



Sensitive to nutrition? A literature review of school feeding effects in the child development lifecycle

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Abstract

The burdens of hunger, malnutrition and ill-health on school-age children are major constraints in achieving the Education for All and the Millennium Development Goals on education. School feeding is a common intervention supporting the education, health and nutrition of children in food-insecure settings. However, school feeding programmes are complex, involving a broad range of stakeholders across different sectors and implementation levels, and designing effective programmes requires managing trade-offs among targeting approaches, feeding modalities, and costs.



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Abstract

Background: The burdens of hunger, malnutrition and ill-health on school-age children are major constraints in achieving the Education for All and the Millennium Development Goals on education. School feeding is a common intervention supporting the education, health and nutrition of children in food-insecure settings. However, school feeding programmes are complex, involving a broad range of stakeholders across different sectors and implementation levels, and designing effective programmes requires managing trade-offs among targeting approaches, feeding modalities, and costs.

Objectives: This paper aims to review the evidence on the nutrition effects and costs of school feeding to support policy-makers in managing trade-offs among alternative targeting approaches and implementation modalities.

Methodology: We develop the programme theory for school feeding and nutrition following a standard programme evaluation approach. The programme theory is then used to inform a review of the recent literature on the nutrition impacts and costs of school feeding. Literature databases were searched to identify relevant studies on the physical and social benefits of providing school feeding to primary and pre-primary school-age children.

Results: From the food supplementation literature, six randomised control trials (RCTs) with medium to large sample sizes and ranging between 8 and 24 months in duration observed anthropometric outcomes. Small, significant effects on weight gain and small, non-significant effects on height gain were reported for school-age children. The spill-over benefits observed for younger siblings indicate that school feeding could have an important role in promoting the health of the next generation of mothers. In four controlled before and after studies (medium sample sizes, ranging between 3 and 24 months in duration), significant effects on height and weight gain were reported. Nearly all of the food supplementation studies that reported significant height and weight gains included an animal-based product, not usually included in school feeding programmes in low-income countries. Additionally, initial nutrition status may play a substantial role. For micronutrient supplementation and fortification, a systematic review of multiple micronutrient fortification reported consistent improvement in micronutrient status and reduced anaemia prevalence but equivocal results for improvements in anthropometric status, potentially due to the provision of energy to control groups as well.

The apparent variation in costs of school feeding programmes among low-income countries implies that there is considerable opportunity for cost containment, provided that the drivers of costs are better understood. The relevance of the modality is an important issue, and there is a particular lack of information on fortified biscuits and for take-home rations. Commodity costs were on average 58 percent of total costs, and were highest for take-home rations and biscuit programmes (68 and 71 percent respectively). As this analysis does not include school level costs, these findings highlight the higher non-transfer costs for programmes delivering cooked meals in schools compared to other school feeding modalities.

Conclusions: The programme theory, existing evidence base, and cost implications are all key considerations in providing evidence-based guidance to national governments on school feeding and nutrition. Understanding the context, identifying the target population, planning the intervention and service delivery, and developing the impact theory – all components of the programme theory – delineates the mechanisms and pathways through which school feeding may affect short- and medium-term outcomes as well as long-term impact. Because of the complex pathways described in this review, we should only expect a limited impact of school feeding on nutritional status of children. However, we might expect an improvement

in children's activity and play and an improvement in nutritional status of siblings (if substitution effects are strong).

The findings from this review suggest that purposely-designed school feeding programs, which include micronutrient fortification, have the potential to provide nutritional benefits and should complement and not compete with nutrition programs for younger children, which remain a clear priority for targeting malnutrition overall. Important gaps in the evidence remain, however, including the link between quality of school food service delivery and impact, as well as the potential for "home-grown" approaches to benefit children of different age-groups, including preschoolers and adolescents.

1. Background

The burdens of hunger, malnutrition and ill-health on school-age children are major constraints in achieving the Education for All and the Millennium Development Goals (MDGs) on education (Bundy, 2011). Poor nutrition and health among schoolchildren contributes to the inefficiency of the educational system (Pollitt 1990). Children with diminished cognitive abilities naturally perform less well and are more likely to repeat grades and to drop out of school; they also enrol in school at a later age, if at all, and finish fewer years of schooling (Jukes, Drake, and Bundy 2008). The irregular school attendance of malnourished and unhealthy children is one of the key factors in poor performance. Even short-term hunger, common in children who are not fed before going to school, can have an adverse effect on learning (Pollitt, Cueto, and Jacoby 1998). Children who are hungry have more difficulty concentrating and performing complex tasks (Grantham-McGregor, Chang, and Walker 1998). In 2006, monitoring data from the World Food Programme (WFP) school feeding programmes showed that in newly-assisted schools 63 percent of pupils on average do not have any food before going to school (WFP 2007).

The recent food, fuel and financial crises have highlighted the importance of school feeding programmes both as a social safety net for children living in poverty and food insecurity, and as part of national educational policies and plans. Recent joint analyses developed by the World Bank, WFP and the Partnership for Child Development (PCD) identified that every country (for which data was available) is in some way and at some scale seeking to provide food to its schoolchildren (Bundy *et al.* 2009, WFP 2013). Countries with the greatest needs in terms of education, poverty and food insecurity, are those where the school feeding programs are currently least adequate. School feeding is a complex intervention and designing effective programs requires an evidence base that allows careful trade-offs among targeting approaches, feeding modalities, and costs. The near universality of school feeding, and the inadequacy of programs in low-income settings, suggest an important opportunity for development partners to assist governments in improving the implementation of school feeding as part of social protection programmes. Calls have been made to leverage opportunities to scale-up nutrition sensitive interventions (Ruel *et al.*, 2013). In particular, *Rethinking School Feeding* identified the need for the development of new technical guidance and knowledge management tools to support the design of school feeding programs. Existing tools to assist the design of school feeding programs require updating in light of new findings and knowledge on the topic.

Objectives and scope

The purpose of this paper is to provide an up-to-date literature review on school feeding and the potential impact on nutrition, including school age children, pre-school and adolescent girls. The review is aimed at providing evidence-based guidance to national governments on school feeding and nutrition from a lifecycle approach. The review seeks to consolidate the existing evidence, analyse what this evidence translates into in terms of programming, and understand the potential of improving nutrition through school feeding programmes globally. Gaps in the evidence are also consolidated in a research agenda.

2. Methodology

The methods for the literature review included searches in multiple online databases on the nutrition effects of school feeding for pre-school and school age children.

Additionally, reference lists of retrieved literature were searched, authors of other relevant reviews were contacted along with researchers undertaking on-going studies of interest, and attempts were made to identify research that may not have been published due to results supporting the null hypothesis. In considering the type of outcome measures to assess, we adapted those chosen by a systematic review of school meals (Kristjannsson et al., 2007). Child health outcomes included nutritional status (anthropometry, body mass index, micronutrient status, haemoglobin, and haematocrit) as well as the reduction of hunger and nutrient intake. Primary and pre-primary school age children were the primary subjects of all the studies we considered. Studies were summarized similarly to help decrease bias, and evidence tables were created to help synthesize the findings across the studies without statistically combining their results.

Given the nutrition focus of this particular scope of work, the focus of the literature review is on the nutrition aspects of school feeding programs. In terms of the range of other benefits that school feeding can have, the evidence is particularly strong for safety nets and for education. Summaries of the evidence in these two areas are provided in the literature review section below, and more detail and further discussion can be found in Bundy et al. (2009) and Alderman and Bundy (2011).

To help frame the literature review, the programme theory for school feeding and nutrition is first presented, outlining the mechanisms or pathways through which a school feeding intervention may affect the nutrition and health of school children. Following this programme theory, there is an elaborated literature review of studies on school feeding (including food supplementation as well as micronutrient supplementation and fortification studies) and the impact on nutrition (including anthropometric status and micronutrient status).¹ Considerations regarding substitution along with physical activity levels and basal metabolic rates are also discussed. The subsequent section addresses the evidence on school feeding costs, to help inform forthcoming nutrition guidance for school feeding programmes. The conclusions section includes a discussion of the findings, including gaps in the evidence and a proposed research agenda.

3. Programme theory: School feeding and nutrition²

School feeding programmes in low and middle income countries are often designed to address the challenges of ill health and hunger on the development of school-age children through the provision of food (including both macro- and micro- nutrients) at school (Aliyar, Gelli, and Hamdani 2012). This section presents the programme theory, the mechanisms or pathways through which a school feeding intervention may affect the nutrition and health of school children, as well as the impact on child development, developed using a standard programme theory approach (Rossi Lipsey, and Freeman 2005). The programme theory for school feeding programmes and nutrition is summarised in Figure 1, with steps from A–H described in the text below.

¹ Overweight and obesity as possible outcomes of school feeding are not reviewed here as there is little to no evidence available. Especially in the context of the rapid urbanisation occurring in low- and middle-income countries and changes in diets, this could be an area of future research.

² This section builds on Masset and Gelli (2013) and Gelli (2010).

3.1 Understanding the context (A)

The design of the intervention will depend on the specific context within which the programme is operating. The five school feeding standards, namely design and implementation, policy frameworks, institutional capacity and coordination, financing and community participation, can be used to characterise the context in a standardised and comprehensive way (Bundy *et al.* 2009). An assessment of the education sector needs, gaps and priorities (as included for instance in education sector plans) undertaken in close collaboration with Government and partners is essential to understand the nature and the magnitude of the problem that can potentially be addressed by school feeding. The needs assessment would examine the main barriers to education, covering different levels of stakeholders ranging from individual children to communities and Ministry of Education resources. Data covering education, health, nutrition and other relevant vulnerability and food insecurity indicators would provide a detailed picture of the country situation, and where possible describe relevant in-country variations. Generally, educational indicators that are specifically relevant to school feeding include measures of access and retention (enrolment, attendance, drop-out, etc.) and student learning (completion, achievement, etc.). Nutrition and health indicators covering micronutrient deficiencies, intestinal parasites, as well as coverage of relevant nutritional and health services currently provided to school-age children should also be included, alongside a range of other socio-economic indicators covering poverty and food insecurity.

3.2 Identifying the target population (B)

The design of the intervention will include the identification of beneficiaries based on vulnerability information collected during the context analysis. An important part of the problem analysis involves describing the characteristics of the target population for the school feeding intervention. The risk of not accessing and/or completing primary school, a form of “educational vulnerability” anchored within a context of poverty and food insecurity, may be used to describe the common characteristic shared by the children targeted by school feeding. This idea reflects the reality that household choices regarding education are often a result of complex decision processes, where poverty and hunger play an important role in determining the schooling outcomes (Drèze and Kingdon 2001). It is important to understand the drivers that keep vulnerable children (e.g. girls) from participating in school: It may be that food alone is not the appropriate solution to the problem — more women teachers, improved sanitation, parents’ perceptions of education and many other reasons have all been found as possible determinants of schooling.

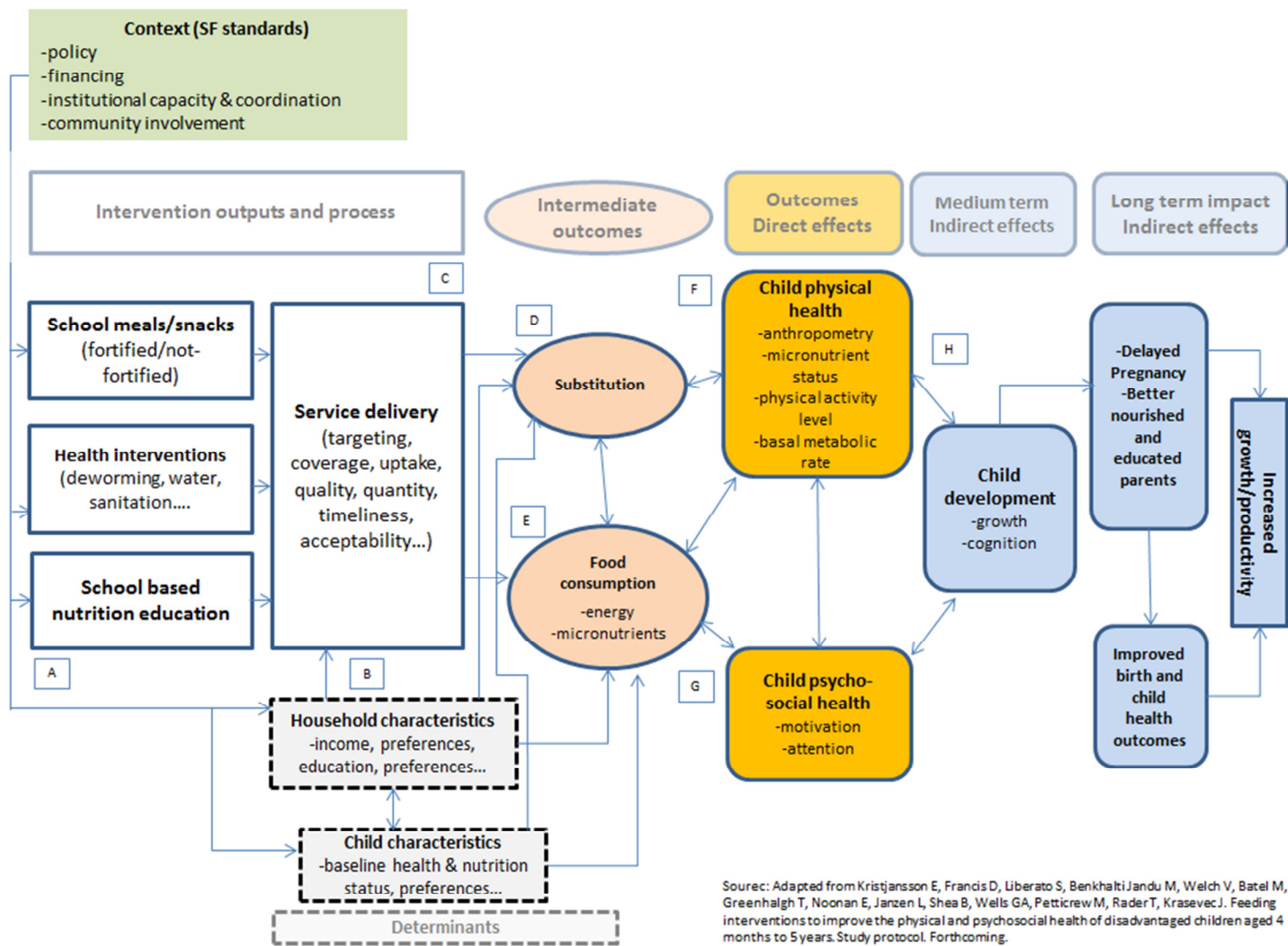


Figure 1: Programme theory of impact on nutritional status of children (Source: Adapted from Kristjansson *et al.* 2012)

Other factors to consider at community and household levels include the gender and social norms regarding foods and who should consume them, the allocation of resources within the household, the education level of parents and knowledge about nutrition.

At child level, the capacity to absorb nutrients and thus the health status are also important determinants. Once in school, children may be too ill or hungry to benefit from the classroom activities.

3.3 Planning the intervention and service delivery (C)

The data from the context and beneficiary identification feeds into the design of the school feeding service delivery, including details on the targeting criteria, coverage and uptake, quality and quantity of the food, timing of delivery, acceptability, etc. These parameters will characterise the outputs of the intervention. School feeding as an intervention can be delivered as cooked meals or snacks, alongside other school health and nutrition interventions, including school based nutrition education.

3.4 Impact theory

Once the school feeding service is underway and outputs are delivered, there are three main issues that influence nutritional outcomes and impact, including:

- a) The overall nutritional impact is mediated by the extent of food substitution effects within the household, and the use of the energy intake by the child and her siblings.
- b) The reduction in malnutrition via diet diversification and the absorption of macro- and micronutrients in the body can have direct effects on cognition.
- c) Better nourished children may be best positioned to learn while in class and outside class.

Food consumption and substitution effects (D&E)

Food consumption, in terms of quantity, quality and diversity plays a major role in determining nutritional status, and provides the most direct link between school feeding and nutrition. School feeding programmes are designed to supplement the food provided at home and improve school children net food intake, by providing energy, micronutrients and macronutrients.

The school food can, in principle, be shared by children with other household members or can substitute (at least partly) for food normally consumed in the home. This is obvious, and in most cases planned for, for take-home-ration interventions, where children take home a quantity of food on a regular basis, some of which being consumed by other family members or sold. This also applies to any school feeding programme, because households may in principle use the school meal as a substitute for food normally consumed at home and spend the monetary equivalent otherwise.

If children benefitting from school feeding are malnourished, substitution within the household could reduce the potential health and nutrition benefits. The evidence on reallocation in households with beneficiaries of on-site feeding generally indicates that most of the calories provided by the programme “stick” with the beneficiaries (Jacoby 2002; Ahmed 2004). Interestingly, the evaluations of fortified biscuits in Bangladesh and Indonesia found that gains in nutritional intake were not limited to the children actually receiving the biscuits at school. The two studies found significant evidence that school children shared the

biscuits with their younger sister or brother at home. The recent RCTs in Burkina Faso also found that take-home ration programmes led to an improved of the nutritional status of younger siblings in beneficiary households. This provides emerging evidence of a spill-over effect and a window of opportunity to also affect children during a critical developmental stage when nutritional interventions can have the strongest impact. It will be important to undertake further research on substitution effects, bearing in mind that children under-5 have different nutritional needs from school-age children.

Child physical health outcomes (F)

Ingested foods contribute to four child physical health outcomes (F), of which physical growth is only one:

- Physical growth. Food can help physical growth in terms of height and weight. It is normally believed that catching-up by stunted children after the age of five is limited. However, food intake should increase storage of macronutrients and therefore weight.
- Micronutrient status. Additional micronutrient intake can reduce the prevalence of micronutrient deficiencies, such as iron deficiency anaemia, iodine deficiency, and vitamin A deficiency.
- Physical Activity Level (PAL). Energy intake is spent in work after school or in more activity and play.
- Basal Metabolic Rate (BMR). Energy is required to maintain the healthy functioning of the body while at rest.

Catch-up growth in children and adolescent may be possible though the process is slower than catch-up in weight and it is not certain up to what age it takes place (probably up to the end of the adolescent growth spurt) (WHO 1985). All malnutrition indicators could change after school feeding is introduced (stunting, wasting and underweight) though the impact will depend on the extent of substitution effects and on whether children are increasing the use of energy for PAL and BMR. A child may have normal height and weight and still be undernourished because he does not expend enough energy in activity and play to maintain health and develop his cognitive abilities.

Assessment of malnutrition should also measure PAL, particularly in adolescents who engage in considerable work and play. Unfortunately there is no accepted theory, nor evidence, on whether children adapt to nutritional stress by reducing weight or PAL. There is also uncertainty on the definition of a minimum acceptable level of PAL (an arbitrary factor of 1.5 of BMR is often used for example by FAO). Finally, there is no standardised way to measure PAL. Observation of behaviour in class and questionnaires for parents and teachers could be used to measure PAL. Finally, highly deprived children may use additional energy intake from school meals simply to restore the original BMR. In addition, higher weight requires more energy, therefore BMR is a function of body weight and the BMR requirement increases as weight increases.

Child psycho-social health outcomes (G)

Micronutrients may have a direct impact on cognitive abilities. It is not well understood how iron affects brain functioning and the central nervous system, but there is ample evidence that reduction in iron deficiency improves mental functions across all age groups (Grantham-McGregor and Ani 2001; Pollitt 1993). Iron interventions were found to have a positive impact on infant development scales, IQ tests and school achievement.

Restoration of micronutrient requirements and energy intake can also have an impact on attention and motivation (G). Energy intake (Pollitt *et al.* 1978) and iron intake (Grantham-McGregor and Anil 2001) can have an impact on hyperactivity, withdrawal, nervousness, hostile behaviour and happiness. The emotional status of children affects the attention span and has other spill-over effects. The quality of teaching in class is likely to be affected as teacher may become more motivated and as the quality of students' performance in class improves (considering, for example, the different impact on learning of improving attention of 10%, 50% or 100% of students in class).

Long term impacts (H)

Improved productivity and income, leads to increased possibility to purchase higher quality food. This will directly improve nutritional status and reduce disease-related absences at school/work.

Better education improves child care, nutrition practices/ dietary choices and intra-household resource allocation.

Effects on the next generation – better educated parents, better nourished mothers have healthier and better nourished children; better nutritional status of mothers improves birth weight.

4. Literature review

This literature review section begins with summaries on the safety net and education benefits of school feeding, arguably the primary objectives for school feeding (further discussion can be found in Bundy [2009] and Alderman and Bundy [2011]). The rest of the section then focuses on the nutrition impact of school feeding.

4.1 School feeding as a safety net

School feeding programs provide an explicit or implicit transfer to households of the value of the food distributed. The programs are relatively easy to scale up in a crisis and can provide a benefit per household of more than 10 percent of household expenditures, even more in the case of take-home rations. In many contexts, well-designed school feeding programs can be targeted moderately accurately, though rarely so effectively as the most progressive of cash transfers. In the poorest countries, where school enrollment is low, school feeding may not reach the poorest people, but in these settings alternative safety net options are often quite limited, and geographically targeted expansion of school feeding may still provide the best option for rapid scale up of safety nets. Targeted take-home rations may provide somewhat more progressive outcomes. Further research is required to assess the longer term relative merits of school feeding versus other social safety net instruments in these situations.

4.2 The educational benefits of school feeding

There is evidence that school feeding programs increase school attendance, cognition, and educational achievement, particularly if supported by complementary actions such as deworming and micronutrient fortification or supplementation. In many cases the programs have a strong gender dimension, especially where they target girls' education, and may also

be used to benefit specifically the poorest and most vulnerable children. What is less clear is the relative scale of the benefit with the different school feeding modalities, and there is a notable lack of engagement of educators on research around these issues.

The clear education benefits of the programs are a strong justification for the education sector to own and implement the programs, while these same education outcomes contribute to the incentive compatibility of the programs for social protection. Policy analysis also shows that the effectiveness and sustainability of school feeding programs is dependent upon embedding the programs within education sector policy. Hence, the value of school feeding as a safety net, and the motivation of the education sector to implement the programs, are both enhanced by the extent to which there are education benefits.

4.3 The nutritional benefits of school feeding

The nutrition evidence on school feeding below is broken up into school feeding studies involving food supplementation and those involving micronutrient supplementation and fortification, including effects on anthropometric status and micronutrient status.

Food supplementation

Anthropometric status

Food supplementation studies at school-age have reported small but significant gains in growth, as highlighted by the recent Cochrane systematic review of the effect of school feeding programmes on both the physical and psychosocial health of students (Kristjansson *et al.* 2007). The review included 18 studies (nine from lower income countries), with both randomised controlled trials (RCTs) and controlled before and after studies (CBAs), of schoolchildren from 5 to 19 years of age. Seven of these studies were from lower income countries and included outcomes related to height and weight. These are described below and detailed in the table in Annex 1, along with three more recent impact evaluations in Burkina Faso, Lao PDR, and Uganda.

Randomised controlled trials

A meta-analysis of three RCTs in lower income countries (Powell *et al.* 1998; Grillenberger *et al.* 2003; Du *et al.* 2004) in the Cochrane review reported a small, significant effect of supplementation on weight gain (0.39 kg, 95% CI 0.11 to 0.67), approximately 0.25 kg per year factoring in study duration (Kristjansson *et al.* 2007). The review also found a small, non-significant effect from the three RCTs on height gain (0.38 cm, 95% CI -0.32 to 1.08).

In one of the studies, 395 children in grades 2–5 in rural Jamaican schools were given breakfast each day for one school year (Powell *et al.* 1998). A RCT compared their height, weight, height-for-age, and weight-for-age gains (among other outcomes) to 396 controls. With the additional gain of 0.25 cm in height ($p < 0.05$) over the eight months, the authors suggest that the breakfast programme could result in a 2.4 cm gain in height over the primary school years, an additional one-third SD in height by age 11. As the weight gain reported in the breakfast group was relatively greater than the height gain, a small increase in BMI was observed (0.16 kg/m²). Small, significant increases were also reported for both height-for-age and weight-for-age z -scores.

Improvements in height-for-age z -scores among the most stunted as well as weight gain were also seen in a supplementation study of 544 Kenyan schoolchildren in class 1 (Grillenberger *et al.* 2003). Children were given a meat, milk, or energy supplement during the first school break of the day for a total of 18 months, and the changes in height, weight,

height-for-age, and weight-for-age for each of the three groups were compared to that of a control group. In each of the supplementation groups, children gained approximately 10% more weight than those in the control group. Decreases in average weight-for-height *z*-scores were reported in all the groups, though the declines for the meat and energy groups were approximately 50% less than for the milk and control groups. The results indicated no overall effect on height gain or height-for-age, though children with baseline height-for-age *z*-scores below the median (-1.4), in the milk group, a 1.3 cm (15%) height gain over the control group ($p = 0.05$) was observed. The authors suggest a lack of rainfall as well as periods of severe food shortage during the time of the study, along with potential substitution at home, may have contributed to the negligible effects on nutrition status observed.

Another school milk intervention trail of 757 girls (average age 10 years) in nine primary schools in Beijing reported statistically significant increases in both height and weight (Du *et al.* 2004). The two-year intervention followed the growth of three groups: group 1 receiving milk fortified with calcium, group 2 receiving milk fortified with both calcium and vitamin D, and group 3 serving as a control group receiving no supplementation. The milk supplementation groups experienced increases of $\geq 0.6\%$ in height and $\geq 2.9\%$ in weight more than the control group ($p < 0.0005$). Results from other outcomes of bone mineral content and bone mineral density suggest that increasing bone mineralisation may have contributed to the increases in height.

More recently, three impact evaluations in Burkina Faso, Lao PDR, and Uganda by the World Food Programme and the World Bank have also assessed the impact of school feeding on anthropometric outcomes, including those of younger siblings of beneficiaries. The impact of both school feeding and take-home rations were examined in Internally Displaced Persons (IDP) camps in northern Uganda (Adelman *et al.* 2008). No significant effects were found on body mass index *z*-scores (BMIZ) or height-for-age *z*-scores in 6–13 year old children, but preschooler siblings in the school feeding group experienced significant HAZ gains of 0.363 relative to the control group, suggesting intrahousehold redistribution.

Similarly, in Burkina Faso, no significant effects of school feeding and take-home rations on BMI or weight-for-age in schoolchildren 6–15 years of age, though marginal gains are observed in weight-for-age for 6–10 year olds (Kazianga, de Walque, and Alderman 2010). For preschooler siblings, the reverse of the Ugandan results were found; significant gains in WAZ (0.38) were reported for take-home rations but not school meals.

Buttenheim, Alderman, and Friedman evaluated the impact of on-site feeding, take-home rations, and a combination of both in schools in remote mountainous areas of Lao PDR (2011). Significant improvements in both height-for-age (0.29 SD) and weight-for-age (0.22 SD) among children 3–10 years of age were reported for take-home rations, though the authors suggest that the nutritional findings are inconclusive because of the complications that arise in stratified analyses. As for spillover effects in younger siblings, significant increases in height-for-age were observed in children 3-5 years of age, but the differences seemed to be driven more by declines in the controls.

Controlled before and after studies

Among CBAs, a meta-analysis of three studies in lower income countries (Bailey 1962; Devadas *et al.* 1979; Agarwal, Agarwal, and Upadhyay 1989) found greater weight gains than those in the RCTs (0.71 kg, 95% CI 0.48 to 0.95), approximately 0.75 kg per year given study duration (Kristjansson *et al.* 2007). In contrast to the RCT findings, meta-analysis of the three CBAs found a significant effect on height gain (1.43 cm, 95% CI 0.46 to 2.41), approximately one-third more than rates of gain in the control groups.

In one of the studies, a 12-month supplementation trial of 504 Indonesian schoolboys 7–13 years of age assessed the impact of six different supplements of varying caloric, protein, and iron content on gains in height and weight (Bailey 1962). No significant difference was seen in weight increment between an expected value predicted by a regression equation and any of the groups. However, the height increment for all of the groups was greater than the expected value, with a significant difference observed for both the sugar and Saridele (soya bean milk) supplements. A tendency for the height and weight gains to be correlated with the caloric value of the supplement was observed, though fluid retention that is associated with higher caloric content unaccompanied by higher protein content as well may have also contributed to the lack of effect reported for weight gains.

Conversely, large and significant effects on both height and weight were reported in a supplementation study of 400 schoolchildren in six villages in India (Devadas *et al.* 1979). Two hundred children aged 5–8 years were provided with a daily supplement of local, low cost food for ten months, and their height and weight increments over the time were compared to those of un-supplemented children serving as a control. Each of the three age sub-groups were reported to have significant height gains of >2.5 cm over the control as well as significant weight gains between 0.33–0.95 kg more than the control.

A controlled before and after study was also undertaken in Jamaica, assessing the impact of school breakfast on the percent of standard height-for-age and weight-for-age in 106 children with a mean age around 12.5 years (Powell, Grantham-McGregor, and Elston 1983). After three months, no significant effect was observed for either height or weight, but a reanalysis by Kristjansson *et al.* (2007) reported a small but significant effect for height in favour of control children. Like in Kenya, the authors suggest that the apparent lack of gains may be due in part to substitution at home.

A study of the India mid-day meal programme assessed the effect of two years of food supplementation on 146 rural primary schoolchildren compared to 304 controls (84–132 months) (Agarwal, Agarwal, and Upadhyay 1989). No significant effect on height gain was observed, though weight gain was 0.63 and 0.79 kg higher for boys and girls respectively in the supplemented group. This minimal influence could be due in part to substitution at home as a dietary survey of a sub-sample of the children found an average increase of 200 kcal rather than the 450–500 kcal of the mid-day meal supplement.

Micronutrient status

In the meat, milk, or energy supplementation RCT in Kenyan schoolchildren, plasma vitamin B-12 concentrations were significantly greater in the meat and milk groups, but no significant improvements were observed for the other micronutrients observed, potentially due to malaria and other infections (Siekman *et al.* 2003). In the school feeding and take-home rations RCT in northern Uganda, both interventions were found to reduce anaemia prevalence of females 10–13 years of age by 17–19 percentage points (Adelman *et al.* 2008).

Micronutrient supplementation and fortification

Anthropometric status

Micronutrient supplementation and fortification have also been found to increase growth at school age. As mentioned above, a meta-analysis of 33 zinc supplementation studies in prepubertal children reported significant effects for both weight (0.31 kg, 95% CI 0.18 to 0.44) and height (0.35 cm, 95% CI 0.19 to 0.51) (Brown *et al.* 2002). In seven of the studies, the mean initial age of the children was greater than 5 years of age. A meta-analysis

of the effects of vitamin A, iron, and multiple micronutrient interventions on the growth of children <18 years of age found significant improvements in height and weight with multiple micronutrient interventions but not with vitamin A or iron alone (Ramakrishnan *et al.* 2004). Of the 14 vitamin A intervention studies, only one was in children of school age, which did report significant improvements in growth (Mwanri *et al.* 2000). Anaemic schoolchildren 9–12 years of age receiving vitamin A supplementation gained 0.4 kg (95% CI 0.19 to 0.65) and 0.2 cm (0.08 to 0.42) more over the three-month study period than those receiving the placebo. Of the 21 iron interventions studies in the meta-analysis, seven were in children of school age (Chwang, Soemantri, and Pollitt 1988; Latham *et al.* 1990; Lawless *et al.* 1994; Aguayo 2000; Beasley *et al.* 2000; Mwanri *et al.* 2000; Sungthong *et al.* 2002). Stratifying all 21 studies by age at baseline did not result in any significant weighted mean effect sizes (Ramakrishnan *et al.* 2004). Five multiple micronutrient interventions were included in the meta-analysis, two of which were in school-age children and reported significant effects for height and weight (Abrams *et al.* 2003; Ash *et al.* 2003).

A more recent systematic review focusing on multiple micronutrient fortification in school-age children reported mixed effects for height and weight gain (Best *et al.* 2011). Significant improvements in weight gain were found in four studies (Abrams *et al.* 2003; Ash *et al.* 2003; Sarma *et al.* 2006; Hyder *et al.* 2007), averaging between 0.47 and 0.56 kg more than the control groups (Best *et al.* 2011). Ash *et al.* (2003) and Sarma *et al.* (2006) also reported significant height gains over the control groups of 0.6 cm after 6 months and 1.2 cm after 14 months, respectively. However, three fortification studies included in the systematic review did not find any significant effects for height or weight (van Stuijvenberg *et al.* 1999; Solon *et al.* 2003; Manger *et al.* 2008), potentially due to extra energy and macronutrients being supplied to the control groups as well.

Micronutrient status

The systematic review on multiple micronutrient fortification also found positive effects on micronutrient status and reductions in the prevalence of anaemia in comparison to no fortification or fortification with a single micronutrient (Best *et al.* 2011). Eight of ten studies observed improvement in iron and haemoglobin status, and consistent improvement in iodine, vitamin A, and B vitamin status were also reported. However, only two of six studies found improvements in zinc status, potentially due to the interaction between zinc and iron or the low reliability of the indicators of individual zinc status. (See Tables 1–3 in Best *et al.* [2011] for further details on the studies.)

Other micronutrient supplementation and fortification studies not reviewed by Best *et al.* (2011) have also found responses dependent on dosages, initial micronutrient status, and multiple micronutrient fortification. A study of iron-fortified whole maize flour in Kenya found dose-dependent improvements in the iron status of schoolchildren in Kenya (Andang'o *et al.* 2007). In a clinical trial in the Philippines, wheat bun flour fortified with vitamin A was found to improve the vitamin A status of schoolchildren whose initial serum retinol concentrations were low (Solon *et al.* 2000). A recent RCT in Vietnamese schoolchildren found that both multiple micronutrient-fortified biscuits and weekly iron supplementation providing the same amount of iron over a six-month period significantly improved iron status over control groups. However, only the multiple micronutrient-fortified biscuits decreased the prevalence of anaemia as well, suggesting that other nutrients in the biscuits affected anaemia status (Hieu *et al.* 2012).

A number of studies have also evaluated the efficacy and effectiveness of using different methods of micronutrient delivery. A dietary supplement providing 11

micronutrients to schoolchildren in Tanzania significantly improved iron and vitamin A status compared with controls in an efficacy trial (Latham *et al.* 2003).

In terms of micronutrient powders (MNP) as a method of delivery, in a randomised controlled efficacy trial of a multiple MNP served with school lunch in northeast Thailand (included in the Best *et al.* [2011] review), no effect was observed for anaemia but improvements in zinc, iodine, and haemoglobin status were reported (Winichagoon *et al.* 2006). In a RCT in Himalayan villages in India, multiple micronutrient fortification of meals cooked and fortified at school using a premixed powder was found to be effective in improving iron, vitamin A, and folate status in schoolchildren (Osei *et al.* 2010). As untargeted MNP containing the Reference Nutrient Intake (RNI) for iron is no longer recommended in malarial areas, a recent study (published after the Best *et al.* [2011] review) of low-iron/-zinc MNP with a phytase and iron as NaFeEDTA and ascorbic acid was still found to be efficacious in reducing iron and zinc deficiency in South African schoolchildren (Troesch *et al.* 2011). An upcoming Cochrane review will be assessing the nutrition, health, and development effects of MNP with iron alone or with iron and other micronutrients among children 24 months to 12 years old, lending insight to the impact by age group (De-Regil, Jefferds, and Peña-Rosas 2012).

5 The costs of school feeding

When designing a school feeding programme with nutrition objectives, cost considerations are a key driver of programming decisions. Generally, the costs of school feeding programmes will depend on several different factors, including the choice of modality, the composition and size of the ration, and the caloric intake per day (all of which are nutrition-related) as well as the number of beneficiaries and school feeding days per year. Logistics, security and climatic conditions also have an impact on programme expenditures. Expenditures will also vary year on year, as programme operations adapt to the particular context.

Remarkably, and despite its popularity as a programme, there is a dearth in the evidence of the costs of school feeding. A handful of field-based studies, mostly from WFP-assisted programmes provide the most recent information on school feeding programme costs. The studies from WFP programmes use practically identical methodologies, thus making comparisons between the findings more meaningful.

The most recent evidence of school feeding costs in the literature involves a study aimed at updating benchmarks and at understanding the cost drivers and cost-containment opportunities of school feeding programmes (Gelli *et al.* 2011). The study covered school feeding activities from 78 WFP and Government supported projects, including over 16 million beneficiaries in 62 low and middle income countries. The standardised yearly average school feeding cost per child was \$48 USD. The yearly costs per child were lowest at \$23 USD for biscuit programmes and highest for take-home rations programmes at \$75 USD. The average cost of programs combining onsite meals with extra take-home rations for children from vulnerable households (e.g. girls in areas with large gender disparities) was \$61 USD. The range of costs is such that there is considerable overlap across the modalities, highlighting the opportunities for cost containment. Commodity costs were on average 58 percent of total costs, and were highest for take-home rations and biscuit programmes (68 and 71 percent respectively). As this analysis does not include school level costs, these findings highlight the higher non-transfer costs for programmes delivering cooked meals in schools compared to other school feeding modalities.

5.1 Costs of on-site meals

Estimating the full cost of on-site meal programmes is not always straightforward, as providing cooked meals in schools generally includes a range of school level costs that are normally not included within overall programme expenditures. A study (Galloway *et al.* 2009) estimated the full costs of on-site meal programmes by collecting data from school feeding programme implementers at all levels in 4 countries in Sub-Saharan Africa (Kenya, Malawi, Lesotho and The Gambia). Programme costs were standardised using a typical 200 feeding day school year, a 700kcal daily ration, and also adjusted for breaks in the food delivery pipeline. The costs of school feeding ranged from \$28 USD to \$63 USD per child per year (weighted average \$40 per child per year). On average, commodity costs accounted for 59 percent of total expenditure. The contribution from local communities averaged at 5 percent of total cost (varying from 0 in Lesotho to 15 percent in Kenya), or about \$2 USD per child per year on average. WFP costs accounted for 60 percent of total programme costs.

Another study covering *only* WFP project expenditures in 42 countries³ (Gelli, Al-Shaiba, and Espejo 2009) found that in 19 countries providing on-site meals the average cost of the programme, standardised using the same parameters outlined above, was \$20.40 USD per child per year. Regional variations in the costs were mostly due to the choice of school feeding modality⁴. Factoring in non-WFP costs, by assuming the same WFP/non-WFP share of full implementation costs as the Galloway *et al.* study, would imply total costs for on-site meals of approximately \$50 USD on average per child per year.

5.2 Costs of fortified biscuits

Analyses of school level costs for biscuit programmes have generally found these fairly negligible, making cost estimations for this school feeding modality more straightforward. A full cost analysis of WFP assisted programmes in three countries⁵ (Gelli *et al.* 2006) found that the weighted average standardised cost of providing fortified biscuits was \$12.77 USD per child per year. The cost per beneficiary varied substantially from one country to another, ranging from \$10.86 USD in Bangladesh to \$17.59 USD in Indonesia. The cost of commodities accounted for an average of 81 percent of total project costs, about 22 points higher than for other cooked meals.

5.3 Costs of take-home rations

As for fortified biscuit programmes, costs at the school level for take-home rations programmes are generally negligible. An analysis of the full cost of the take-home rations programme in Pakistan (Ahmed *et al.* 2007) found that the full cost of implementing the programme, adjusted over breaks in the food pipeline, was \$63 USD per child per year. Food costs accounted for 63 percent of total programme expenditure.

³ 26 countries in Sub-Saharan Africa, 5 in Asia, 8 in Latin America and the Caribbean, 3 in Middle East and Central Asia. 19 countries SF programmes provided on-site meals, 3 provided fortified biscuits, 4 provided take-home rations, and 16 combined on-site and take-home rations.

⁴ Notably, in Sub-Saharan Africa, no SF programmes at the time offered fortified biscuits.

⁵ Bangladesh, India and Indonesia.

An analysis of only WFP costs (Gelli *et al.* 2009), covering four countries (China, Ghana, Pakistan and Yemen) found that the average cost of take-home rations was \$52 USD. The higher costs for take-home rations compared to other modalities of school feeding were found to be mostly due to the larger volumes of food distributed to each child; in this data set, over a school year, take-home rations delivered approximately twice as much food per child compared to on-site meals. Moreover, the standardisation methodology used in this analysis might not always be appropriate for take-home rations programmes, where food is distributed conditional to attendance. Adjusting costs by planned tonnage over distributed tonnage is likely to overestimate costs for take-home rations.

5.4 Cost-efficiency considerations

The choice of modality of food delivery in school has considerable implications, both from the programme objectives and costs perspectives. To date there is a dearth in the evidence on cost-effectiveness comparisons across the different modalities; this remains an important area of future research. However, there is some emerging data on cost-efficiency: On-site meals are approximately three times more costly than fortified biscuits: This is a very considerable overhead, particularly if we consider that most schools assisted by WFP are located in vulnerable, food-insecure areas and communities around the schools will generally have to bear these costs.

Table 1: Comparison of average cost per beneficiary, and per nutrient delivery for fortified biscuits and on-site meals (in \$USD) (Source: Bundy *et al.*, 2009).

Modality	Standardised cost per beneficiary	Cost per 100 kcal delivered	Cost per mg of Iron delivered	Cost per 100 mcg of Vitamin A delivered	Cost per 100 mcg of Iodine delivered
On-Site ⁶	40	11	9	19	130
Biscuits ⁷	13	5	2	4	19

Furthermore, as shown in Table 1, biscuits are more cost-efficient in terms of energy and micronutrient delivery, making them an ideal choice in contexts where micronutrient deficiencies in school-age children are widespread and the infrastructure and resources for school meal programmes are constrained.

Only one other study was identified in the literature that analysed the costs of school feeding in different countries (Horton 1992). In this analysis the cost of programmes providing food through schools standardised over 365 days and 1000 kilocalories varied from \$19.35 to \$208.59. Average costs by region ranged from \$79 USD in Sub-Saharan Africa to \$91 USD in Asia. In addition, only two other impact evaluations of school feeding programmes in Bangladesh included data on costs. The cost of the Government take home ration programme was reported to be US\$0.10 per child per day (Ahmed and del Ninno 2002), though no analysis of the costs was provided. The fortified biscuit program costs were reported to be US\$18 per child per year, covering 240 school days (Ahmed 2004).

⁶ Data from Galloway *et al.* 2009 for school feeding in Kenya, Lesotho, Malawi and The Gambia.

⁷ Data from Gelli *et al.* 2006 for school feeding in Bangladesh, India and Indonesia.

5.5 Cost drivers

There is very limited data on the cost drivers of school feeding programmes. In the WFP analyses, commodity costs were generally found to be the main cost drivers, with the food basket and ration nutritional content varying considerably from country to country. Because of in-kind donations to WFP, in several countries, commodities were used in the food basket that might have otherwise been replaced by foods procured on the market at lower prices. Landlocked countries such as the Central African Republic, Malawi and Mali, or countries with poor road networks to assisted areas such as Madagascar were found to face high transportation costs. This finding may reflect the nature of WFP programmes, where the bulk of the food is not generally purchased in close proximity to assisted schools which are generally found in food in-secure areas. From this perspective, food purchases in the vicinity of schools could be used to offset the transportation costs associated with traditional food-aid programmes. Often, logistics on difficult roads are compounded by volatile security situations, as in WFP assisted areas in Pakistan, Sudan, and Uganda, for example.

Further analysis of cost drivers was limited in these studies by the aggregate nature of the cost categories in the data. Staff costs, for example, were aggregated alongside maintenance and other recurrent costs with the Direct Support Costs category. More in-depth country analysis will be required to determine specific cost drivers. The analysis of the costs of WFP school feeding programmes also suggested that the flexibility of the school feeding programme design is often limited by the in-kind donations to WFP, which also contribute to higher costs, and therefore lower the overall cost-efficiency of the programme. The benchmarks presented in this analysis reflect the centralised WFP implementation model that is not always relevant in terms of Government school feeding programmes, particularly those models procuring food in the communities surrounding assisted schools. Understanding the cost drivers associated with the different school feeding models remains an important area of future research.

5.6 Costs of other school health and nutrition interventions

Addressing micro-nutrient deficiencies, in particular iron and iodine, has been shown to have a positive impact on learning (see Taras [2005] for a review of studies on nutrition and school performance). Micronutrient powders can be a cost-effective solution to combat micronutrient deficiencies, for example, by adding 15 micronutrients to unprocessed home-grown school meals reaching school children in food insecure and remote areas. The Copenhagen Consensus ranked micronutrient interventions first among all development interventions in terms of spending priorities based on benefit-cost ratios. For multi-dose sachets of 8 gram (20 servings) appropriate for use in school feeding programmes the costs are ~0.01 USD per serving. The average WFP programme cost per child for one school year is 3.2 USD.

Other school-health and nutrition interventions (see FRESH/Essential Package framework) have also been shown to have benefits on learning in the classroom, some for a fraction of the cost of school feeding. A key intervention in within FRESH/Essential Package is helminth control, or deworming. School-age children typically have the highest intensity of worm infection of any age group (Bundy *et al.* 1992). De-worming interventions have been shown to reduce school absenteeism and contribute to the improvement of cognitive function in school age children (Grigorenko *et al.* 2006), all for a very modest investment of approximately \$0.50 USD per child per year (Bundy 2011). The cost per added year of

schooling in deworming interventions was estimated to be approximately \$3.50 USD per child per year (Miguel and Kremer 2004).

Iron deficiency anaemia is thought to affect about 210 million school-age children worldwide, with prevalence of anaemia reaching approximately 40 percent amongst children in various parts of Asia and Africa. Research shows that children with iron deficiencies sufficient to cause anaemia are at a disadvantage academically, and their cognitive performance has been shown to improve with iron therapy. Iron supplementation, coupled with deworming, was found to increase per-school participation by 5.8 percent, at a cost of approximately \$1.70 USD per child (Bobonis, Miguel, and Puri-Sharma 2006).

Conditional cash transfer (CCT) programmes have been shown to have significant effect on pupils' education, health and nutrition (Rawlings and Rubio 2005). In Progreso, the CCT programme in Mexico, the costs per added year of schooling were found to be over \$4,000USD (Schultz 2004). On the other hand CCT programmes have also been shown to have contributed to reducing inequality in three Latin American countries, through well targeted, large-scale social transfer programmes.

6. Conclusions

6.1 Programme theory: School feeding and nutrition

The programme theory, existing evidence base, and cost implications are all key considerations in providing evidence-based guidance to national governments on school feeding and nutrition. Understanding the context, identifying the target population, planning the intervention and service delivery, and developing the impact theory – all components of the programme theory – delineates the mechanisms and pathways through which school feeding may affect short- and medium-term outcomes as well as long-term impact. Framing these pathways helps inform the interpretation of the literature review findings here, focused on school feeding and nutrition (e.g. the substitution effects discussed above).

6.2 Literature review

Based on the evidence reviewed in the literature review, Table 2 provides a qualitative assessment of the relative evidence bases on anthropometric and micronutrient outcomes for in-school meals, take-home rations, multiple micronutrient fortification, and micronutrient powder, specifically.

Table 2. An Assessment of the Effect of School Feeding on Nutrition Outcomes

School feeding activity	Anthropometric status		Micronutrient status					
	Height/stunting	Weight/underweight	Iron	Hemoglobin/anemia	Iodine	Vitamin A	Zinc	B-vitamins
In-school meals	+++	+++	+	++	n.a.	+	+	+
Take-home rations	++	++	n.a.	+	n.a.	n.a.	n.a.	n.a.
Multiple micronutrient fortification	++	++	+++	+++	+	+++	+++	+
Multiple micronutrient powder	++	++	++	++	+	++	++	+

Source: Authors' compilation. See text for data sources.

Note: n.a. = not assessed by an RCT.

+ = evidence from one RCT.

++ = evidence from two RCTs.

+++ = evidence from more than two RCTs.

Because of the complex pathways described in this review, we should only expect a limited impact of school feeding on nutritional status of children. However, we might expect an improvement in children's activity and play and an improvement in nutritional status of siblings (if substitution effects are strong).

Food supplementation

To summarize the findings from food supplementation studies, six RCTs with medium to large sample sizes and ranging between 8 and 24 months in duration observed anthropometric outcomes. Small, significant effects on weight gain and small, non-significant effects on height gain were reported for school-age children. The spill-over benefits observed for younger siblings indicate that school feeding could have an important role in promoting the health of the next generation of mothers. In four controlled before and after studies (medium sample sizes, ranging between 3 and 24 months in duration), significant effects on height and weight gain were reported.

Nearly all of the food supplementation studies that reported significant height and weight gains included an animal-based product (Powell *et al.* 1998; Grillenberger *et al.* 2003; Du *et al.* 2004), not usually included in school feeding programmes in low-income countries. Additionally, initial nutrition status may play a role, as seen in the Grillenberger *et al.* (2003) study, which reported a significant effect on height gain in the subset of children with baseline HAZ ≤ -1.4 .

Micronutrient supplementation and fortification

For micronutrient supplementation and fortification, a systematic review of multiple micronutrient fortification reported consistent improvement in micronutrient status and reduced anaemia prevalence but equivocal results for improvements in anthropometric status, potentially due to the provision of energy to control groups as well. No RCTs that assessed anthropometric status were found to have a two-by-two design to separate the effects of macronutrients and multiple micronutrients (see research agenda below).

The different methods of delivering micronutrients are currently being studied to assess acceptability to children and develop methods of reducing the risk of overdose while maintaining a sufficiently high dose to impact nutritional status.

Cost considerations

The apparent variation in costs of school feeding programmes among low-income countries implies that there is considerable opportunity for cost containment, provided that the drivers of costs are better understood. The relevance of the modality is an important issue, and there is a particular lack of information on fortified biscuits and for take-home rations. Commodity costs were on average 58 percent of total costs, and were highest for take-home

rations and biscuit programmes (68 and 71 percent respectively). As this analysis does not include school level costs, these findings highlight the higher non-transfer costs for programmes delivering cooked meals in schools compared to other school feeding modalities.

6.3 Research agenda

As identified above, there are a number of key areas for research on school feeding and nutrition.

- ***Impact studies that assess the potential nutritional contribution of different designs of school feeding programmes.*** The need for more operational studies exploring how to improve the capacity and effectiveness of nutrition-related programmes, for example, by adding nutrition and family health elements to existing school feeding programmes, also examining the substitution effect at household level, has been identified as a key part of the overall school feeding research agenda (Bundy *et al.* 2009).
- ***School feeding and nutrition impact studies that also measure physical activity levels (PAL), particularly in adolescents who engage in considerable work and play.*** As described above, the impact of food supplementation depends on the extent of substitution effects and on whether children are increasing the use of energy for PAL and BMR. Research (including theoretical framing, a definition of the minimum acceptable level of PAL, and a standardised way of measuring it) is needed to determine whether children adapt to nutritional stress by reducing weight or PAL.
- ***Assessments on whether rapid urbanisation and changes in diets in low- and middle-income countries is resulting in overweight and obesity.*** As there is little to no evidence available on this topic, overweight and obesity outcomes are not covered in the paper. However, the nutrition transition that many countries are experiencing has led to changes in school feeding policy (e.g. in Brazil and Mexico) and highlights the need for further research in this area.
- ***Analysis of nutrition outcomes of school feeding by age group and content and size of the ration.*** To help inform evidence-based guidance using a life-cycle approach, further analysis is needed to evaluate any differential impacts of school feeding by age group. Additionally, more analysis on content and size of rations will strengthen programme design guidance.
- ***Assessments to separate the effects of macronutrients and multiple micronutrients as well as evaluate interactions in micronutrient supplementation and fortification studies.*** Two-by-two designs for future multiple micronutrient intervention studies have been recommended, involving multiple micronutrient fortification against an unfortified food, a multiple micronutrient tablet, and no intervention (Best *et al.* 2011).
- ***Comparisons of costs and cost-effectiveness across different modalities and associated nutrient composition, along with analysis of the cost drivers.*** Remarkably, and despite its popularity as a programme, there is a dearth in the evidence of the costs of school feeding, particularly on cost-effectiveness comparisons across the different modalities and associated nutrient composition. Additionally, understanding the cost drivers associated with the different school feeding models remains an important area of future research.

In conclusion, findings from this review suggest that well-designed school feeding programs, which include micronutrient fortification, can provide nutritional benefits and should complement and not compete with nutrition programs for younger children, which remain a clear priority for targeting malnutrition overall. Important gaps in the evidence remain, however, including the link between quality of school food service delivery and impact, as well as the potential for “home-grown” approaches to benefit children of different age-groups, including preschoolers and adolescents.

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Annex 1. Studies of the effect of food supplementation on height and weight in school-age children

Reference	Country	Intervention (if relevant, quality in terms of protein/fat/carbs)	Study type	Sample characteristics (size, features)	Age at intervention	Length of intervention	Effect size for height and weight
Bailey 1962	Indonesia	<p><i>group I</i>: iron (control, 100 mg)</p> <p><i>group II</i>: palm-sugar (180 kcal, 1.5 g protein)</p> <p><i>group III</i>: green gram and palm-sugar (195 kcal, 12 g protein, 3.1 mg iron)</p> <p><i>group IV</i>: skimmed milk (powder, 90 kcal, 10 g protein, 0.3 mg iron)</p> <p><i>group V</i>: Saridale (powder, 170 kcal, 10 g protein, 1.3 g iron)</p> <p><i>group VI</i>: tempeh (soya, 80 kcal, 12.5 g protein, 5.0 mg iron)</p> <p><i>group VII</i>: tempeh (velvet bean, 50 kcal, 10 g protein)</p> <p>All supplements served as a mid-morning snack, except for the tempeh which was given before school.</p>	CBA	<p>504 boys from relatively wealthy backgrounds</p> <p>Mean values for height and weight at baseline slightly greater than those of boys in more remote villages</p>	Range: 7–13 yrs	12 mo (average of 201 days of supplementation per group)	<p><i>height</i>: 0.63 cm for group II; 0.60 cm for group V; no significant effect in other groups</p> <p><i>weight</i>: no significant effect in any groups</p>
Devadas <i>et al.</i> 1979	India	<p><i>supplement group</i>: vegetable protein mixture (395 kcal and 14 g protein)</p> <p><i>control group</i>: no supplement</p> <p>Supplement of local, low cost food made up for caloric deficit (20%) and micronutrient deficits of home diet.</p>	CBA	<p>400 children (214 boys and 186 girls)</p> <p>Caloric and micronutrient intake without the supplement was less than recommended</p>	Range: 5–8 yrs	10 mo	<p><i>height</i>: 2.62 [2.22 to 3.02] cm for 5–6 years of age; 2.75 [2.24 to 3.26] cm for 6–7 years; 2.55 [2.24 to 2.86] cm for 7–8 years</p> <p><i>weight</i>: 0.95 [0.70 to 1.20] kg for 5–6 years; 0.33 [0.08 to 0.58] kg for 6–7 years</p>

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Reference	Country	Intervention (if relevant, quality in terms of protein/fat/carbs)	Study type	Sample characteristics (size, features)	Age at intervention	Length of intervention	Effect size for height and weight
							years; 0.90 [0.68 to 1.12] for 7–8 years †
Powell, Grantham-McGregor, and Elston 1983	Jamaica	<i>breakfast group</i> : half pint milk (130 kcal and 8 g protein) and banana cake (250 kcal and 5 g protein) or patty (meat and vegetable pastry, 600 kcal and 16.5 g protein) <i>control group</i> : no supplement <i>control syrup group</i> : syrup drink (33 kcal) Breakfast served daily at 9:00 a.m. Patties served 35% of the time.	CBA	106 children, the majority from poor farming families <i>weight-for-age</i> : 82.7% of standard for breakfast group, 87.6% for control group, 82.3% for control syrup group <i>height-for-age</i> : 94.3% of standard for breakfast group, 95.3% for control group, 93.5% for control syrup group	Mean: 12.6 ± 0.4 yrs for breakfast group; 12.5 ± 0.3 yrs for control group; 12.6 ± 0.3 yrs for syrup group Range: 11–17 yrs	3 mo	<i>height-for-age, percentage of standard</i> : -0.75 [-1.11 to -0.39] <i>weight-for-age, percentage of standard</i> : 0.90 [-0.40 to 2.20] †
Agarwal, Agarwal, and Upadhyay 1989	India	<i>supplement group</i> : mid-day meal (450–500 kcal and 10–12 g protein) <i>control group</i> : no supplement All meals served during the recess on all school days.	CBA	450 children (331 boys and 115 girls)	Range: 7–11 yrs	2 yrs (175 days in first year and 181 days in second year)	<i>height</i> : boys -0.30 [-0.95 to 0.35] cm; girls 0.20 [-0.74 to 1.14] cm <i>weight</i> : boys 0.70 [0.39 to 1.01] kg; girls 0.80 [0.35 to 1.25] kg †
Powell <i>et al.</i> 1998	Jamaica	<i>breakfast group</i> : cheese sandwich or spiced bun and cheese and flavoured milk (576–703 kcal and 27.1 g protein) <i>control group</i> : one-quarter of an orange (18	RCT	407 <i>undernourished</i> children (≤ -1 WAZ) 407 <i>adequately-nourished</i> children (> -1 WAZ)	Mean: 9.0 ± 1.2 yrs	8 mo †	<i>height</i> : 0.25 [0.06 to 0.44] cm <i>weight</i> : 0.37 [0.19 to 0.55] kg

Reference	Country	Intervention (if relevant, quality in terms of protein/fat/carbs)	Study type	Sample characteristics (size, features)	Age at intervention	Length of intervention	Effect size for height and weight
		kcal and 0.4 g protein) All meals served before start of classes on all school days.					HAZ: 0.04 [0.02 to, 0.06] WAZ: 0.07 [0.04 to 0.10] †
Grillenberger et al. 2003	Kenya	<i>meat supplement</i> : githeri and minced beef (~250–300 kcal, >50% RDI vitamin A, >75% RDI vitamin B-12, ~33% RDI iron, >50% RDI zinc) <i>milk supplement</i> : githeri and cow's milk (~250–300 kcal, >50% RDI vitamin A, >75% RDI vitamin B-12, >75% RDI riboflavin) <i>energy supplement</i> : githeri and extra oil (~250–300 kcal) <i>control group</i> : no supplement All supplements served at 9:30 a.m. on school days.	RCT	544 children <i>stunting</i> (<-2 HAZ): 19.4% <i>severe stunting</i> (<-3 HAZ): 4.6% <i>underweight</i> (<-2 WAZ): ~30% of boys and 30% of girls <i>mild underweight</i> (-1 to -2 WAZ): 42.1% of boys and 31.1% of girls ‡	Mean: 7.4 yrs Range: 6–14 yrs ‡	23 mo (18 mo of which schools were in session)	<i>height</i> : no significant overall effect (but for milk group, 1.3 cm (15%) gain in children with HAZ <-1.4, p = 0.05) <i>weight</i> : ~0.39 kg for each group (p < 0.02) HAZ: no overall effect WHZ: declines in each group
Du et al. 2004	China	<i>group 1</i> : 330 ml milk fortified to contain 560 mg Ca (~10 g protein and ~10 g fat) <i>group 2</i> : 330 ml milk fortified to contain 560 mg Ca and vitamin D (~10 g protein and ~10 g fat) <i>group 3</i> : no supplementary milk Milk served in the morning before classes or during the first break on every school day over the two-year period (average daily intake of 144 ml milk). Daily increase of energy about 5%, protein about 8%, and	RCT	757 girls low calcium intake (43.1% RDI) low vitamin D intake (9.0% RDI)	Mean: 10.1 ± 0.4 yrs for group 1; 10.1 ± 0.3 yrs for group 2; 10.1 ± 0.3 yrs for group 3	24 mo	<i>height</i> : for group 1, 1.20 [0.46 to 1.94] cm <i>weight</i> : for group 1, 1.50 [0.25 to 2.75] kg †

Reference	Country	Intervention (if relevant, quality in terms of protein/fat/carbs)	Study type	Sample characteristics (size, features)	Age at intervention	Length of intervention	Effect size for height and weight
		calcium about 50%.					
Adelman <i>et al.</i> 2008	Uganda	<p><i>school feeding programme (SFP)</i>: mid-morning snack of corn-soya-blend and lunch of beans and rice or posho (maize-meal), oil, and salt (combined, ~1049 kcal, 32.6 g protein, 24.9 g fat; 99% RDI iron, and >two-thirds of other vitamin and mineral requirements)</p> <p><i>take-home rations (THR)</i>: equivalent amount of food to school feeding programme</p> <p><i>control group</i>: no treatment</p> <p>Children in school feeding programme received daily in-school meals while take-home rations (21 days worth) were distributed once a month conditioned on 85% attendance rate.</p>	RCT	<p>2,159 children living in IDP camps</p> <p><i>stunted</i>: >20%</p> <p><i>HAZ</i>: -0.87 for SFP; -0.83 for THR; -0.95 for control</p> <p><i>WAZ</i>: -0.74 for SFP; -0.73 for THR; -0.88 for control</p> <p><i>BMIZ</i>: -0.60 for SFP; -0.59 for THR; -0.63 for control</p>	<p>Mean: 9.59 yrs for SFP; 9.61 yrs for THR; 9.42 for control</p> <p>Range: 6–13 yrs</p>	<p><i>SFP</i>: average of 145.7 school feeding days per child</p> <p><i>THR</i>: average of 4.2 mo of rations per child</p>	<p><i>HAZ</i>: no significant effect</p> <p><i>BMIZ</i>: no significant effect</p>
Kazianga, de Walque, and Alderman 2010	Burkina Faso	<p><i>school canteens</i>: daily in school lunch meal, boys and girls</p> <p><i>take-home rations</i>: 10 kg of cereal flour per month, girls only, conditioned on 90% attendance rate</p> <p><i>control group</i>: no treatment</p>	RCT	<p>4,140 children in the Sahel region</p> <p><i>HAZ (6–60 mo)</i>: -2.35 for school meals; -2.09 for THR; -2.32 for control</p> <p><i>WAZ (6–60 mo)</i>: -2.20 for school meals; -2.52 for THR; -2.39 for control</p>	<p>Mean: 9.78 yrs for school meals; 9.79 yrs for THR; 9.84 for control</p> <p>Range: 6–15 yrs</p>	1 school yr	<p><i>WAZ</i>: no significant effect</p> <p><i>BMIZ</i>: no significant effect</p>
Buttenheim, Alderman, and Friedman 2011	Lao PDR	<p><i>on-site feeding (OSF)</i>: 100 g corn-soya blend and 12.5 g sugar each school day, with a target of 83 feedings per term</p> <p><i>on-site feeding and take-home rations</i>: see above and below</p>	quasi-experimental longitudinal comparison	<p>9,810 children aged 3–14 surveyed</p> <p><i>HAZ</i>: -2.34 for OSF; -2.31 for OSF & THR; -2.47 for THR; -2.23 for control</p>	<p>Mean: 7.86 yrs for OSF; 7.97 yrs for OSF & THR; 7.87 yrs for THR; 7.97 yrs for control</p>	Considerable variation in start-up date among villages (majority)	<p><i>HAZ (3–10 yrs)</i>: 0.29 (p < 0.01) for THR; no significant effect for other groups</p> <p><i>WAZ (3–10 yrs)</i>: 0.22</p>

Reference	Country	Intervention (if relevant, quality in terms of protein/fat/carbs)	Study type	Sample characteristics (size, features)	Age at intervention	Length of intervention	Effect size for height and weight
		<i>take-home rations</i> : 15 kg rice upon enrolment, 30 kg rice at end of school year if attendance was 80%; one can of fish per month if attendance was 80% <i>control group</i> : no treatment		WAZ: -1.91 for OSF; -1.94 for OSF & THR; -2.18 for THR; -1.82 for control	Range: 6–14 yrs	between fall 2006 and fall 2007); follow-up survey fall 2008 Median 280 days for OSF and 235 days for OSF & THR	SD ($p < 0.05$) for THR; no significant effect for other groups

† Kristjansson *et al.* 2007

‡ Neumann *et al.* 2003



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