Special Article

School feeding programs in developing countries: impacts on children's health and educational outcomes

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School feeding programs (SFPs) are intended to alleviate short-term hunger, improve nutrition and cognition of children, and transfer income to families. The present review explores the impact of SFPs on nutritional, health, and educational outcomes of school-aged children in developing countries. Peer-reviewed journal articles and reviews published in the past 20 years were identified and screened for inclusion. Analysis of the articles revealed relatively consistent positive effects of school feeding in its different modalities on energy intake, micronutrient status, school enrollment, and attendance of the children participating in SFPs compared to non-participants. However, the positive impact of school feeding on growth, cognition, and academic achievement of school-aged children receiving SFPs compared to non-school-fed children was less conclusive. This review identifies research gaps and challenges that need to be addressed in the design and implementation of SFPs and calls for theory-based impact evaluations to strengthen the scientific evidence behind designing, funding, and implementing SFPs.

INTRODUCTION

Hunger is an ongoing problem that affects more than 1.2 billion people who do not have enough to eat in the world today.[1] The recent global economic crisis, fluctuations in food prices in 2006–2008, wars and political conflicts, and devastating natural disasters have deprived millions of people of access to adequate food. Most of the individuals affected are in the most impoverished regions of the world. Previous efforts by heads of states, international organizations, and local agencies to address poverty and hunger-related issues resulted in the UN Millennium Declaration (2000). The goals outlined in the declaration were established to eradicate poverty, alleviate hunger, reduce gender inequalities, improve health and longevity, overcome environmental degradation, and most importantly, develop global partnerships to achieve the goals.[2]

Education and health were central components of the roadmap towards implementing the stated goals. The first millennium development goal (MDG) emphasized the eradication of extreme poverty and hunger, whereas the second and third MDGs focused on "achieving universal primary education" and overcoming gender disparities in primary and secondary education. The UN declaration and its roadmap have set the platform for global trends and national efforts to meet the MDGs within a reasonable timeframe (mostly by 2015) and the World Bank (WB) and its development partners, including the World Food Program (WFP), took more rapid steps to meet these goals and launched the Education for All (EFA) Fast Track Initiative (FTI) in 2002. The main objective of EFA FTI was to help low-income countries meet the MDGs, particularly the "education for all" goal.[3] Despite the major efforts exerted, the progress towards universal primary education (2nd MDG) has been slow and uneven. More than 121 million school-aged children are still out of school, and two-thirds of them are girls living in rural areas in the most vulnerable regions of the

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Key words: children's health, cognitive functions, developing countries, dietary intake, education, growth, micronutrient status, school-aged children, school feeding programs

doi:10.1111/j.1753-4887.2010.00369.x

world. One of the major reasons for this lag in progress toward universal primary education is the persistence of poverty, hunger, and malnutrition.[4] Infants and children are among the most vulnerable population groups subject to the adverse, and when very young, irreversible, short- and long-term cognitive, physical, and psychosocial consequences of hunger and undernourishment.[5,6] There is also increased evidence that childhood undernutrition imposes significant economic costs on individuals and nations, and that improving children's diets and nutrition can have positive effects on their academic performance and behaviors at school as well as their long-term productivity as adults.[7,8]

School feeding programs (SFPs) have been continuously gaining popularity in developing countries, mostly among those affected severely by childhood hunger and malnourishment. These programs aim to enhance the concentration span and learning capacity of school children by providing meals in schools to reduce short-term hunger that may otherwise impair children's performance.[9] Currently, SFPs exist in 70 of the 108 low- and lower-middle income countries, and most of them have been initiated and funded by the WFP.[10] Some of these SFPs have evolved and been adopted nationally while others still rely on the assistance, funding, and/or expertise of the WFP and its development partners in varying degrees. The WFP and its development partners have been promoting school feeding in its different modalities for years as effective interventions that help alleviate hunger and improve the cognitive and educational abilities of children. When children are provided with food at school, not only do parents receive an incentive to send their children to school, particularly girls, children are also encouraged to attend and complete a school day. Thus, SFPs can help developing countries and their development partners meet a number of MDGs, including the eradication of hunger, achieving universal primary education, and closing the gender gap by giving boys and girls equal opportunities for completion of primary schooling.[11,12]

According to Belgeron and Del Rosso's conceptual framework for Food for Education (FFE),[13] also known as SFPs, FFE programs provide food transfer to children at school, income transfer to their families, and resource transfer to the schools operating these programs. In 2009, the World Bank and the WFP published a joint review on SFPs[14] re-emphasizing the rationale and objectives of these programs. The three main objectives identified were to provide safety nets for families to absorb social and economic shocks, improve the education and scholastic performance of school-aged children, and enhance children's nutrition and health status. To parallel the three main pillars or objectives of SFPs (safety nets, nutrition, and education), a logical framework for SFPs was developed mapping the inputs, outputs, outcomes, and impacts for each of the objectives and rationales of the programs.[15] Resources or inputs include micronutrient fortified meals, snacks, and take-home rations, as well as anthelmentic treatments; outputs include the numbers of children fed, schools reached, and food rations/deworming tablets distributed. If nutrition is the objective of the program, the outcomes identified are the alleviation of hunger and improvement of the micronutrient status of school-aged children; the intended impacts are to improve the nutrition and health of beneficiary children and improve their learning capacities. The main impacts of SFPs with regard to meeting educational objectives are to improve learning, increase lifetime earnings of targeted children, and increase access to education for girls, orphans, and vulnerable children. In addition, educating families and future generations about family planning, HIV/AIDs prevention, and other health topics are among the intended impacts of SFPs.

Although the benefits of school feeding are well-documented, controversy remains over the effectiveness of SFPs. According to Kristjansson et al.,[16] "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)". The present review was conducted to summarize the nutrition literature on the impact of school feeding, focusing primarily on the relationship between school feeding and changes in the nutritional and health outcomes of targeted school-aged children and secondarily on more established cognitive and educational outcomes. The review sheds light on gaps in the literature regarding school feeding in developing countries and other challenges faced by those implementing SFPs. Furthermore, it highlights the need for theory-based impact evaluation studies to strengthen the design and implementation of existing and future SFPs.

METHODOLOGY AND CRITERIA FOR SELECTION OF EMPIRICAL EVIDENCE INCLUDED IN THE REVIEW

Articles and manuscripts included in this review were identified using primarily PubMed and Web of Science databases, as well as the World Food Program headquarters online database and library. Research articles addressing this topic and published in peer-reviewed journals in the past 20 years (1990–2009) were screened and those that did not meet the inclusion criteria of our review were excluded (see Table 1). Variations of terms were used in the search process to find studies of different designs and interventions conducted in developing countries. Randomized controlled trials (RCTs), which

Table 1 **Inclusion and exclusion criteria for studies and publications included in this review.**

Study characterstic	Inclusion criteria	Exclusion criteria
Setting	Developing countries	Developed countries
Sample	Primary school-aged children	Children < 5 years (infants, toddlers, preschoolers) Children at secondary school level
Intervention	Effect of in-school meals, fortified/supplemented meals and/or snacks, and take-home food rations (THRs) Complimentary health/ nutrition interventions (ex. De-worming)	Effect of micronutrient supplements, not part of a school feeding program or study
Publication timeframe	1990 and later	Prior to 1990

are experiments in which investigators allocate eligible people randomly into treatment and control groups to receive or not to receive one or more of the interventions being compared, are regarded as the gold standard of research. However, non-randomized trials are seen as important complimentary studies when randomization or blinding is inappropriate, unethical, or sometimes not feasible. Thus, our review included RCTs, intervention/ control studies, crossover design studies, and effectiveness reports of existing SFPs. Table 2 includes a summarized description of the studies included in the review, outlining their research designs, study participants, duration of observations/interventions, outcomes measured, and the main findings.

IMPACT OF SCHOOL FEEDING ON NUTRITION AND HEALTH OF SCHOOL-AGED CHILDREN

Growth and body composition

Evidence of the impact of SFPs on children's growth and body composition remains inconclusive due to the mixed results reported from different studies. A few studies found a positive effect of school feeding on children's growth and anthropometric indices, while others showed no effect. In 2006, Kristjansson et al.[16] conducted the first systematic review and meta-analysis to explore the impact of school feeding on a number of physical and psychosocial variables in school-aged children. A total of 18 studies were included in the review, nine of which were conducted in developing/lower income countries (Kenya, Jamaica, India, Indonesia, and China), five of which were RCTs, and four of which were controlled before and after (CBA) trials. The meta-analysis showed an overall small, non-significant change in height between children who did or did not receive meals at school in RCTs,[17–19] whereas a significant increase in height was observed in CBA trials.[16,20–22] On average, school-fed children gained 1.43 cm in height more than controls. The meta-analysis of two RCTs within the same review showed a small, yet significant effect of school feeding on height-for-age (z-score change = 0.04 [95%CI: 0.02–0.06]). However, authors found a stronger and more consistent effect of school feeding on weight gain from the three RCTs and three CBA trials that were analyzed; a gain that ranged between 0.25 to 0.75 kg a year.

Similar positive effects of school feeding were reported by Powell et al.[18] Researchers reported positive nutritional outcomes from their RCT in which they provided 395 primary school-aged children (2nd to 5th graders), from 16 rural Jamaican schools, breakfast meals every day for one school year (8 months). Children in the control group ($n = 396$ children) were given one-quarter of an orange as a placebo. Researchers found that children in the breakfast group gained significantly more weight ($\beta = 0.42$), height ($\beta = 0.25$), and BMI ($\beta = 0.16$) than children in the control group ($P < 0.05$). A slight substitution effect was observed among breakfast consumers over lunchtime, as they consumed 54 calories less on average than the control group. Substitution is a reduction in home diet for students who are receiving food at school. However, the decrease in energy intake did not offset the total energy consumed from the school breakfast meal and a net increase in dietary (energy) intake was observed among breakfast consumers. Children receiving breakfast gained, on average, an additional 0.25 cm during the 8-month intervention, a gain which, when extrapolated by researchers, was found to be equivalent to 0.4 cm increase in height per year or approximately 1

Table 2 **Summary of reviewed papers on the impact of school feeding on nutrition, health, education, and learning of school-aged children in developing countries (13 studies).**

Reference	Study design	Setting, participants, intervention, and duration of study	Outcomes measured	Main findings
Kristjansson et al. (2007)[16]	Cochrane systematic review	Included 18 studies, 9 from developed and 9 from developing countries	Weight/ height/micronutrient status/Hb levels	Mixed results for change in heights between school-fed and non-school-fed children (RCTs and CBAs from lower and higher income countries)
			School enrollment and attendance	School-fed children gained an average of 0.39 kg more than controls (RCTs in lower income countries) and 0.71 kg over 11.3 months (CBAs in lower income countries)
			School achievement in math, reading, and spelling	Increase in muscle mass (assessed in only 1 RCT)
			Attention problems, on-task behavior	Improvements in certain micronutrient intakes and biochemical parameters (ex. Vit B_{12} intake and blood concentration from Neumann's RCT in Kenya and improved Ca from study in Beijing, China)
Ahmed (2004; Bangladesh)[24]	Primary data collected from school, household, and community-level surveys in Bangladesh	SFP provides mid-morning snack consisting of fortified wheat biscuits to chronically food-insecure areas of Bangladesh	School enrollment, attendance, and dropout rate + performance on achievement tests	SFP increased school enrollment by 14.2%
		Approx. 6,000 primary schools (1.21 million primary school-aged children)	Two 24-hour recalls were collected per household to estimate individual intake and food consumption patterns	Increased school attendance by 1.3 days a month
		Snack provides 300 kcal and 75% of RDAs for vitamins and minerals		Reduced dropout rate by 7.5%
				Increased achievement test* scores by 15.7% points, mainly in mathematics where SFP participants scored 28.5% higher than nonparticipant counterparts
				Mothers of SFP participants reported increased concentration on studies among their children
Simeon (1998; Jamaica)[23]	Review of a case-control study	Study I: 115 children in grade 7 (12–13 y) in 3 classrooms† at a rural school in Jamaica. One class ($n = 44$) was served an early morning school meal and two classes served as controls (1 served a drink as placebo and the other nothing) $n = 76$	Study I: Attendance, weight, and performance on spelling and arithmetic tests	No difference in weight gain between intervention group and control group
		Duration = 2 semesters (1st semester baseline, 2nd semester intervention)		Attendance decreased in both groups, but provision of breakfast lead to lower drop in attendance
				Greater achievement in arithmetic tests (breakfast group versus control) but no difference in spelling
Simeon (1998; Jamaica)[23]	Study II: Crossover design (each child tested on 2 mornings, 1 with breakfast, 2nd without. 1 week apart as washout period)	Study II: 90 children (9–10 y) performance under breakfast and no-breakfast conditions (short-term food deprivation) Study conducted in a metabolic ward Three groups (30 children in each): 1) severely malnourished group (1st two years of life) – previously hospitalized; 2) stunted (HAZ < ⁻2); 3) non-stunted (HAZ > ⁻1) Group 1 from hospital records and groups 2 and 3 from primary schools	Cognitive battery tests (7 tests) used for testing mental arithmetic, verbal fluency, short-term memory, etc. These tests were used in North American children	Significant treatment-group interactions in verbal fluency and mental arithmetic tests (undernourished group had lower performance when breakfast was omitted, fasting did not have that effect on non-stunted group) + wasted children performed lower on auditory short-term memory versus non-wasted after missing breakfast)

Powell et al. (1998; Jamaica)[18]	RCT	Breakfast offered to undernourished (WAZ ≤ ⁻1 SD of NCHS) and adequately nourished children WAZ > ⁻1 SD (*n* = 395) and control groups were not offered breakfast (*n* = 396)	Measurements taken at baseline and at end of intervention	Adequately nourished children were of higher SES, had higher attendance, better nutritional status, and higher scores on arithmetic, reading, and spelling tests at baseline versus undernourished children Results after intervention were similar, except for differences in reading scores
		Primary school children (grades 2–5) at 16 rural Jamaican schools; mean age, 9 y,	Weights and heights	Breakfast effect: children receiving breakfast had significantly better attendance, arithmetic scores, and increased weight, height, and BMI scores than controls
		Duration: breakfast provided every school day for 1 school year	WRAT used to assess student achievement (reading, spelling, and arithmetic) School attendance (school registers)	Adequately nourished group gained significantly more height and BMI versus controls but nutritional status did not affect changes in achievement tests Gender differences exist: females had higher gains in weight, height, and BMI + improved reading/spelling/arithmetic tests compared with boys Younger children in the breakfast group improved in arithmetic compared with older children
Jacoby (1996; Peru)[28]	Effectiveness trial (randomized controlled)	Study to measure short-term impact of Peruvian school breakfast program on diet, school attendance, and cognition of 4[th] and 5[th] graders	24-h recalls were used to assess the amounts of nutrients, E, protein, and Fe consumed per day with and without breakfast at school	Sign increase in E, protein, and iron intakes of children receiving school breakfast versus controls
		10 schools from outskirts of an Andean city (Huaraz) were randomly but equally assigned to treatment or control conditions (approx. 400 children)	Attendance (teacher-recorded roll)	Improved rates of attendance (breakfast effect)
		Subsample of 60 children selected to test effect of breakfast on dietary intake Meal provided 30% of total E requirements, 60% of RDAs for minerals and vitamins + 100% RDA for iron	Psycho-educational parameters (3 tests for cognitive processes and 3 tests for complex mental abilities; reading/vocabulary/math)	Improved performance on vocabulary test, mainly among children of greater weight No significant improvements were observed on coding, reading comprehension, or mathematics tests among the experimental group
Afridi (2010; India)[30]	Randomized program evaluation	A 24-h food consumption survey was developed to assess dietary intake of children (*n* = 976, ages 4–14 y) enrolled in private primary schools in the central region of Madhya Pradesh on two consecutive days (school and non-school day).	Total daily consumption and calorie intake on school and non-school day Individual nutrients (protein, carbohydrate, calcium, and iron) on school and non-school day	On average, the difference between RDA and actual daily intake of children in primary school was reduced by 100% for protein intake, 30% for calorie intake, and 10% for iron intake, 49–100% of the food transfers were reflected in the total daily intakes of children
		Individual food consumption data was used to assess intake of essential nutrients	Daily activities recall data (include cooking, household cleaning, sibling care, livestock care, collecting water and firewood)	
Jacoby (1998; Peru)[29]	Overview paper and evaluation of a SFP	Results from two studies that explored the impact of school breakfast program on diet, nutritional status, and number of educational outcomes of school children aged 5–10 y in Andes region in Peru: 1) Jacoby et al. 1996 in Huaraz; and 2) Program evaluation conducted in Matahuasi	Effect of breakfast on diet, anemia, and school attendance were assessed using the measures indicated in Jacoby 1996 paper	Significant dietary improvements in energy, protein, and essential nutrients intake Notable improvement in iron intake and drop in incidence of anemia from 66 to 14% in 6 months

Table 2 **Continued**

Reference	Study design	Setting, participants, intervention, and duration of study	Outcomes measured	Main findings
Van Stuijvenberg (1999; South Africa)[32]	RCT	Micronutrient status of 6–11-year-old children (grades 1–5) at a rural school in South Africa assessed after the provision of biscuits fortified with Fe, beta-carotene, and iodine + a Vit C-fortified cold drink to 115 children (intervention group) and compared to control group of children receiving non-fortified biscuits ($n = 113$) Duration: 12 months	Weight and height were measured Micronutrient (serum ferritin, serum iron, iron-binding capacity, serum retinol, urinary iodine), and anthropometric (weight, height, HAZ WAZ) measurements Thyroid size was examined Cognitive assessment tests were conducted on children in grades 2–4 Morbidity data was collected (assess reasons for absence)	*At baseline:* High levels of Vit A deficiency and goiter in targeted population 1/3 of the sample was infected with at least 1 parasite Small % of children were stunted and none were underweight *After intervention*: No significant difference in weight or height recorded over 12 months between intervention versus control group Reduced incidence of illnesses; fewer school days missed by intervention versus control group Improvements in Vit A, Fe, and iodine status of intervention group and reduced anemia, Vit A, and iodine deficiencies *Cognitive outcomes*: Greater treatment effects in children with low Fe and Hb and with goiter at baseline on one of the cognitive tests
Grillenberger et al. (2003; Kenya)[25]	RCT	554 students in Grade 1 from 12 selected primary schools in a rural malaria-endemic area in Kenya were randomly assigned to a supplement group (meat, milk, or energy supplement) or to a control group Children received food as a mid-morning snack in schools over an intervention period of 23 months	Growth parameters (weight, height, skinfold thickness, mid-upper arm muscle, and fat area)	Children in supplementation groups gained approx. 0.4 kg (10%) more weight than children in the control group Children in the meat, milk and energy groups gained 0.33, 0.19, and 0.27 cm more MUAC, respectively, than children in the control group Children in 3 treatment groups, mainly meat, followed by milk group, gained more muscle area than control group Positive effect of milk supplement on height gain was observed in a subgroup (stunted children with HAZ $\leq {}^{-}1.4$) Overall effect of supplementation on height, HAZ, WHZ, and measures of body fat were insignificant
Neumann (2003; Kenya)[17]	RCT	Children in grade 1 ($n = 554$) from 12 schools in a malaria-endemic area in Kenya were randomized into 4 feeding interventions: 1) meat, 2) milk, 3) energy, 4) control Duration of study: 2 school years (7 terms; each term 3 months)	Baseline measures included nutritional status, home food intake, anthropometry, biochemical measures of micronutrient status, malaria, intestinal parasites, health status, and cognitive and behavioral outcomes	Baseline data reported: Inadequate micronutrient intakes through 24-hour recalls confirmed withhigh biochemical deficiencies of Vit A,B_{12}, zinc, iron, and riboflavin ~ 30% of children were stunted and underweight High prevalence of malaria (50% of children have enlarged spleens) and other parasitic infections
Neumann (2007; Kenya)[26]	RCT	Same as Neumann 2003	Outcomes measured at baseline and longitudinally (at different intervals throughout the 2-year intervention) and presented here: weight, MUAC, skinfold thickness measures, and observations for activity levels and behaviors (social interactions in classroom)	Meat and energy-supplemented children performed significantly better on arithmetic tests over time compared to milk and control groups Meat group had the greatest % increase in total test scores (indicator of school performance), mainly arithmetic, compared to other feeding groups and control Meat group showed the steepest rate of increase in mid-upper-arm muscle (lean mass) and greatest increase in % of time spent on high levels of physical activity (free play observed) compared to all other groups Children in the meat, milk, and energy groups all gained weight at a greater rate than control group and younger stunted children in the milk group showed a greater rate of gain in height compared to other groups

Siekmann et al. (2003; Kenya)[36]	RCT	Same as Grillenberger and Neumann (2003)	Baseline anthropometric data (weight and height measurements)	Plasma Vit B_{12} concentration increased significantly among meat- and milk-supplemented groups leading to a 17% decrease in Vit B_{12} deficiency among meat group and 27% decrease in milk group after 1 year of supplementation
		Duration: 1 school year (9 months)	Biochemical markers were collected to assess certain micronutrients (Vit B_{12}, Vit A, Fe, Zn, Cu, folate, Vit B_2) and inflammation and infection markers (CRP, spleen, and stool samples to assess certain parasites and malaria)	No significant changes between groups were observed for other micronutrients (Zn, Fe, Cu, Vit A) Lower infection prevalence in this population after 1-year intervention
Murphy et al. (2003; Kenya)[37]	RCT	Same as Grillenberger and Neumann (2003)	Energy, protein, and micronutrient intakes of children were assessed at baseline and during 2-year feeding period of feeding study	Total E intake of meat group greater than milk and energy groups separately Intakes of Vit B_{12}, Vit A, riboflavin, and Ca in milk group greater than control group Intakes of Vit B_{12}, Vit A, available Fe, and Zn in meat group greater than control group
Aresenault et al. (2009; Colombia)[31]	Observational investigation	Measure the impact of Bogota's Secretary of Education snack program on health and nutritional status of 3,202 children (1,803 in schools that received snack program and 1,399 control children in schools not covered by snack program)	Growth outcomes (HAZ, BMI-for-age z-scores)	Greater increases in Vit B_{12} levels among children at schools receiving the snack compared to children at schools not receiving snack (effect after 3 months)
		Children recruited (5–12 years old)	Micronutrient status outcomes (plasma ferritin and Vit B_{12} and erythrocyte folate were measured)	Snack was not associated with folate or ferritin levels in children HAZ of all children decreased, but children receiving snacks had smaller decrease in HAZ than children not receiving the snack
		Duration: 3 months	Morbidity rate (fever, cough, diarrhea, vomiting, no. of days with symptoms, no. of doctor visits, no. of days student absent from school)	Change in BMI-for-age z-scores was not significantly different between 2 groups of children Significantly fewer morbidity symptoms (57% fewer days with cough and fever symptoms, 30% fewer days of diarrhea, 55% fewer days with diarrhea and vomiting) and 44% fewer doctor visits among children receiving snacks (≥23% fewer days of school absenteeism)

* Conclusive: consistent findings that support the link SFP provisions and intended outcomes.
† Inconclusive: mixed results from the literature, weaker evidence on link between SFP provisions and intended outcomes.
‡ Unexplored: no empirical evidence to explore the relationship between SFP provisions and intended outcomes.
Abbreviations: BMI, body mass index; Ca, calcium; CBA, controlled before and after trials; Cu, copper; E, energy; Fe, iron; HAZ, height-for-age z-score; Hb, hemoglobin; kcal, kilocalories; RCT, randomized controlled trial; RDA, recommended dietary allowance; SFP, school feeding program; Vit B_2, riboflavin; Vit B_{12}, cobalamin; WAZ, weight-for-age z-score; WHZ, weight-for-height z-scores; WRAT, wide range achievement test; Zn, zinc.

month of growth in the National Center for Health Statistics (NCHS) reference population. The increase in weight among intervention group members was found to be even greater than the increase in height, an equivalent of 2–3 months of weight gain in the reference population. Analyzing the effect of breakfast based on the nutritional status of children, researchers observed more significant gains in height and BMI among adequately nourished children compared to undernourished children, $\beta = 0.77$ and $\beta = 0.18$ ($P < 0.005$), respectively.[18] The significantly greater increase in the height and BMI of adequately nourished children compared to undernourished children was somewhat unexpected. Powell et al.[18] argued that the "undernourished" group of children recruited in this study was only moderately undernourished, whereas children in previous studies were more severely undernourished. The undernourished children may have greater dietary needs than their well-nourished counterparts and these dietary requirements were either not met through the school breakfast meals or were offset by reduced dietary intakes at home. This study had some limitations as it lacked data on the micronutrient status of children and their health conditions and possible infections that may interfere with the absorption of nutrients from school meals. In addition, the sample of undernourished children may have been suffering from subclinical infections that could have impeded their absorption of nutrients, such as iron and zinc, that are needed for adequate growth and development. It is also possible that energy and nutrient utilization were better in the adequately nourished group of children compared to the malnourished children.

Simeon's review of a study conducted in a rural school in Jamaica did not show remarkable changes in the weight gain of children following consumption of a morning meal each school day for two semesters.[23] A total of 115 students in grade 7 (12–13 years old) were recruited; one class ($n = 44$ students) received the school meal (100 mL milk and either a slice of cake or a meat-filled pastry providing a total of 500 kcal on average) and two classes served as controls. Weight for age was measured before the school feeding intervention started (1st semester) and at the beginning and end of the second semester (during which intervention took place). Students in both the intervention and the control groups gained weight after the 2nd semester; however, there was no significant difference in weight gain between both groups. The lack of impact of school feeding on the weight gain of these children may be attributed to several limitations of this study. Data on the height of children at baseline was not collected due to time constraints; thus, researchers could not measure the change in height after the intervention was completed and observe whether there were significant differences in height change between the intervention and control groups. In addition, total dietary intake of participants was not assessed to learn if the school meal provided additional calories and nutrients to the child's dietary intake or if it was compensated for with diminished energy and food consumption outside of school hours.

A large study that was conducted in Bangladesh by Ahmed Akhter and the International Food Policy Research Institute provided evidence regarding the positive impact of SFPs on dietary intakes and educational outcomes of school-aged children. The SFP was implemented by the WFP and the Government of Bangladesh in approximately 6,000 primary schools located in highly food-insecure rural areas and four slum areas in Dhaka city, Bangladesh. Ahmed[24] reported that the BMI of children receiving a midmorning snack at school increased by 4.3% compared to children in control schools who were not receiving these snacks. The midmorning snack consisted of a packet of fortified wheat biscuits providing a total of 300 calories and 75% of the recommended daily allowances of vitamins and minerals for school-aged children; it was given to students for each day of school attendance. The average energy intakes of participants were 11% and 19% higher in rural and urban slum areas, respectively, than the energy intakes of sex- and age-matched students in control schools who did not participate in the SFP. Energy intake consumed from biscuits was 97% additional to the child's normal diet; thus, the SFP improved net food consumption of the participating children, and the extra energy from the biscuits was not compensated for by a decrease in food consumption at home. Using household food consumption surveys, researchers observed that the majority of students receiving SF shared fortified biscuits with other members of their families on a regular or intermittent basis. These spillover effects of SF biscuits on food consumption of the participants' siblings (ages 2–5 years) led to a 7% increase in total calories consumed, on average, by these preschoolers.

In terms of body composition, studies have also shown promising results. Grillenberger et al.[25,26] conducted an RCT in 12 primary schools from a rural malaria-endemic area in Kenya (Embu District). Schools were assigned to one of three food supplement groups: 1) energy, 2) milk, or 3) meat supplement. In larger schools with more than one grade 1, classes were randomly assigned to one of the three isocaloric supplement groups. A total of 544 students participated in the study and, depending on the group to which their school or classroom was assigned, they were further randomly assigned to a food supplement group (treatment) or no supplement group (control). The number of children in each group was relatively equal, approximately 140 children per group. Children in the treatment groups (receiving food supplements) were fed Githeri, a local vegetable stew, with meat, milk, or extra oil added, depending on the treatment group to which they were assigned, i.e., meat, milk, or energy. The control groups did not receive food. Researchers observed that children in each of the supplementation groups gained approximately 0.4 kg (10%) more weight than children in the control groups. In addition, children in the three treatment groups showed increases in mean upper-arm area circumference (MUAC), a measure that is usually used as an indicator of protein-energy malnutrition. They also gained more mid-upper arm muscle circumference (MUAMC), which is a fine indicator for the total body muscle mass, than the control groups; this was mainly observed in members of the meat group, whose gain reached up to 90%. The significant gain in MUAMC among children in the meat group highlights the importance of providing children with a good source of high-quality protein that is also rich in multiple micronutrients and can increase the bioavailability of iron and zinc. This is important, especially among children living in rural communities where the staple plant-based foods are low in iron and zinc content and people are susceptible to micronutrient deficiencies. The overall effects of supplementation on height, height for age, weight for height z-scores, and measures of body fat were insignificant in this study; however, researchers observed a positive effect of milk supplements on height gain in a subgroup of children (stunted children with height for age z scores $\leq {}^{-}1.4$).

In another study conducted in South Africa,[27] the fortification of soup powders with iron and vitamin C, when combined with deworming within a SFP, led to significant improvements in height, height-for-age, and weight-for-height z scores of primary school children aged 6–8 years; the improvements were mainly among those with low baseline iron stores. Furthermore, combined food fortification and deworming led to improvements in weight and weight for age z scores of children who had adequate iron stores at baseline. One important finding of this study is that the combined positive effects of iron fortification and deworming on children's anthropometric status surpassed the individual effects of each treatment alone.

Dietary and micronutrient status

The nutritional benefits of school breakfast programs were further documented in studies conducted in Peru.[28,29] In 1993, the government of Peru launched a school breakfast program in one of the poorest provinces of the country, the Andes region. An evaluation of the school breakfast program implemented in the outskirts of two Peruvian cities (Matahuasi and Huaraz) showed significant improvements in the energy, protein, and micronutrient intakes of a subsample of children receiving the school breakfast. A total of 120 children were recruited from the 3rd and 4th grades and were divided equally between the experimental and control groups. After implementation of the school breakfast program, significant differences were seen between the experimental group and the control group with respect to total energy intake (2,182 versus 1,731 kcal/day), protein intake (56.1 versus 43.6 g/day), and iron intake (21.6 versus 12.5 mg), $P < 0.001$.[28] The energy intake of children receiving the school breakfast increased by 15.2%, their protein intake increased by 16.1%, and their dietary iron intake increased by 60%. One of the strengths of this study is that the observed increase in the dietary intake of children within the experimental group was not compensated for by lower food consumption at home. Instead, children consuming a breakfast meal at school had significantly higher overall dietary intakes compared to their control counterparts. In addition, the study controlled for a number of variables, including children's stature (height-for-age) and nutritional status (weight-for-age) in their regression analyses in an attempt to measure the independent effect of school breakfast consumption on dietary intake and a number of educational and cognitive markers. Using data from a nationally mandated school meal program in India, Afridi[30] conducted an empirical analysis of 24-hour food consumption recalls for children (age range, 4–14 years; $n = 976$) on school and non-school days to estimate the extent to which children benefit from the targeted school meal program. Afridi's study showed that the meal program provided children with a significant proportion of their daily intake of five nutrients (energy/calories, proteins, carbohydrates, calcium, and iron). Furthermore, 49–100% of the food transfers were reflected in the total daily intakes of children, indicating that the program succeeded in improving dietary intake for the five essential nutrients for which the diets of children in India were found to be highly deficient.

In Bogota, Colombia, Arsenault et al.[31] conducted a longitudinal observation of 3,202 children aged 5–12 years in public schools to examine whether a state-launched snack program (initiated in 2004 in all public primary schools) had any impact on the nutritional status of children. The snack consisted of a beverage, a cereal and/or a protein component, was well as a "sweet" component that included peanuts and Petit Suisse cheese, as well as fruits on most days. The snack was designed to provide children with a certain percentage of recommended daily intakes (30% of energy, 50% of iron, and 40% of calcium). Only 3 months after the program was pilot-tested, researchers observed greater increases in serum vitamin B_{12} levels among children receiving the snacks compared to the controls. However, significant changes were not observed in the hemoglobin, serum ferritin, or folate levels of children. This can be explained by the low prevalence of iron deficiency at baseline and the fact that children in both the schools receiving the snack and the controls were receiving iron supplements prior to this program's initiation.

Food fortification with micronutrients or the supplementation of children with multiple nutrients are among the strategies used in certain SFPs to reduce multiple micronutrient deficiencies and improve the nutritional status and cognitive and learning capacities of school-aged children. Van Stuijvenberg et al.[32] were interested in determining the effects of providing schoolchildren with mineral-fortified biscuits on their micronutrient status. The researchers conducted their study in a rural school in South Africa located in an area with a high prevalence of micronutrient deficiencies. They recruited 115 children (6–11 years old) to serve as the treatment group and 113 children served as controls. The treatment group received biscuits fortified with iron, beta-carotene, and iodine (at 50% of the RDA) whereas the control group consumed non-fortified biscuits. Significant improvements were observed in the vitamin A, iron, and iodine status of children who received the fortified biscuits. In addition, anemia, vitamin A, and iodine deficiencies were reduced by 13%, 28%, and 67%, respectively, in this sample. However, improvements seen in the vitamin A and iron status of children were not sustained after consumption of the fortified biscuits was interrupted during the school's summer break. The researchers concluded that since the biscuits provided only 50% of the RDA for vitamin A in the form of carotene, this may have been only sufficient to maintain the day-to-day vitamin A levels but not sufficient for replenishing very low or depleted vitamin A stores. Also, the dietary intake of vitamin A from meals consumed at home during the summer months, were assessed to be approximately 10% of the RDA per day; thus, during the period in which the fortified biscuit were not offered to students, retinol values reverted to the baseline level. All these findings indicate that the diets of these children contained very low amounts of micronutrients and the children's body stores were depleted rapidly during the summer months. According to the same authors, resolving iron deficiency through food fortification can be very challenging due to the low bioavailability and high reactivity of the iron compounds used in food fortification.[33] However, the provision of vitamin C-fortified drinks (rich in ascorbic acid) along with fortified food has been shown to improve iron status and is thus encouraged in SFPs targeting children with high levels of iron deficiency and iron-deficiency anemia, when feasible.[34] Only iodine did not return to the levels measured prior to the intervention, and that was probably because iodization of salt was mandated in South Africa 6 months after the intervention was in place.

This study provides promising results in terms of food fortification and its impact on children's micronutrient status. The fortification of food proved successful in alleviating highly prevalent micronutrient deficiencies, such as iron and vitamin A, which can lead to serious consequences for the health and cognition of children. However, the amount and duration of fortification were insufficient to maintain these changes. Thus, the challenge remains for researchers and policy planners to design SFPs that not only provide the targeted children with adequate types and amounts of micronutrients, depending on their deficiencies, but also ensure that the duration of fortification or micronutrient supplementation is sufficient to replenish depleted body stores.

In another intervention-control study conducted in South Africa by Kruger et al.,[27] the fortification of soup powder with iron and vitamin C, when combined with the use of anthelmintic treatment (deworming) as part of a school feeding scheme, resulted in significant, positive changes in the hemoglobin, mean corpuscular volume (MCV), and serum ferritin levels of children receiving fortified soups compared to controls. These positive effects were observed mainly among children with low baseline iron stores. Furthermore, fortification of biscuits with bovine-hemoglobin as part of a nationwide SFP in Chile led to significant improvements in the iron status of children (aged 6–11 years) who received fortified biscuits compared to children consuming non-fortified biscuits.[35] These positive findings were observed despite the low rates of iron-deficiency anemia found among the recruited samples of school children. In addition, increases in hemoglobin concentrations and iron stores (serum ferritin) were observed among boys across all ages and among girls, mainly after menarche. These findings highlight the importance of providing micronutrients to school-aged children, particularly during growth phases with high micronutrient demands.

The use of food supplements to overcome multiple micronutrient deficiencies among school-aged children in developing countries is another area of interest to some researchers and program planners. Neumann et al.[17] assessed the micronutrient status of children before intervention using 24-hour recalls and biochemical measures. They found that children had low micronutrient intakes of vitamins A, B_{12}, B_2, zinc, and iron. Furthermore, at baseline, approximately 30% of children were found to be stunted and underweight. The same research group later analyzed the effect of providing three different food supplements (meat, milk, and energy) on the micronutrient status of these primary school children. In their 1-year intervention, researchers succeeded in reducing the prevalence of vitamin B_{12} deficiency by 17% for the meat supplement group and by 27% for the milk group. The fact that a similar effect was not observed in the energy group can be explained by the higher level of vitamin B_{12} in animal-source foods such as meats and dairy products.[36] The prevalence of infection among children participating in this study decreased after 1 year of receiving school food supplementations (lower prevalence of elevated C-reactive protein levels and enlarged spleens with a decrease in plasma ferritin and copper levels). However, the researchers did not observe any significant improvements in the levels of other micronutrients, such as iron, zinc, copper, or vitamin A and could not find any diet-related explanation for the lack of significant effects of meat and milk supplementation on these micronutrients. Researchers attributed the lack of significant increases in vitamin A, iron, zinc, and copper levels to the confounding effect of malaria and the high rate of infection among this population. In a follow-up study, Murphy et al.[37] reported changes in the children's micronutrient intakes after comparing three 24-hour recalls collected before school feeding started with three 24-hour recalls collected after feeding was initiated. The researchers observed that the intakes of vitamin B_{12}, vitamin A, riboflavin, and calcium of children in the milk group were greater than those of children in the control group. Also, children in the meat group had higher intakes of vitamin B_{12}, vitamin A, and available iron and zinc than the control group. The total energy intake of children in the meat group was also higher than that found in either the milk or the energy groups. Although the energy intake of children at home decreased upon consuming one of the fortified snacks, the decrease in energy intake was lowest in the meat group. Thus, consumption of the meat snacks in this study improved the dietary quality (micronutrient status) and dietary quantity (total energy intake) of participant children, whereas the milk snacks had a positive impact solely on dietary quality.

IMPACT OF SCHOOL FEEDING ON EDUCATION AND LEARNING

In addition to the promising nutritional outcomes, studies highlight the importance and benefits of offering school-aged children school meals and/or snacks to improve certain cognitive functions and scholastic achievement, especially among disadvantaged malnourished children. Thus, school feeding is once again of particular significance in developing countries with the highest percentages of malnourished children, low school enrollment, and high dropout rates. Almost all types of SFPs reported in the literature demonstrate a positive impact on school enrollment and attendance.[23,24,28,32,38,39] The impact of school feeding on academic achievement shows consistent positive effects on arithmetic tests, but lower effects on reading, writing, and spelling tests.[16,18,23,24,26] School feeding helps improve school progress by reducing the dropout rate. This applies to both school meals and take-home rations, with greater benefits to girls, in particular, when both modalities of school feedings are offered together at school.[38]

EVALUATING THE EVIDENCE

Findings from the nutrition literature may be mixed and equivocal at times, thus weakening the evidence on how effective SFPs are for improving various markers of nutrition status, growth, and health. Mixed findings may be attributed to a multitude of factors, mainly differences in the objectives and methodologies used in SFPs. Differences lie in the design of household and school surveys, the quality and quantity of food served to children, available school resources, durations of the interventions (ranging from 1-month to 2- or 3-year interventions), and the modalities of school feeding (school meals, fortified snacks, take-home rations) in various settings and studies. In addition, findings from various studies and national programs are difficult to compare as outcome variables and indicators vary, and the age groups, degree of malnourishment, and severity of worm infections and illnesses in targeted school-aged children differ from one program to another. Since study designs, sample populations, and outcome variables vary considerably, meta-analyses of studies become more difficult to perform. Despite the somewhat mixed results, the present review demonstrates that SFPs have promising, positive impacts on the nutrition and health status of school-aged children. Providing food to children in the form of school meals, snacks, or take-home rations can help alleviate hunger, address the nutrition needs of children, improve children's micronutrient status (if food is fortified with essential micronutrients or if micronutrient supplements are provided), and reduce the susceptibility of children to infectious diseases and illnesses (as summarized in Table 3). However, the school feeding studies and programs in developing countries published to date lack an in-depth investigation of whether children are receiving culturally and developmentally appropriate nutrition and health education lessons to complement the nutritious foods and snacks being offered during a regular school day. According to Powell et al.,[18] in order for the achievement levels of children to improve and for children in developing countries to fully benefit from the school feeding and supplemental services offered at their schools, integrated interventions that include nutrition, health, and educational components are needed. Successful school nutrition and feeding programs in developed countries have learned the importance of integrating nutrition education into these programs.[40,41]

A meta-analysis that explores school feeding and its impact on the nutrition and cognition of school-aged

Table 3 **Summary of the scientific evidence on the impact of school feeding activities and provisions on intended nutrition, health, and educational outcomes in school-aged children and their households.**

School feeding provisions and activities	Positive intended outcomes
In-school meals (breakfast, lunch, or mid-day), snacks, and take-home rations Energy and micronutrient content of school meals, snacks, and/or take-home rations	School-aged children (participants): Energy intake* Nutritional status* School enrollment* School attendance* Growth (weight and height)† Cognition (memory, complex mental abilities) and classroom behavior (attention and participation)† Educational achievement (arithmetic and literacy tests)† *Household*: Energy intake of siblings and other family members (in-school meals and take-home rations)†
Deworming Frequency and dosage of anthelmentic treatment	Decreased morbidities and illnesses* Improved micronutrient/nutritional status of school-aged children – if deworming is coupled with micronutrient fortification of school meals/snacks†
Health and nutrition education curricula Age, developmentally and culturally appropriate nutrition and health education lesson plans	*School-aged children:* Nutrition and health knowledge, attitudes, and behaviors‡ *Household:* (c) Nutrition and health knowledge and attitudes of household members, and allocation of food and health resources‡

* Conclusive: consistent findings that support the link between SFP provisions and intended outcomes.
† Inconclusive: mixed results from the literature, weaker evidence on link between SFP provisions and intended outcomes.
‡ Unexplored: no empirical evidence to explore the relationship between SFP provisions and intended outcomes.

children showed mixed, yet promising, results on changes in the nutritional status of school-fed children compared to non-school-fed children in developing countries.[16] Numerous studies in the nutrition literature, which were discussed in this review, show that school feeding can enhance children's diets by increasing the total energy intake of children consuming meals and/or snacks at school. Although a substitution effect does occur, studies have shown that the increase in total dietary intake from school feeding offsets any diminished intake at home. The substitution effect varies depending on the modality of school feeding (e.g., snacks/biscuits result in lower substitution effects than meals), as well as the timing and composition of meals (e.g., breakfast or mid-morning meals result in lower substitution effects than lunches).[16,42–44]

A growing body of literature supports micronutrient fortification (fortifying commonly eaten foods) and supplementation (providing nutrients through micronutrient pills or suspensions) as part of the SFPs in communities with high levels of micronutrient deficiencies. Studies highlight the importance of school deworming (anthelmintic treatments) in regions where high rates of worm infections prevail. As a result, the WFP has been strongly recommending that multiple nutrient fortification and meal supplementation, as well as deworming, be complementary services to school feeding and included in the "essential package."[45] In addition, research shows that the effect of school feeding on the dietary intake and growth of school-aged children is greater among those that are malnourished compared to adequately nourished children.[25,27] Furthermore, greater benefits are observed among younger school-aged children.[16] These findings have very important implications regarding the design and targeting criteria that are set for SFPs. Thus, program designers and planners are encouraged to target children from highly food-insecure areas with high infection rates in their populations in order to provide food to those who are most susceptible to hunger and malnutrition and to overcome the burdens of illness and diseases that may otherwise impair the children's growth and nutrition.

Evidence on the positive impact of school feeding on education outcomes seems to be even stronger than that observed and reported with nutritional outcomes. The present review of the literature shows that SFPs have a positive impact on children's school enrollment and attendance.[23,24,28,32,38,39] The impact of school feeding on school-aged children's academic achievement is consistently positive for arithmetic tests, yet inconclusive for reading, writing, and spelling tests.[16,18,23,24,26] Although there is reasonable evidence for school feeding and its positive effects on short-term cognitive functions and various dimensions of children's school performance, randomized controlled trials and well-designed evaluation studies are needed to demonstrate the long-term impact of these programs on children's school completion and productivity as adults. Table 3 includes a summary of the scientific evidence that justifies the link between school feeding provisions and activities and intended positive outcomes on the nutrition, health, and academic performance of school-aged children. The evidence was considered conclusive if consistent findings were reported across studies reviewed in this paper; they were considered inconclusive if findings were mixed, and unexplored if there is a lack of scientific measurement of the link between the SFP provision or activity and the intended outcome.

RESEARCH AND EVALUATION GAPS

The school feeding literature is rich with well-designed trials and country reports; however, rigorous theory-based impact evaluations are required in this area. Experimental and quasi-experimental studies on the nutritional benefits of school feeding may target and evaluate specific outcomes and biomarkers of children's nutrition and health status; however, these studies mostly fall short of identifying the causal chain or theory behind the implemented programs. Furthermore, many of these studies lack a detailed description of the political, social, and economic context of a SFP, thereby limiting the possibility of replicating the program in similar contexts or the generalizability of the findings.

The International Initiative for Impact Evaluation (3ie)[46] highlights the importance of theory-based impact evaluations of programs in developing countries designed to improve the livelihood of populations. Numerous principles are needed for a theory-based impact evaluation including the existence of a program theory (causal chain), understanding the context of the program, anticipating heterogeneity, conducting rigorous factual analysis, and using mixed methods to validate the outcomes and impact of a program.[47] In the case of school feeding, there are insufficient rigorous theory-based evaluations of the nutritional and health impact of these programs on school-aged children in developing countries. The theory and context of SFPs that are funded and managed by the WFP or transitioning to become nationally owned are well-defined. However, the design of these programs falls short from fulfilling other principles needed for theory-based impact evaluations, including the use or reporting of mixed methods (qualitative and quantitative data), and the availability of factual and counterfactual analyses (experimental versus control or pre- and post-intervention results) in some of these programs. On the other hand, experimental and quasi-experimental studies assessing school feeding, such as those reviewed in this paper, meet the scientific caliber needed in impact evaluations yet often lack a clear definition of the logical framework of the SFP being implemented; moreover, their inconclusive findings, at times, limit them from validating the links between resources, outputs, and outcomes within a causal chain of a school feeding framework.

Furthermore, several questions were raised from the literature on school feeding and should be addressed when future programs and trials are designed to test the effectiveness of SFPs. Some of these research gaps were pointed out throughout this review, while others are summarized as follows. 1) Studies on the SFPs vary in design and some lack scientific rigor. Thus, efforts need to be exerted to provide guidance to researchers on what standardized methods, designs, and outcomes would be best implemented and measured to improve the quality of evidence on school feeding. 2) The benefits of school feeding on nutrition, health, and education of school-aged children are identified in the literature; however, the scale of these benefits requires further exploration. 3) Independent and combined effects of SFPs with supplemental health and educational interventions, including school-based health and nutrition education, on the nutritional knowledge and eating behavior of targeted children and their households are areas of needed study. 4) Studies that explore or control for the substitution effect of SFPs based on various factors including modality, timing, and composition of snacks or meals, age of child, and other household characteristics are still limited, yet necessary. 5) Long-term studies and program evaluations are needed to track the impact of school feeding on nutritional/health status, educational attainment, and productivity of children as they reach adulthood. 6) Research on the cost-drivers, cost-effectiveness, and benefit-to-cost ratio of various feeding programs, including cross-sectional and randomized trials, is needed to better advise governments on how to best allocate their limited resources

CHALLENGES AND FUTURE DIRECTIONS

School feeding programs face numerous and continuous challenges, some of which are context-specific; however others are more universal and apply to all SFPs implemented in developing countries. The sustainability of these programs, procurement of food in light of food price fluctuations and environmental and agricultural changes, as well as questions of a program's cost-effectiveness are common challenges faced by SFP planners and designers. Despite their importance, these issues are beyond the scope of this review and were discussed in depth in the most recent joint WB and WFP publication on school feeding.[48,49]

Based on the most recent "transition process" theories and modules developed by the WFP and the WB with the collaboration of national governments, the trend for SFPs is to become government-driven and owned, more cost-contained and cost-efficient, and linked with wider school health and nutrition services such as water sanitation, supplementation, and deworming, among other services. The aim is for these SFPs to become embedded into national policies and frameworks. Questions remain about the feasibility and effectiveness of nationally owned, funded, and managed SFPs. Thus, a working database of success stories, country and program evaluation reports that can be publicly accessible and updated not only by the international agencies and funders but also by national governments can help advance research in this area. This would be an invaluable database and a reference document that could be used by various stakeholders involved in designing, funding, implementing, and evaluating SFPs.

Local procurement of food is yet another area that seems to be the focus of international non-governmental and governmental organizations and that will be expanding to provide full coverage to the growing number of SFPs, especially in response to the financial and food crises. In addition, home-grown school feeding (HGSF) is a new framework that is suggested to link school feeding with local agricultural production.[50] HGSF seems to be the next revolution in school feeding. Therefore, more interest and funding might be channeled to expand on this new framework. Furthermore, SFPs that offer more nutritious food fortified or supplemented with required micronutrients will also be sought in order to increase the effectiveness of SFPs and their impact on the nutrition, cognition, and health of children.

Researchers design rigorous randomized controlled trials to examine the efficacy of SFPs and to establish cause and effect relationships, when possible, between school feeding in its different modalities and positive nutrition and educational outcomes. However, ethical issues arise as researchers deny or delay the provision of foods and complimentary services, such as anthelmentic treatment and micronutrient supplements, to children in control groups that may otherwise benefit from the treatment.

CONCLUSION

Global efforts were exerted to set the MDGs, yet we are still far from achieving those highly aspired goals. Millions of children are still deprived of some of their basic human rights to be fed and taken care of, to receive the necessary medical and health care, to go to school and get a formal education that prepares the child for a productive adult life. The present review of the literature shows a relatively consistent positive effect of SFPs on the energy intake and micronutrient status of school-aged children, and a decline in infections and morbidities, particularly in programs in which micronutrient fortification and deworming are provided to school-aged children in regions with multiple micronutrient deficiencies and heavy loads of worm infections. Mixed findings were reported from various studies in terms of the impact of school feeding on weight, height, and BMI gains among school-aged children. Long-term studies that assess the benefits of school meals, snacks, and take-home rations on children's growth and household food consumption patterns are still lacking. Furthermore, as SFPs shift from emergency and post-crisis strategies to stable and long-term development projects and safety nets, complementary nutrition and health education curricula will need to be further emphasized with provision of school meals and food rations to address long-term sustainable improvements in nutrition.

In conclusion, the success and almost universality of SFPs highlights the important yet challenging task of sustaining these programs and ensuring that they expand and benefit a larger target population of school-aged children, preschoolers, and their households. Collaborative efforts are required to ensure that SFPs not only expand, but become increasingly cost-effective and efficient and achieve intended outcomes in the short and long terms. Health professionals, educators, researchers, and community workers need to work together when developing national and regional SFPs and designing trials to evaluate their impact on various intended outcomes.

Acknowledgments

This review was conducted in part at the World Food Programme (WFP) headquarters in Rome, Italy. The authors thank Mr. Andreas Psoroulas, the head of the WFP library, Ms. Nancy Walter, the Chief of the School Feeding Policy at the WFP, and Ms. Carmen Burbano, co-author of the joint WFP and WB publication "Rethinking School Feeding: Social Safety Net, Child Development, and the Education Sector," as well as all members of the School Feeding Division for providing helpful information and sharing their expertise in this area.

Declaration of interest. The authors have no relevant interests to declare.

REFERENCES

1. Food and Agriculture Organization. *The State of Food Insecurity in the World 2009*. Rome: FAO; 2009.

2. United Nations. *Declaration of Millenium Development Goals: United Nations Resolution*. 2000; Available at: http://www.un.org/millennium/declaration/ares552e.pdf. Accessed 8 March 2010.
3. World Bank. *Education for All Fast Track Initiative*. 2002; Available at: http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTEDUCATION/0,contentMDK:20278663~menuPK:617564~pagePK:148956~piPK:216618~theSitePK:282386,00.html. Accessed 5 August 2009.
4. United Nations Children's Fund, World Food Programme. *The Essential Package: Twelve Interventions to Improve the Health and Nutrition of School-Age Children*. Rome: World Food Programme; 2005.
5. World Hunger Education Service. *World Hunger Poverty Facts and Statistics 2010*. 2010; Available at: http://www.worldhunger.org/articles/Learn/world%20hunger%20facts%202002.htm. Accessed January 1, 2011.
6. Weinreb L, Wehler C, Perloff J, et al. Hunger: its impact on children's health and mental health. Pediatrics. 2002; 110:e41.
7. Broca S, Stamoulis K. Micro- and macroevidence on the impact of undernourishment. *Nutrition Intake and Economic Growth*. Economic and Social Development Department. Food and Agriculture Organization of the United Nations. 2003. http://www.fao.org/docrep/006/y4850e/y4850e03.htm. Accessed January 5, 2010.
8. Victora CG, Adair L, Fall C, et al. Maternal and child undernutrition: consequences for adult health and human capital. Lancet. 2008;371:340–357.
9. Food and Agriculture Organization. *The State of Food Insecurity in the World: Eradicating World Hunger – Key to Achieving the Millenium Development Goals*. Rome: FAO; 2005.
10. World Food Programme. *Figures on WFP School Feeding Programmes*. 2008; Available at: http://home.wfp.org/stellent/groups/public/documents/communications/wfp205343.pdf. Accessed 26 January 2010.
11. United Nations. *Road Map toward the Implementation of the United Nations Millenium Declaration*. 2000; Available at: http://www.un.org/News/Press/docs/2001/pi1380.doc.htm. Accessed January 2, 2010.
12. Bundy D, Burbano C, Grosh M, Gelli A, Jukes M, Drake L. Why implement school feeding? *Rethinking School Feeding: Social Safety Nets, Child Development, and the Education Sector*. Washington, DC: World Bank; 2009:15–34.
13. Bergeron G, Del Rosso JM. *Food for Education Indicator Guide. Food and Nutrition Assistance Project*. 2001; Available at: http://www.fantaproject.org/downloads/pdfs/FFE.pdf. Accessed 28 June 2010.
14. Bundy D, Burbano C, Grosh M, Gelli A, Jukes M, Drake L. *Rethinking School Feeding: Social Safety Nets, Child Development, and the Education Sector*. Washington, DC: World Bank; 2009.
15. World Food Programme. *School Feeding Policy: Informal Consultation*. 2009; Available at: http://home.wfp.org/stellent/groups/public/documents/resources/wfp205242.pdf. Accessed 26 June 2010.
16. Kristjansson E, Robinson V, Petticrew M, et al. School feeding for improving the physical and psychosocial health of disadvantaged students. Cochrane Database Syst Rev. 2006; 1. doi:10.4073/csr.2006
17. Neumann CG, Bwibo NO, Murphy SP, et al. Animal source foods improve micronutrient status, growth and cognitive function in Kenyan school children: background, study design and baseline findings. J Nutr. 2003;133(Suppl):S3941–S3949.
18. Powell C, Walker SP, Chang SM, Grantham-McGregor SM. Nutrition and education: a randomized trial of the effects of breakfast in rural primary school children. Am J Clin Nutr. 1998;68:873–879.
19. Du X, Zhu K, Trube A, et al. School-milk intervention trial enhances growth and bone mineral accretion in Chinese girls aged 10–12 years in Beijing. Br J Nutr. 2004;92:159–168.
20. Agarwal DK, Agarwal KN, Upadhyay SK. Effect of mid-day meal programme on physical growth & mental function. Indian J Med Res. 1989;90:163–174.
21. Bailey KV. Rural nutrition studies in Indonesia IX: feeding trial on school boys. Trop Geogr Med. 1962;14:129–139.
22. Devadas RP, Jamala S, Surabhi A, Murthy NK. Evaluation of a food supplement to school children. Indian J Nutr Diet. 1979;16:335–341.
23. Simeon D. School feeding in Jamaica: a review of its evaluation. Am J Clin Nutr. 1998;67(Suppl):S790–S794.
24. Ahmed AU. *The Impact of Feeding Children in School: Evidence from Bangladesh*. Washington, DC: International Food Policy Research Institute; 2004.
25. Grillenberger M, Neumann CG, Murphy SP, et al. Food supplements have a positive impact on weight gain and the addition of animal source foods increases lean body mass of Kenyan schoolchildren. J Nutr. 2003;133(Suppl):S3957–S3964.
26. Neumann CG, Murphy SP, Gewa C, Grillenberger M, Bwibo NO. Meat supplementation improves growth, cognitive, and behavioral outcomes in Kenyan children. J Nutr. 2007;137:1119–1123.
27. Kruger M, Badenhorst CJ, Laubscher JA, Spinnler Benade AJ. Effects of iron fortification in a school feeding scheme and anthelmintic therapy on the iron status and growth of six- to eight year-old schoolchildren. Food Nutr Bull. 1996;17:11–21.
28. Jacoby E, Cueto S, Pollitt E. Benefits of a school breakfast programme among Andean children in Huaraz. Bull Nutr Food. 1996;17:54–64.
29. Jacoby E, Cueto S, Pollitt E. When science and politics listen to each other: good prospects from a new school breakfast program in Peru. Am J Clin Nutr. 1998;67:(Suppl):S795–S797.
30. Afridi F. Child welfare programs and child nutrition: evidence from a mandated school meal program in India. J Dev Econ. 2010;92:152–165.
31. Arsenault JE, Mora-Plazas M, Forero Y, et al. Provision of a school snack is associated with vitamin B-12 status, linear growth, and morbidity in children from Bogota', Colombia. J Nutr. 2009;139:1744–1750.
32. Van Stuijvenberg ME, Kvalsvig JD, Faber M, Kruger M, Kenoyer DG, Benade AJS. Effect of iron-, iodine-, and beta-carotene-fortified biscuits on the micronutrient status of primary school children: a randomized controlled trial. Am J Clin Nutr. 1999;69:497–503.
33. Van Stuijvenberg ME. Using the school feeding system as a vehicle for micronutrient fortification: experience from South Africa. Food Nutr Bull. 2005;26(Suppl 2):S213–S219.
34. Hurrell RF. Preventing iron deficiency through food fortification. Nutr Rev. 1997;55:210–222.
35. Walter T, Hertrampf E, Pizarro F, et al. Effect of bovine-hemoglobin-fortified cookies on iron status of school children: a nationwide program in Chile. Am J Clin Nutr. 1993;57:190–194.
36. Seikmann J, Allen LH, Bwibo NO, Demment MW, Murphy SP, Neumann CG. Kenyan school children have multiple micronutrient deficiencies, but increased plasma vitamin B12 is

the only detectable micronutrient response to meat or milk supplementation. J Nutr. 2003;133(Suppl):S3972–S3980.
37. Murphy SP, Gewa C, Lliang LJ, Grillenberger M, Bwibo NO, Neumann CG. School snacks containing animal source foods improve dietary quality for children in rural Kenya. J Nutr. 2003;133(Suppl):S3950–S3956.
38. Gelli A, Meir U, Espejo F. Does provision of food in school increase girls' enrollment? evidence from schools in sub-saharan Africa. Food Nutr Bull. 2007;28:149–155.
39. Ahmed AU, del Ninno C. *The Food for Education Program in Bangladesh: An Evaluation of Its Impact on Educational Attainment and Food Security*. Washington, DC: International Food Policy Research Institute; 2002.
40. McConnell PE, Shaw JB. Position of the American Dietetic Association: child and adolescent food and nutrition programs. J Am Diet Assoc. 1996;96:913–917.
41. Centers for Disease Control and Prevention. Guidelines for school health programs to promote lifelong healthy eating. Morb Mortal Wkly Rep. 1996;45(RR-9):1–33.
42. Orphans and Vulnerable Children (OVC) Toolkit. *Education Sector Programs*. World Bank. 2009; Available at: http://info.worldbank.org/etools/docs/library/248484/toolkiten/sector/education4.htm. Accessed 26 February 2010.
43. The Caroline Walker Trust and the National Heart Forum. *Eating Well at School: Nutritional and Practical Guidelines*. 2005; Available at: http://www.cwt.org.uk/pdfs/EatingWellatSchool.pdf. Accessed 29 July 2010.
44. Centers for Disease Control and Prevention, Division of Adolescent and School Health. *Coordinated School Health Program*. 2008; Available at: http://www.cdc.gov/healthyyouth/CSHP/. Accessed 29 July 2010.
45. Bundy D, Burbano C, Grosh M, Gelli A, Jukes M, Drake L. What is school feeding? *Rethinking School Feeding: Social Safety Nets, Child Development, and the Education Sector*. Washington, DC: The World Bank; 2009:9–14.
46. International Initiative for Impact Evaluation (3ie). *Global Development Network*. 2007; Available at: http://www.3ieimpact.org/. Accessed 9 July 2010.
47. White H. *Theory-Based Impact Evaluation: Principles and Practice (Working Paper 3)*. 2009; Available at: http://www.3ieimpact.org/admin/pdfs_papers/51.pdf. Accessed 23 July 2010.
48. Bundy D, Burbano C, Grosh M, Gelli A, Jukes M, Drake L. What is school feeding? *Rethinking School Feeding: Social Safety Nets, Child Development, and the Education Sector*. Washington, DC: The World Bank; 2009:9–14.
49. Bundy D, Burbano C, Grosh M, Gelli A, Jukes M, Drake L. Institutional and procurement arrangements. *Rethinking School Feeding: Social Safety Nets, Child Development, and the Education Sector*. Washington, DC: The World Bank; 2009:69–81.
50. Espejo F, Burbano C, Galliano E. *Home-Grown School Feeding: A Framework to Link School Feeding with Local Agricultural Production*. Rome: World Food Programme (WFP); 2009.