The impact of preschool feeding programmes on the growth of disadvantaged young children in developing countries: a systematic review of randomised trials

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Abstract

Background: Childhood malnutrition in developing countries contributes to developmental delays, as well as increased morbidity and mortality. The effectiveness of feeding programmes as a strategy to improve childhood malnutrition has been questioned.

Objective: A systematic review was undertaken to examine the effectiveness of preschool feeding programmes in fostering the growth of children in developing countries.

Design: A systematic literature search was undertaken to identify published studies that related to the objective. Studies had to be randomised intervention studies that reported on the growth outcomes of children from birth to six years of age in order to be included.

Setting: An initial literature search yielded 59 studies, of which 44 were excluded based on initial screening. Five more were omitted based on detailed data extraction. Ten studies met the inclusion criteria. The results of these studies were compared and narratively described in the context of the objective.

Results: The studies showed a great level of heterogeneity with regard to sample characteristics, intervention and reporting of results. In the context of recovery from malnutrition, most studies reported there to be a positive effect from feeding programmes. In studies that reported on weight gain, those that employed a supervised intake of food supplements resulted in higher rates of weight gain. Micronutrient fortification was described as having a positive influence on the rate of linear growth in studies that reported on linear growth. Intensive nutrition education aimed at mothers and caregivers is a sustainable way in which to change child feeding behaviour and may contribute to the effectiveness of nutrition intervention.

Conclusion: The limitations of the study included the following: there was a low number (59) of identified studies in the initial search because of the use of limited search terms, assessment of risk of bias was carried out by only one reviewer using a self-designed grading system, there were high levels of heterogeneity, and less than half of the individual studies were rated to be of a high quality. In view of these limitations, no firm conclusion can be drawn. Additional research, aimed at determining the impact of supplementary feeding programmes in supporting the growth of disadvantaged children, is encouraged.

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Introduction

"Malnutrition" is a broad term that includes both over- and undernutrition. In the context of undernutrition, the World Health Organization (WHO) classifies malnutrition in children as underweight, wasting or stunting. Underweight represents a low weight-for-age z-score (WAZ), wasting represents a low weight-for-height z-score (WHZ), and stunting represents a low height-for-age z-score (HAZ). Moderate malnutrition is reflected by a z-score of more than two units below standard, whereas severe malnutrition is reflected by a z-score of more than three units below standard.[1] According to the United Nations Children's Fund conceptual framework, the causes of malnutrition include immediate, underlying and basic causes. Immediate causes include a poor diet, disease and inadequate psychosocial care. Underlying causes are ascribed to poor household food security, poor mother and child care, inadequate health services and sanitary conditions, as well as poor education. Basic causes are ascribed to poverty and its determinants.[2]

In developing countries, childhood malnutrition is a growing health concern. Close to two million children < 5 years of age are affected by stunting.[3] Apart from increasing morbidity and mortality, malnutrition is associated with delayed motor and mental development which eventually brings about a decreased work capacity[4] and impacts on the economy of developing countries. Furthermore, malnutrition contributes to approximately half of the worldwide deaths of children < 5 years.[5]

The devastating effects of malnutrition have prompted initiation of several strategies to improve childhood nutrition in developing countries. Such strategies include the distribution of ready-to-use therapeutic food (RUTF) and fortified blended foods (FBF) through community feeding centres, as well as other food fortification and food security programmes aimed at improving both macro- and micronutrient intake. Although no meta-analysis has been published to date, previous narrative reviews have attempted to establish whether such programmes were effective in improving the growth of children. A review by Jomaa et al reported on the effect of school feeding programmes that targeted children > 5 years.[6] The authors found that despite a positive effect on energy intake, micronutrient status and school attendance, the effectiveness of supplementation on growth outcome could not be confirmed. However, in consideration of the fact that the first two years of a child's life are the "window of opportunity" for nutrition intervention and the time for greatest benefit from nutrition supplementation,[6] earlier intervention at a younger age (< 5 years) might better support growth than intervention at a later stage.[7] In this regard, Perez-Exposito and Klein[8] reported similar findings in their review that evaluated feeding programmes that targeted younger children, but focused specifically on the distribution of FBF and did not take into account other interventions, such as RUTF, which have shown promising results.[9-11] A systematic review by Sguassero et al[12] included only four randomised controlled trials (RCTs) published up to the year 2005. No firm conclusions could be drawn as a result of limited included data. A recent updated publication of this review took into account eight RCTs that evaluated the effectiveness of community-based supplementary feeding in children < 5 years in low- and middle-income countries.[13] The findings suggest that supplementary feeding has a negligible impact on child growth, although the authors stated that firm conclusions could not be drawn as a result of the scarcity of data and diversity of studies.

Compared to previously published reports, this review takes into account:

- Intervention at a younger age.
- Information from more recent studies.
- The effect of various types of nutrition intervention.

The primary objective was to establish whether the provision of additional food to children, beyond their normal intake, could have a positive effect on growth outcomes. Data described in this review could possibly guide policy-makers regarding implementation of strategies aimed at alleviating childhood malnutrition.

Method

The researchers attempted to conduct a comprehensive literature search in order to identify studies that related to the objective. A systematic electronic literature search was undertaken from March to April 2011 to identify studies that met the eligibility criteria as outlined in Table I. Searched databases included EBSCO (including Medline), Cochrane (Cochrane Database of Systematic Reviews and Cochrane Controlled Trials Register), PubMed, ScienceDirect and Controlled Trials Registry, using the keywords "preschool feeding programmes", "growth", "anthropometric outcomes", "disadvantaged", "children" and "randomised controlled trial". Reference lists of identified studies were checked to identify other sources of information. The literature search was carried out independently by six reviewers, after which one generic list of publications was compiled. All publications on the study topic that were published in English from 1994 onwards were considered. No unpublished studies or abstract reported studies were included.

Table I: Eligibility criteria

Population	Disadvantaged children of preschool age. The term "disadvantaged" refers to children growing up in a developing country as per the list of countries identified in the International Monetary Fund's *World economic outlook report.*[14] Preschool age refers to a child from birth to six years of age.
Intervention	Trials that reported on nutrition intervention as supplementary feeding in any form. "Supplementary feeding" refers to any form of food supplementation taken in addition to a child's normal dietary intake, whether a commercialised product, or a locally produced food-based supplement.
Control	Studies without a control group were included.
Outcome measures	Trials were included if they reported on the following outcomes: weight, height, rate of weight/height gain, or other measurements, such as recovery from malnutrition or incidence of malnutrition.
Study design	Individual or cluster randomised primary intervention studies. Clinical effectiveness trials without intervention were excluded. Trials comparing two or more different interventions were included if they were randomised. Randomisation was considered to be adequate when stated to be such, even if the method was not described.

Selection of studies

An initial screening of all identified studies was undertaken independently by six reviewers, excluding articles based on the title or abstract. After the screening phase, reviewers assessed each study according to the eligibility criteria as outlined in Table I and extracted data by means of a standard data extraction form. Any disagreements were resolved, and the researchers unanimously agreed on the inclusion or exclusion of studies, taking into account information that was recorded on the data extraction forms.

Data extraction

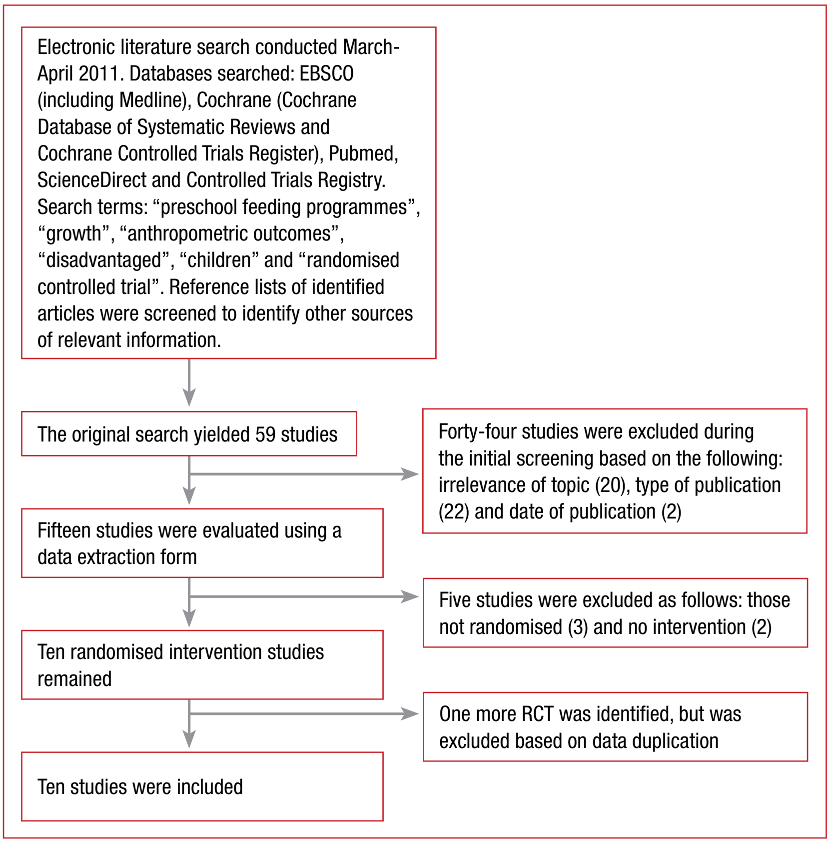
Each study was evaluated according to research method, randomisation, setting, sample size and characteristics, nutrition intervention and outcome measures.

The researchers identified certain important factors for consideration in an attempt to compare nutritional supplementation programmes beforehand. These included the dose of supplementation, the baseline nutritional status of participants and the nutritional value of the food supplement that was given. The dose of supplementation was difficult to compare since not every study routinely reports on

Table II: Summary of excluded studies

Author reference	Description and reason for exclusion
Agha[15]	Study reports on the effectiveness of a supplementary feeding programme in Iraq. Children aged six months to three years who were enrolled in the feeding programme were followed-up for seven months. Children received high-energy, high-protein biscuits for one month and a ration of soybean flour, vegetable oil and sugar throughout the follow-up period. Supplementation with the high-energy, high-protein biscuit resulted in a significant weight increase, but the study reported a significant high dropout rate. *Reason for exclusion:* Effectiveness trial without any intervention.
Ciliberto et al[9]	Study evaluating the effectiveness of supplementing malnourished children with RUTF versus standard treatment. Children aged 10-60 months were included and systematically allocated to intervention (RUTF) or control (F100 and maize/soy blended flour) groups. Results indicated a greater rate of weight increase in children receiving RUTF versus control. *Reason for exclusion:* Not randomised.
Colecraft et al[16]	Study examining the growth of malnourished children participating in nutrition rehabilitation centres that provided meals. Results indicated a small, but significant, increase in WHZ and WAZ. *Reason for exclusion:* Effectiveness trial without any intervention.
Ndekha, Manary, Ashorn, Briend[10]	Study comparing the effectiveness of RUTF versus traditional food in malnourished, immune-compromised children. Children aged 12-60 months were systematically allocated to receive either RUTF or a maize/soy flour blend. Results indicated greater weight gain in children who received RUTF. *Reason for exclusion:* Not randomised.
Patel et al[17]	A comparative clinical effectiveness trial of two supplementary feeding schemes. Children aged 10-60 months were systematically allocated to receive RUTF or maize/soy blended flour. Results indicated better weight gain in children receiving RUTF. *Reason for exclusion:* Effectiveness trial, not randomised.

RUTF: ready-to-use therapeutic food, WAZ: low weight-for-age z-score, WHZ: low weight-for-height z-score



RCT: randomised control trial

Figure 1: Flow chart representing the search, screening and selection of studies

the minimum and maximum dose, nor allows for the measurement of actual dosage intake. In addition, the requirements of the children in the respective age groups that were included were not uniform. Where possible, dosages of food supplementation were recorded. Secondly, the baseline nutritional status of participants could have affected the response to nutrient supplementation. Where possible, data on background nutritional status were recorded. Thirdly, the specific characteristics of each intervention (commercial product with known nutritional formulation or locally produced food-based alternative) could have impacted on the results. Since it was expected that interventions in the included studies would not be homogenous, specific data on this were recorded.

For each of the above points, information that was available was recorded and is indicated in Table II.

Risk of bias

To ascertain the risk of bias in the included studies, one reviewer evaluated each study in terms of randomisation procedure and allocation concealment; blinding of study participants, data collectors and outcome assessors; training of field assistants; and extent of loss to follow-up and results presented as intention to treat. Each of these criterion was scored, and based on the final score, studies were rated as high (met $\geq$ 80% of criteria), medium (met 60-79% of criteria) or low (met < 60% of criteria) quality.

Statistical analysis

Because of differences in the reporting of outcome measures, the researchers decided not to compare the results of individual studies in the form of a meta-analysis. Results were compared and reported by means of a narrative systematic review.

Results

Literature search

The initial literature search yielded 59 studies, of which 44 were excluded based on irrelevance of topic, type of publication (including review article, process evaluation, special report and theoretical statement), and data collection prior to 1980. The remaining 15 studies were evaluated. Five more were excluded because they were not randomised (3) or did not involve any intervention (2) (Figure 1). Tables II and III summarise the characteristics of excluded and included studies, respectively.

Risk of bias

Five studies were rated to be of low quality,[11,18-21] one of medium quality,[4] and four of high quality.[3,5,22,23]

Table III: Summary of included studies

Reference	Study characteristics	Intervention	Main outcome measures	Summary of results
Phuka et al[3]	*Study design:* RCT *Country:* Malawi *Study participants:* 176 children aged 6-18 months *Baseline nutritional status:* Malnourished with WAZ < -2	*Intervention period:* 12 weeks Participants randomised to: • *FS group:* Fortified spread 50 g/day, providing 256 kcal/day • *M/S group:* Maize/soy flour 71 g/day, providing 282 kcal/day	Recovery from underweight, wasting and stunting	• No significant differences were found between the two intervention groups • Underweight was significantly reduced in both intervention groups • Neither intervention had a significant impact on stunting
Lopriore et al[4]	*Study design*: RCT *Country:* Algeria *Study participants:* 374 Saharawi refugee children aged 36-72 months *Baseline nutritional status:* Malnourished with HAZ < -2	*Intervention period:* Six months Participants randomised to: • *FS group:* Fortified spread 50 g/day, providing 319 kcal/day • *US group:* Unfortified spread 50 g/day, providing 319 kcal/day • *Control:* No intervention	Weight, height and knee-heel length	• Linear growth was 30% faster in the FS group, compared to the US group, by three months
Perez-Exposito, Klein[5]	*Study design:* RCT *Country:* Malawi *Study participants:* 182 healthy rural children aged 6-18 months *Baseline nutritional status:* Healthy children who were not necessarily malnourished	*Intervention period:* 12 months with 24-month follow-up period Participants randomised to: • *FS50 group:* Fortified spread 50 g/day in 2-3 daily doses, providing 256 kcal/day • *FS25 group:* Fortified spread 25 g/day in 2-3 daily doses, providing 127 kcal/day • *M/S group:* Fortified maize/soy flour 71 g/day in 2-3 daily doses, providing 282 kcal/day	Incidence of severe stunting, mean z-score changes in WAZ, HAZ and WHZ	• Incidence of severe stunting after 36 months was 19.6% in the M/S group, 10.3% in the FS25 group, and only 3.6% in the FS50 group
Ruel et al[18]	*Study design*: Cluster RCT *Country:* Haiti *Study participants:* Children aged 6-23 months (preventative model) or underweight children aged 6-60 months (recuperative model) from 20 community clusters *Baseline nutritional status:* Mixed. Preventative model open for all children aged 6-23 months and children aged 24-59 months with WAZ < -3. Recuperative model only for underweight children with WAZ < -2	*Intervention period:* 18 months in preventative, and nine months in recuperative model. Follow-up information obtained after three years. Participants were randomised to: • *Preventative group:* 18 months of food assistance in the form of a monthly ration per child of 8 kg fortified wheat/soy blend and 2 kg oil • *Recuperative group:* Nine months of food assistance in the form of a monthly ration per child of 8 kg fortified wheat/soy blend and 2 kg oil An indirect household ration was supplied in both groups, including 10 kg wheat/soy blend and 2.5 kg lentils Mothers and caregivers in both groups attended nutrition education sessions Both groups included pregnant and lactating women with a monthly supply of 5 kg soy-fortified bulgur, 1.5 kg vegetable oil and 2 kg lentils, as well as an indirect household ration of 5 kg wheat/soy blend, 1.5 kg oil and 2 kg lentils	Incidence of under-nutrition in children aged 12-41 months	• Both groups showed a decrease in the incidence of under-nutrition • The incidence of underweight and wasting was significantly lower in the preventative group • Differences in outcome were greatest in children aged 24-35 months at the time of the final survey. These children were exposed to intervention during the period of greatest nutritional vulnerability (aged between 6 and 23 months)
Diop et al[11]	*Study design:* RCT *Country:* Senegal *Study participants:* 70 severely malnourished children aged 3-36 months *Baseline nutritional status:* Malnourished with WHZ < -2	*Intervention period:* Until rehabilitation. Initially, all subjects received a vitamin A supplement, folic acid supplement and F75 formula. Participants were randomised to: • F100 group: F100 *ad libitum* three times daily plus 3 meals/day local food plus a Fe supplement • *RUTF group:* RUTF *ad libitum* three times daily plus 3 meals/day local food plus a Fe supplement	Differences in weight gain, average duration to rehabilitation	• Average weight gain was significantly higher in the RUTF group (15.6 g/kg/day vs. 10.1 g/kg/day in the F100 group) • The difference in weight gain was greater in most wasted children • Average duration for rehabilitation was significantly lower in the RUTF group (13.4 days for children in RUTF and 17.3 days for those in the F100 group)

Nackers et al[19]	*Study design:* RCT *Country:* Niger *Study participants:* 451 children aged 6-59 months *Baseline nutritional status:* Moderate acute malnutrition as indicated by weight-for-height 70 - < 80% (NCHS standard) with MUAC ≥ 110 mm	*Intervention period:* 16 weeks or until recovery. Initially, all subjects received vitamin A and folic acid supplements. Fe supplement was only given to children with low haemoglobin upon admission Participants were randomised to: • *RUTF group:* RUTF two packs daily, providing 1 000 kcal/day • *C/S group:* Corn/soy blend premix (1 750 g corn/soy blend plus 175 ml vegetable oil plus 105 g sugar), providing 1 231 kcal/day • A weekly family ration (both groups) of 2.45 kg corn/soy blend, 140 ml oil and 140 g sugar • Discharge ration (both groups) of 50 kg cereals, 7.5 kg legumes and 7.5 l oil	Weight gain, recovery from malnutrition	• Average weight gain was 5.67 g/kg/day in the RUTF group and 4.59 g/kg/day in the C/S group • The recovery rate was significantly higher in the RUTF group (79.1% and 64.4% in the RUTF and C/S groups respectively)
Oelofse et al[20]	*Study design:* RCT *Country:* South Africa *Study participants:* 60 children from a disadvantaged community, aged 6-12 months *Baseline nutritional status*: Healthy children, who were not necessarily malnourished	*Intervention period:* Six months Participants were randomised to: • *Intervention group:* Micronutrient-fortified complementary food (cereal): 60 g dry product per day, providing 312 kcal/day • *Control group:* No intervention	Weight gain, linear growth	• No benefit in terms of weight gain or linear growth was observed in the intervention group
Roy et al[21]	*Study design:* Prospective randomised trial *Country:* Bangladesh *Study participants*: 282 moderately malnourished children aged 6-24 months *Baseline nutritional status:* Weight-for-age 61-75% (NCHS standard)	*Intervention period:* Three months with a six-month follow-up. Participants were randomised to: • *Group 1:* Mothers received intensive nutrition education twice weekly. Children received no intervention in the form of feeding • *Group 2:* Mothers received intensive nutrition education twice weekly. Children received a supplement of 40 g roasted powdered rice, 20 g roasted powdered pulse, 10 g molasses and 6 g oil. Supplementation was given six days/week, providing 300 kcal/day • *Control:* Mothers received nutrition education every second week. No feeding support was offered to the children	Improvement in nutritional status and feeding behaviour	• Recovery from moderate malnutrition was similar in groups 1 and 2, but significantly better compared to control
Maleta et al[22]	*Study design:* RCT *Country:* Malawi *Study participants:* 61 malnourished children aged 42-60 months *Baseline nutritional status:* malnourished with WAZ or HAZ < -2	*Intervention period*: 12 weeks Participants were randomised to: • *RUTF group:* RUTF 92 g/day taken in 3-4 rations/day supplemental to customary food intake, providing 534 kcal/day • *M/S group:* Maize/soy flour 140 g/day taken in 3-4 rations/day supplemental to customary food intake, providing 531 kcal/day	Weight gain, length gain	• Both groups showed a modest weight gain. The weight increase was better sustained in the RUTF group • No effect on linear growth was observed
Matilsky et al[23]	*Study design:* RCT *Country:* Malawi *Study participants:* 1 362 malnourished children aged 6-60 months *Baseline nutritional status:* Wasted as per WHZ < -2 but ≥ -3	*Intervention period:* A maximum of eight weeks, or until recovery from wasting • Participants were randomised to: • *MFS group:* Milk- or peanut-fortified spread, providing 314 kJ/kg/day • *SFS group:* Soy/peanut-fortified spread, providing 314 kJ/kg/day • *C/S group:* Corn/soy flour blend, providing 314 kJ/kg/day	Malnutrition recovery rate. Rate of weight gain and length gain	• The rate of weight gain in the first two weeks was 2.6 g/kg/day in the MFS group, 2.4 g/kg/day in the SFS group, and 2 g/kg/day in the C/S group • The rate of length gain did not differ among the groups

Fe: iron, HAZ: height-for-age Z-score, Hb: haemoglobin, MUAC: mid-upper-arm circumference, NCHS: National Centre of Health Statistics, RCT: randomised controlled trial, RUTF: ready-to-use therapeutic food, WAZ: weight-for-age Z-score, WHZ: weight-for-height Z-score

Study characteristics

Most trials were conducted in developing countries in sub-Saharan Africa. Study participants differed in terms of their nutrition status at baseline. Seven studies included malnourished children,[3,4,11,19,21-23] whereas study participants were not necessarily malnourished in two trials,[5,20] and in one study both well-nourished and malnourished children were targeted.[18] The age of the children ranged from 6-72 months.

Supplementary feeding differed among the trials, ranging from the use of FBF to cereal, and fortified and unfortified spread as a form of RUTF. In some studies, the effectiveness of a trial supplement was compared to the effectiveness of a supplement used in existing feeding programmes, whereas others compared two or more trial supplements with each other. One study[21] compared the effects of combined supplementation and intensive nutrition education with intensive nutrition education only. The education programme targeted mothers of malnourished children twice weekly for a period of three months.

In most studies, a specific daily dosage of supplementary feed was offered. One study promoted the use of the supplement *ad libitum,*[11] while others provided a monthly ration only. The duration of supplementation varied widely across individual studies, with a maximum of 12 months. One study reported that supplementation was continued until all children recovered from malnutrition.[11]Apart from the supplementation period, three studies[5,18,21] also included a post-intervention observation period, of which the shortest was six months and the longest three years.

Only two studies reported supervised intake of the supplement.[4,11] The supplement was taken at home in the remaining studies. Some of the implemented measures to monitor actual consumption in the case of home intake included the collection of empty food containers,[3,22] focus group discussions,[23] weekly visits by trained field assistants,[3,5,20] completion of a questionnaire,[19] or no implemented measures.[18,21]

Most studies reported standardised measurement techniques for height/length and weight, taken at baseline, exit and regular intervals during the supplementation period. In one study, knee-heel length was measured as part of anthropometric assessment,[4] head circumference in another,[5] and mid-upper-arm circumference in four studies.[3,5,19,23]

Study outcomes

Weight gain

Three studies reported weight gain in grams per kilogramme per day (g/kg/day). Diop et al[11] reported an average weight gain of 15.6 g/kg/day for children who received supplementary feeding in the form of RUTF and 10.2 g/kg/day for children who received F100 formula. In both cases, the supplement was given *ad libitum* three times per day. A lower rate of average weight gain was reported by Nackers et al,[19] who described a weight gain of 5.67 g/kg/day and 4.59 g/kg/day for children receiving RUTF or a corn/soy blend premix, respectively. The study by Matilsky et al[23] reported a daily weight gain of 2.6 g/kg (milk/peanut-fortified spread), 2.4 g/kg (soy/peanut-fortified spread) and 2 g/kg (corn and soy flour blend). In these three studies, reporting of the dosages, as well as the amount of macro- and micronutrients given, differed greatly. Therefore, it was not possible to identify whether any connection existed between the amount of nutrients supplemented and the rate of weight gain. A possible explanation for the 3-5 times higher rate of weight gain reported by Diop et al[11] is that intake of the supplement was supervised when consumed on site, whereas in the other two studies supplements were consumed at home and actual intake could not be controlled. It is possible that the slow rate of weight gain related to insufficient intake of the supplement.

The study by Matilsky et al[23] compared weight gain in groups receiving three different types of supplement, all providing the same amount of energy (314 kJ/kg/day). The rate of weight gain in the two groups receiving the fortified spread was significantly higher compared to that in those who received the corn and soy flour blend, suggesting that energy is not the only factor that determines weight gain. The amount of protein in the corn and soy blend was almost twice the amount in the fortified spread, indicating that protein quantity did not play a major role in weight gain. Unfortunately, this study does not indicate the actual intake of the supplementary foods. Therefore, it is not known whether differences in weight gain could be the result of poor programme compliance.

Three studies reported on weight gain in the context of recovery from malnutrition. Phuka et al[3] reported a recovery rate of 20% and 16% for underweight children receiving the fortified spread (50 g/day) or the enriched maize and soy flour blend (71 g/day), respectively. The same authors reported recovery of 93% and 75% in the same treatment groups for wasting. The observed difference between the fortified spread and the maize and soy flour was significantly different, although both interventions were found to be effective. A second study[23] reported a similar recovery rate from wasting: 72% and 80% for children receiving a fortified corn and soy flour blend or fortified spread, respectively. A third study[19] reported recovery from acute moderate malnutrition at a rate of 79.1% in children receiving RUTF and 64.4% in children receiving a corn and soy blend. This difference was significant. It is important to note that the third study used the National Centre of Health Statistics weight-for-height reference and that the other two studies used the WHO z-scoring system in their definition of recovery.

Linear growth

Two studies[3,22] reported that nutrition supplementation did not have any effect on linear growth. The intervention period in both trials was only 12 weeks. This period may have been too short to demonstrate any effects. Furthermore, included children in the study by Maleta et al[22] were underweight and stunted, and aged 42-60 months. Intervention may have come at an age where it was too late to induce catch-up growth since it is documented that catch-up growth after the age of 24-36 months is unlikely, especially in those with a history of height faltering,[21] and thus would not have had a significant effect on linear growth.

In comparing the effects of fortified versus unfortified spread on linear growth, one study[4] reported on the significant role of micronutrient supplementation. Stunted children receiving micronutrient-fortified spread showed a 30% faster increase in linear growth compared to those receiving an isocaloric, isonitrogenous supplement. The authors speculated that zinc, vitamin B_{12} and iron could be especially beneficial in stunted children to induce catch-up growth.

For a sustained impact on the reversal of stunting, Phuka et al[5] reported that supplementation with fortified spread at a dosage of 50 g/day might be more beneficial than the provision of a 25 g/day dosage, or the provision of maize and soy flour. These authors found that the incidence of stunting during a cumulative 36-month period (12-month intervention plus a 24-month follow-up) was significantly lower (3.6%) compared to a smaller dosage of 25 g (10.3%), or maize and soy supplementation (19.6%).

Discussion

Preschool feeding programmes seem to have a positive impact on weight gain, subject to adequate intake. In studies in which intake was closely monitored, the increase in weight gain was higher than that in studies in which intake was not supervised. This suggests that an adequate amount of supplement needs to be consumed in order to provide sufficient amounts of nutrients in order to induce weight gain.

This aspect brings three important considerations to mind: sharing, substitution, and convenience and compliance.

Sharing

In poor settings where food security is low, it is almost inevitable that supplementation will be shared with other members of the household, resulting in insufficient intake. Previous data show that in developing countries, 50-75% of supplementary food rations do not reach the intended recipients.[17] Agha[15] illustrates the importance of providing a family ration in low-income settings. In this study, children received supplementation for a seven-month period, during which a family ration was included for the first four months. A significant increase in dropout started in the fifth month, when the family ration was no longer provided. The value of the supplement for one child only was lower than the expense of a trip to the feeding centre, where the supplement had to be collected. Therefore, the provision of a ration or supplement for the child only, while ignoring the family, can result in inadequate intake.

Substitution

Consumption of supplements may fail to improve nutrient intake and growth, simply because the supplement may displace other food in the diet. Substitution can be problematic, especially when cereal- or legume-based supplementation is provided, since these foods resemble the traditional staple diet.[22] Substitution may be less problematic when RUTF is supplemented, since a smaller volume is required which has a smaller impact on habitual intake.

Convenience and compliance

The supplementation of cereal- or legume-based food or FBF may be less effective because preparation is required before it can be consumed. The amount of labour involved in cooking and preparation may explain lower compliance rates[19] compared to supplementation with RUTF which does not require any preparation. Because of individual packaging, RUTF is more likely to be interpreted as a therapeutic product, which decreases the probability of sharing.

The benefits of RUTF may, in part, explain the fact that those studies that compared RUTF to other forms of supplementation reported a greater impact on growth. Another factor that may relate to this finding is that RUTF contains a concentrated source of nutrients. The energy density of RUTF is approximately five times higher than that of cereal- and legume-based supplements, as well as liquid formulations, such as F100.[11,22] This decreases the volume of supplementation required to supply an adequate amount of energy and other nutrients to support growth. Furthermore, RUTF resists bacterial growth because it does not contain any water and this reduces the risk of contracting infections.

Data suggest that intervention at an early age is more effective with regard to the reversal of stunting. Since stunting is a sign of chronic malnutrition, the problem has its origin at an early age, from 2-4 months.[20] Early intervention, at the first sign of acute malnutrition, can prevent the development of acute to chronic malnutrition. Prevention, rather than intervention, might be even more effective. The study by Ruel et al[18] which targeted children aged 6-23 months (preventative model) versus only malnourished children (recuperative model) found that mean z-scores for HAZ, WAZ and WHZ were significantly higher after a cumulative 36-month follow-up period.

Poor feeding practices, owing to a lack of knowledge, contribute to the development of nutritional deficiencies and malnutrition, even in settings where the availability of food is not necessarily low.[20] The role of intensive nutrition education is highlighted in the publication by Roy et al.[21] In comparing the effectiveness of intensive nutrition education with or without supplementation, similar results were reported in the recovery from moderate malnutrition. Education programmes can motivate parents and caregivers to change feeding behaviour, even under difficult circumstances, and provide valuable information on feeding frequency and food choices. While supplementation may be effective in inducing recovery from malnutrition, education may contribute towards sustainability.

Study limitations

The number of identified studies from the initial search (59) in this study was very low. This could possibly be because of the use of limited search terms. The use of broader search terms could have resulted in a greater number of studies being included in the initial search. The search term "growth" could have been expanded to include the terms "weight", "height", "stunting", "wasting" and "malnutrition". The search term "preschool feeding programmes" could have been widened to include the terms "supplementary feeding programmes" and "feeding schemes". The search term "developing countries" could have been used in addition to the term "disadvantaged".

A second limitation relates to the fact that assessment of risk of bias was carried out by one researcher only, according to a self-designed grading system. Ideally, the quality of the evidence should have been assessed by multiple researchers using a recognised grading system. Although such grading systems have been developed, none could be found that were specific to this review.

This review is limited by high levels of heterogeneity in terms of interventions, the intervention period, reported outcomes and participant characteristics. As with all meta-analyses, the quality of the findings are only as good as the quality of the individual studies, of which less than half were rated to be of a high quality.

Conclusion

Based on the aforementioned limitations, no firm conclusions can be drawn. More high-quality research relating to the impact of preschool feeding programmes on the growth of disadvantaged children is needed. These studies should consider factors such as compliance and sharing, combining feeding programmes with educational interventions to sustain the effects of food supplementation in the long term, and targeting children at an early stage of malnutrition, or even earlier, as part of a preventative approach.

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One of the authors is an employee of Nestlé Health Science.

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