by various study attributes

Study ID	Date	Type of study	Blinding	Energy	Weight	Height	Attendance	Intelligence	Math
Bailey 1962	1962	CBA		U	9% Low	.21 ns	0.2		
Devadas 1979	1979	CBA	U	18-21%: higher	.95, .33, .90, sig	2.62, 2.75, 2.65			
Powell 1983	1983	CBA	A	18-21%: higher			2.8 days per semester diff.		Beta = .15
Agarwal 1989	1989	CBA	U	25%: higher	.7 and .8 s	-.3, .2'		3.92 FS, 5.69 P, 3.3 V	3.7 points per year
Chandler 1995	1995	RCT	A	24%: higher					
Jacoby 1996	1996	RCT	U	26%: higher			3.5 % diff. 6 days a year		
Powell 1998	1998	rCT	A	32%: higher	.47 a, sig	.17 a ns	2.3% diff. 4 days a year		.71 points per year
Neumann 2003	2003	RCT	A	13%: lower	.28 (N.S)	-0.37			.17 points per year
Du 2004	2004	RCT	A	10%: lower	1.5	1.20 (S)			

Table 07. Table 7: HIC: Effect size and significance by various study attributes

Study ID	Date	Type of study	Blinding	Energy	Weight	Height	Attendance	Intelligence	Math
Correy-Mann 1926	1926	CBA		U	19%: higher		1.42 kg	1.98cm	
Orr 1928	1928	CBA	U	14-18%: higher	.05-.54	0.65			
Tisdall 1951	1951	CBA	U	36%: higher	0.32	0.25	n.s.		
Lieberman 1976	1976	CBA	U	14%: lower			5 days a year, n.s.		

Table 07. Table 7: HIC: Effect size and significance by various study attributes (Continued)

Study ID	Date	Type of study	Blinding	Energy	Weight	Height	Attendance	Intelligence	Math
Paige 1976	1976	CBA	U	12%: lower	.09-.96	.2-1.0	2.5 days per year, .n.s		
Baker 1980	1980	RCT	A	5%: higher	.15 ns	0.22 ns			
Bro 1994	1994	ITS	I						
Bro 1996	1996	ITS	I						
Shemilt 2004	2004	RCT	U						

ANALYSES

Comparison 01. Developing country: School meal vs control. RCT

Outcome title	No. of studies	No. of participants	Statistical method	Effect size
01 Weight gain kg	3	1462	Weighted Mean Difference (Random) 95% CI	0.39 [0.11, 0.67]
02 Height gain (cm)	3	1462	Weighted Mean Difference (Random) 95% CI	0.38 [-0.32, 1.08]
03 Weight for age: z-scores	1	785	Weighted Mean Difference (Random) 95% CI	0.07 [0.04, 0.10]
04 Height for age: z-scores	2	1021	Weighted Mean Difference (Random) 95% CI	0.04 [0.02, 0.06]
14 MAUC	1	236	Weighted Mean Difference (Random) 95% CI	0.31 [0.16, 0.46]
21 Mid-upper arm muscle area	1	236	Weighted Mean Difference (Random) 95% CI	68.22 [39.57, 96.87]
22 Mid upper arm fat area	1	236	Weighted Mean Difference (Random) 95% CI	-0.31 [-26.12, 25.50]
23 weight for height gain	1	236	Weighted Mean Difference (Random) 95% CI	0.20 [-0.24, 0.64]

Comparison 02. Developing country RCT: Subgroup analysis: meals vs control

Outcome title	No. of studies	No. of participants	Statistical method	Effect size
01 Undernourished vs adequately nourished: Weight gain in kg			Weighted Mean Difference (Random) 95% CI	Subtotals only
02 Undernourished versus adequately nourished, height in cm			Weighted Mean Difference (Random) 95% CI	Subtotals only
03 Age subgroup analysis: weight gain in kg			Weighted Mean Difference (Random) 95% CI	Subtotals only
04 Age subgroup analysis: height gain (cm)			Weighted Mean Difference (Random) 95% CI	Subtotals only

Comparison 03. Developing country: School meal vs control. CBA

Outcome title	No. of studies	No. of participants	Statistical method	Effect size
01 Weight gain kg- adjusted ICC 0.025	6	989	Weighted Mean Difference (Random) 95% CI	0.71 [0.48, 0.95]
05 Height gain (cm)- adjusted ICC =0.016	6	986	Weighted Mean Difference (Random) 95% CI	1.45 [0.52, 2.39]
09 subgroup analysis weight by sex			Weighted Mean Difference (Fixed) 95% CI	Subtotals only

10 Subgroup analysis: height by sex	2	446	Weighted Mean Difference (Fixed) 95% CI	-0.14 [-0.73, 0.44]
11 Subgroup by age: weight gain in kg - Agarwal adjusted			Weighted Mean Difference (Random) 95% CI	Subtotals only
12 Subgroup by age: height gain in cm - Agarwal adjusted			Weighted Mean Difference (Random) 95% CI	Subtotals only
13 Full scale IQ (total): adjusted-ICC 0.15	1	46	Weighted Mean Difference (Fixed) 95% CI	3.90 [-11.33, 19.13]
21 Full scale IQ (separated): cluster size as in analysis: icc = .15	4	231	Weighted Mean Difference (Random) 95% CI	3.80 [0.51, 7.10]
24 Performance IQ (separated): numbers as in analysis: ICC = 0.15	4	231	Weighted Mean Difference (Fixed) 95% CI	5.74 [1.73, 9.74]
26 Performance IQ (total): adjusted-ICC 0.15	1	46	Weighted Mean Difference (Fixed) 95% CI	5.00 [-11.97, 21.97]
28 Verbal IQ (separated): cluster size as in analysis: ICC= 0.15	4	231	Weighted Mean Difference (Random) 95% CI	3.35 [-0.21, 6.92]
29 Verbal IQ (total): adjusted-ICC 0.15	1	46	Weighted Mean Difference (Fixed) 95% CI	3.10 [-10.49, 16.69]
34 Math Change - Overall - adjusted ICC 0.15	2		SMD (Random) 95% CI	0.66 [0.13, 1.18]
35 Math Change : by nutritional status - Adjusted ICC 0.15	5		SMD (Random) 95% CI	0.72 [0.34, 1.09]
36 Percent weight for age: ICC= .025	1	106	Weighted Mean Difference (Fixed) 95% CI	0.90 [-0.40, 2.20]
40 Percent height for age: ICC= 0.016	1	106	Weighted Mean Difference (Fixed) 95% CI	-0.75 [-1.11, -0.39]
44 Change in reading: ICC= .15	1	106	Weighted Mean Difference (Random) 95% CI	0.09 [-0.11, 0.29]
47 change in spelling: ICC= .15	1	106	Weighted Mean Difference (Fixed) 95% CI	0.24 [0.01, 0.47]
56 change in attendance: icc = .15	1	108	Weighted Mean Difference (Random) 95% CI	4.95 [-3.56, 13.46]
57 End of study: attendance: icc = .15	1	72	Weighted Mean Difference (Random) 95% CI	-0.23 [-16.81, 16.35]

Comparison 04. developed country: school meal versus control: CBA

Outcome title	No. of studies	No. of participants	Statistical method	Effect size
01 Weight gain in kg.- adjusted icc =0.025. Leighton used for Orr	4	703	Weighted Mean Difference (Random) 95% CI	0.84 [0.33, 1.35]
02 Weight gain: Corry-Mann alone	1	102	Weighted Mean Difference (Fixed) 95% CI	1.42 [1.19, 1.65]
06 Height gain in cm. Adjusted with Icc = 0.016. Leighton used for Orr	4	703	Weighted Mean Difference (Fixed) 95% CI	1.01 [0.80, 1.22]
07 Height gain in cm. adjusted ICC=0.016	4	703	Weighted Mean Difference (Random) 95% CI	0.92 [0.16, 1.67]

Comparison 05. Developed country: School meal vs control RCT

Outcome title	No. of studies	No. of participants	Statistical method	Effect size
01 change in height	1	520	Weighted Mean Difference (Random) 95% CI	0.28 [-0.01, 0.57]
02 Subgroup analysis: height by sex			Weighted Mean Difference (Fixed) 95% CI	Subtotals only
03 change in weight (kg)	1	520	Weighted Mean Difference (Random) 95% CI	0.13 [-0.23, 0.49]
04 Subgroup analysis: weight by sex	2	520	Weighted Mean Difference (Fixed) 95% CI	0.15 [-0.19, 0.49]

Comparison 10. Developing country: School meal vs control. RCT- Sensitivity

Outcome title	No. of studies	No. of participants	Statistical method	Effect size
05 Weight gain kg- sensitivity ICC 0.01	3	1462	Weighted Mean Difference (Random) 95% CI	0.47 [0.10, 0.84]
06 Weight gain kg- sensitivity ICC 0.05	3	1462	Weighted Mean Difference (Random) 95% CI	0.36 [0.18, 0.54]
07 Weight gain kg- sensitivity ICC 0.1	3	1462	Weighted Mean Difference (Random) 95% CI	0.36 [0.19, 0.52]
09 Height gain (cm), sensitivity ICC 0.01	3	1462	Weighted Mean Difference (Random) 95% CI	0.40 [-0.32, 1.11]
10 Height gain (cm), sensitivity ICC 0.05	3	1462	Weighted Mean Difference (Random) 95% CI	0.29 [-0.34, 0.91]
11 Height gain (cm), sensitivity ICC 0.1	3	1462	Weighted Mean Difference (Random) 95% CI	0.21 [-0.33, 0.76]

Comparison 11. Developing country: School meal vs control. CBA - Sensitivity

Outcome title	No. of studies	No. of participants	Statistical method	Effect size
01 Math change - overall sensitivity - ICC 0.2	2		SMD (Random) 95% CI	0.67 [0.25, 1.10]
02 Weight gain kg- sensitivity ICC 0.01	6	989	Weighted Mean Difference (Random) 95% CI	0.71 [0.48, 0.94]
03 Weight gain kg- sensitivity ICC 0.05	6	989	Weighted Mean Difference (Random) 95% CI	0.72 [0.47, 0.96]
04 Weight gain kg- sensitivity ICC 0.1	6	989	Weighted Mean Difference (Random) 95% CI	0.72 [0.46, 0.97]
05 Math change - overall sensitivity - ICC 0.1	2		SMD (Random) 95% CI	0.67 [0.32, 1.02]
06 Height gain (cm)- sensitivity ICC 0.01	6	986	Weighted Mean Difference (Random) 95% CI	1.41 [0.37, 2.45]
07 Height gain (cm)- sensitivity ICC 0.05	6	986	Weighted Mean Difference (Random) 95% CI	1.50 [0.62, 2.37]
08 Height gain (cm)- sensitivity ICC 0.1	6	761	Weighted Mean Difference (Random) 95% CI	2.09 [1.48, 2.70]
09 Math (change): by nutritional status - sensitivity ICC 0.1	5		SMD (Random) 95% CI	0.72 [0.38, 1.06]
10 Math (change): by nutritional status - sensitivity ICC 0.2	5		SMD (Random) 95% CI	0.71 [0.30, 1.12]

11	Percent height for age: icc = 0.05	1	106	Weighted Mean Difference (Random) 95% CI	-0.75 [-1.18, -0.32]
12	Percent height for age: icc = .1	1	106	Weighted Mean Difference (Random) 95% CI	-0.75 [-1.27, -0.23]
14	Full scale IQ (total)- sensitivity 0.1	1	46	Weighted Mean Difference (Fixed) 95% CI	3.90 [-9.21, 17.01]
16	Math (change) : cluster size as in analysis Sensitivity ICC=0.2	5	337	Standardised Mean Difference (Random) 95% CI	0.41 [0.18, 0.63]
17	Math (change) : cluster size as in analysis Sensitivity ICC=0.1	5	337	Standardised Mean Difference (Random) 95% CI	0.49 [0.27, 0.72]
18	Full scale IQ (total)- sensitivity 0.20	1	46	Weighted Mean Difference (Fixed) 95% CI	3.90 [-13.04, 20.84]
20	Full scale IQ (end study): sensitivity cluster size as in analysis ICC= 0.1	4	231	Weighted Mean Difference (Random) 95% CI	3.85 [0.79, 6.91]
22	Full scale IQ (end study): sensitivity cluster size as in analysis: ICC = 0.2	4	231	Weighted Mean Difference (Random) 95% CI	3.76 [0.26, 7.26]
23	Performance IQ (end study): Sensitivity cluster size as in analysis: ICC= 0.1	4	231	Weighted Mean Difference (Random) 95% CI	5.78 [2.12, 9.45]
25	Performance IQ (end study): Sensitivity cluster size as in analysis: ICC = 0.2	4	231	Weighted Mean Difference (Fixed) 95% CI	5.69 [1.38, 10.00]
27	Verbal IQ (end study): Sensitivity cluster size as in analyses: ICC = 0.1	4	231	Weighted Mean Difference (Random) 95% CI	3.32 [-0.03, 6.67]
29	Verbal IQ (end study): Sensitivity cluster size as in analysis: ICC = 0.2	4	231	Weighted Mean Difference (Random) 95% CI	3.36 [-0.48, 7.20]
30	Percentage standard weight. Sensitivity = 0.01	1	70	Weighted Mean Difference (Random) 95% CI	0.90 [-0.59, 2.39]
32	Percent weight for age: Sensitivity ICC= 0.05	1	106	Weighted Mean Difference (Random) 95% CI	0.90 [-0.56, 2.36]
33	Percent weight for age: Sensitivity ICC= 0.1	1	106	Weighted Mean Difference (Random) 95% CI	0.90 [-0.83, 2.63]
36	Verbal IQ (total): sensitivity-0.10	1	46	Weighted Mean Difference (Fixed) 95% CI	3.10 [-24.63, 30.83]
37	Verbal IQ (total): sensitivity-0.20	1	46	Weighted Mean Difference (Fixed) 95% CI	3.10 [-34.89, 41.09]
38	Performance IQ (total): sensitivity-0.10	1	46	Weighted Mean Difference (Fixed) 95% CI	5.00 [-9.69, 19.69]
39	Percentage standard height. Sensitivity = .01	1	70	Weighted Mean Difference (Random) 95% CI	-0.74 [-1.18, -0.30]
41	Performance IQ (total): sensitivity-0.20	1	46	Weighted Mean Difference (Fixed) 95% CI	5.00 [-13.98, 23.98]
45	change in reading: sensitivity ICC= .1	1	106	Weighted Mean Difference (Random) 95% CI	0.09 [-0.09, 0.27]
46	change in reading: sensitivity ICC= .2	1	106	Weighted Mean Difference (Random) 95% CI	0.09 [-0.13, 0.31]
50	change in spelling: sensitivity ICC= .1	1	106	Weighted Mean Difference (Fixed) 95% CI	0.23 [0.02, 0.44]

52 change in spelling: sensitivity ICC= 0.2	1	106	Weighted Mean Difference (Random) 95% CI	0.23 [-0.01, 0.47]
58 Change in attendance: sensitivity = .10	1	108	Weighted Mean Difference (Fixed) 95% CI	4.95 [-2.64, 12.54]
59 change in attendance: sensitivity = .20	1	108	Weighted Mean Difference (Fixed) 95% CI	4.95 [-4.40, 14.30]
60 End of study attendance: sensitivity icc = .10	1	72	Weighted Mean Difference (Fixed) 95% CI	-0.23 [-14.69, 14.23]
61 End of study attendance: sensitivity icc at .2	1	72	Weighted Mean Difference (Fixed) 95% CI	-0.23 [-18.69, 18.23]
62 Change in Attendance: Sensitivity = .05	1	106	Weighted Mean Difference (Fixed) 95% CI	4.95 [-1.65, 11.55]

Comparison 12. Developed country: school meal versus control: CBA - Sensitivity

Outcome title	No. of studies	No. of participants	Statistical method	Effect size
03 Weight gain in kg- sensitivity icc=0.01. Leighton 1929 used for Orr	4	703	Weighted Mean Difference (Random) 95% CI	0.84 [0.34, 1.34]
04 Weight gain in kg.- sensitivity icc=0.05. Leighton used for Orr	4	703	Weighted Mean Difference (Random) 95% CI	0.86 [0.31, 1.41]
05 Weight gain in kg. - sensitivity ICC=0.1. Leighton used for Orr	4	703	Weighted Mean Difference (Random) 95% CI	0.88 [0.31, 1.45]
07 Height gain in cm. adjusted ICC=0.016	4	703	Weighted Mean Difference (Random) 95% CI	0.92 [0.16, 1.67]
08 Height gain in cm. sensitivity ICC=0.01	4	703	Weighted Mean Difference (Random) 95% CI	0.91 [0.19, 1.64]
09 Height gain in cm. sensitivity ICC=0.05	4	703	Weighted Mean Difference (Random) 95% CI	0.94 [0.09, 1.79]
10 Height gain in cm. sensitivity ICC=0.1	4	703	Weighted Mean Difference (Random) 95% CI	0.97 [0.06, 1.87]
12 Height gain in cm. Leighton used for Orr. Sensitivity 0.01	4	703	Weighted Mean Difference (Fixed) 95% CI	1.01 [0.80, 1.22]
13 Height gain in cm. Sensitivity ICC = 0.05. Leighton used for Orr	4	703	Weighted Mean Difference (Fixed) 95% CI	1.01 [0.80, 1.22]
14 Height gain in cm. Sensitivity ICC = .1. Leighton used for Orr	4	703	Weighted Mean Difference (Fixed) 95% CI	1.01 [0.80, 1.22]

COVER SHEET

Title	School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
Authors	Kristjansson EA, Robinson V, Petticrew M, MacDonald B, Krasevec J, Janzen L, Greenhalgh T, Wells G, MacGowan J, Farmer A, Shea BJ, Mayhew A, Tugwell P

Contribution of author(s)	<p>BK had the idea for the review, obtained funding for developing the protocol, wrote the protocol, identified articles to retrieve, looked over all of the articles, decided on inclusion/exclusion of studies, extracted data, performed analyses, rated quality, and wrote the review. VR helped with writing the protocol, identified articles to retrieve, looked over all of the articles, decided on inclusion/exclusion of studies, performed analyses, extracted data, and edited the review/.</p> <p>MP provided guidance on many aspects of the review, and edited the review at all stages. BM helped to decide on inclusion/exclusion of studies, helped to calculate RDA for energy, read each study for clinical impact, gave advice on clinical relevance, and helped to write the review</p> <p>JK calculated RDA for energy, extracted data for nutritional tables on each study, read each study for clinical impact, gave advice on clinical relevance, and helped to write the review. TG provided input on classification and inclusion/exclusion of studies, wrote a thorough realist review, and edited the review. Parts of the realist review were incorporated into the discussion. It will also be published as a complementary article.</p> <p>LJ read all included papers with psycho-social outcomes, rated baseline measurement and reliability of outcome measures, identified clinical significance of these outcomes, and wrote sections of the discussion.</p> <p>GW was the study statistician and provided statistical advice at all stages of the review. JM developed the search strategy and performed literature searches. AF rated baseline measurement and reliability of outcome measures for growth outcomes. BS rated quality of included studies.</p> <p>AM provided advice on certain study designs, inclusion/exclusion of studies, helped with quality ratings, and edited the review.</p> <p>PT provided advice and guidance, rated the reliability of biochemical outcome measurements and biochemical measurements at baseline, and edited the review.</p>
Issue protocol first published	2004/1
Review first published	2007/1
Date of most recent amendment	21 February 2007
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What's New	Information not supplied by author
Date new studies sought but none found	Information not supplied by author
Date new studies found but not yet included/excluded	Information not supplied by author
Date new studies found and included/excluded	Information not supplied by author
Date authors' conclusions section amended	Information not supplied by author
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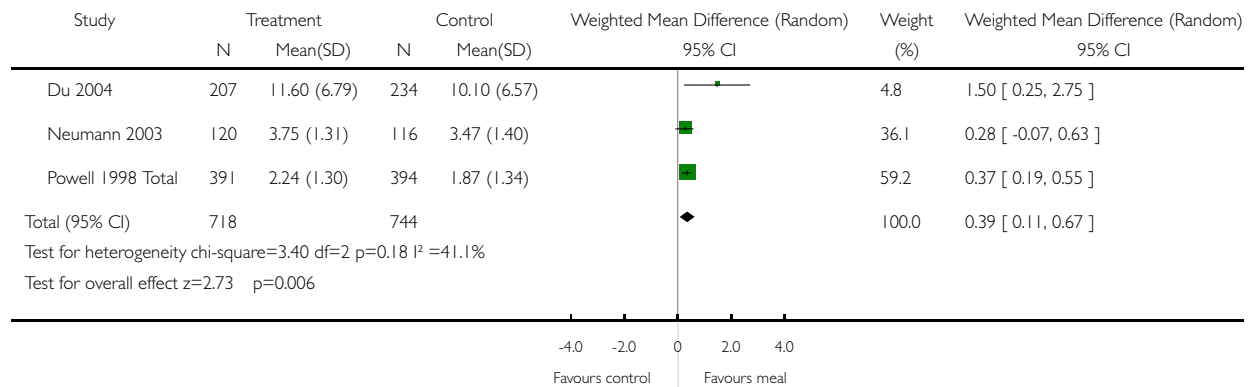
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GRAPHS AND OTHER TABLES

Analysis 01.01. Comparison 01 Developing country: School meal vs control. RCT, Outcome 01 Weight gain kg

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 01 Developing country: School meal vs control. RCT
 Outcome: 01 Weight gain kg

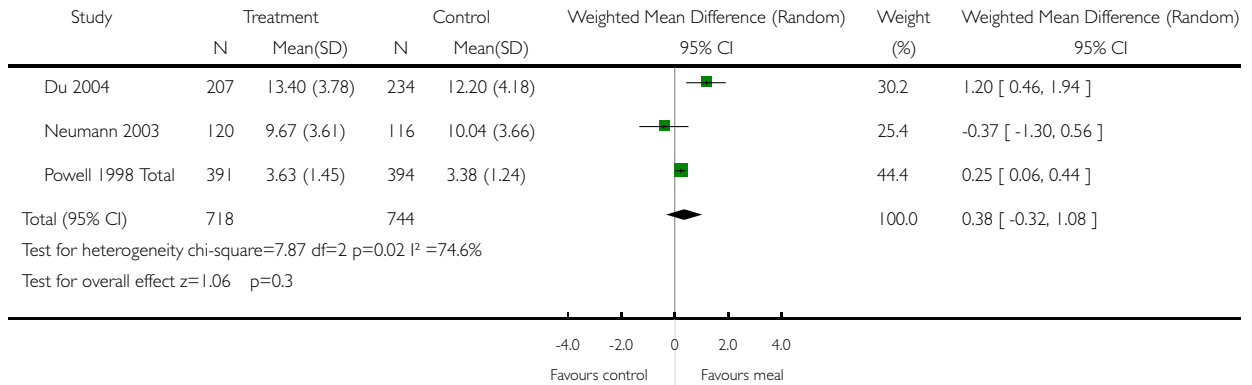


Analysis 01.02. Comparison 01 Developing country: School meal vs control. RCT, Outcome 02 Height gain (cm)

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 01 Developing country: School meal vs control. RCT

Outcome: 02 Height gain (cm)

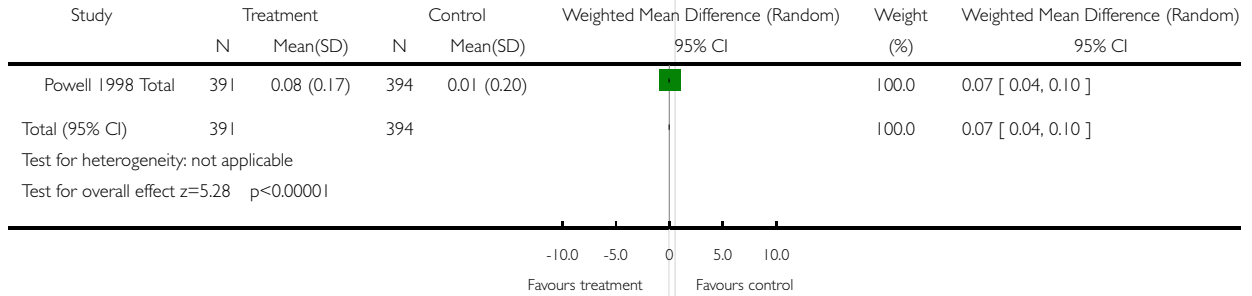


Analysis 01.03. Comparison 01 Developing country: School meal vs control. RCT, Outcome 03 Weight for age: z-scores

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 01 Developing country: School meal vs control. RCT

Outcome: 03 Weight for age: z-scores

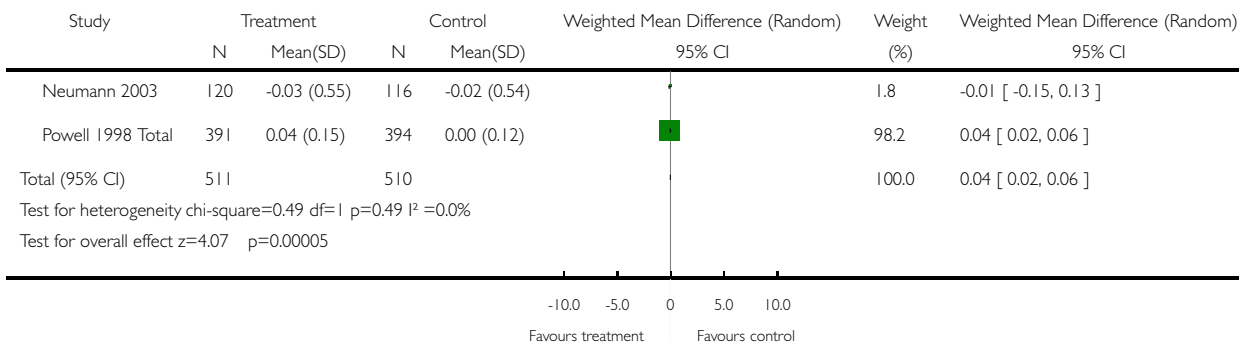


Analysis 01.04. Comparison 01 Developing country: School meal vs control. RCT, Outcome 04 Height for age: z-scores

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 01 Developing country: School meal vs control. RCT

Outcome: 04 Height for age: z-scores

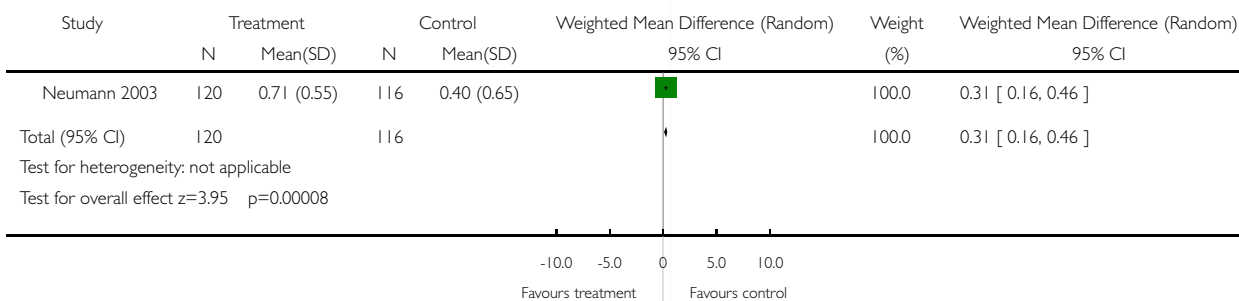


Analysis 01.14. Comparison 01 Developing country: School meal vs control. RCT, Outcome 14 MAUC

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 01 Developing country: School meal vs control. RCT

Outcome: 14 MAUC

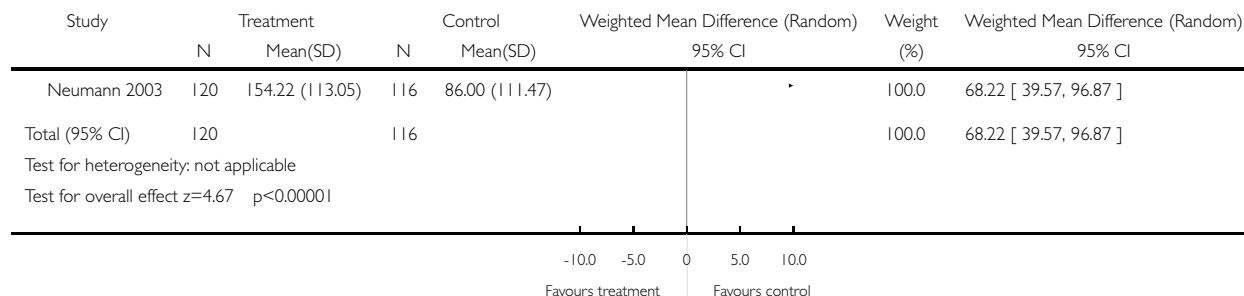


Analysis 01.21. Comparison 01 Developing country: School meal vs control. RCT, Outcome 21 Mid-upper arm muscle area

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 01 Developing country: School meal vs control. RCT

Outcome: 21 Mid-upper arm muscle area

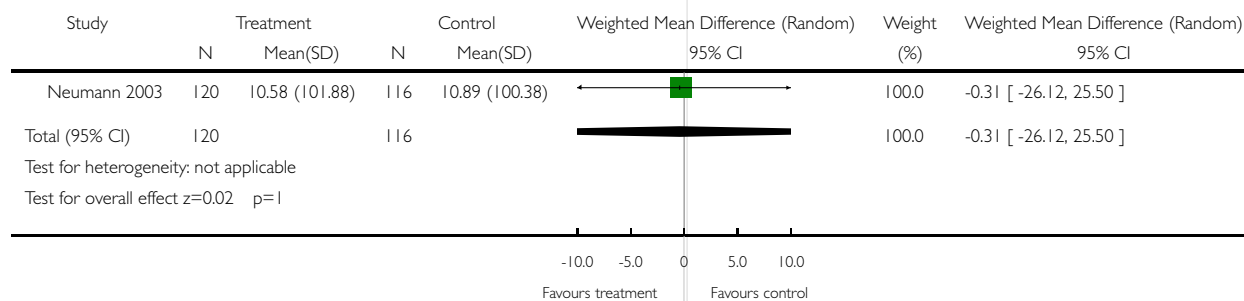


Analysis 01.22. Comparison 01 Developing country: School meal vs control. RCT, Outcome 22 Mid upper arm fat area

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 01 Developing country: School meal vs control. RCT

Outcome: 22 Mid upper arm fat area

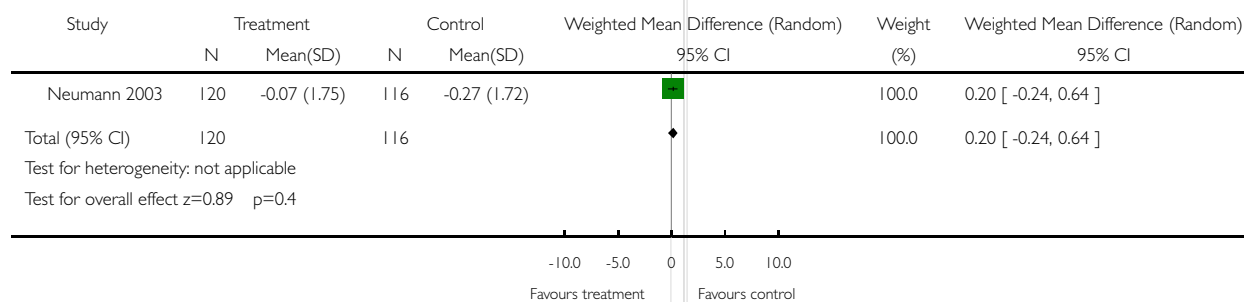


Analysis 01.23. Comparison 01 Developing country: School meal vs control. RCT, Outcome 23 weight for height gain

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 01 Developing country: School meal vs control. RCT

Outcome: 23 weight for height gain

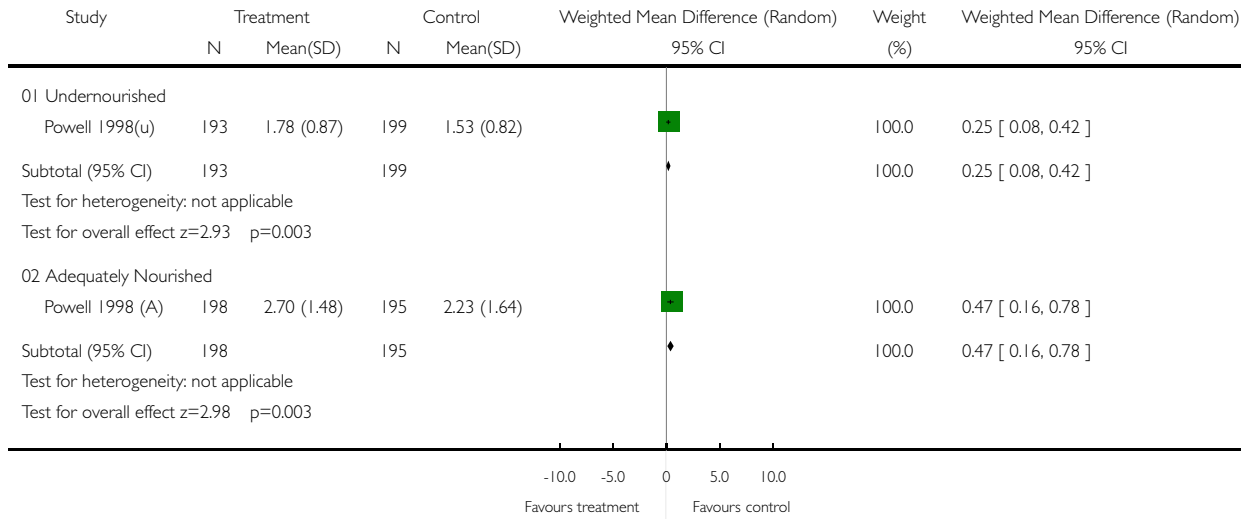


Analysis 02.01. Comparison 02 Developing country RCT: Subgroup analysis: meals vs control, Outcome 01 Undernourished vs adequately nourished: Weight gain in kg

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 02 Developing country RCT: Subgroup analysis: meals vs control

Outcome: 01 Undernourished vs adequately nourished: Weight gain in kg

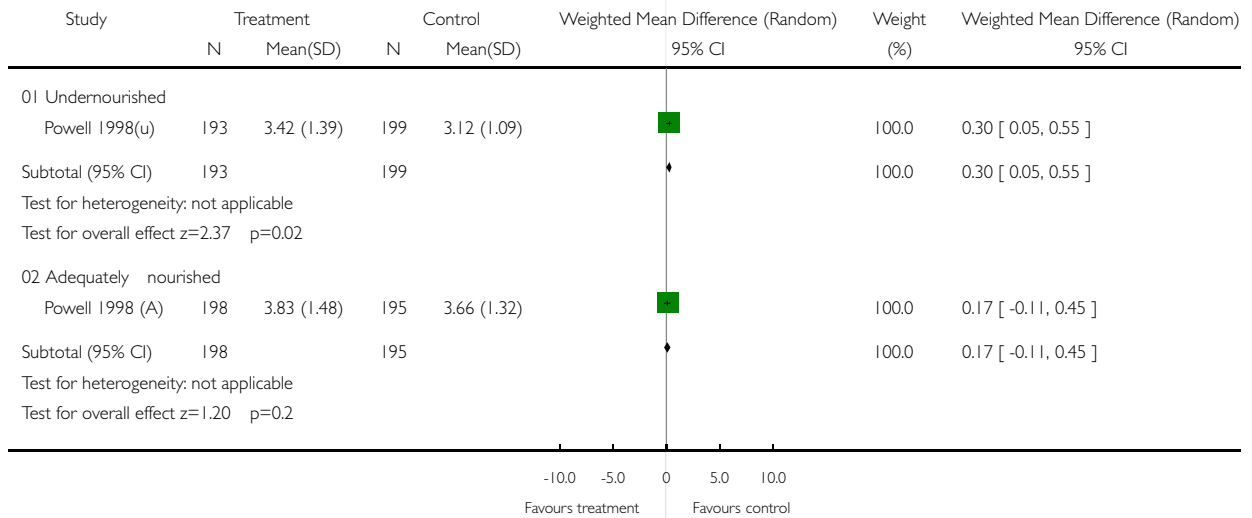


Analysis 02.02. Comparison 02 Developing country RCT: Subgroup analysis: meals vs control, Outcome 02 Undernourished versus adequately nourished, height in cm

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 02 Developing country RCT: Subgroup analysis: meals vs control

Outcome: 02 Undernourished versus adequately nourished, height in cm

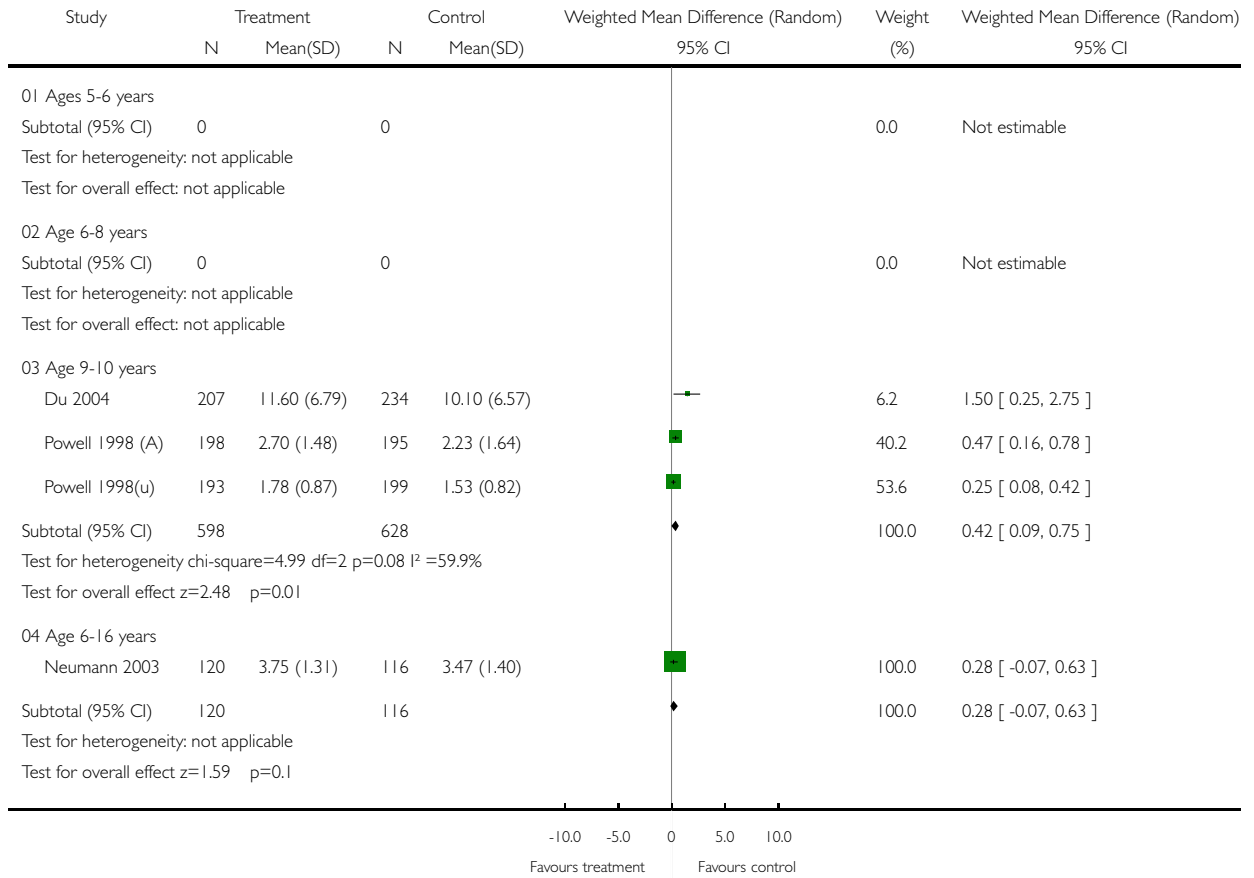


Analysis 02.03. Comparison 02 Developing country RCT: Subgroup analysis: meals vs control, Outcome 03 Age subgroup analysis: weight gain in kg

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 02 Developing country RCT: Subgroup analysis: meals vs control

Outcome: 03 Age subgroup analysis: weight gain in kg

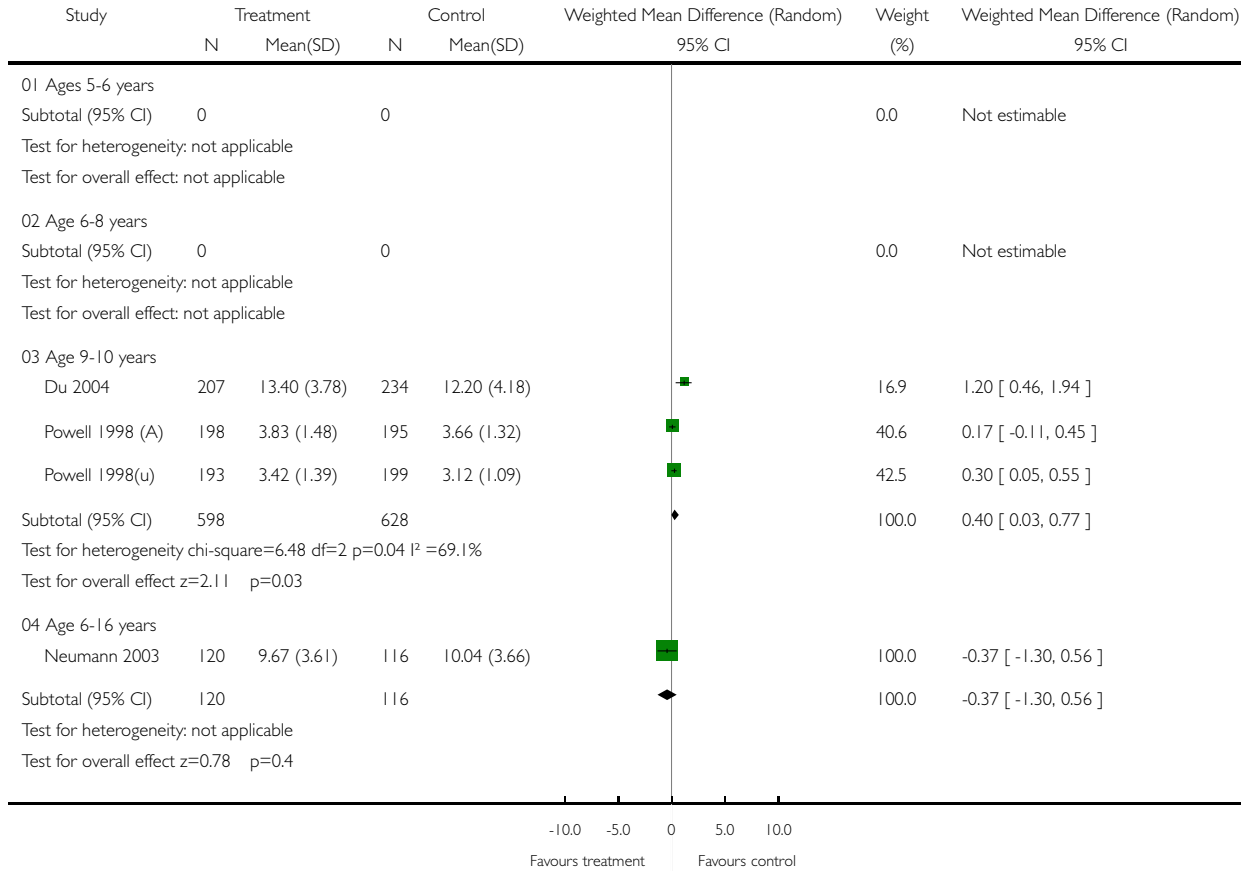


Analysis 02.04. Comparison 02 Developing country RCT: Subgroup analysis: meals vs control, Outcome 04 Age subgroup analysis: height gain (cm)

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

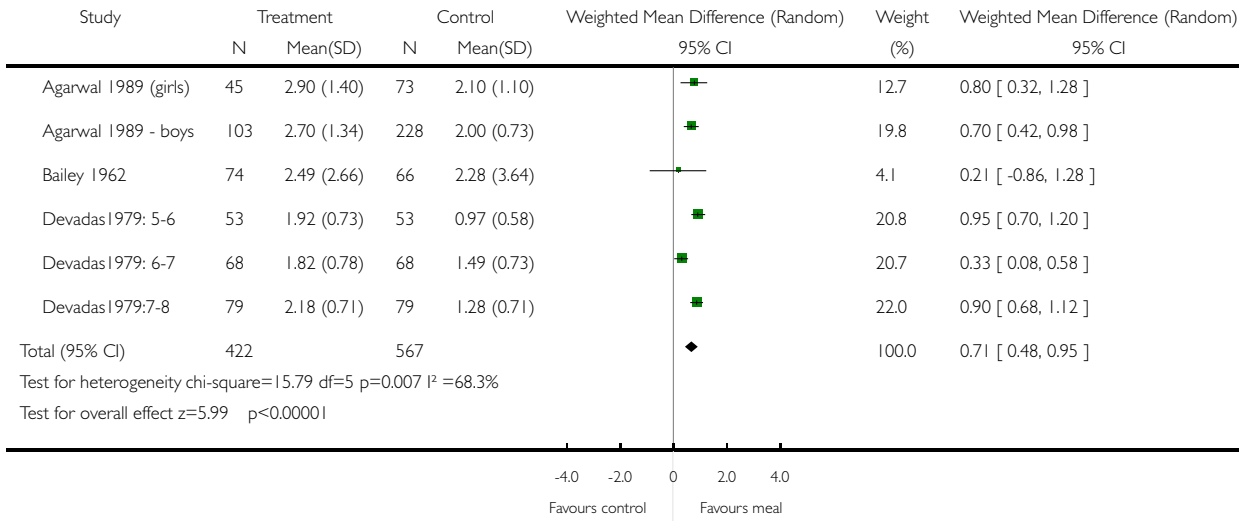
Comparison: 02 Developing country RCT: Subgroup analysis: meals vs control

Outcome: 04 Age subgroup analysis: height gain (cm)



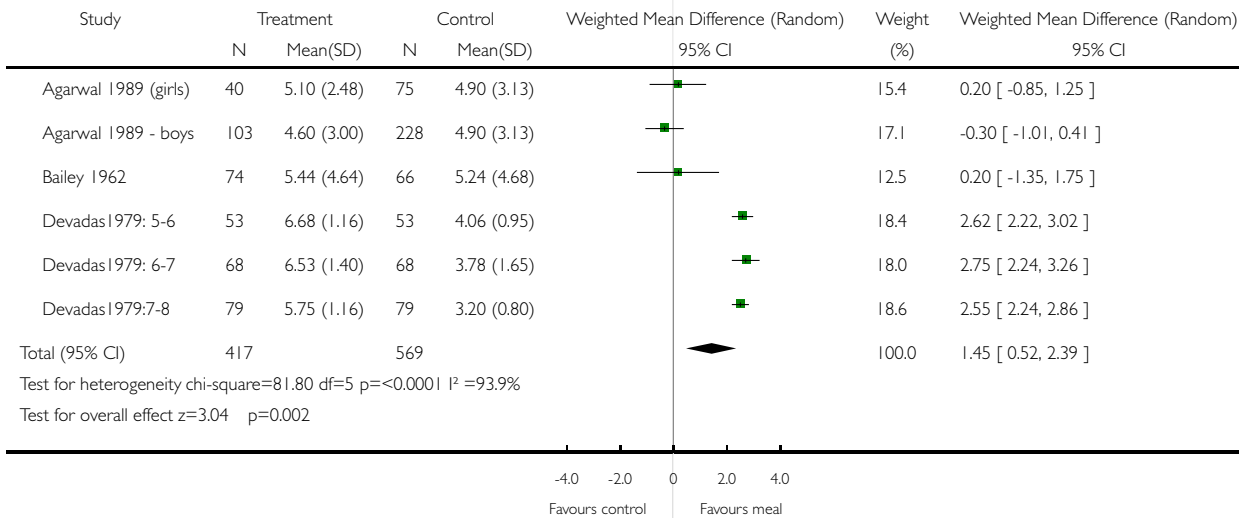
Analysis 03.01. Comparison 03 Developing country: School meal vs control. CBA, Outcome 01 Weight gain kg- adjusted ICC 0.025

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 03 Developing country: School meal vs control. CBA
 Outcome: 01 Weight gain kg- adjusted ICC 0.025



Analysis 03.05. Comparison 03 Developing country: School meal vs control. CBA, Outcome 05 Height gain (cm)- adjusted ICC =0.016

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 03 Developing country: School meal vs control. CBA
 Outcome: 05 Height gain (cm)- adjusted ICC =0.016

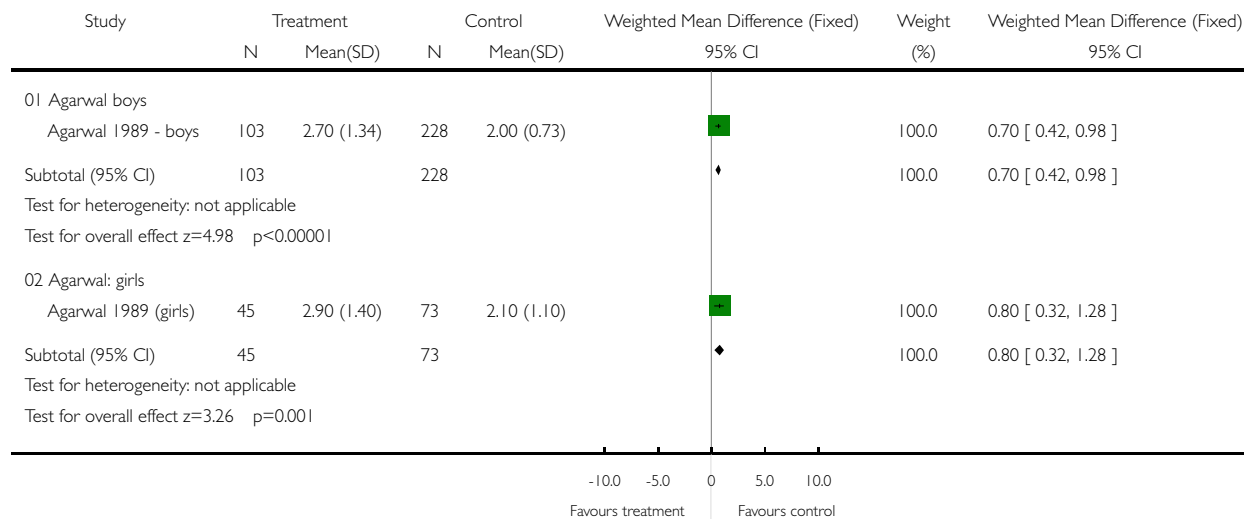


Analysis 03.09. Comparison 03 Developing country: School meal vs control. CBA, Outcome 09 subgroup analysis weight by sex

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 03 Developing country: School meal vs control. CBA

Outcome: 09 subgroup analysis weight by sex

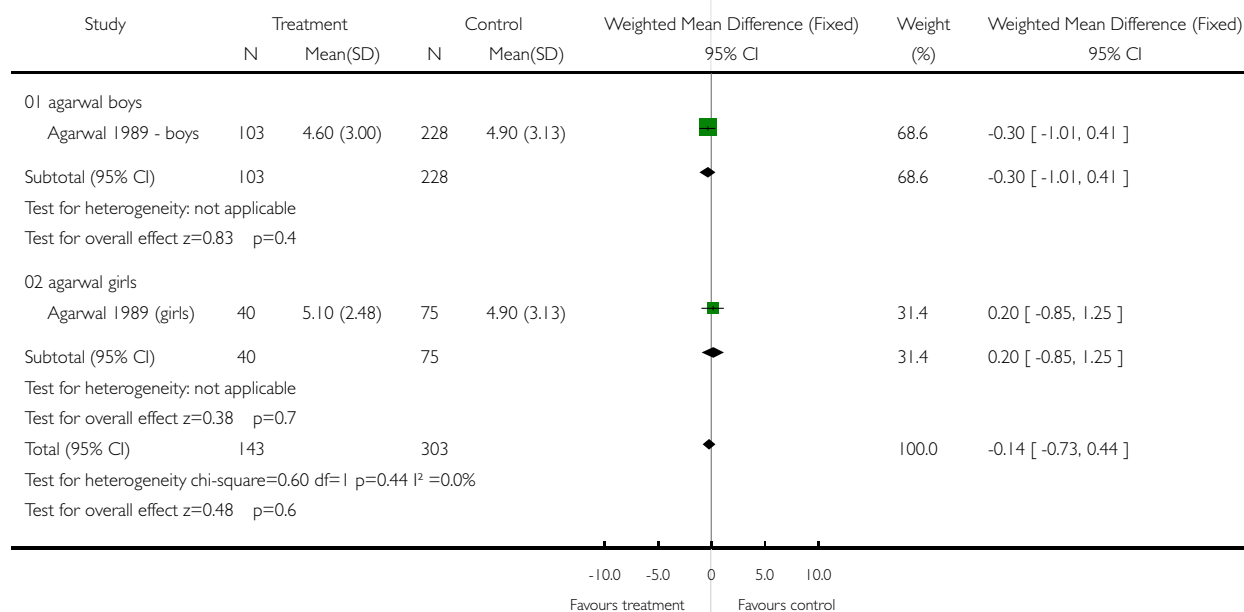


Analysis 03.10. Comparison 03 Developing country: School meal vs control. CBA, Outcome 10 Subgroup analysis: height by sex

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 03 Developing country: School meal vs control. CBA

Outcome: 10 Subgroup analysis: height by sex

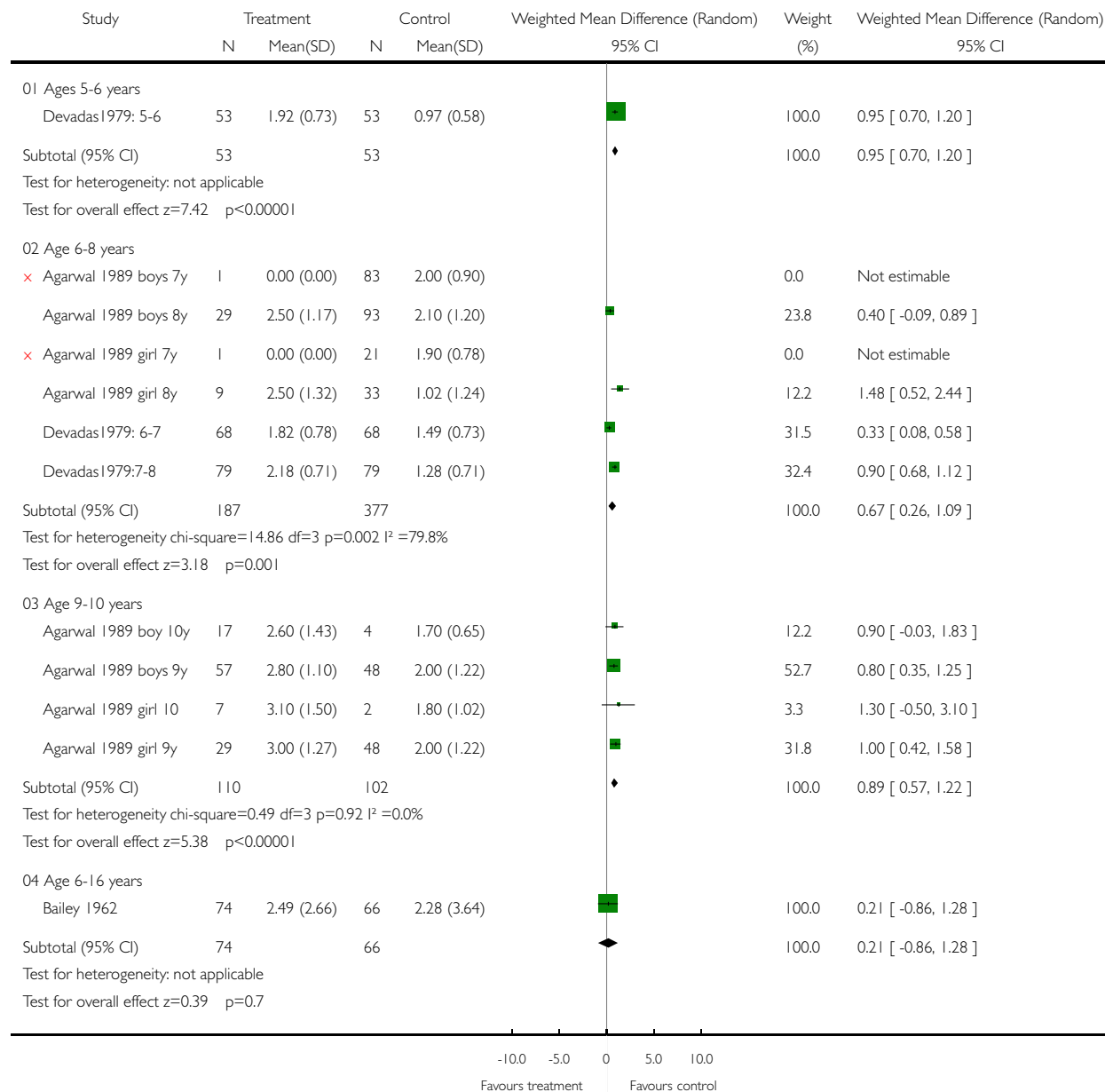


Analysis 03.11. Comparison 03 Developing country: School meal vs control. CBA, Outcome 11 Subgroup by age: weight gain in kg - Agarwal adjusted

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 03 Developing country: School meal vs control. CBA

Outcome: 11 Subgroup by age: weight gain in kg - Agarwal adjusted

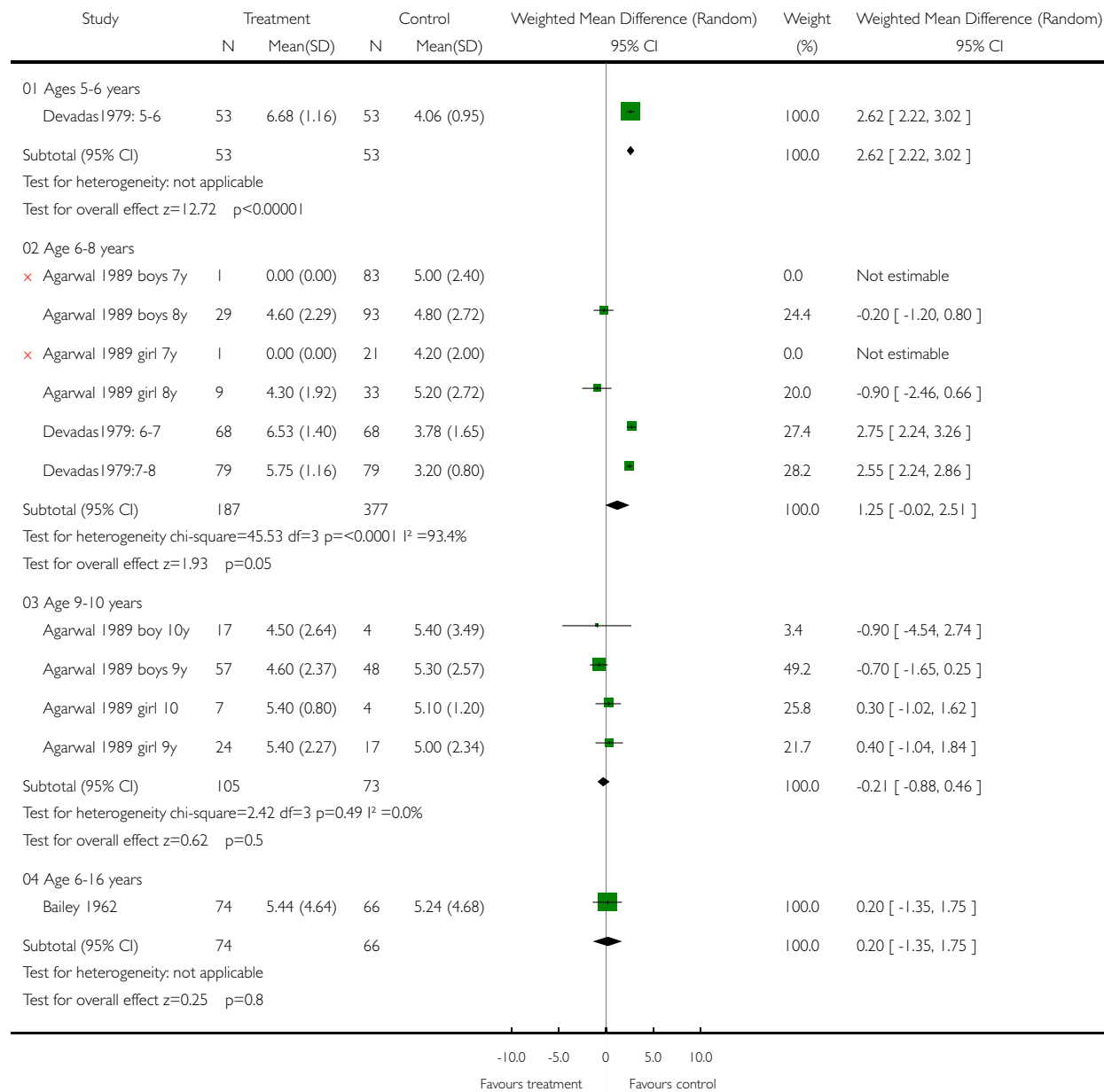


Analysis 03.12. Comparison 03 Developing country: School meal vs control. CBA, Outcome 12 Subgroup by age: height gain in cm - Agarwal adjusted

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 03 Developing country: School meal vs control. CBA

Outcome: 12 Subgroup by age: height gain in cm - Agarwal adjusted

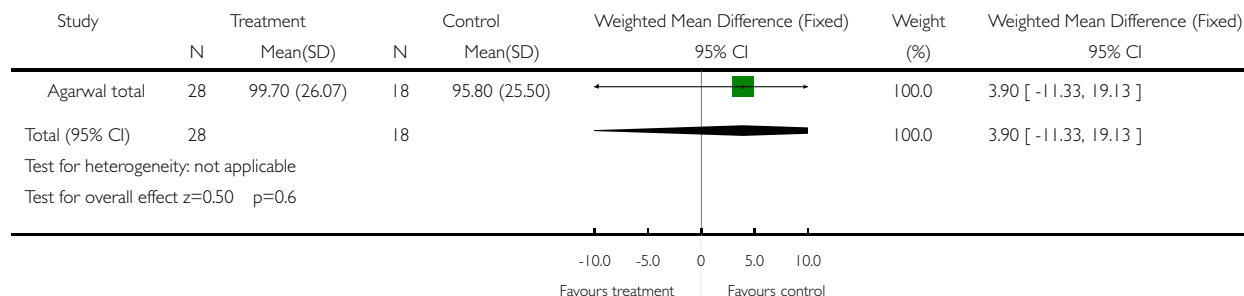


Analysis 03.13. Comparison 03 Developing country: School meal vs control. CBA, Outcome 13 Full scale IQ (total): adjusted-ICC 0.15

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 03 Developing country: School meal vs control. CBA

Outcome: 13 Full scale IQ (total): adjusted-ICC 0.15

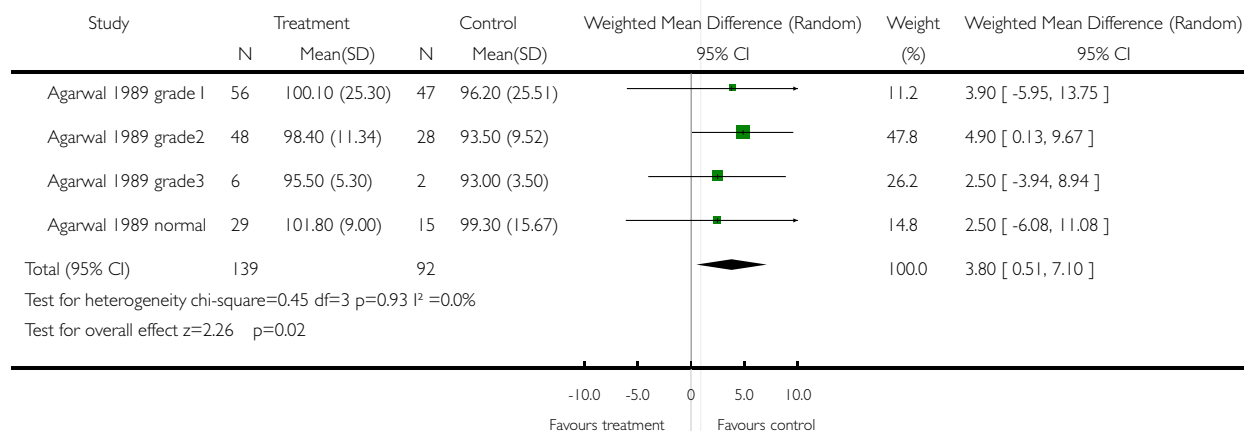


Analysis 03.21. Comparison 03 Developing country: School meal vs control. CBA, Outcome 21 Full scale IQ (separated): cluster size as in analysis: icc = .15

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

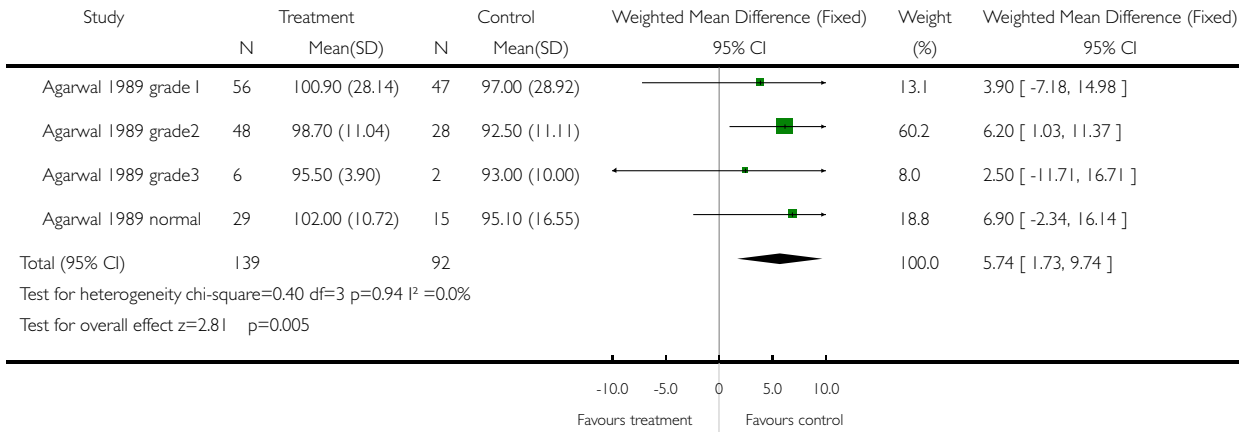
Comparison: 03 Developing country: School meal vs control. CBA

Outcome: 21 Full scale IQ (separated): cluster size as in analysis: icc = .15



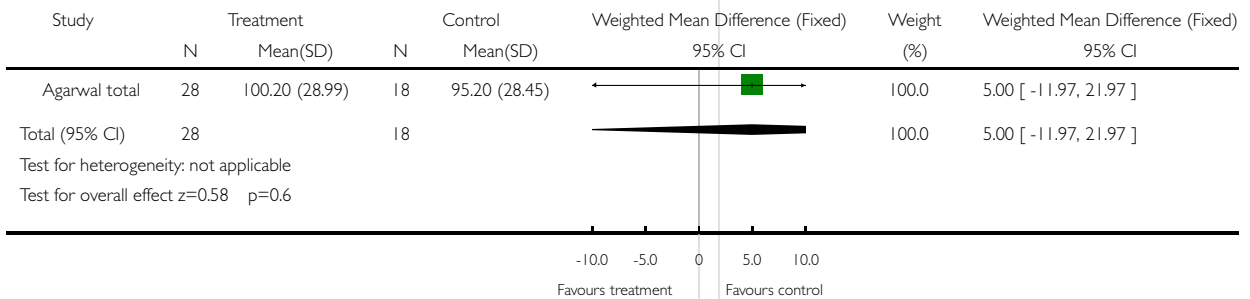
Analysis 03.24. Comparison 03 Developing country: School meal vs control. CBA, Outcome 24 Performance IQ (separated): numbers as in analysis: ICC = 0.15

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 03 Developing country: School meal vs control. CBA
 Outcome: 24 Performance IQ (separated): numbers as in analysis: ICC = 0.15



Analysis 03.26. Comparison 03 Developing country: School meal vs control. CBA, Outcome 26 Performance IQ (total): adjusted-ICC 0.15

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 03 Developing country: School meal vs control. CBA
 Outcome: 26 Performance IQ (total): adjusted-ICC 0.15

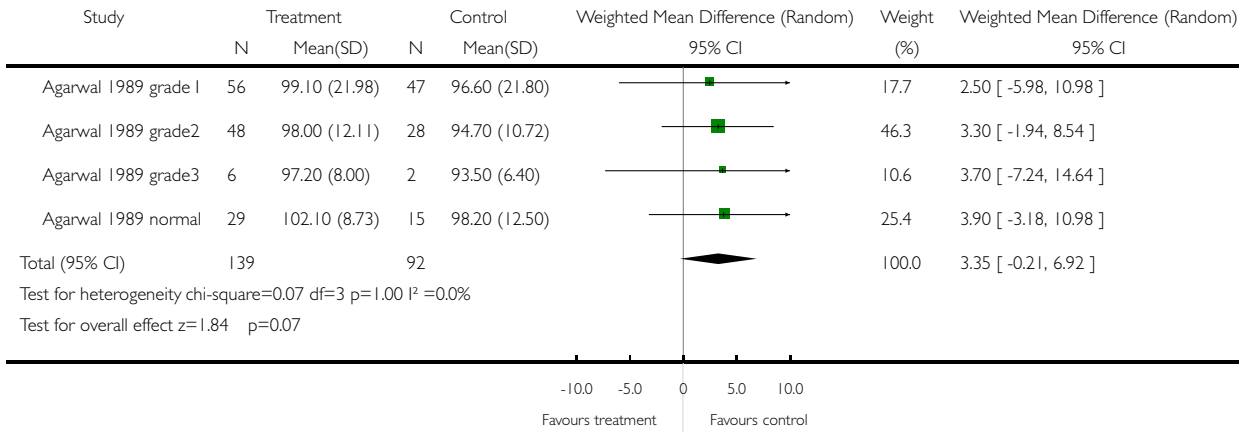


Analysis 03.28. Comparison 03 Developing country: School meal vs control. CBA, Outcome 28 Verbal IQ (separated): cluster size as in analysis: ICC= 0.15

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 03 Developing country: School meal vs control. CBA

Outcome: 28 Verbal IQ (separated): cluster size as in analysis: ICC= 0.15

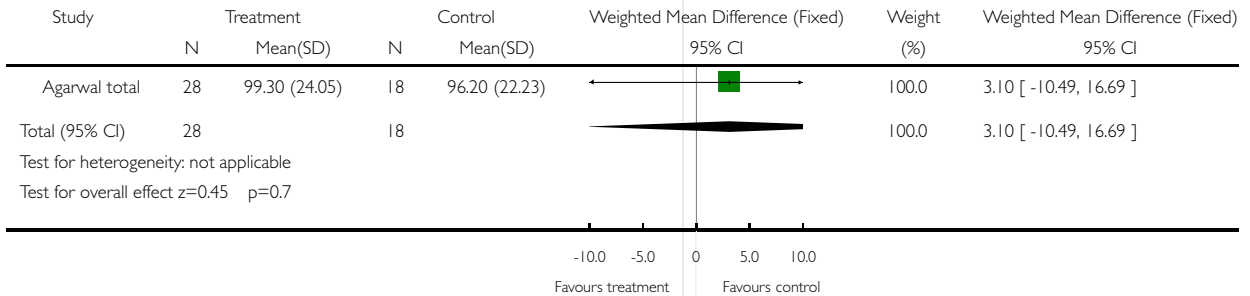


Analysis 03.29. Comparison 03 Developing country: School meal vs control. CBA, Outcome 29 Verbal IQ (total): adjusted- ICC 0.15

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

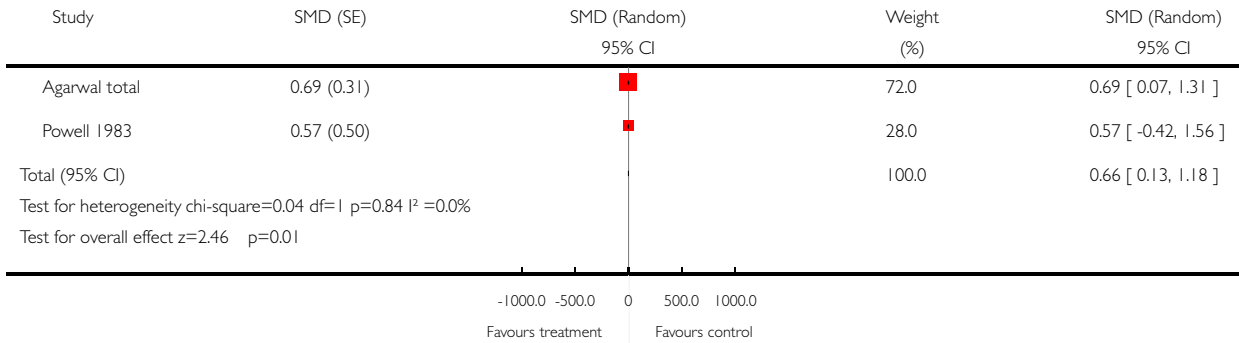
Comparison: 03 Developing country: School meal vs control. CBA

Outcome: 29 Verbal IQ (total): adjusted- ICC 0.15



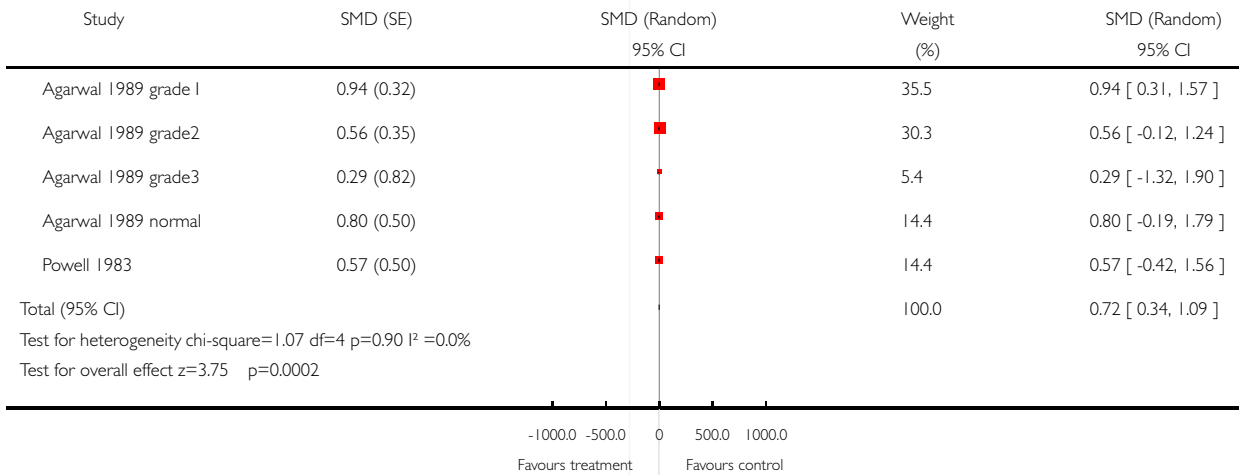
Analysis 03.34. Comparison 03 Developing country: School meal vs control. CBA, Outcome 34 Math Change - Overall - adjusted ICC 0.15

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 03 Developing country: School meal vs control. CBA
 Outcome: 34 Math Change - Overall - adjusted ICC 0.15



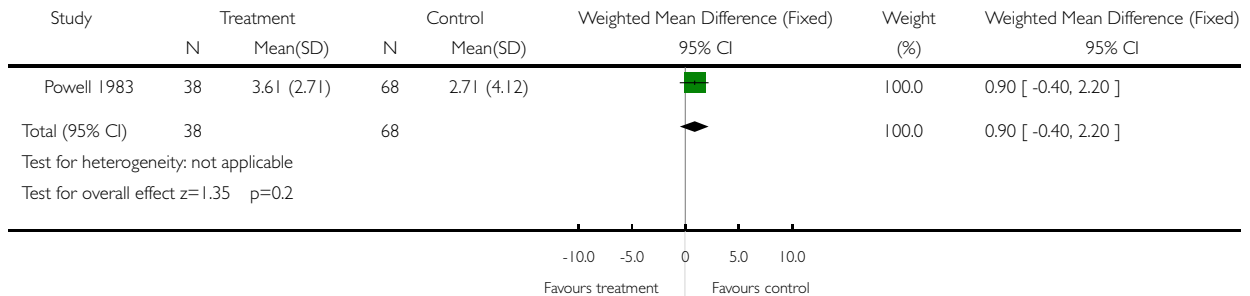
Analysis 03.35. Comparison 03 Developing country: School meal vs control. CBA, Outcome 35 Math Change : by nutritional status - Adjusted ICC 0.15

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 03 Developing country: School meal vs control. CBA
 Outcome: 35 Math Change : by nutritional status - Adjusted ICC 0.15



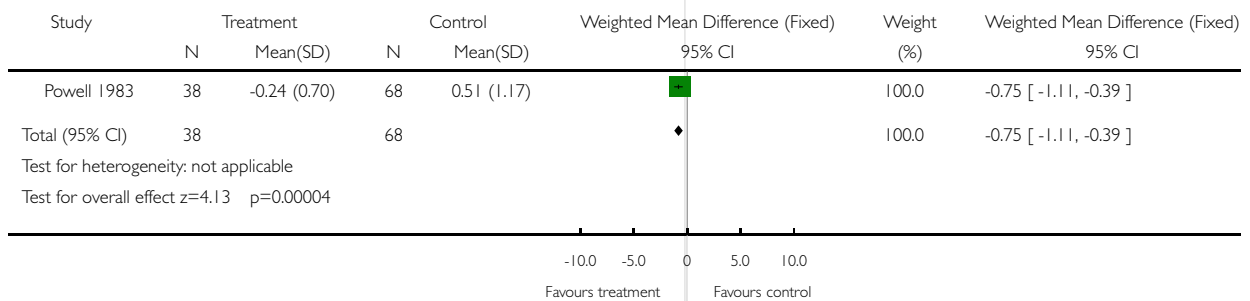
Analysis 03.36. Comparison 03 Developing country: School meal vs control. CBA, Outcome 36 Percent weight for age: ICC= .025

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 03 Developing country: School meal vs control. CBA
 Outcome: 36 Percent weight for age: ICC= .025



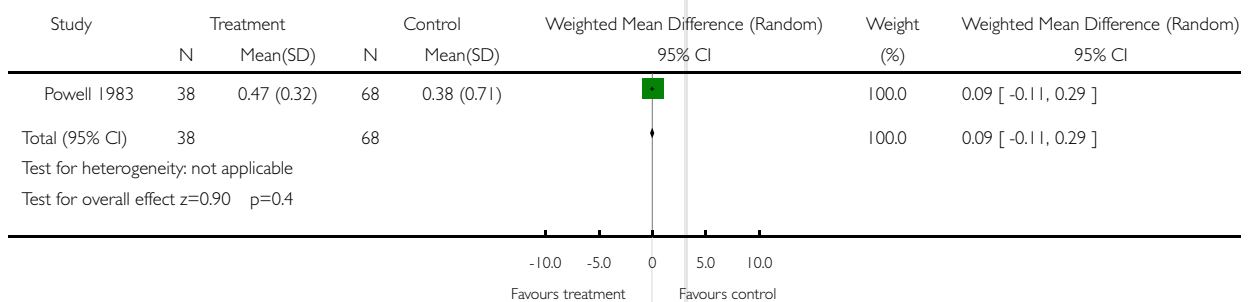
Analysis 03.40. Comparison 03 Developing country: School meal vs control. CBA, Outcome 40 Percent height for age: ICC= 0.016

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 03 Developing country: School meal vs control. CBA
 Outcome: 40 Percent height for age: ICC= 0.016



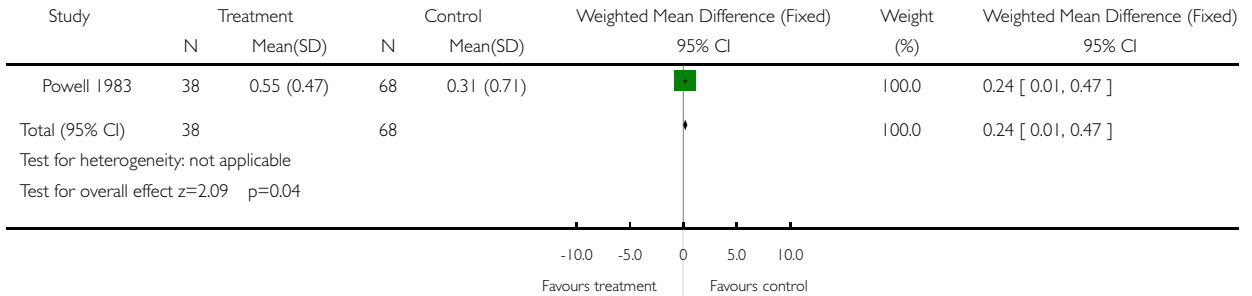
Analysis 03.44. Comparison 03 Developing country: School meal vs control. CBA, Outcome 44 Change in reading: ICC= .15

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 03 Developing country: School meal vs control. CBA
 Outcome: 44 Change in reading: ICC= .15



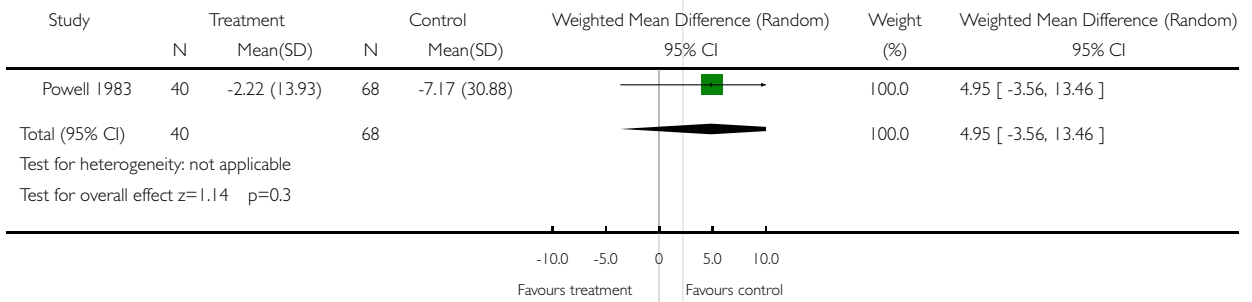
Analysis 03.47. Comparison 03 Developing country: School meal vs control. CBA, Outcome 47 change in spelling: ICC= .15

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 03 Developing country: School meal vs control. CBA
 Outcome: 47 change in spelling: ICC= .15



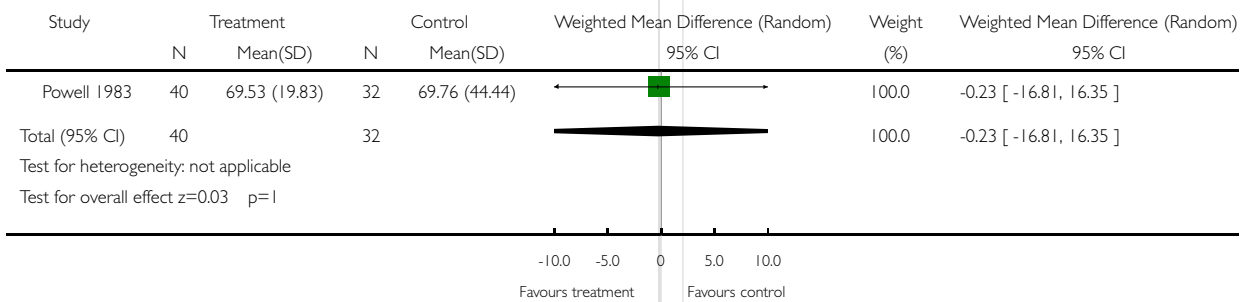
Analysis 03.56. Comparison 03 Developing country: School meal vs control. CBA, Outcome 56 change in attendance: icc = .15

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 03 Developing country: School meal vs control. CBA
 Outcome: 56 change in attendance: icc = .15



Analysis 03.57. Comparison 03 Developing country: School meal vs control. CBA, Outcome 57 End of study: attendance: icc = .15

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 03 Developing country: School meal vs control. CBA
 Outcome: 57 End of study: attendance: icc = .15

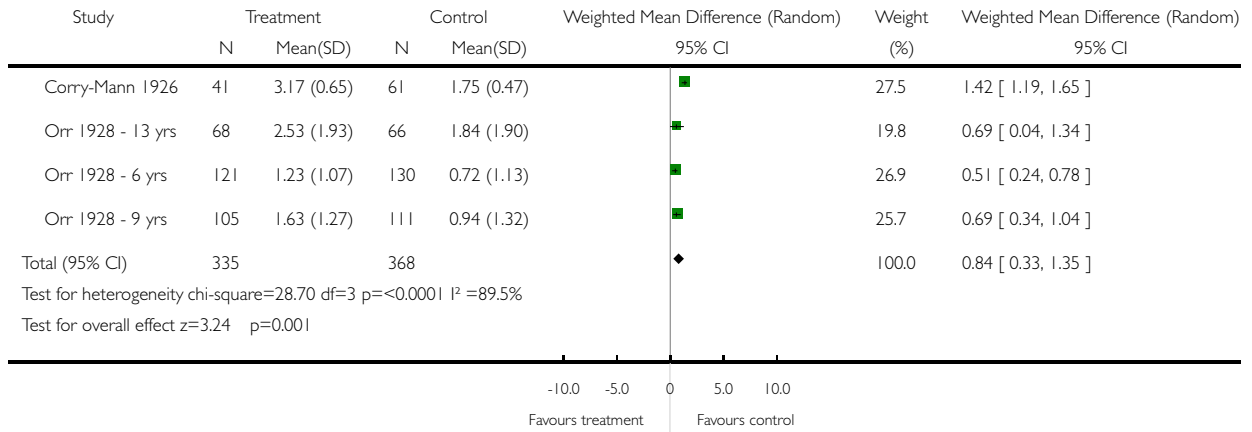


Analysis 04.01. Comparison 04 developed country: school meal versus control: CBA, Outcome 01 Weight gain in kg.- adjusted icc =0.025. Leighton used for Orr

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 04 developed country: school meal versus control: CBA

Outcome: 01 Weight gain in kg.- adjusted icc =0.025. Leighton used for Orr

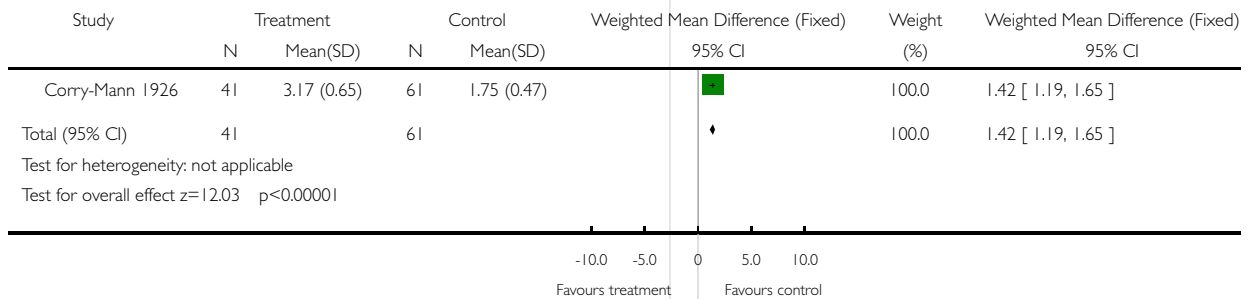


Analysis 04.02. Comparison 04 developed country: school meal versus control: CBA, Outcome 02 Weight gain: Corry-Mann alone

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 04 developed country: school meal versus control: CBA

Outcome: 02 Weight gain: Corry-Mann alone

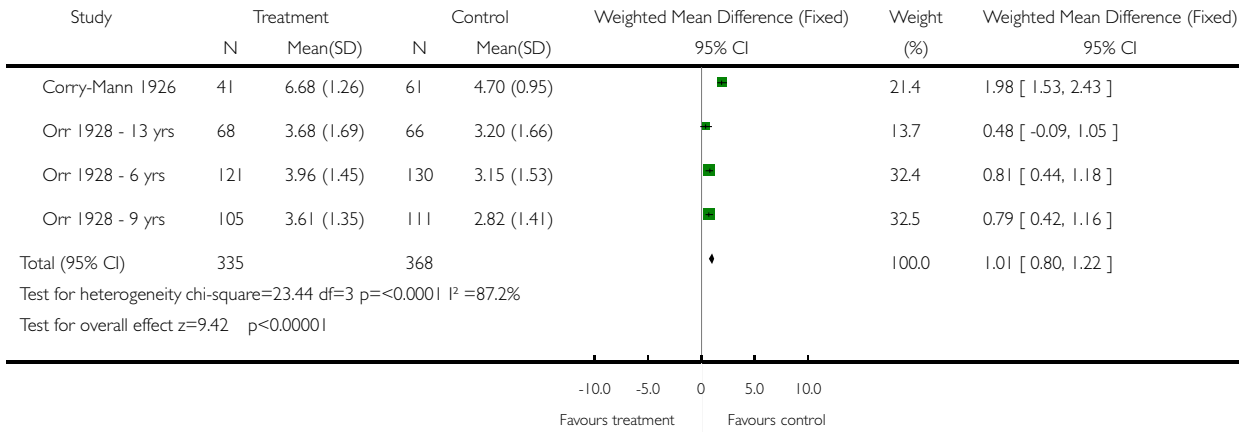


Analysis 04.06. Comparison 04 developed country: school meal versus control: CBA, Outcome 06 Height gain in cm. Adjusted with Icc = 0.016. Leighton used for Orr

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 04 developed country: school meal versus control: CBA

Outcome: 06 Height gain in cm. Adjusted with Icc = 0.016. Leighton used for Orr

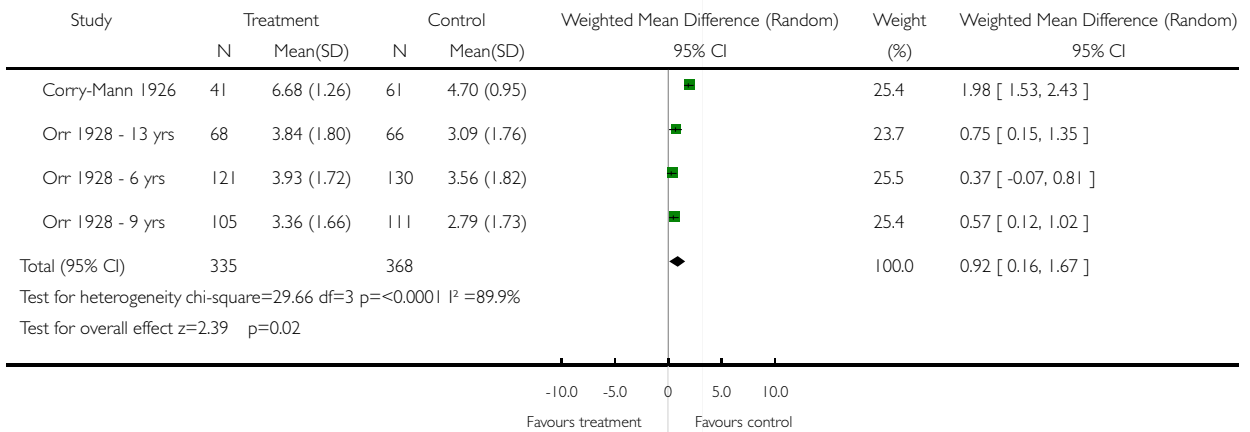


Analysis 04.07. Comparison 04 developed country: school meal versus control: CBA, Outcome 07 Height gain in cm. adjusted ICC=0.016

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 04 developed country: school meal versus control: CBA

Outcome: 07 Height gain in cm. adjusted ICC=0.016

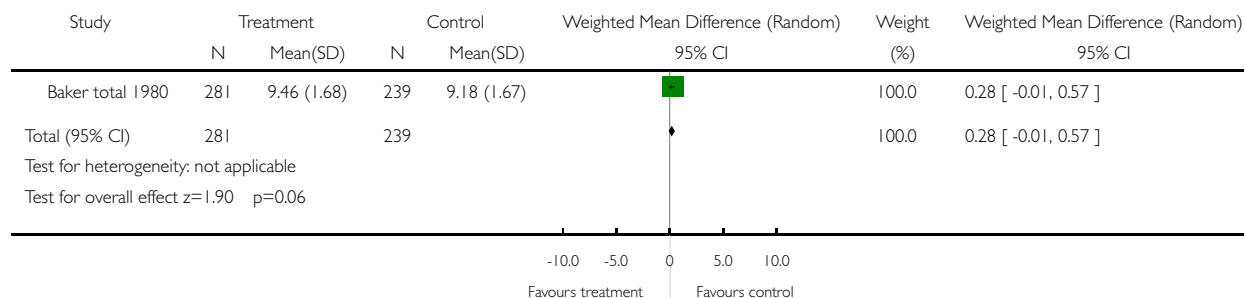


Analysis 05.01. Comparison 05 Developed country: School meal vs control RCT, Outcome 01 change in height

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 05 Developed country: School meal vs control RCT

Outcome: 01 change in height

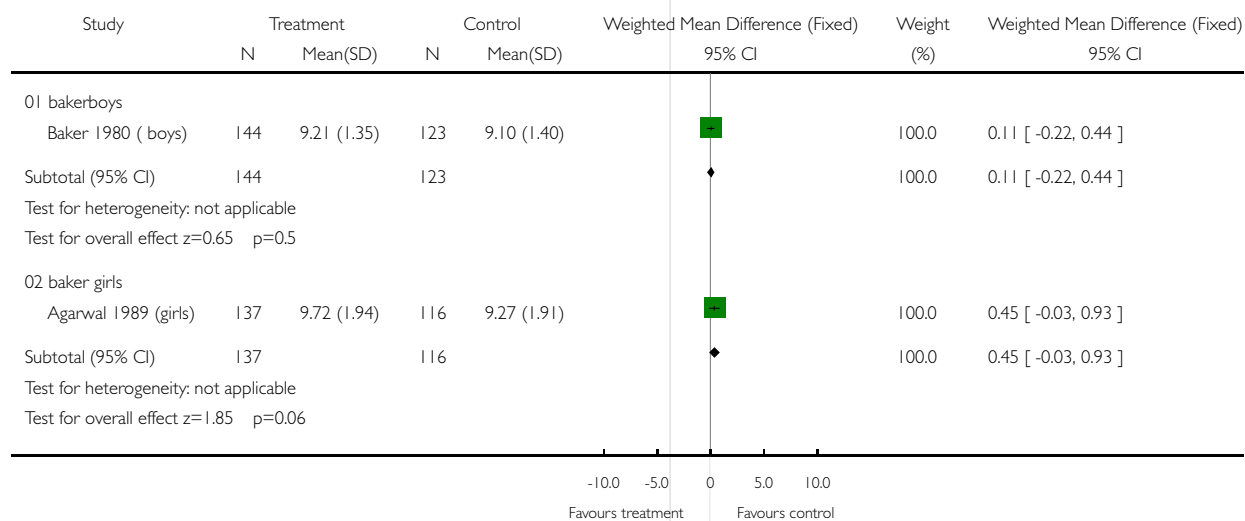


Analysis 05.02. Comparison 05 Developed country: School meal vs control RCT, Outcome 02 Subgroup analysis: height by sex

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

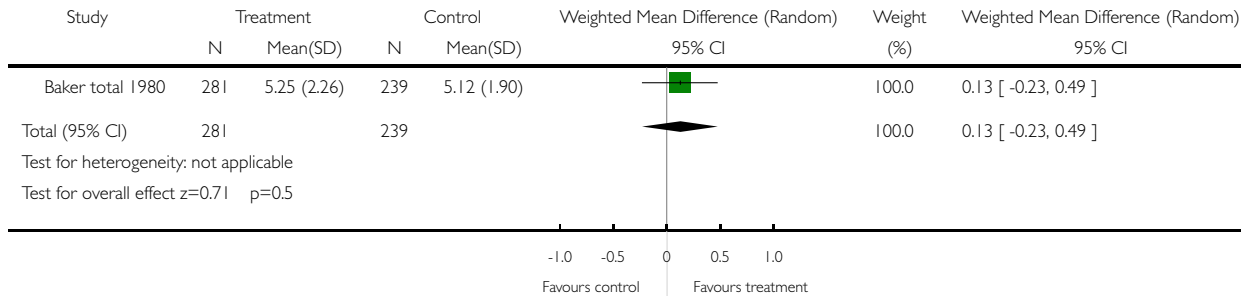
Comparison: 05 Developed country: School meal vs control RCT

Outcome: 02 Subgroup analysis: height by sex



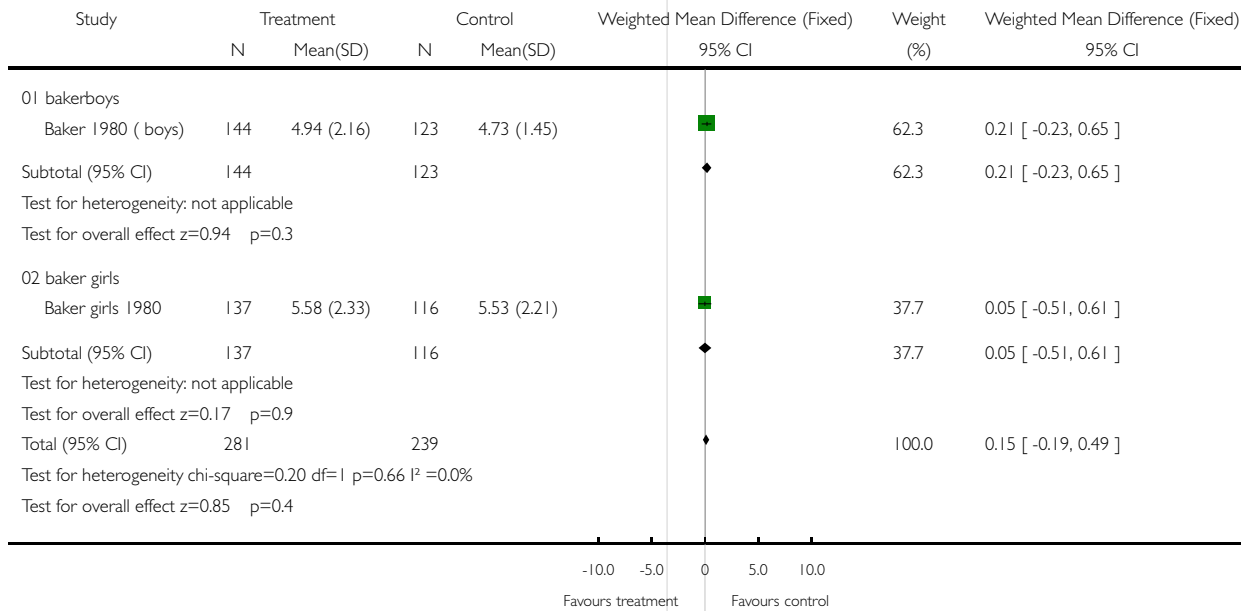
Analysis 05.03. Comparison 05 Developed country: School meal vs control RCT, Outcome 03 change in weight (kg)

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 05 Developed country: School meal vs control RCT
 Outcome: 03 change in weight (kg)



Analysis 05.04. Comparison 05 Developed country: School meal vs control RCT, Outcome 04 Subgroup analysis: weight by sex

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 05 Developed country: School meal vs control RCT
 Outcome: 04 Subgroup analysis: weight by sex

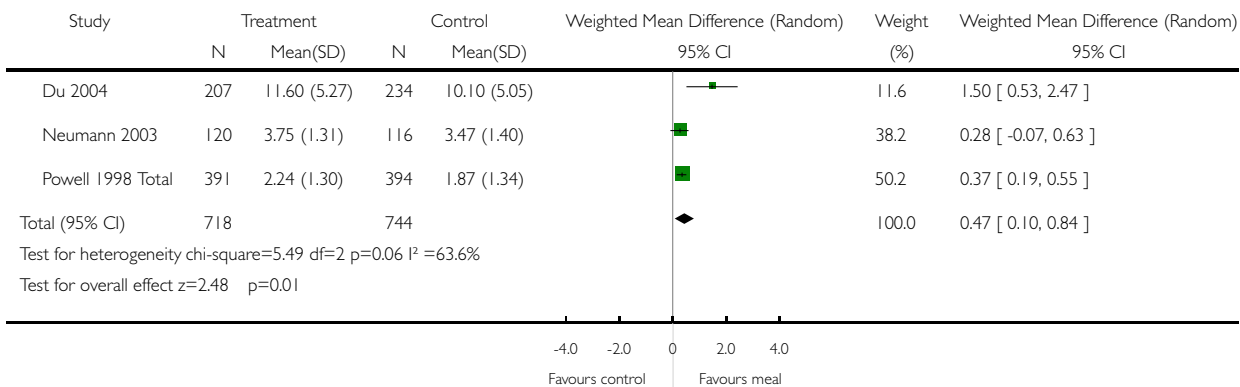


Analysis 10.05. Comparison 10 Developing country: School meal vs control. RCT- Sensitivity, Outcome 05
Weight gain kg- sensitivity ICC 0.01

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 10 Developing country: School meal vs control. RCT- Sensitivity

Outcome: 05 Weight gain kg- sensitivity ICC 0.01

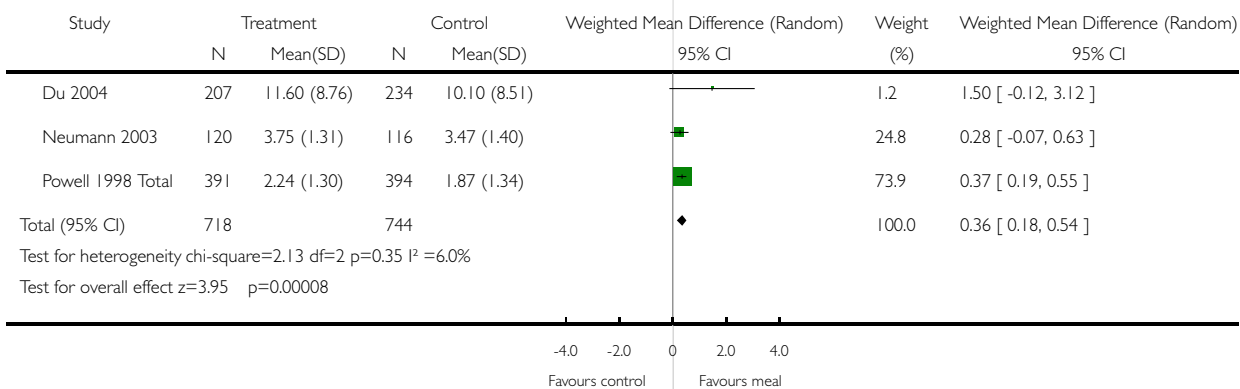


Analysis 10.06. Comparison 10 Developing country: School meal vs control. RCT- Sensitivity, Outcome 06
Weight gain kg- sensitivity ICC 0.05

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

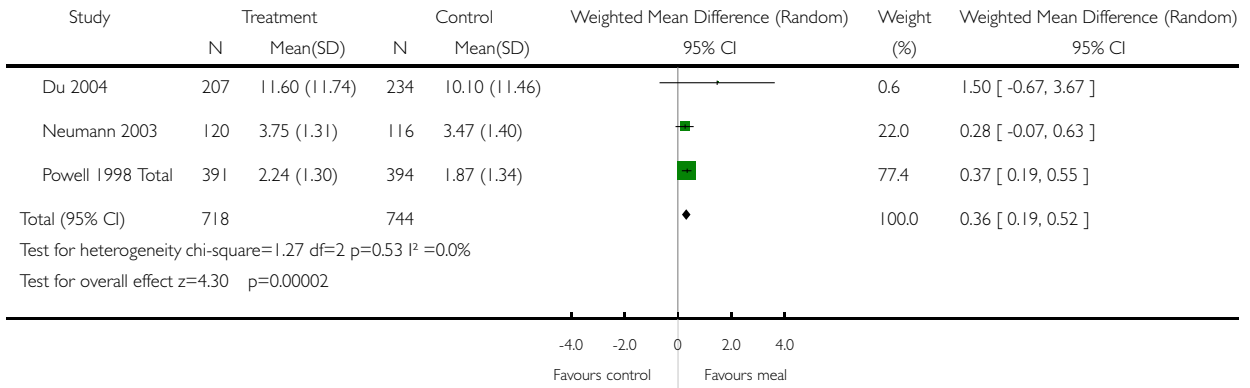
Comparison: 10 Developing country: School meal vs control. RCT- Sensitivity

Outcome: 06 Weight gain kg- sensitivity ICC 0.05



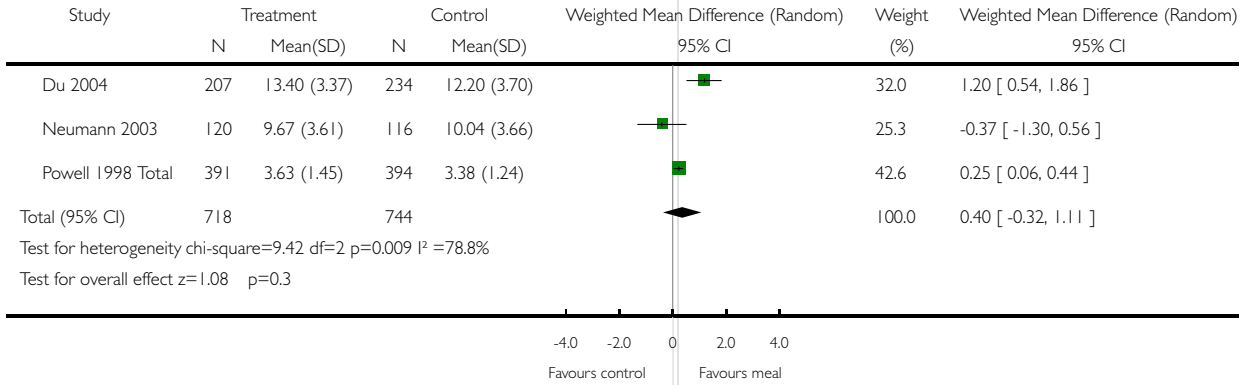
Analysis 10.07. Comparison 10 Developing country: School meal vs control. RCT- Sensitivity, Outcome 07 Weight gain kg- sensitivity ICC 0.1

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 10 Developing country: School meal vs control. RCT- Sensitivity
 Outcome: 07 Weight gain kg- sensitivity ICC 0.1



Analysis 10.09. Comparison 10 Developing country: School meal vs control. RCT- Sensitivity, Outcome 09 Height gain (cm), sensitivity ICC 0.01

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 10 Developing country: School meal vs control. RCT- Sensitivity
 Outcome: 09 Height gain (cm), sensitivity ICC 0.01

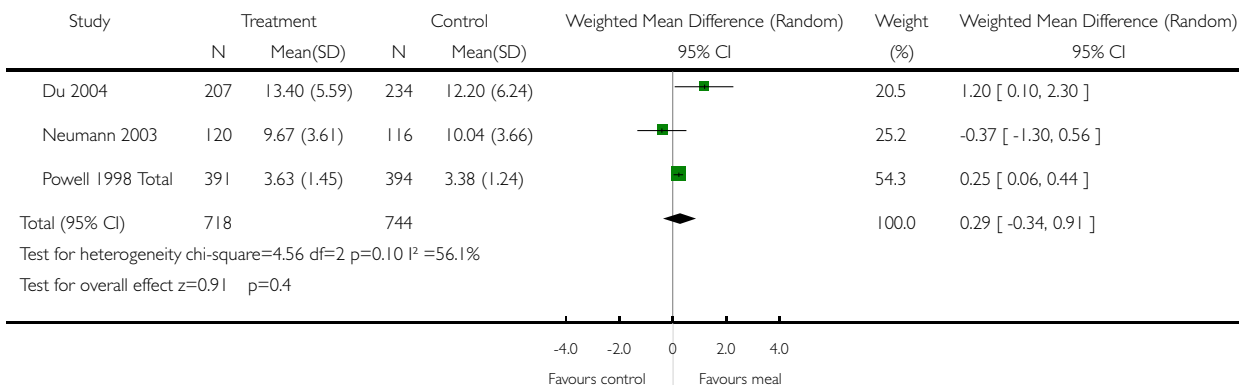


Analysis 10.10. Comparison 10 Developing country: School meal vs control. RCT- Sensitivity, Outcome 10 Height gain (cm), sensitivity ICC 0.05

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 10 Developing country: School meal vs control. RCT- Sensitivity

Outcome: 10 Height gain (cm), sensitivity ICC 0.05

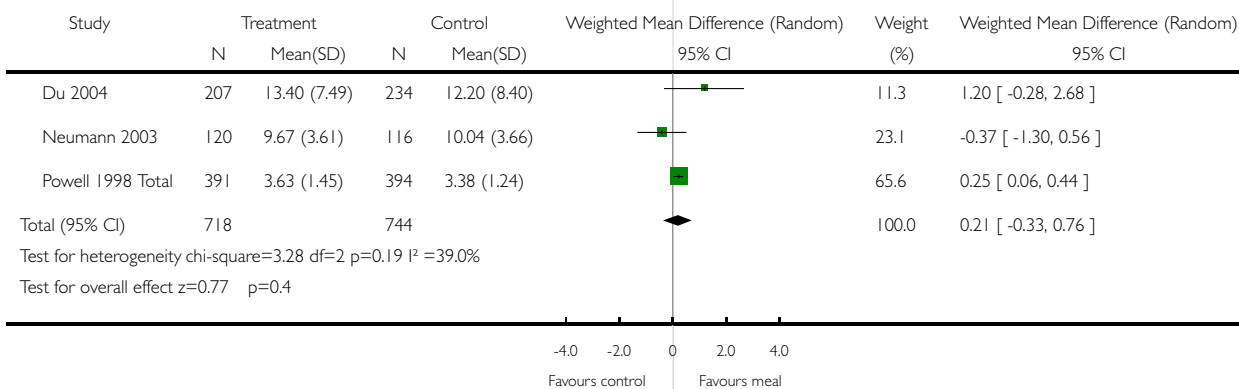


Analysis 10.11. Comparison 10 Developing country: School meal vs control. RCT- Sensitivity, Outcome 11 Height gain (cm), sensitivity ICC 0.1

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

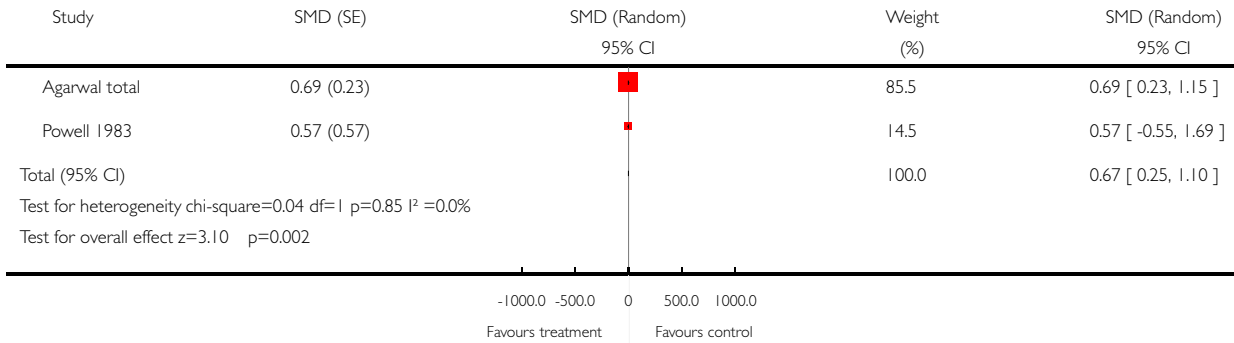
Comparison: 10 Developing country: School meal vs control. RCT- Sensitivity

Outcome: 11 Height gain (cm), sensitivity ICC 0.1



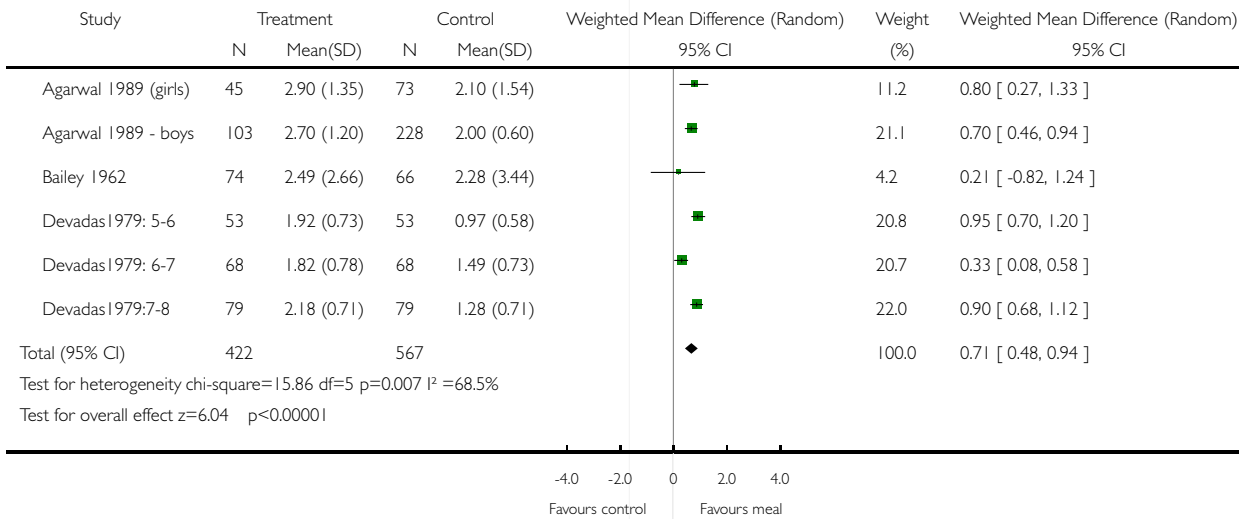
**Analysis 11.01. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 01
Math change - overall sensitivity - ICC 0.2**

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
 Outcome: 01 Math change - overall sensitivity - ICC 0.2



**Analysis 11.02. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 02
Weight gain kg- sensitivity ICC 0.01**

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
 Outcome: 02 Weight gain kg- sensitivity ICC 0.01

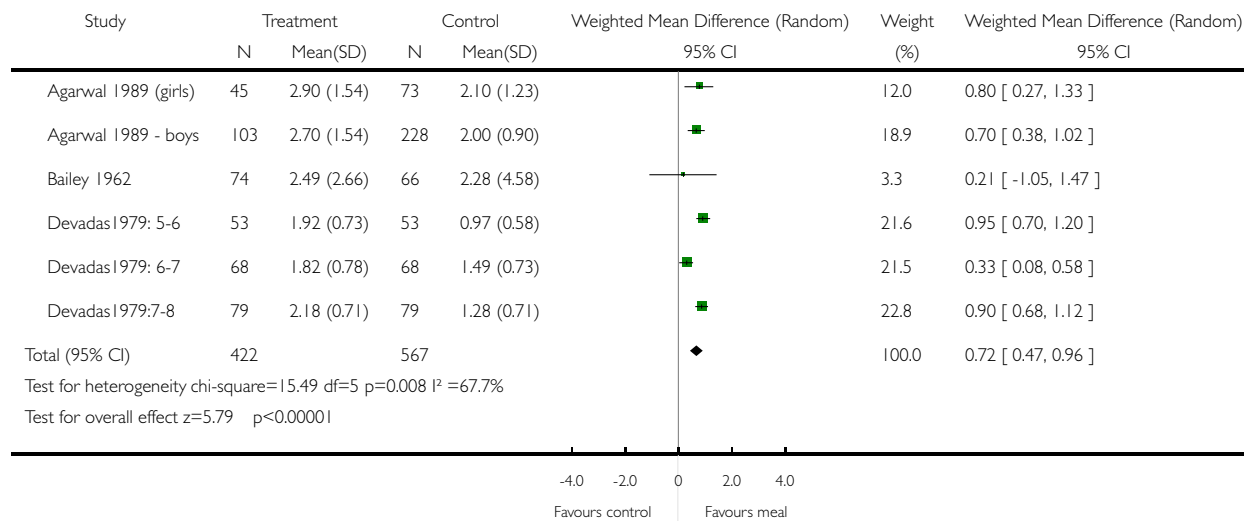


**Analysis 11.03. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 03
Weight gain kg- sensitivity ICC 0.05**

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity

Outcome: 03 Weight gain kg- sensitivity ICC 0.05

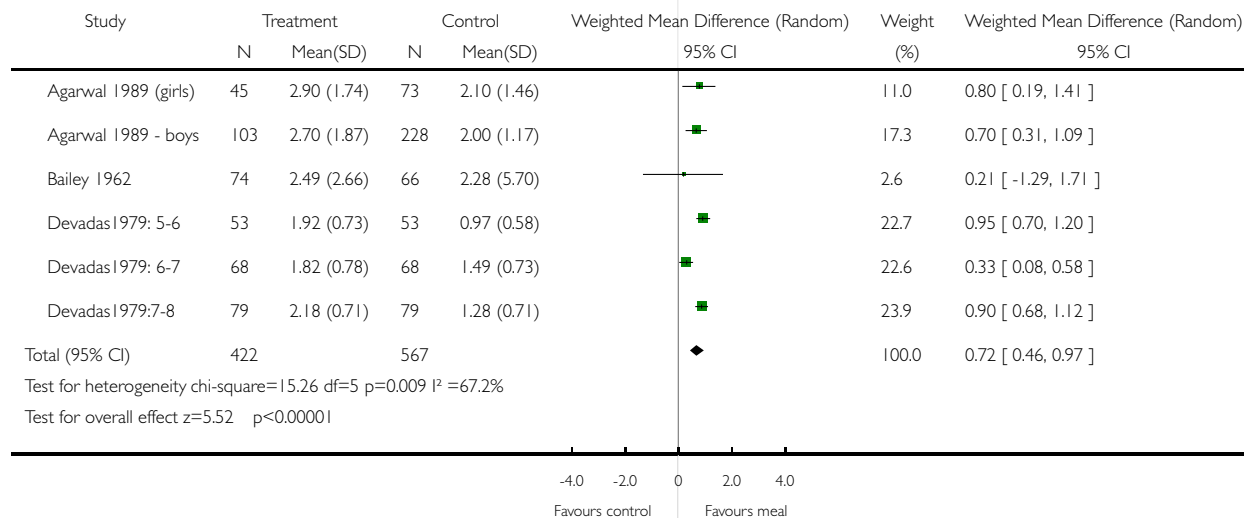


**Analysis 11.04. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 04
Weight gain kg- sensitivity ICC 0.1**

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

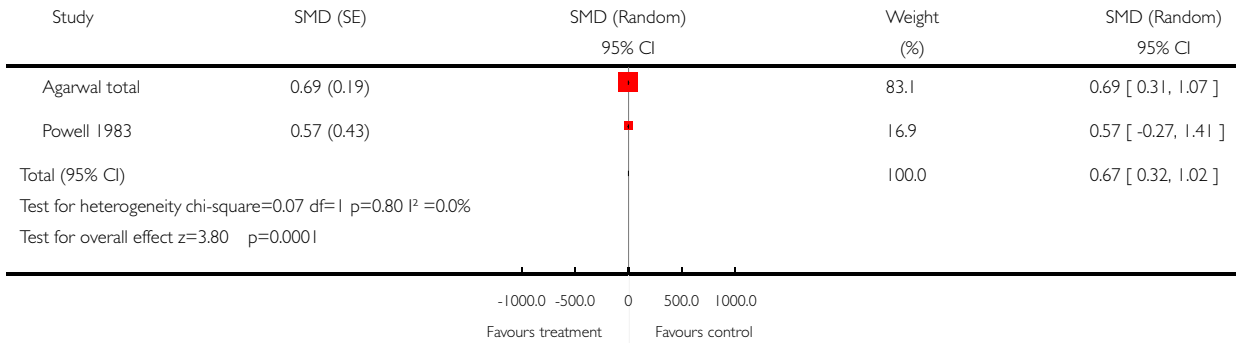
Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity

Outcome: 04 Weight gain kg- sensitivity ICC 0.1



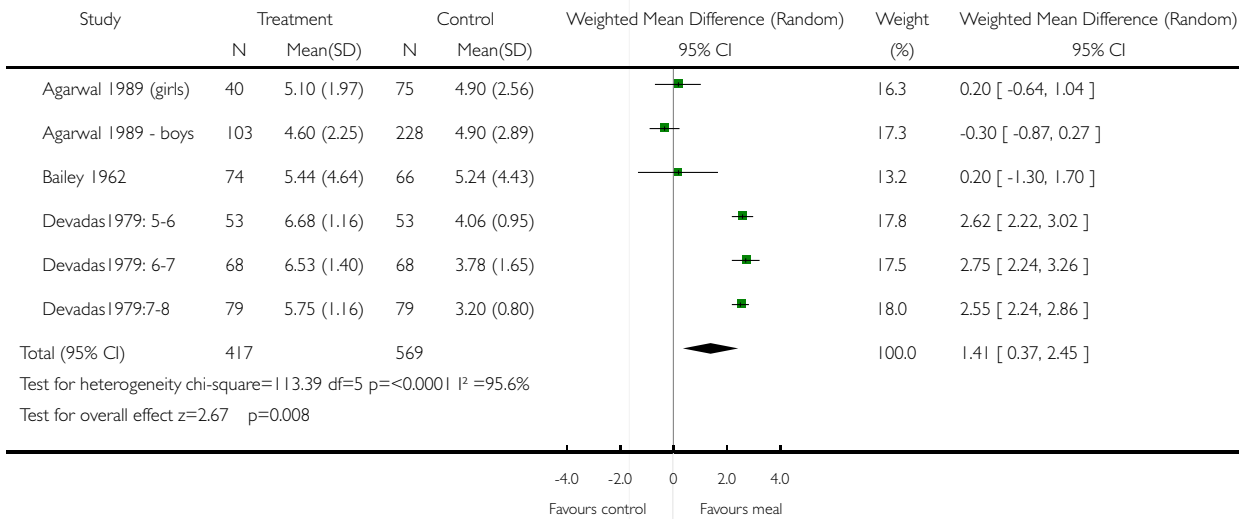
Analysis 11.05. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 05 Math change - overall sensitivity - ICC 0.1

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
 Outcome: 05 Math change - overall sensitivity - ICC 0.1



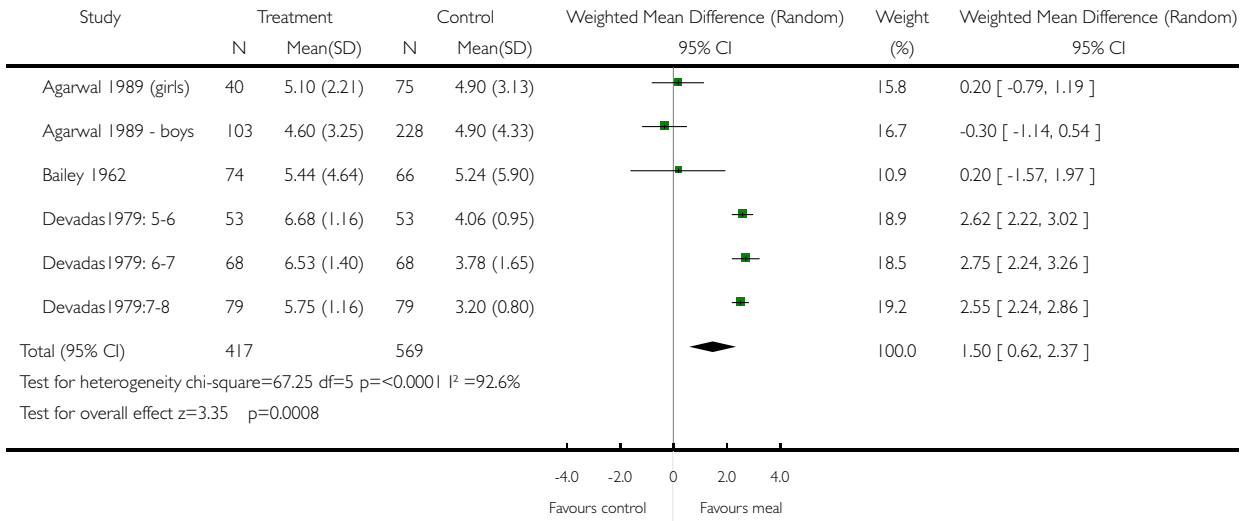
Analysis 11.06. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 06 Height gain (cm)- sensitivity ICC 0.01

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
 Outcome: 06 Height gain (cm)- sensitivity ICC 0.01



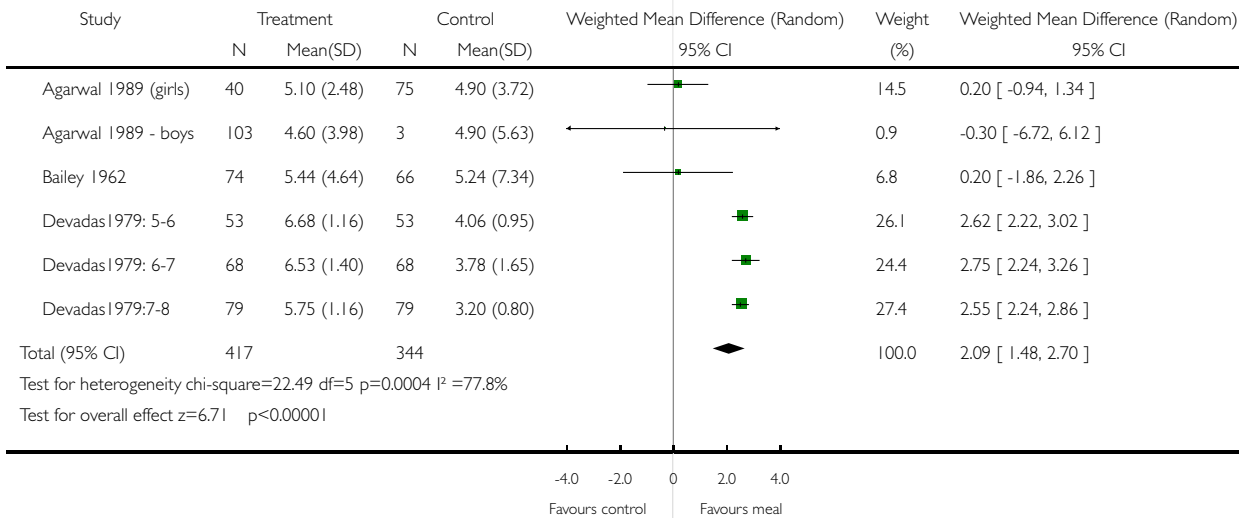
**Analysis 11.07. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 07
Height gain (cm)- sensitivity ICC 0.05**

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
Outcome: 07 Height gain (cm)- sensitivity ICC 0.05



**Analysis 11.08. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 08
Height gain (cm)- sensitivity ICC 0.1**

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
Outcome: 08 Height gain (cm)- sensitivity ICC 0.1

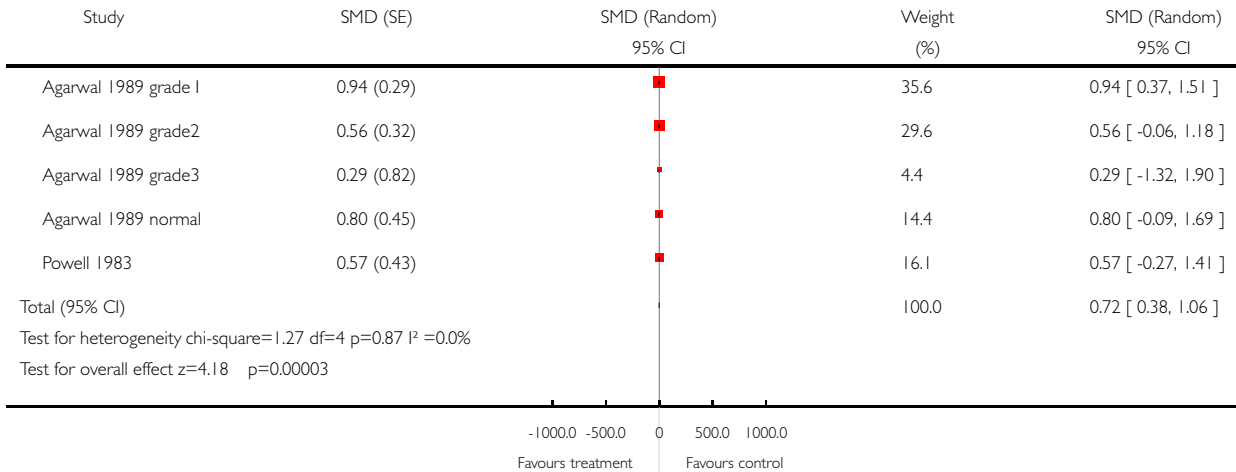


Analysis 11.09. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 09 Math (change): by nutritional status - sensitivity ICC 0.1

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity

Outcome: 09 Math (change): by nutritional status - sensitivity ICC 0.1

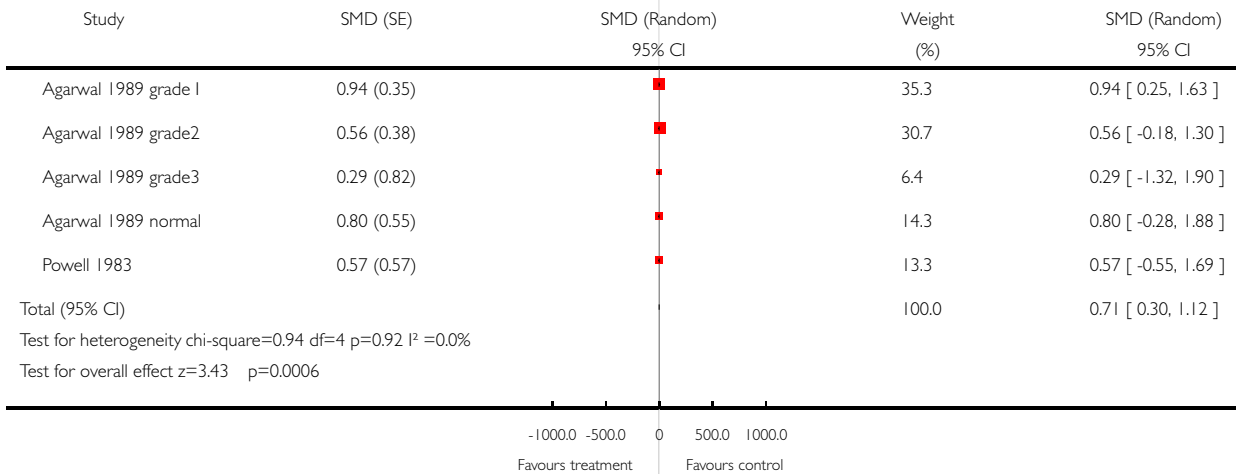


Analysis 11.10. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 10 Math (change): by nutritional status - sensitivity ICC 0.2

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity

Outcome: 10 Math (change): by nutritional status - sensitivity ICC 0.2

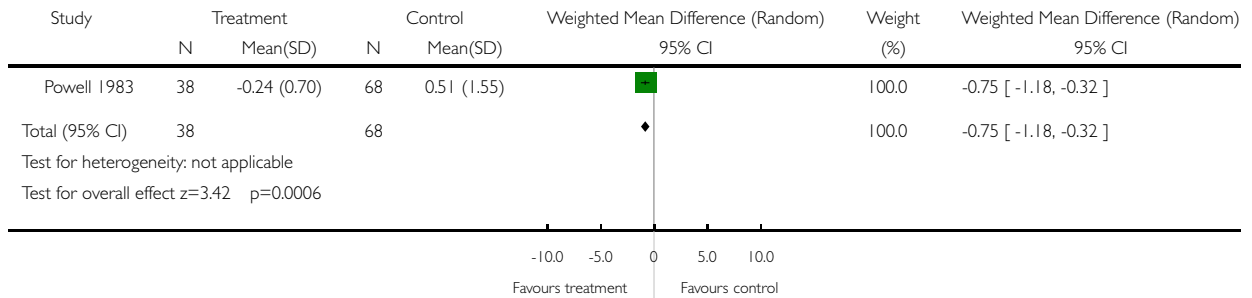


**Analysis 11.11. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 11
Percent height for age: $icc = 0.05$**

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity

Outcome: 11 Percent height for age: $icc = 0.05$

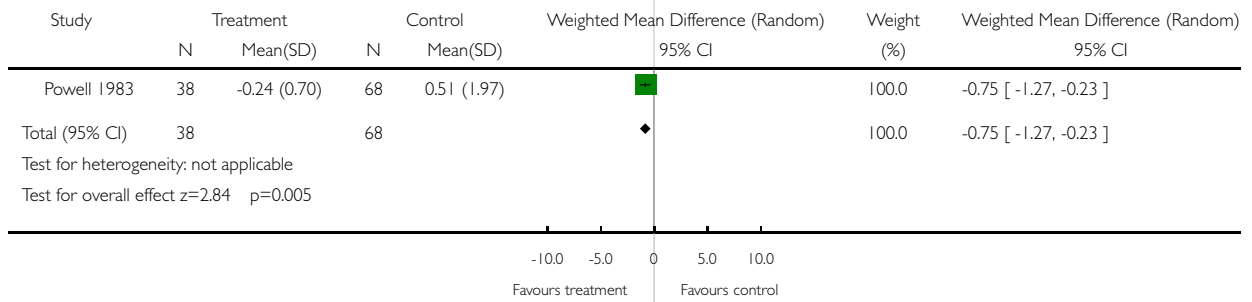


**Analysis 11.12. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 12
Percent height for age: $icc = .1$**

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity

Outcome: 12 Percent height for age: $icc = .1$

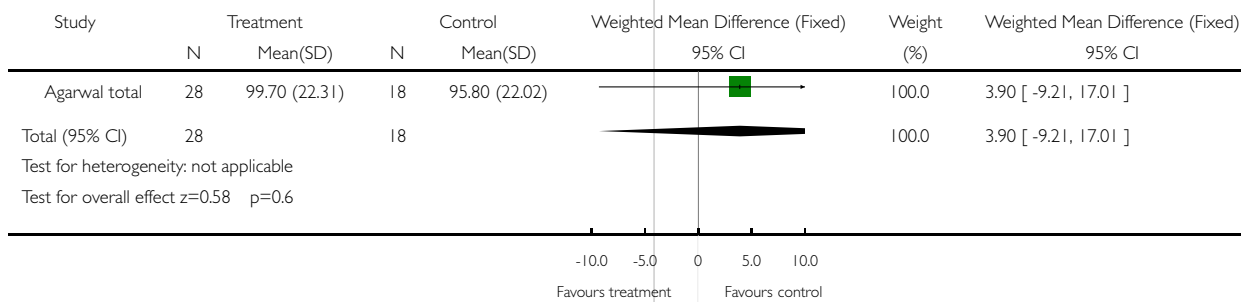


**Analysis 11.14. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 14
Full scale IQ (total)- sensitivity 0.1**

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity

Outcome: 14 Full scale IQ (total)- sensitivity 0.1

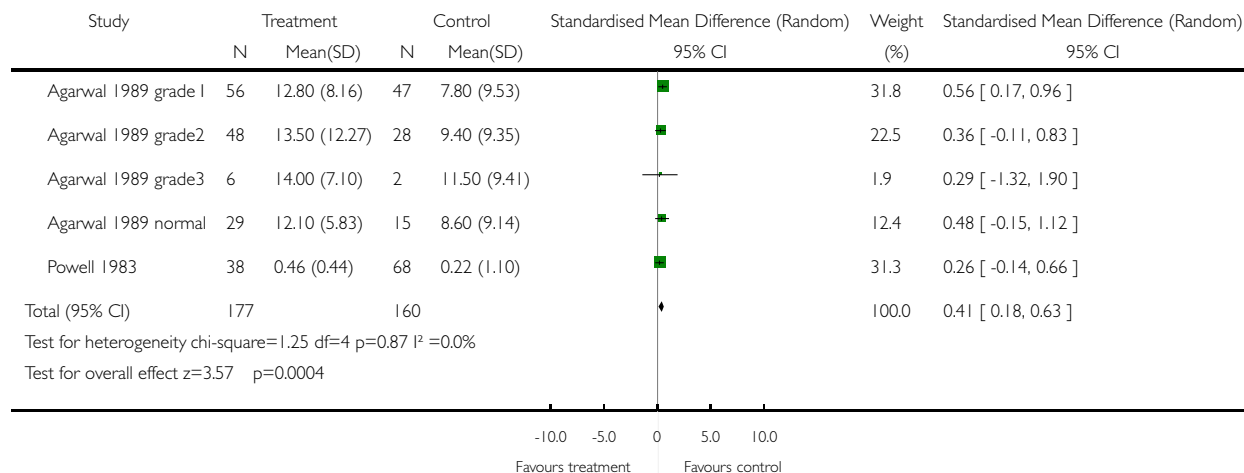


Analysis 11.16. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 16 Math (change) : cluster size as in analysis Sensitivity ICC=0.2

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity

Outcome: 16 Math (change) : cluster size as in analysis Sensitivity ICC=0.2

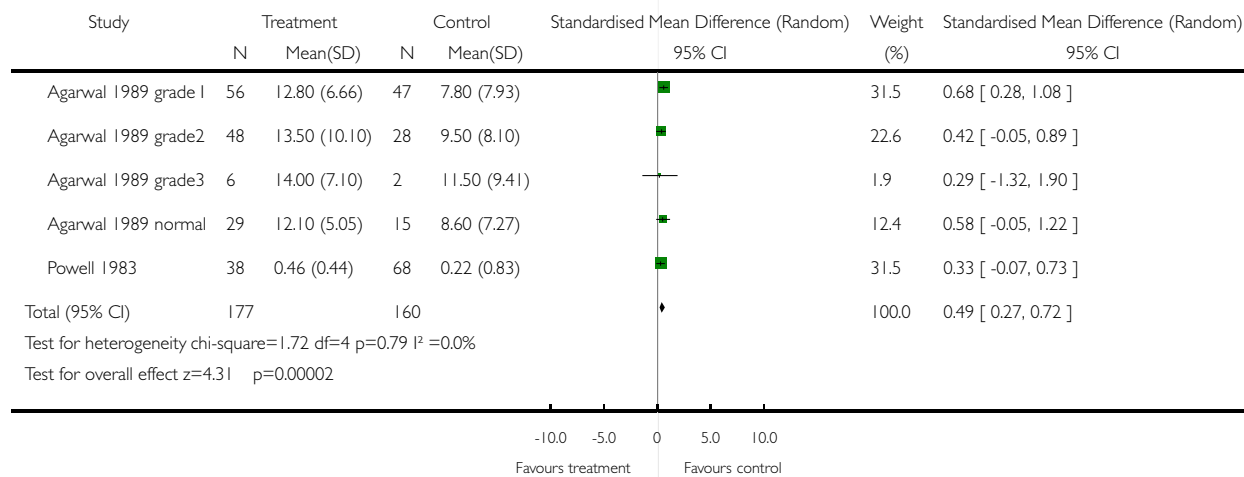


Analysis 11.17. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 17 Math (change) : cluster size as in analysis Sensitivity ICC=0.1

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

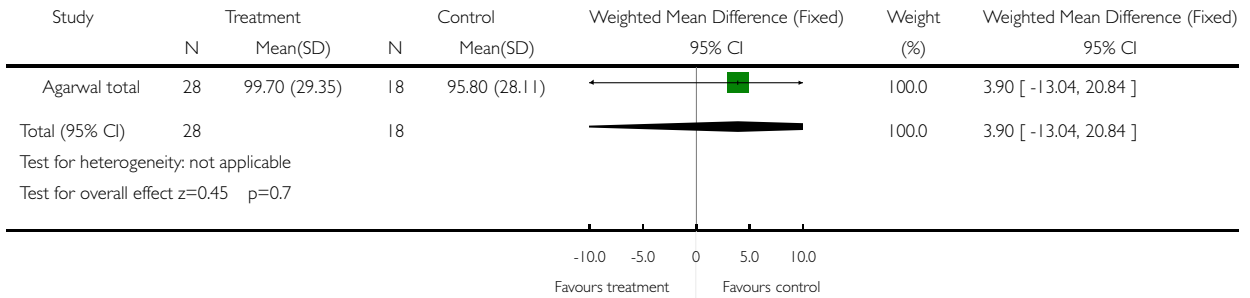
Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity

Outcome: 17 Math (change) : cluster size as in analysis Sensitivity ICC=0.1



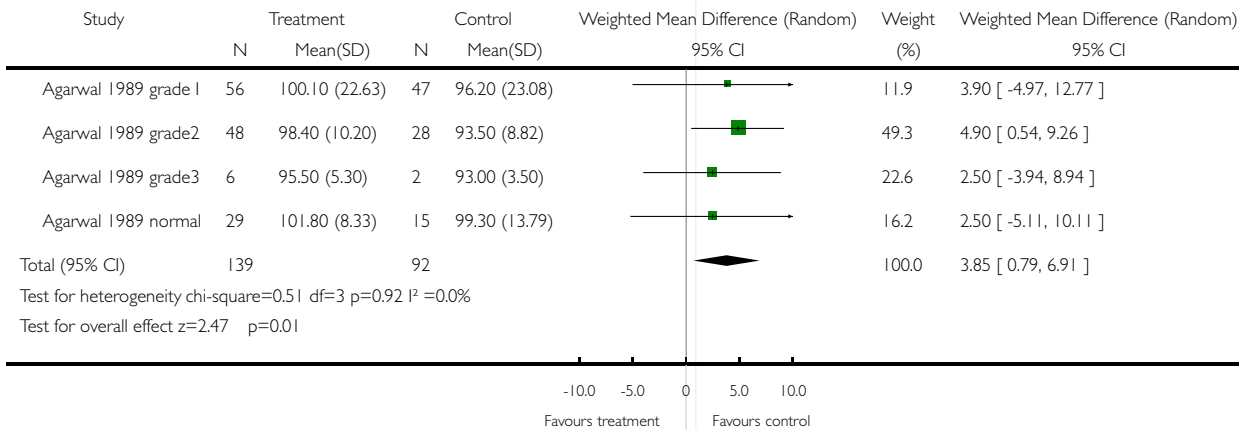
Analysis 11.18. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 18 Full scale IQ (total)- sensitivity 0.20

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
 Outcome: 18 Full scale IQ (total)- sensitivity 0.20



Analysis 11.20. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 20 Full scale IQ (end study): sensitivity cluster size as in analysis ICC= 0.1

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
 Outcome: 20 Full scale IQ (end study): sensitivity cluster size as in analysis ICC= 0.1

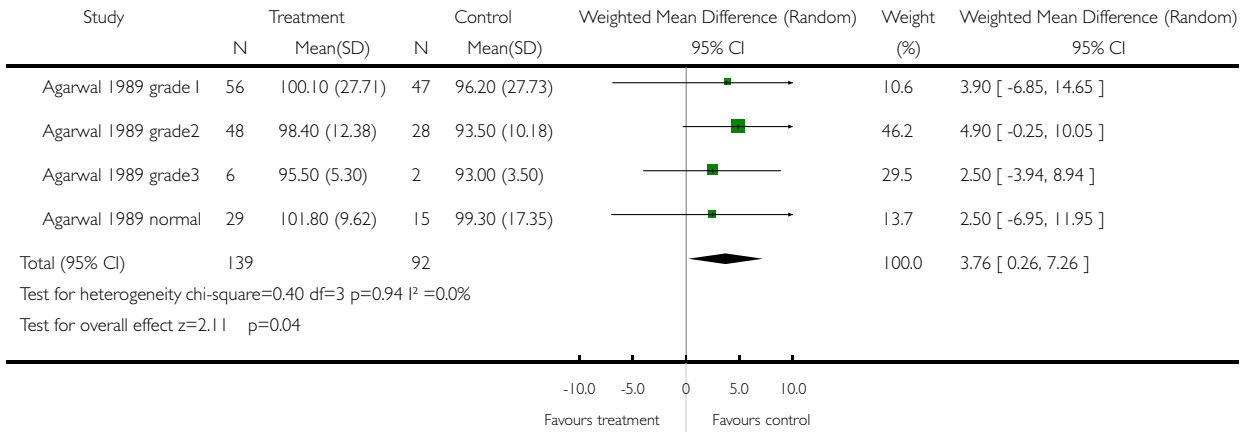


Analysis 11.22. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 22 Full scale IQ (end study): sensitivity cluster size as in analysis: ICC = 0.2

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity

Outcome: 22 Full scale IQ (end study): sensitivity cluster size as in analysis: ICC = 0.2

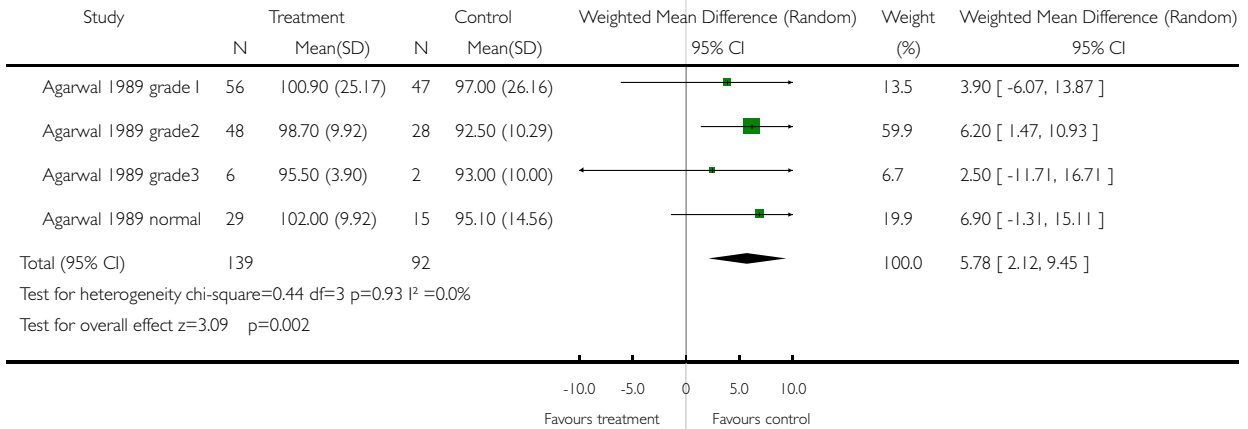


Analysis 11.23. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 23 Performance IQ (end study): Sensitivity cluster size as in analysis: ICC= 0.1

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity

Outcome: 23 Performance IQ (end study): Sensitivity cluster size as in analysis: ICC= 0.1

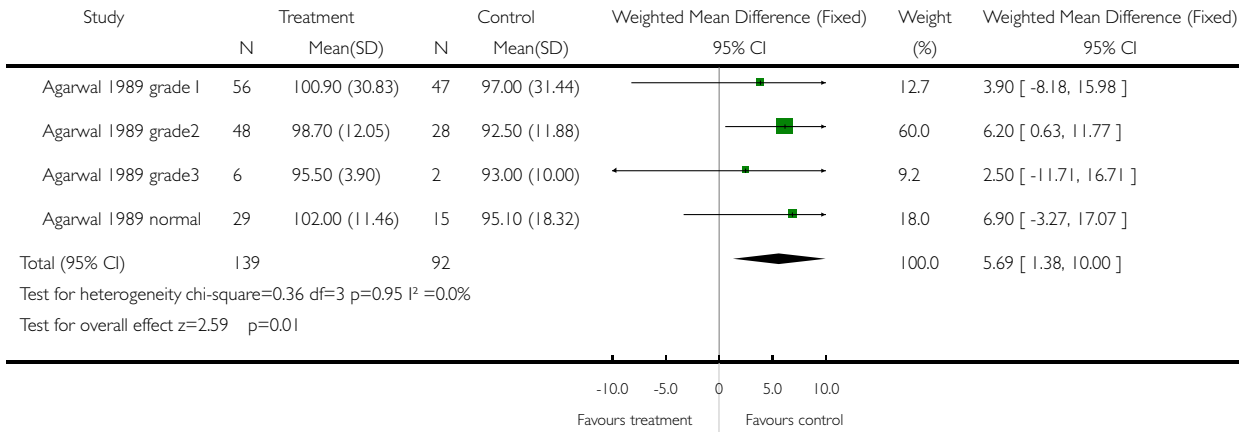


Analysis 11.25. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 25 Performance IQ (end study): Sensitivity cluster size as in analysis: ICC = 0.2

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity

Outcome: 25 Performance IQ (end study): Sensitivity cluster size as in analysis: ICC = 0.2

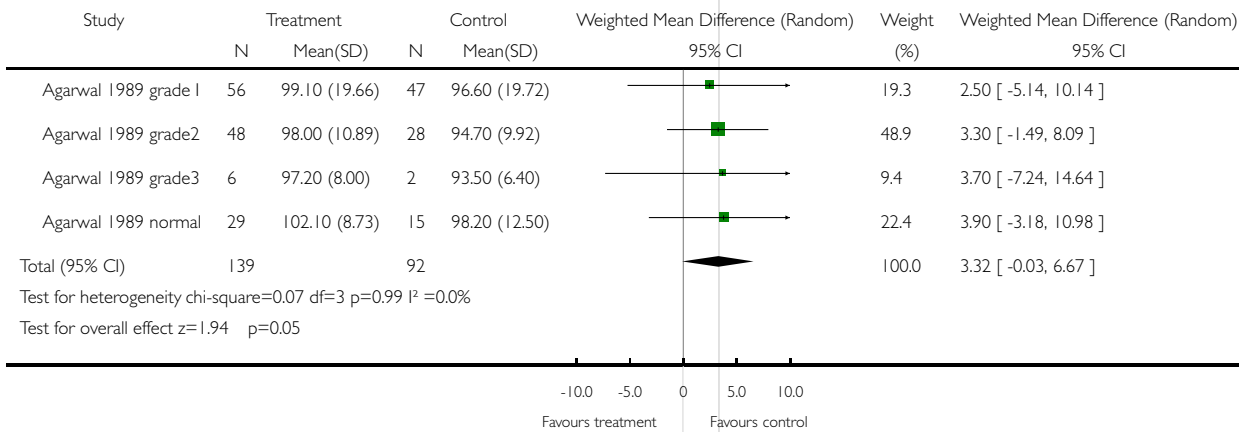


Analysis 11.27. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 27 Verbal IQ (end study): Sensitivity cluster size as in analyses: ICC = 0.1

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity

Outcome: 27 Verbal IQ (end study): Sensitivity cluster size as in analyses: ICC = 0.1

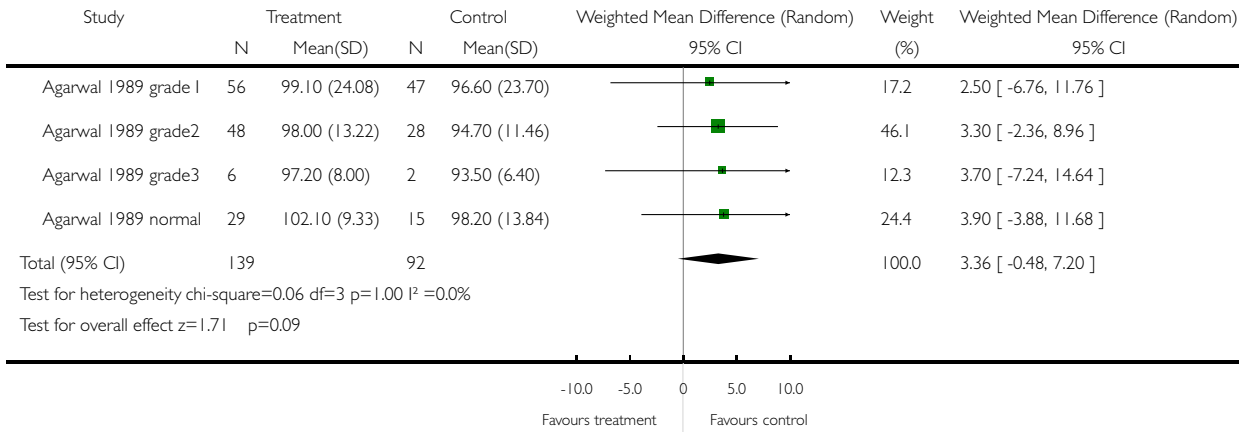


Analysis 11.29. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 29 Verbal IQ (end study): Sensitivity cluster size as in analysis: ICC = 0.2

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity

Outcome: 29 Verbal IQ (end study): Sensitivity cluster size as in analysis: ICC = 0.2

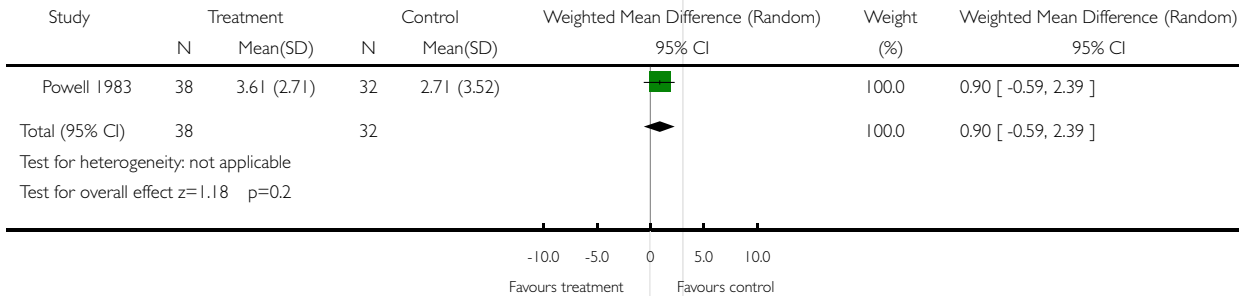


Analysis 11.30. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 30 Percentage standard weight. Sensitivity = 0.01

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

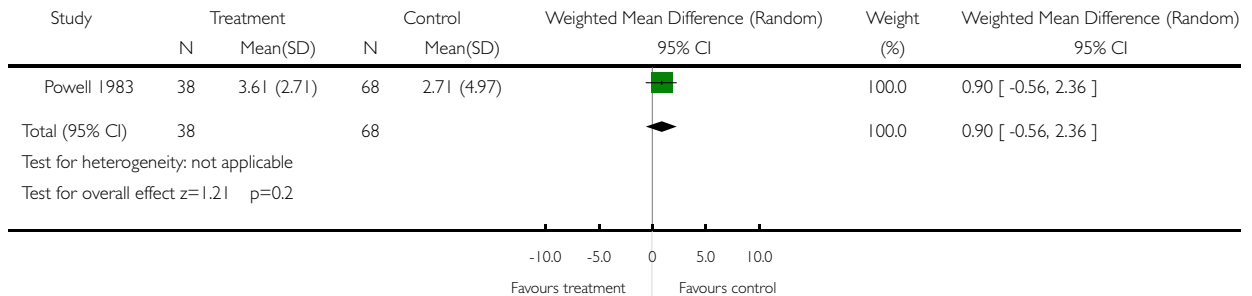
Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity

Outcome: 30 Percentage standard weight. Sensitivity = 0.01



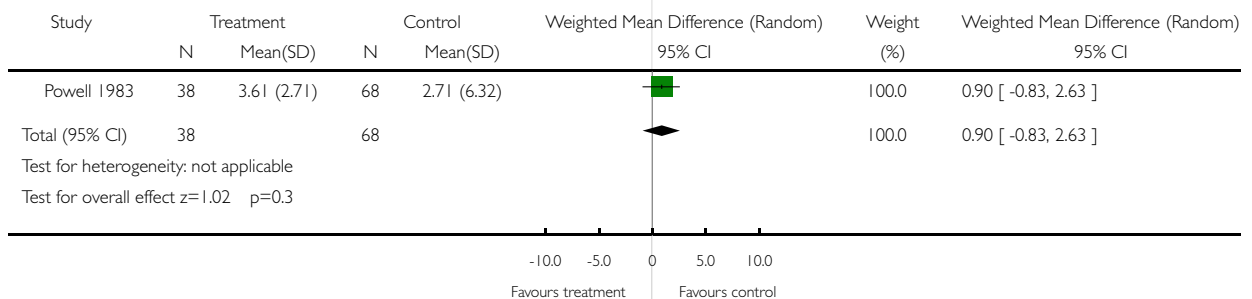
**Analysis 11.32. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 32
Percent weight for age: Sensitivity ICC= 0.05**

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
 Outcome: 32 Percent weight for age: Sensitivity ICC= 0.05



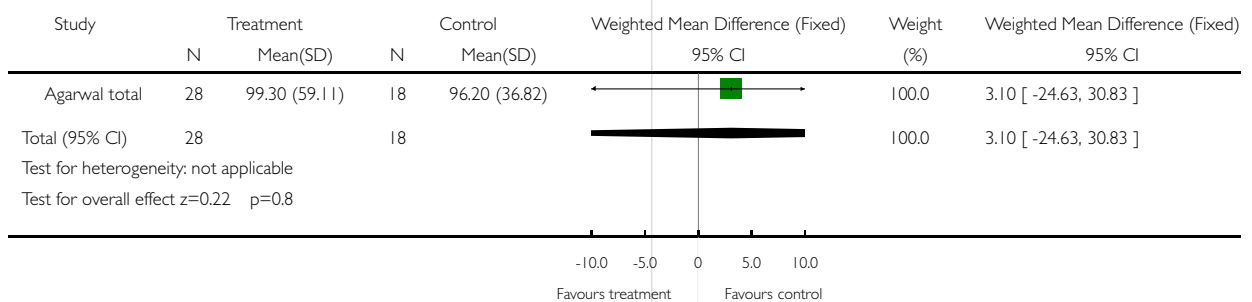
**Analysis 11.33. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 33
Percent weight for age: Sensitivity ICC= 0.1**

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
 Outcome: 33 Percent weight for age: Sensitivity ICC= 0.1



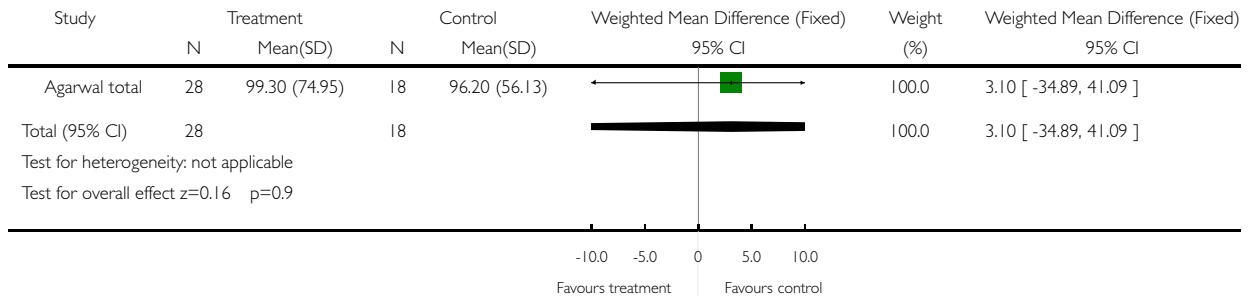
**Analysis 11.36. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 36
Verbal IQ (total): sensitivity-0.10**

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
 Outcome: 36 Verbal IQ (total): sensitivity-0.10



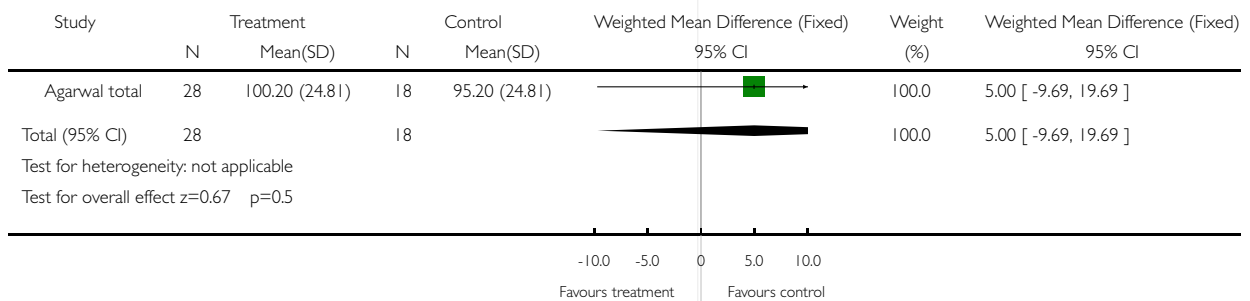
Analysis 11.37. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 37 Verbal IQ (total): sensitivity-0.20

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
 Outcome: 37 Verbal IQ (total): sensitivity-0.20



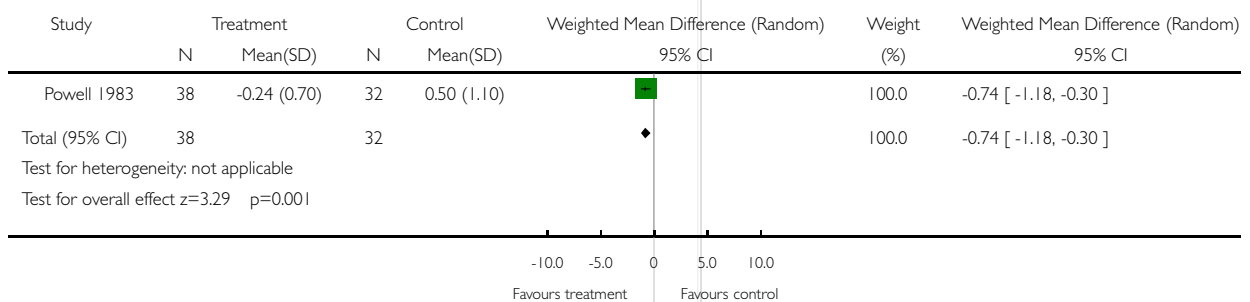
Analysis 11.38. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 38 Performance IQ (total): sensitivity-0.10

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
 Outcome: 38 Performance IQ (total): sensitivity-0.10



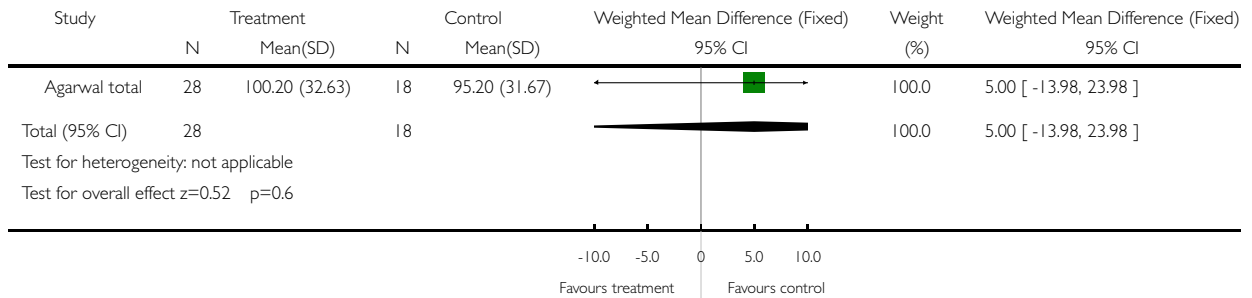
Analysis 11.39. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 39 Percentage standard height. Sensitivity = .01

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
 Outcome: 39 Percentage standard height. Sensitivity = .01



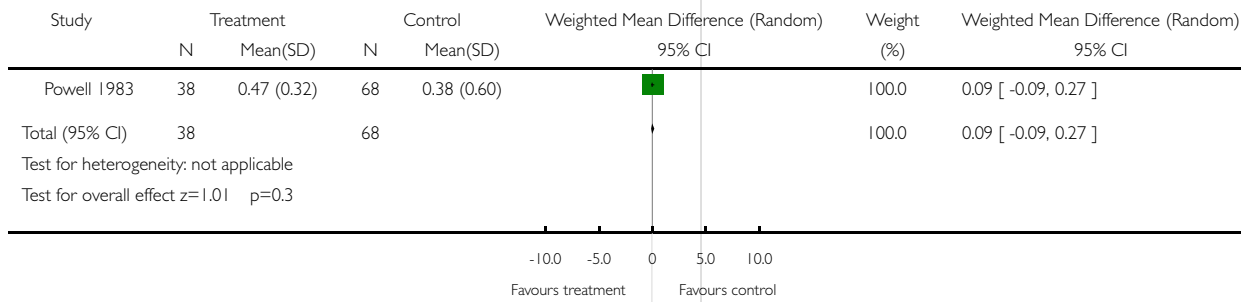
Analysis 11.41. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 41 Performance IQ (total): sensitivity-0.20

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
 Outcome: 41 Performance IQ (total): sensitivity-0.20



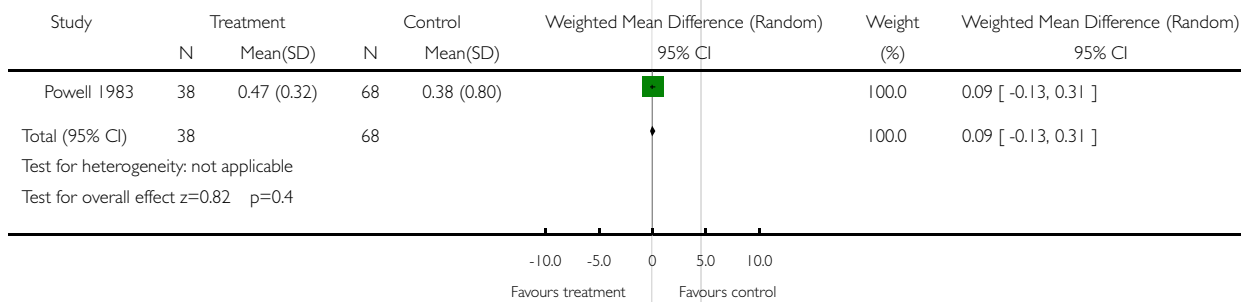
Analysis 11.45. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 45 change in reading: sensitivity ICC= .1

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
 Outcome: 45 change in reading: sensitivity ICC= .1



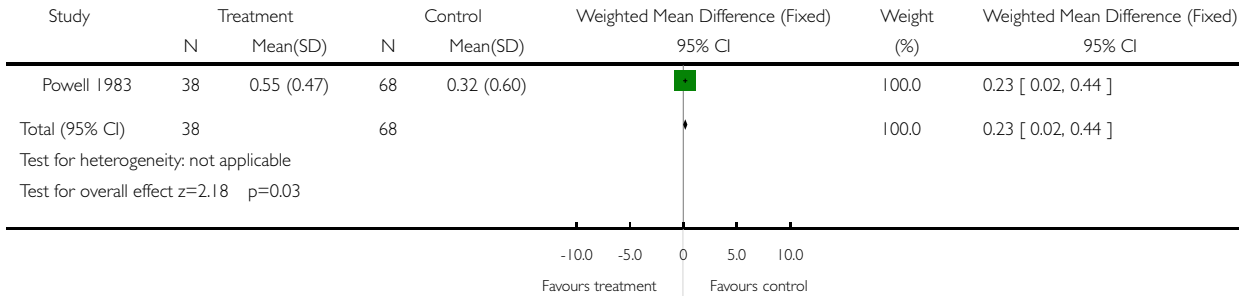
Analysis 11.46. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 46 change in reading: sensitivity ICC= .2

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
 Outcome: 46 change in reading: sensitivity ICC= .2



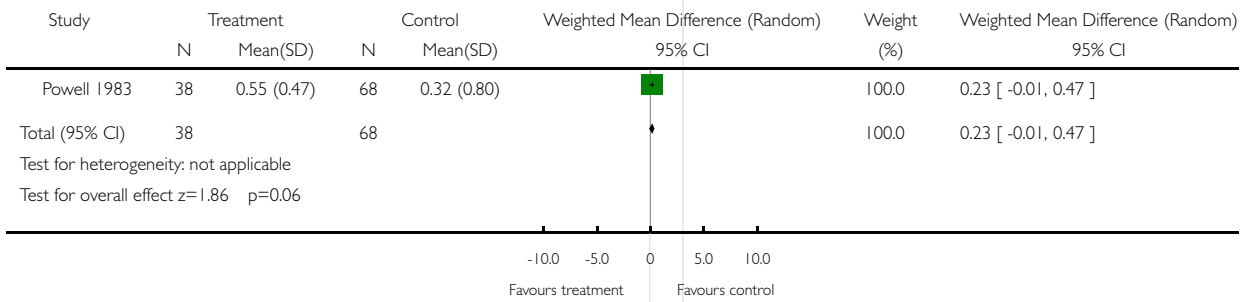
Analysis 11.50. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 50 change in spelling: sensitivity ICC= .1

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
 Outcome: 50 change in spelling: sensitivity ICC= .1



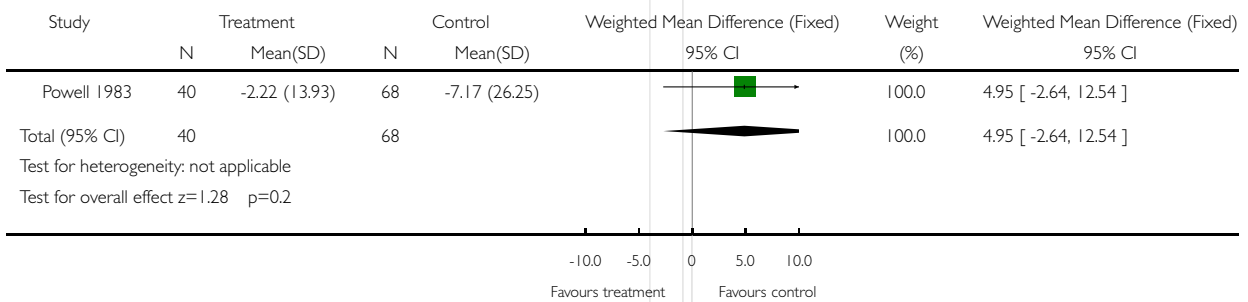
Analysis 11.52. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 52 change in spelling: sensitivity ICC= 0.2

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
 Outcome: 52 change in spelling: sensitivity ICC= 0.2



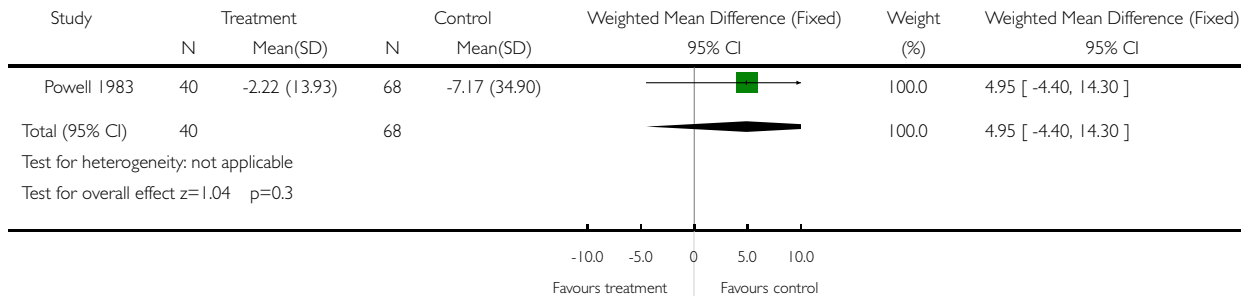
Analysis 11.58. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 58 Change in attendance: sensitivity = .10

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
 Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
 Outcome: 58 Change in attendance: sensitivity = .10



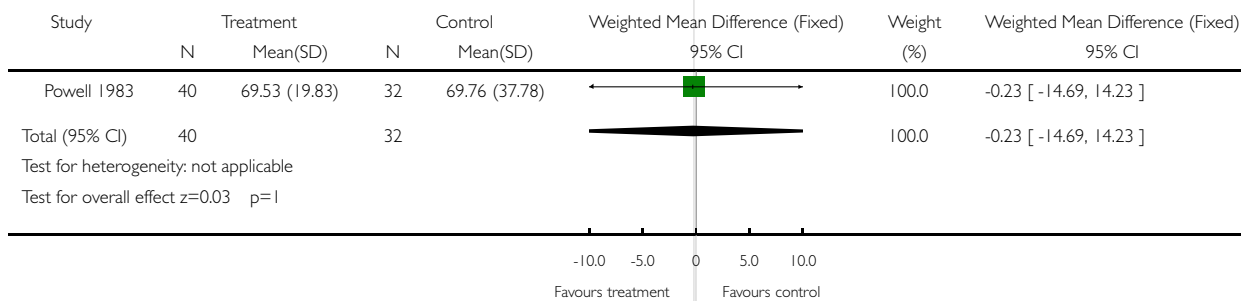
**Analysis 11.59. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 59
change in attendance: sensitivity = .20**

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
Outcome: 59 change in attendance: sensitivity = .20



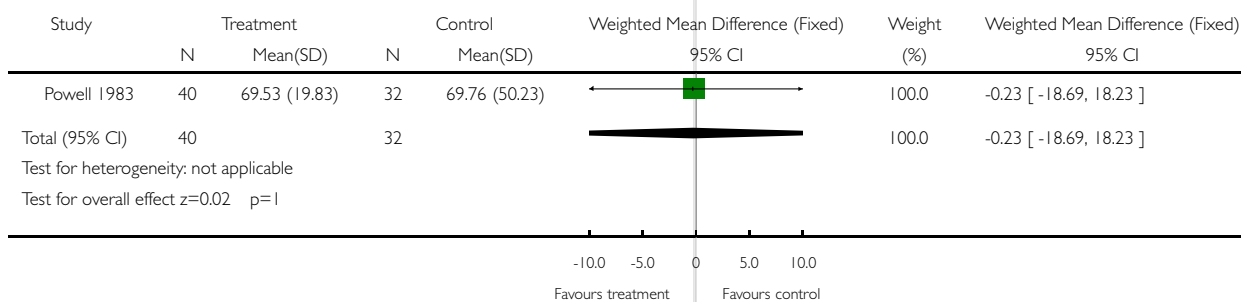
**Analysis 11.60. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 60
End of study attendance: sensitivity icc = .10**

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
Outcome: 60 End of study attendance: sensitivity icc = .10



**Analysis 11.61. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 61
End of study attendance: sensitivity icc at .2**

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children
Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity
Outcome: 61 End of study attendance: sensitivity icc at .2

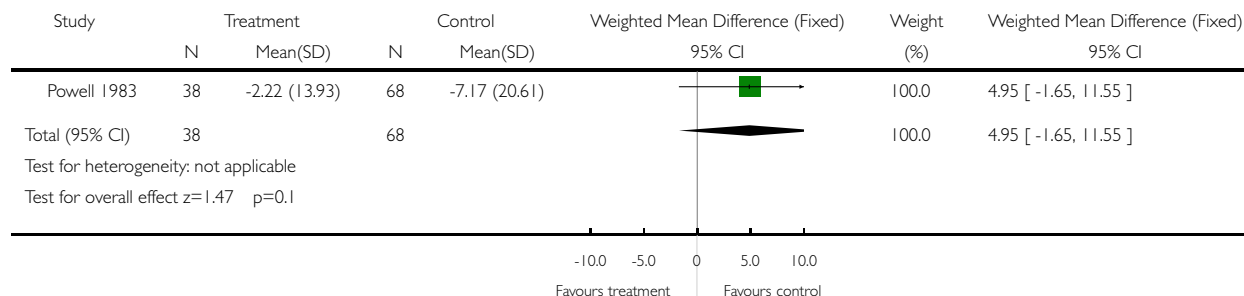


**Analysis 11.62. Comparison 11 Developing country: School meal vs control. CBA - Sensitivity, Outcome 62
Change in Attendance: Sensitivity = .05**

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 11 Developing country: School meal vs control. CBA - Sensitivity

Outcome: 62 Change in Attendance: Sensitivity = .05

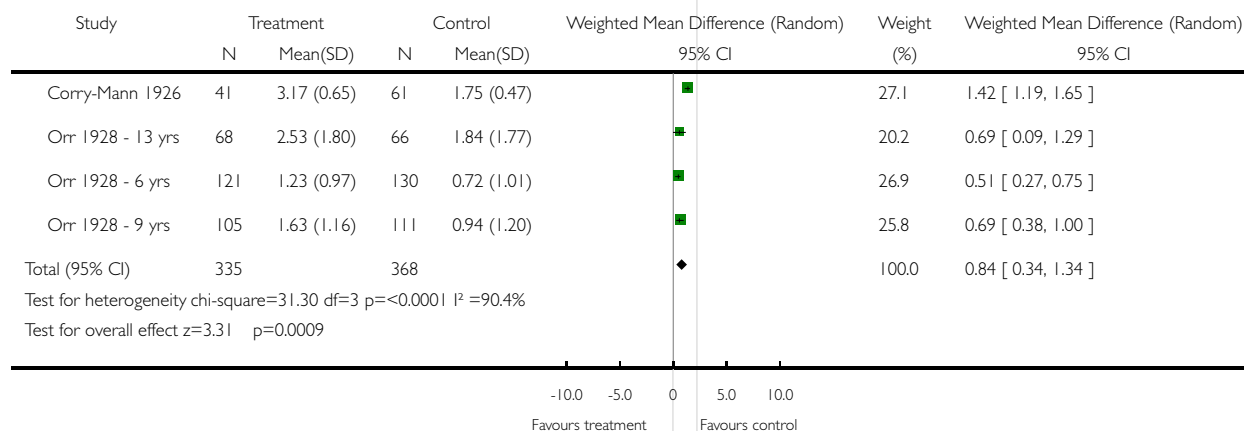


Analysis 12.03. Comparison 12 Developed country: school meal versus control: CBA - Sensitivity, Outcome 03 Weight gain in kg- sensitivity icc=0.01. Leighton 1929 used for Orr

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 12 Developed country: school meal versus control: CBA - Sensitivity

Outcome: 03 Weight gain in kg- sensitivity icc=0.01. Leighton 1929 used for Orr

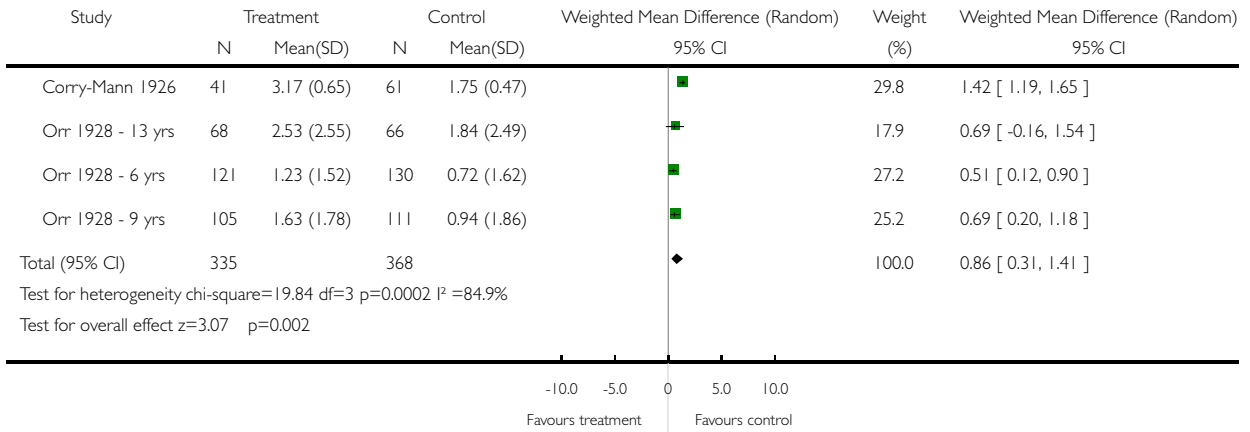


Analysis 12.04. Comparison 12 Developed country: school meal versus control: CBA - Sensitivity, Outcome 04 Weight gain in kg.- sensitivity icc=0.05. Leighton used for Orr

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 12 Developed country: school meal versus control: CBA - Sensitivity

Outcome: 04 Weight gain in kg.- sensitivity icc=0.05. Leighton used for Orr

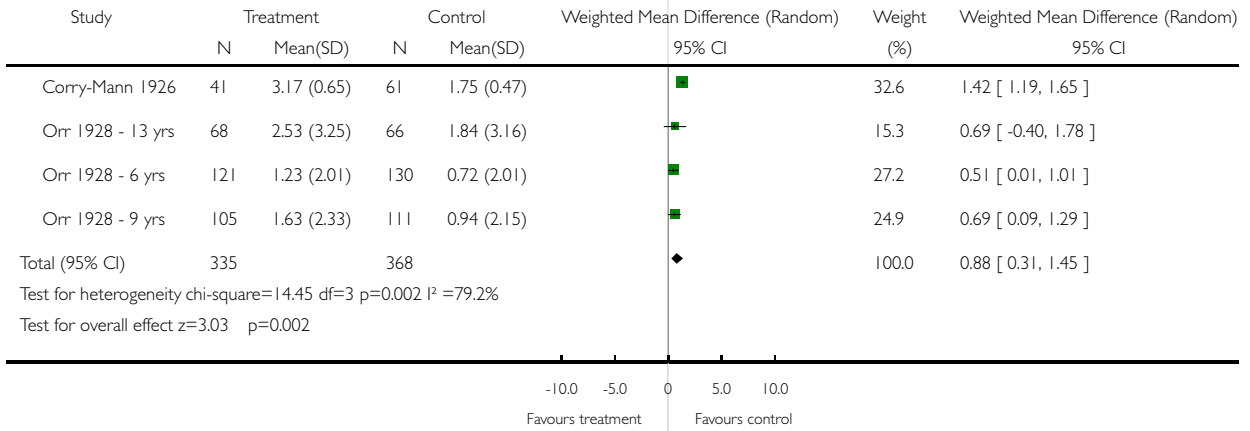


Analysis 12.05. Comparison 12 Developed country: school meal versus control: CBA - Sensitivity, Outcome 05 Weight gain in kg. - sensitivity ICC=0.1. Leighton used for Orr

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 12 Developed country: school meal versus control: CBA - Sensitivity

Outcome: 05 Weight gain in kg. - sensitivity ICC=0.1. Leighton used for Orr

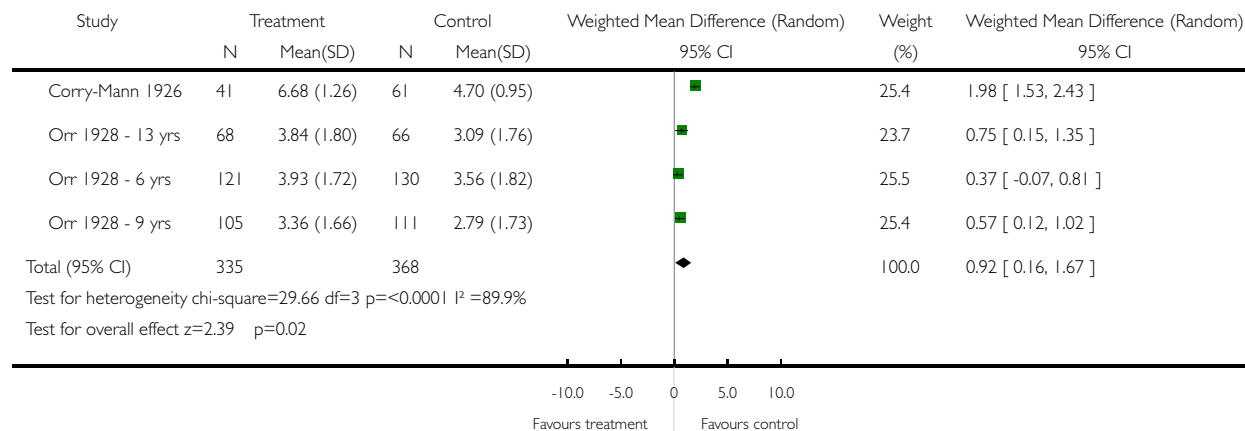


Analysis 12.07. Comparison 12 Developed country: school meal versus control: CBA - Sensitivity, Outcome 07 Height gain in cm. adjusted ICC=0.016

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 12 Developed country: school meal versus control: CBA - Sensitivity

Outcome: 07 Height gain in cm. adjusted ICC=0.016

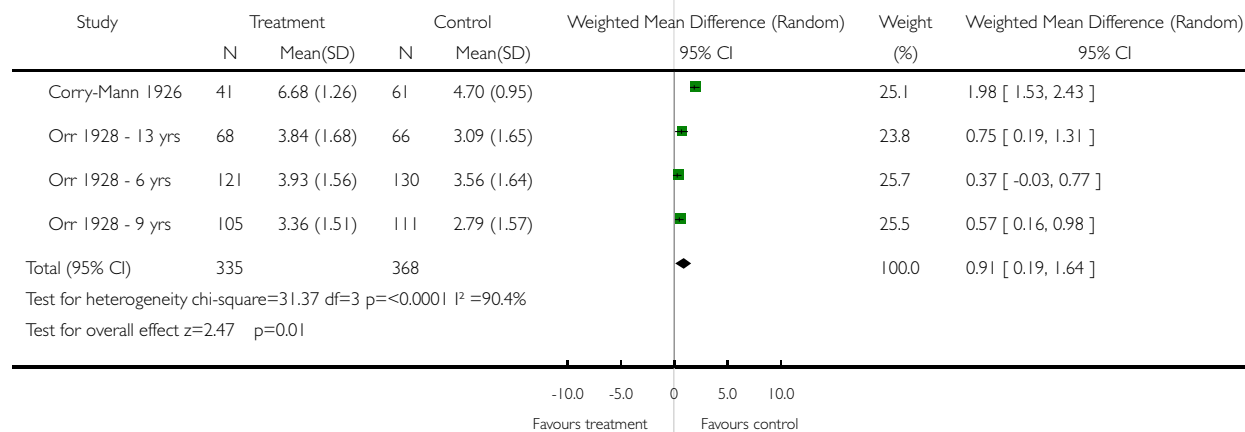


Analysis 12.08. Comparison 12 Developed country: school meal versus control: CBA - Sensitivity, Outcome 08 Height gain in cm. sensitivity ICC=0.01

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 12 Developed country: school meal versus control: CBA - Sensitivity

Outcome: 08 Height gain in cm. sensitivity ICC=0.01

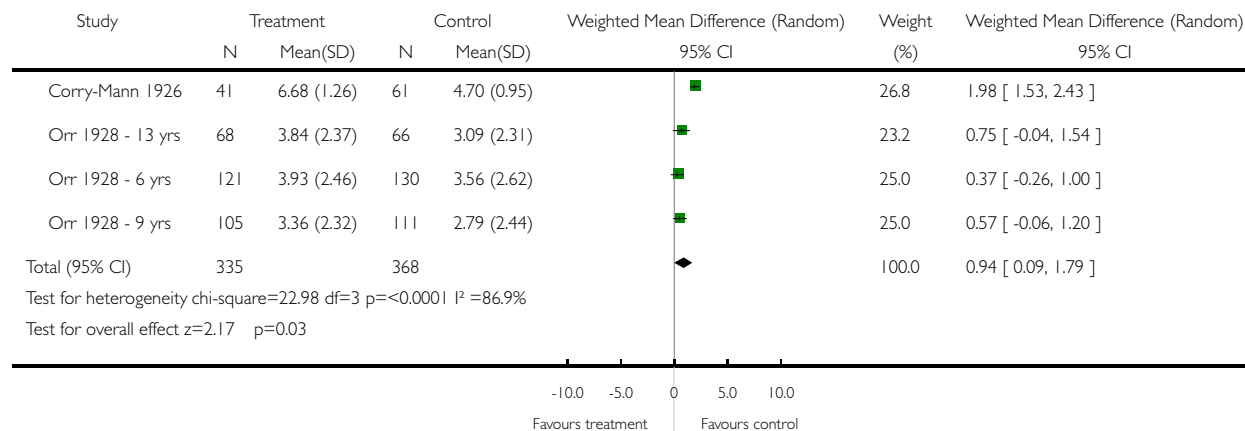


Analysis 12.09. Comparison 12 Developed country: school meal versus control: CBA - Sensitivity, Outcome 09 Height gain in cm. sensitivity ICC=0.05

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 12 Developed country: school meal versus control: CBA - Sensitivity

Outcome: 09 Height gain in cm. sensitivity ICC=0.05

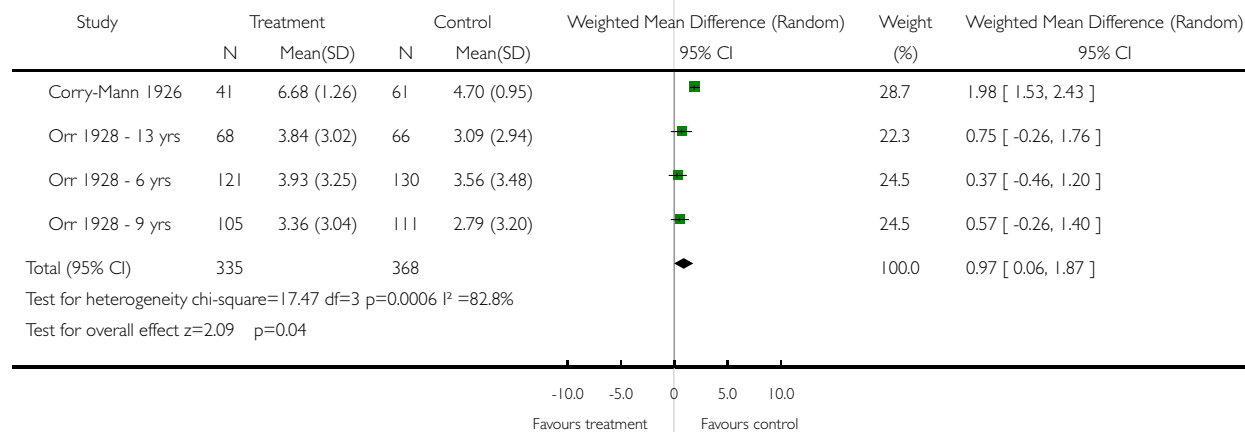


Analysis 12.10. Comparison 12 Developed country: school meal versus control: CBA - Sensitivity, Outcome 10 Height gain in cm. sensitivity ICC=0.1

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 12 Developed country: school meal versus control: CBA - Sensitivity

Outcome: 10 Height gain in cm. sensitivity ICC=0.1

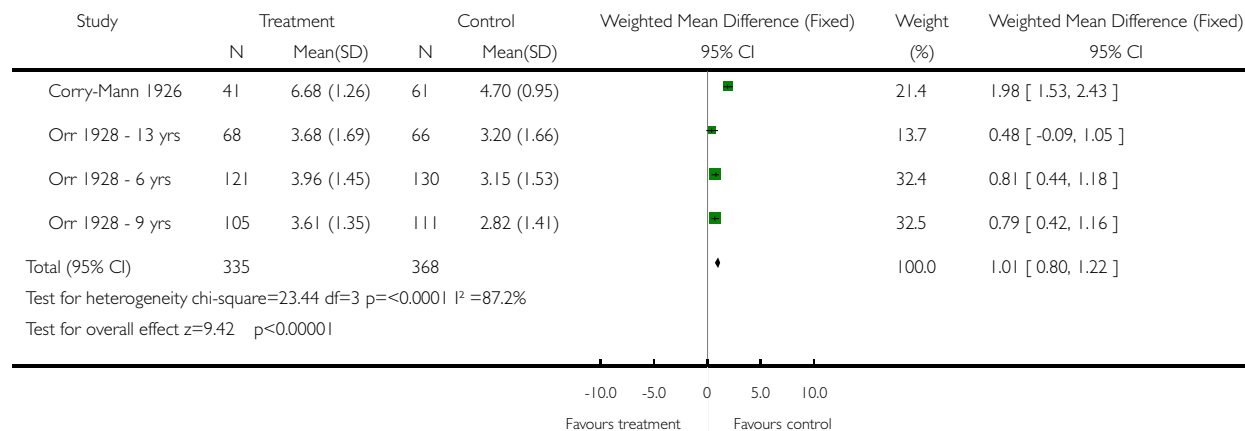


Analysis 12.12. Comparison 12 Developed country: school meal versus control: CBA - Sensitivity, Outcome 12 Height gain in cm. Leighton used for Orr. Sensitivity 0.01

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 12 Developed country: school meal versus control: CBA - Sensitivity

Outcome: 12 Height gain in cm. Leighton used for Orr. Sensitivity 0.01

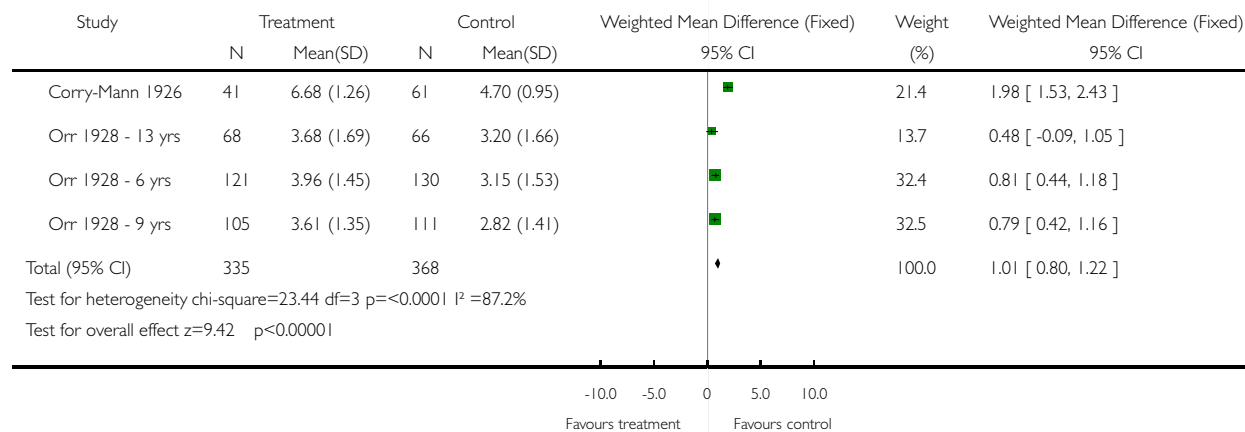


Analysis 12.13. Comparison 12 Developed country: school meal versus control: CBA - Sensitivity, Outcome 13 Height gain in cm. Sensitivity ICC = 0.05. Leighton used for Orr

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 12 Developed country: school meal versus control: CBA - Sensitivity

Outcome: 13 Height gain in cm. Sensitivity ICC = 0.05. Leighton used for Orr



Analysis 12.14. Comparison 12 Developed country: school meal versus control: CBA - Sensitivity, Outcome 14 Height gain in cm. Sensitivity ICC = .1. Leighton used for Orr

Review: School feeding for improving the physical and psychosocial health of disadvantaged elementary school children

Comparison: 12 Developed country: school meal versus control: CBA - Sensitivity

Outcome: 14 Height gain in cm. Sensitivity ICC = .1. Leighton used for Orr

